EuroAsiaSPI² 2015 Proceedings

Proceedings

The papers in this book comprise the industrial proceedings of the EuroSPI² 2015 conference. They reflect the authors' opinions and, in the interests of timely dissemination, are published as presented and without change. Their inclusion in this publication does not necessarily constitute endorsement by EuroSPI² and the publisher.

EuroSPI²

EuroSPI² is a partnership of large Scandinavian research companies and experience networks (SINTEF, WHITEBOX [formerly DELTA], FiSMA), iSQI as a large German quality association, the American Society for Quality SW Division, the ECQA (European Certification and Qualification Association), and ISCN as the co-ordinating partner.

The EuroSPI² conference presents and discusses results from **systems, software and services process improvement and innovation (SPI)** projects in industry and research, focusing on the gained benefits and the criteria for success. This year's event is the 22nd of a series of conferences to which international researchers and professionals contribute their lessons learned and share their knowledge as they work towards the next higher level of software management professionalism.

Since 2009 we have extended the scope of the conference from software process improvement to systems, software and service based process improvement.

The TSE (Turkish Standards Institute) is the leading government body which implements international and European standards in the Turkish industry. TSE also has set up a group of ISO 15504 (and Automotive SPICE) assessors and performs assessments in leading IT industry. TSE holds a key note at EuroSPI, co-edited the books, and supports the conference by the political and industry network.

The conference is hosted by the Ankara University, faculty of law, which is one of the oldest universities in Ankara, founded with the foundation of the Turkish state. This university is placed in the city centre of Ankara and has a long standing relationship with European institutions and is the host of the EuroSPI 2015 conference.

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Welcome Address by the EuroSPI² General Chair

Richard Messnarz

ISCN, Austria/Ireland

EuroSPI² is an initiative with 5 major goals (www.eurospi.net):

1. An annual EuroSPI² conference supported by System, Software and Services Process Improvement Networks from different European countries.

2. EuroSPI² supported the establishment of a world-wide SPI Manifesto (SPI = Systems, Software and Services Process Improvement) with SPI values and principles agreed among experts world-wide. We build clusters of experts and knowledge libraries for these values and principles.

3. Establishing a web-based experience library based on hundreds of experience reports contributed to EuroSPI² since 1994 and which is continuously extended over the years and is made available to conference attendees.

4. Establishing a European Qualification Framework for a pool of professions related with SPI and management. This is supported by Europe-wide certification for qualifications in the SPI area, exam systems, and online training platforms (European Certification and Qualification Association, www.ecqa.org).

5. Establishing a world-wide cooperation with publishers to support thematic topics of EuroSPI (SPRINGER CCIS series, Wiley annual volume about process Evolution, Volume in the SQP Journal of the ASQ, and more).

EuroSPI² is a partnership of large Scandinavian research companies and experience networks (SINTEF, WHITEBOX [formerly DELTA], FiSMA), the iSQI as a large German quality association, the American Society for Quality, and ISCN as the co-coordinating partner. EuroSPI² collaborates with a large number of SPINs (System, Software and Services Process Improvement Network) in Europe.

EuroSPI^2 conferences present and discuss results from **systems, software and services process improvement (SPI)** projects in industry and research, focussing on the benefits gained and the criteria for success. This year's event is the 22nd 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.

A typical characterization of EuroSPI² was stated by a company using the following words:

> *"... the biggest value of EuroSPI² lies in its function as a European knowledge and experience exchange mechanism for SPI and innovation".*

A cluster of European projects (supporting ECQA and EuroSPI²) contribute knowledge to the initiative, including AE (Automotive Engineer), and LEADSUS (Leadership in Sustainability). A pool of more than 30 qualifications has been set up (see www.ecqa.org).

Join the community of cross-company learning of good practices!

Contact: Richard Messnarz, ISCN, Austria/Ireland, e-mail: rmess@iscn.com

Welcome by Alexander Poth –Co-editor of EuroSPI Books

Alexander Poth

Volkswagen AG,

Germany

In my opinion we can have more effective and efficient IT solutions with better methods for professional development and improvement of software systems and services.

I think a key to reaching this goal is to focus on methods that ensure the explicit and implicit demanded quality of IT systems and services leading to more customer and user satisfaction. In a user perspective added value by IT solutions is based on adequate quality. To deliver adequate quality we have to continuously realign the quality of the IT solution with the current quality demands of the users.

EuroSPI is a platform that brings together people from the industry and academic world to address this demand for more effective and efficient high quality IT solutions. This is the reason why I'm an active member in the EuroSPI community. My personal objective is to give ideas and feedbacks to the EuroSPI community to improve innovative concepts and methods for usage in the daily IT business to realize a higher added value with IT solutions.

Alexander Poth received the Dipl. Ing. (Master) degree in 2004 in computer engineering from the Technical University of Berlin. He is IT Quality Manager at Volkswagen AG.

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Welcome by WHITEBOX, Editors of the Improvement Series

Jørn Johansen

WHITEBOX, Denmark

EuroSPI is the best and most efficient European conference for news and experience in process improvement and innovation. Here you meet all the experts, the researcher and companies with the deep interest for this topic.

I have taken part in EuroSPI form the very beginning more than 20 years ago – and it has always been my best source for knowledge and inspiration.

Jørn Johansen has been working with Software Process Improvement (SPI) for more than 250 years including maturity assessment according to BOOTSTRAP, SPICE and CMMI. DELTA has also been a partner in the EuroSPI² conference from the very beginning 20 years ago. We are now for the 6th time the publisher of the Industrial Proceedings from EuroSPI² making it part of the DELTA Whitebox series about Process Improvement.

He has an M.Sc.E.E. from Ålborg University and more than 35 years of experience in IT. He has worked in a Danish company with embedded and application software as a Developer and Project Manager for 15 years. Mr. Johansen has been involved in all aspects of software development: specification, analysis, design, coding, and quality assurance. Furthermore he has been involved in the company's implementation of an ISO 9001 Quality System and was educated to and functioned as Internal Auditor. He was Director of Process Improvement and Senior Technology Specialist at DELTA.

For the last 20 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 100 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 than 25 person-year SPI project and Talent@IT, a 26 person-year project that involves 4 companies as well as the IT University in Copenhagen and DELTA. The Talent@IT project developed the ImproveAbility™ model, which help organisations to improve more efficient. Latest Mr. Johansen was the Project Manager of SourceIT project, an 18 person-year research project focusing on outsourcing and maturity.

He has also been a main driver in establishing and performing a large set of innovation checks in Danish companies. He has by him selve taken part in more than 50.

Mr. Johansen is also the co-ordinator of the Danish knowledge exchange groups: Improving the Software Development Process, Outsourcing and the newest group Software Measurement and the newest group Software MeasurementQuality.

Mr. Johansen was lead editor on ISO/IEC 33014 Guide for process improvement, which was published November 2013.

In January 2015 Jørn and two DELTA colleagues continued the DELTA SPI activities in the new company Whitebox.

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Welcome from the Local Organization and Scientific Programme Committee Chair in Ankara

Umay Akkaya

Turkish Standards

Institute

Kerem Kemaneci

Turkish Standards

Institute

Welcome to the 22nd EuroSPI² Conference in Ankara, Turkey.

TSE (Turkish Standards Institution) is the leading government body which prepares, implements and certifies international and European standards in the Turkish industry since 1960. TSE is full member of ISO, CEN/CENELEC, EOQ, CCRA and related to many other international organizations. TSE is authorizing member of CCRA-Common Criteria Recognition Arrangement and Common Criteria (IT Product Security Standard) Certificates are recognized within 26 countries. TSE has set up a group of ISO/IEC 15504 (and Automotive SPICE) assessors and performs assessments in leading IT industry. TSE IT Test and Certification Department also gives certificates from ISO/IEC 27001 IT Security Management System, ISO/IEC 20000-1 IT Service Management System, ISO/IEC 25051 Software Quality(COTS), ISO EN 9241-151 (Web Usability), ISO/IEC 40500(Web Accessibility), ISO/IEC 19790 Crypto Modules, ISO/IEC 24759 Crypto Test Techniques, Certified Ethical Hacker, Iqnet-Qweb mark, Basic Level Security Certification, Site Security Certification, Pentest Company Certification standards and criteria. And develops many IT and IT security standards for the sector. TSE holds a key note at EuroSPI, co-edited the books, and supports the conference by the political and industry network.

Mariye Umay Akkaya is the head of the IT Test and Certification Department of the Turkish Standards Institution. She has a Computer Engineer and Information Science degree with MSc from Bilkent University/Turkey. She started to work at Turkish Standards Institution (TSE) in 2003 and is currently the head of the IT Test and Certification Department of TSE and Turkish Common Criteria Certification Scheme. She was the Technical and Quality Responsible of Turkish Common Criteria Certification Scheme and IT Department. She is also responsible for many IT Test and Certification Standards such as ISO/IEC 15408-Common Criteria, ISO/IEC 27001(ISMS), SPICE-ISO/IEC 15504, ISO 19790 and 24759-Crypto Modul and Algorithm Certifications etc. as an inspection and certification expert. She is currently a voting member of Common Criteria- CCRA, CCMB, CCDB, CCES and CCMC committees, NATO CC_Cat on behalf of TSE and Turkey.

Kerem Kemaneci, Computer Engineer (BSc.), is a certified ISO 15504 SPICE Competent Assessor and works at the TSE-Turkish Standards Institution in the IT Test and Certification Department. After his graduation from the Computer Engineering Program at Selçuk University in 2008, he started working at the IT Department of the Turkish Ministry of Culture and Tourism in 2009. Then he transferred to the IT Department of State Supply Office. Since October 2010 he works as a competent assessor and continues his studies at the Production Management Master Program (MSc.) at Gazi University in Ankara.

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Welcome from the ECQA President

Michael Reiner

ECQA, Austria

The European Certification and Qualification Association (ECQA) is a not-for-profit association that aims to unify the certification processes for various professions in Europe. It joins institutions and thousands of professionals from all over Europe as well as globally and offers the certification to participants for numerous professions. Currently, 27+ professions are active and some new professions being developed right now. ECQA services are offered in more than 24 countries across Europe and worldwide by more than 60 ECQA members. With the help of Ambassadors, the ECQA is also enhancing its activities by expanding to all over the world (e.g. USA, China, Thailand, India, Singapore, Japan etc.).

The main objective of the ECQA is to develop and maintain a set of quality criteria and common certification rules across the different regions. Therefore, the ECQA ensures that the same knowledge is presented to participants across Europe and all participants are tested according to the same requirements. The knowledge to be provided and tested for certain professions is defined by experts from industry and research, who know best what the requirements of the market are and what the state of the art knowledge is within certain domains. These experts work in ECQA groups called Job Role Committees. The EQCA coordinates their work and provides the infrastructure and IT support. The modularization is, according to European quality framework, split into units, elements and performance criteria. The certification exam then shows exactly which elements and units have been passed and which have not.

The ECQA has developed a set of quality criteria, which are used for the certification of the following types of service providers: trainers, training organizations, exam organizations, and certification organizations. The aim is to ensure the same level of training and certification quality in all participating countries.

Working today means cooperating with a many international partners. Thus, the understanding on both sides is essential. Certifications can help to better understand the different views of different professions. Because of this, the ECQA Job roles aim at core competences in networking and understanding as well as concentrate on the needs of the industry.

Michael Reiner, president of the ECQA and lecturer for Business Administration and E-Business Management at the IMC University of Applied Sciences Krems, has several years of experience in the field of IT, Microsoft Office, Microsoft NAV (ERP), Knowledge Management, Business Intelligence, Web 2.0 and social networks. Moreover, Mr. Reiner coordinates and participates in various EU projects.

In the last 3 years, ECQA has developed towards an international certifier issuing certificates and establishing partnerships in all European countries as well as in India, South America, China, Japan and the Middle East. This expansion on the one hand enriches ECQA and its job roles with new views and different cultural aspects but also shows that there will be the need of new approaches for the solution of international certification schema.

Additionally ECQA also works as exam- and certification organization for various international organizations such as iNTACS and ISTQB.

I wish you a good time at the EuroSPI² 2015, a lot of interesting networking partners and informatory meetings.

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Implementing Functional Safety Standards

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Abstract

In the EU project SafEUr (518632-LLP-1-2011-1-AT-LEONARDO-LMP) the partnership developed a skill set with learning objectives, training materials, and tools to teach and coach the implementation of IEC 61508 and ISO 26262. Automotive, Medical, and Nuclear industry gave inputs to the project. A group of above 20 multinational companies (SOQRATES www.soqrates.de) which also are active in automotive industry (some of them represent the largest suppliers in Automotive industry) organised reviews and trial courses with safety managers. This led to a defined set of skills and tools we expect from functional safety managers and functional safety engineers. In this paper we describe the results of SafEUr, and we explain based on an example how these new methods impact the future system and software design strategies in Automotive industry.

The AQUA Automotive Sector Skills Alliance: Best Practice in an Integrated Engineering Approach

Christian Kreiner[1], Richard Messnarz[2], Andreas Riel[3], Serge Tichkiewitch[3], Dick Theisens[4]

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Abstract

The AQUA Automotive Sector Skill Alliance integrates core elements of three complementary disciplines in Automotive into one practical, compact skill set. Alliance experts on Automotive SPICE (ISO 15504), Functional Safety (ISO 26262), and Six Sigma collaborated to collect best integrated practice and devise a training with personal certification. The AQUA skills set is highly modular, comprises eleven learning elements – each with four very compact sub-views: Automotive SPICE, Functional Safety, Design for Six Sigma, and an integration view. Some integrated topics are highlighted and illustrated by an example: integrated development process, multi-discipline information flows, and entangled iterations. AQUA courses are currently offered via Automotive Clusters and training providers across Europe, and as regular University courses. Feedback confirms AQUA is meeting a vital demand in Automotive not covered so far.

Keywords

Automotive SPICE, Functional Safety, ISO 26262, Design for Six Sigma (DfSS), Integrated Approach for Engineering, AQUA - Automotive Knowledge Alliance

Reference

Characterization of tests focused on validation of software project

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Abstract

In this paper, a method is applied to identify and characterize what software testing should be applied to a software project for technological validation. The method was applied to a Web project and resulted in a characterization of the tests to which a project must be subjected to verify its functional and non-functional requirements. The characterization determined which tests should be applied to the project. Furthermore, the results of the characterization define a test plan that presents the validation tests for a specific project, and the problem of applying specific and appropriate tests to the project is thus resolved.

Keywords

Validation, software testing, characterization, software project

1 Introduction

It is necessary that every organization that is dedicated to software development set a series of control mechanisms to for determining your that each product meets the standards, processes and quality standards to and thereby ensure that your product it is free of errors, as a guarantee before entering the national and international competitive market. One of the processes that ensure this competitiveness is validation.

Thus, the whole entire software development process is linked to the validation process through the implementation of a series of activities or processes, usually called tests, which ensure that the software meets its specification. The main concern of validation focuses on product requirements. If implementation of the requirements is not are not implemented according to the actual needs of the user and the real environment where the same, in fact, the software will run, you can not it is not possible to meet the customer requirements. This leads to therefore, many projects to be defective due to because the system functionality expected so do not satisfy the needs of users in the workplace [2]. For [8], validation is intrinsically linked to the activity of software testing, which is the necessary support to ensure product quality. The One paper [5] shows that each product presents requirements and different validation activities and that, so it is necessary, a process is thus needed to identify the appropriate activities of product validation activities. That is, that every software product is to apply a specific or individualized series of validation tests should be applied to every software product. In that sense, [9] indicates that projects software development fails, due to inadequate software testing, to specifically poor or unplanned tests or poor, indicating that the project is not methodologically checked which further leads to affect failures due to the absence or lack of training of users, who are unaware of the purpose of the tests. Similarly, refers [6], no testing that the lack of testing and quality standards, as due to the absence of consistency, are precursors of interruptions happen that occur in organizations due to software bugs, that which can be expensive. While Furthermore, [10] indicates that there is a lack in terms of the type of project and software testing tool that would implement the project specific tools and therefore create an adequate proof relationship.

All this overall situation is expressed by [1], which states that there is no clear definition of the types of tests to that can be applied to the a specific type of project, used by each that each organization, applies and by [3], which indicate that one of the biggest problems in the test software is whether the appropriate according to the types of test have been conducted appropriate tests.

Therefore, it is critical that organizations produce evidence of software development or testing that is are defined by based on the technological projects that they develop, apply because as the tests required by a demands a particular project and the must reduce the impact of failures or errors of omission or ignorance must be reduced the tests required by a project. Therefore, we ask the following questions: ¿How to can we determine what software testing to should be applied to a project? ¿Characterize the project will provide evidence a for specific validation testing project? ¿The characterization allows for defining of a test plan for a software project?

The answers to these questions will try to answer. We will attempt to answer these questions raised by the application of applying a method focused designed to characterize for the technological characterization of software testing for a software development project by technology.

The article is divided into the following sections: 1. Introduction 2. Related Work 3. Method for characterizing software Test 4. Conclusion 5. Bibliography.

2 Related work

[4] Characterizes software testing approaches based on models that determine the tests, techniques, tools, quality characteristics, and other features required. [12] Establishes a characterization scheme for the selection of V & V techniques for modeling and simulation projects. This characterization

scheme selects techniques according to the project and provides a catalog of applications as a repository of information that will allow selection of the technique specified for the project. [11] Provides a characterization scheme for selection from a catalog that provides the information needed to select the best technique tests for a project.

2.1   Importance and benefits of Characterization

Characterization tests are important as a means to identify and establish the characteristics or attributes that identify a project in regard to software testing. Through such a characterization, it is possible to determine which software tests are appropriate for a software project or product. Characterization tests make it possible to identify the software development group or test set required to accurately test strategies related to the project. The characterization seeks to establish which tests are appropriate for a project according to the implemented technology.

Also presents benefits or advantages in addressing problems such as the lack of methodologies, methods or similar studies in the area of software testing. Moreover, the difficulty of characterization will depend on how the attributes are identified and organized and how these attributes are considered to select studies that support the characterization. The benefits gained by applying the characterization are mainly (Figure 1):
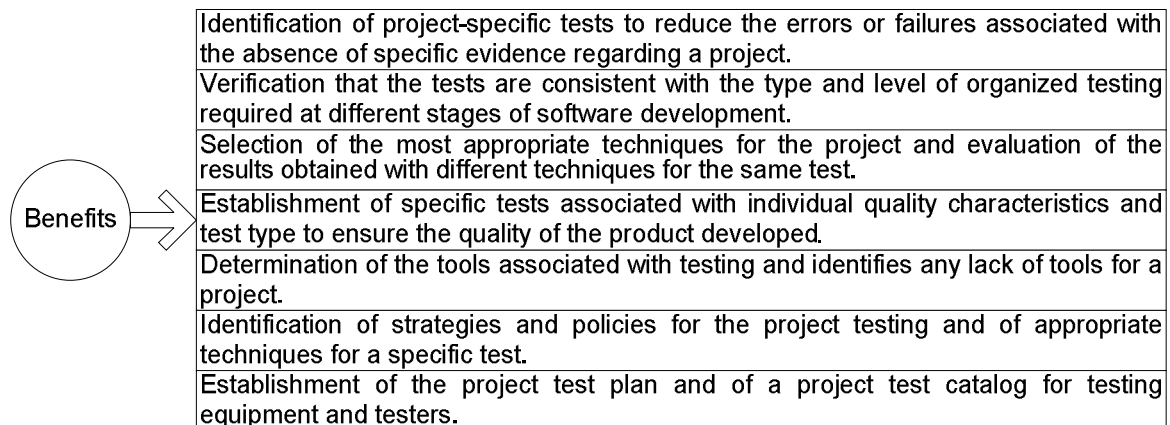
Figure 1. Benefits of the characterization.

3   Method of characterizing software testing

The method presented is adapted from the method applied in [4]. The proposed method allows for the characterization of software testing for given software project through the six steps described below (Figure 2):
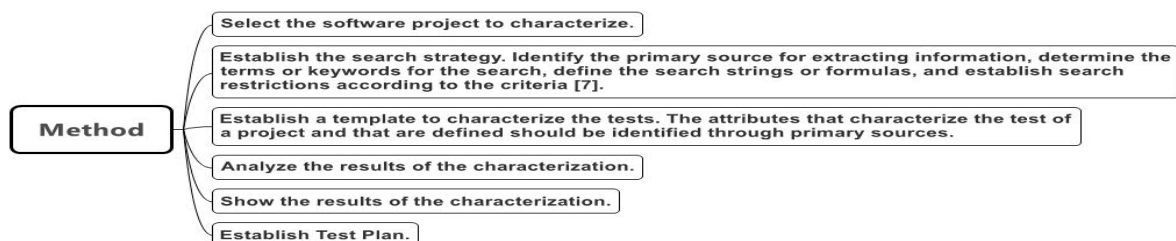
Figure 2. Method of characterizing.

3.1   Select the Software Project to Characterize

The project is aimed at developing Web applications. A validation test for a Web project is characterized.

3.2   Establish the search strategy

• Identify the primary source for the extraction of information: primary sources selected search are: IEEE Xplore, ACM Digital Library, Springer Link y Science Direct Avoid

• The search terms are: Web Application Testing, Web Application Testing Tool, Web Application Level Testing, Non functional Web testing, functional Web testing y functional Web testing tool. Definir las cadenas o fórmulas de búsqueda y establecer las restricciones de la búsqueda. Defining search strings or formulas and set search restrictions.

• The search strings or formulas:IEEE Xplorer: (((((((("Document Title":Testing Web Applications) OR "Document Title":Web Application Testing) OR "Document Title":Web Application Testing Tool) OR "Document Title":Web Application Level Testing) OR "Document Title":Web non fuctional testing) OR "Document Title":Web functional testing) OR "Document Title":functional testing tool for web applications) NOT "Document Title":web services), ACM: Web Application Testing , Web Application Testing Tool, Web Application Level Testing, Web non functional testing, Web functional testing, Functional web testing tool, Springer link:(Web and applications and testing or web and applications and testing and tool or web and applications and level)' published between '1 Jan 1990' and '11 Feb 2013' with no filters and (web and non and functional and testing or web and functional and testing or web and functional and testing)' published between '1 Jan 1990' and '11 Feb 2013' with no filters, Science Direct: TITLE(Web Application Testing) or TITLE(Web Application Testing Tool OR Web Application Level Testing OR Web non functional testing OR Web functional testing OR web applications functional testing tool)[All Sources(Computer Science)] y Web Application Testing Tool OR Web Application Level Testing OR Web non functional testing OR Web functional testing OR web applications functional testing tool.

• The search constraint is limited from the years 1990 to 2013 only for Web applications and does not include Web services and Web 2.0.

3.3   Characterize Template

The characterization template is the tool that is used to organize the attributes that identify the tests to be applied to a project: Author, Title (name of article), Test type (functional or non functional test), Test level; Quality features. Specific test, Technique, tool.

3.4   Analyze the Results.

The obtained data are analyzed by searching the different sources of information and identifying the attributes set in the template. The table 1 establishes the results of the search for Web applications.

Digital Library	Search Results	Select Paper
IEEE Xplore	183	17
ACM Dgital Library	201	7
Springer Link	14	3
Science Direct	13	4

Table 1. Search Results.

4 Results

The results obtained through this characterization make it possible to determine and identify which software testing should be applied to Web application projects. Moreover, the characterization facilitates the establishment of a test plan that is appropriate for the project. The results suggest which tests should be applied for Web projects and which require more intensive application to reduce or eliminate errors or failures. The results of the characterization are described below:

The test types were organized into functional and non-functional tests (Figure 3). Functional tests represent 71% of the tests, whereas 29% are non-functional. This result indicates that there is an increased interest in functional testing because it verifies the correct operation of the project.
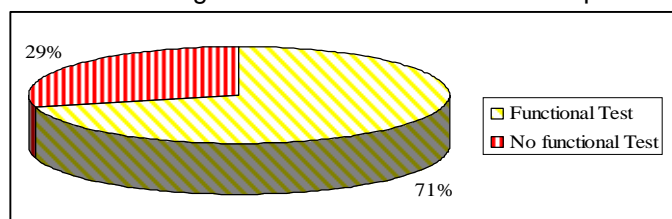
Figure 3. Type of Test.

Regarding the test level (Figure. 4), 87% were for the system level, and 13% were for the acceptance level. Integration testing and unit testing were not considered. These results show that most of the tests focus on the system level.
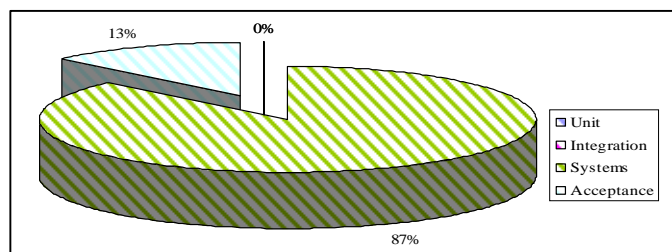
Figure. 4. Test Level.

The quality characteristics (Figure. 5) indicate that the tests are oriented as follows: 71% toward functionality, 26% toward efficiency and 3% toward usability. These results show that functional tests have priority in Web projects.
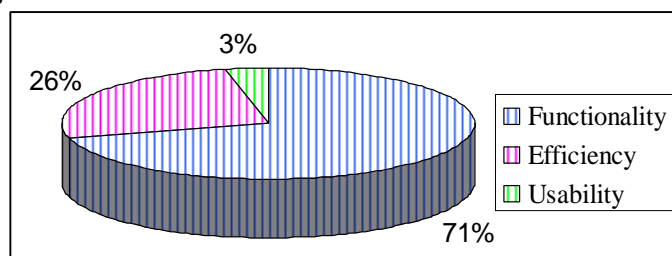
Figure. 5. Quality Characteristics.

Specific tests (Figure 6) show that the security tests have a demand of 30% since the Web security is vital, functional 20%, performance 19%, 10% acceptance and 3% other tests. However, testing graphical interface and browser compatibility as well as security and acceptance is part of the cate-

gory of functional tests. Similarly, load testing and stress fall within the category of performance testing. Database testing represents a different entity from a web project and therefore has been considered separately.
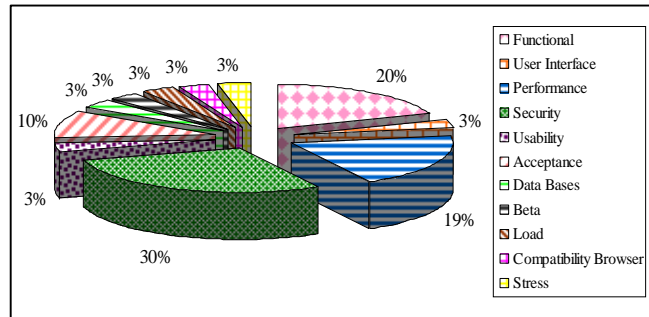
Figure 6. Specific Tests.

The results show that 67% of the tests represent the tools and that 33% represent techniques (Figure 7).
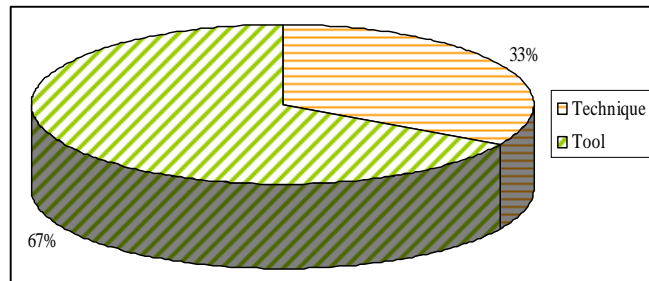
Figure. 7. Technique and Tool.

The test plan is the result of the characterization testing. The plan summarizes the tests to be applied to the Web project. The plan (Table 2) is organized according to the type of test. But it does not make any reference to the techniques or the tools, that are, in many cases, experimental.

Table 2. Test Plan.

Test Type: Functional
Test Level: Unit, Systems, Acceptance
Quality Characteristics: Functionality, security
Specifics Test: Functionality, security, user interface, browser compatibility, database, beta, acceptance
Techniques:
Tool:

5   Conclusions

A method to characterize software validation testing has been adapted and applied. The method is a feasible and effective way to determine the tests to which a project should be subjected. The method identifies the type of tests, test levels, quality characteristics and specific tests for a project. It also allows the identification of techniques and testing tools.

It has been determined that there is increased interest in the application of functional testing for Web projects where safety testing has greater importance. The test level is systems, and

the quality characteristic is functionality. The review shows the lack of unit testing and integration testing.

The review presented difficulties due to the lack of related studies validating Web applications, as there are few studies on the characterization of software testing to provide insight into what aspects have been of software testing have been characterized. This lack may be because the main motivation for researchers is to develop methods or techniques that eliminate or reduce errors or failures when applied to the validation of Web applications.

The characterization has facilitated the establishment of a test plan that allows testers or test equipment to develop validation tests with confidence for a Web project.

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7 Author CV

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Objective-driven Process Appraisals: An educational Experiment

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Abstract

Software improvement frameworks are often perceived to be expensive and oriented towards larger companies. It is also difficult to teach about these frameworks to students who lack any experience with software development in a commercial setting. In this paper we report experience with teaching software process improvement using a series of small exercises that together establish a quick objective-driven appraisal of a software organization. We show how the focus on practical results reinforces the educational value of the exercise by making it more engaging for students.

Keywords

CMMI, SCAMPI, Software Process Improvement, Appraisals

1 Introduction

In an earlier paper [1] we reported on experience with teaching and applying process appraisals at a university by executing a real appraisal on a set of projects executed by university students. The appraisal method is based on the Standard CMMI Appraisal Method for Process Improvement (SCAMPI) [2] using the Capability Maturity Model Integration (CMMI®) [3]. The approach was well received by students. They find the practical experience in the appraisal exercise a necessary complement to the classroom training in process improvement frameworks. Some disadvantages of the method could not be addressed by incremental improvements anymore and this led us to explore an entirely different approach. In this paper we report on the early experience with this new way of working and compare the results with the former approach.

2 Organizational Context and Background

The training in software appraisals is part of a one-semester Software Management course at Ghent University. All students who follow that course also follow a Software Development Project course in which they gain experience with the project management aspects of software development. The projects apply Scrum for planning, monitoring and control. That set of projects and their organizational context is the subject of the appraisal exercise.

We use the Capability Maturity Model Integration for Development (CMMI-DEV 1.3) [3] as global improvement framework in the course because it provides a structure to understand the relationship between many other frameworks, methods and techniques [4].

The CMMI-DEV 1.3 identifies 22 process areas. Process areas are classified in four Categories (Process Management, Project Management, Engineering and Support) and in four Maturity Levels (2 - Managed, 3 – Defined, 4 – Quantitatively Managed and 5 – Optimizing). A process area involves specific and generic goals with their associated specific and generic practices. The practices define requirements for the processes implementing the process areas. They specify *what* needs to be done, not *how*. Specific practices are specific for each process area and occur only once. Generic practices are common to all process areas. The generic practices contribute to the so-called institutionalization of the process ensuring it becomes engrained in the organization and part of its culture.

3 Problem Statement

In the approach discussed in [1] a relatively large group of students is divided in mini-teams of 2-3 people. Each of the mini-teams has to perform an in-depth appraisal of a set of software development projects in the scope of a single process area using the method of Managed Discovery [2]. They present the intermediate findings in plenary classroom feedback sessions and develop the final findings based on the feedback received during these sessions. Students can gain an in-depth but narrow understanding of a single process area and gain experience with the appraisal technique in a real-life context.

The approach has the following disadvantages:

- Mini-teams work too much in isolation from each other on their process area and experience difficulties with contributing effectively during the feedback sessions. The approach works well from an educational and knowledge creation perspective but insufficiently supports identifying opportunities for improvement in the projects.

- Although the ramp up time and invested effort is reduced by limiting the scope to a single process area, it is not possible to cover the entire process improvement cycle in the time frame of a single semester. We can cover the appraisal phase but little time remains for effective action identification or implementation.

- We asked the students to report intermediate results in order to correct issues as early as possible. Yet they continue to have problems with some fundamental characteristics of the process model in the course of the exercise. Students have difficulties elaborating the generic practices in the context of their process area. E.g. "Plan the Process" and "Monitor and Control the Process" are immediately associated with planning, monitoring and controlling the *project* and not with the process implementing their process area. Many also fail to understand that organizational process areas (e.g. Organizational Training, Organizational Process Focus) must be addressed at the organizational level and not the project level. The relevance of university courses and the appraisal exercise itself tend to be overlooked as evidence.

- It is not always possible to combine effective education with an entertaining experience but the exercise scored too low on the second aspect with many students. Their attention was drawn too much to the tedious work of understanding the finer details of the specific practices in a certification-oriented spirit. The exercise was therefore too much perceived as prescriptive rather than inductive. Inductive frameworks focus on improvements based on an understanding of the current strengths and weaknesses of the organization. Prescriptive frameworks include a predefined set of practices that must be satisfied by a development process [5].

4 Approach

Instead of performing a narrow and in-depth analysis of a single process area we are now doing a broad and shallow appraisal covering all Maturity Level 2 process areas except Supplier Agreement Management and a selection of Maturity Level 3 process areas: Organization Process Focus and Organizational Training, Risk Management and the engineering process areas.

We are not requiring students to establish a detailed understanding of the specific practices of the selected process areas but give them a high-level introduction of the scope of each process area and a more detailed training on the generic practices for Maturity Level 2.

The exercises include weekly assignments requiring about 1-2 hours individual effort and a short discussion of a synthesis of the results at the beginning of each class. Only the final assignment is performed collaboratively in the classroom. The assignments successively cover the following aspects

1. General appraisal of all process areas

2. Generic practices of the Maturity Level 2 process areas

3. Generic practices of the Maturity Level 3 process areas

4. Identification of major artifacts as evidence of specific practice implementation + "dream questions" (what is going well? What must be changed?)

5. Brainstorming session to develop an action plan for a selected opportunity for improvement.

4.1 Training and Preparation

In preparation of the appraisal exercise students get a high-level introduction of the Capability Maturity Model Integration to establish a basic understanding of the scope of each the process areas in terms of the specific goals. We do not enter into the details of the specific practices. That enables them to perform the first assignment.

In a second step the generic practices of Maturity Level 2 are taught with particular emphasis on the relationship with the supporting process areas. That is facilitated by practical insight in the implementation of process areas they have gained by that time through the first assignment.

The sequence of course topics is aligned with the sequence of assignments to ensure a mutual reinforcement of building theoretical insight and gaining practical experience.

Sessions on quality assurance methods and root cause analysis in particular prepare for the final session for action planning.

4.2   General appraisal of all Process Areas

The first assignment builds on the general introduction of process areas but can also rely on the knowledge students have already established through earlier courses in their curriculum. They are not expected to interview project team members but can rely on their own understanding of how the process areas are implemented in their own project. The assignment can therefore be executed individually and with very modest effort.

The result must not be very elaborate. It can be expressed in terms of a tool or method that is used to support the implementation of the process area. We obviously know that a tool should not be confused with the process or method it is supporting, but students can more easily relate to tools and they are a very convenient way to refer to underlying processes. Tools are also a good source of objective evidence.

A typical summary of the results of the first assignment is shown in Table 1.

Table 1 Key Methods and Tools by Process Area (PA)

PA	Key Method, Tool
PP	Team Foundation Server, Jira Agile Rapid Boards, Virtual Standups on Slack.com
PMC	Team Foundation Server, Jira Agile Rapid Boards, Gantt Charts, TeamGantt
REQM	Use Cases, Quality Attribute Scenarios, Jira, Requirements List, Product Vision Board, Confluence
MA	Jira Agile (Burndown Charts), Sonarqube
CM	Ansible, Stash, Confluence
PPQA	Quality Gates, Sonarqube
OPF	Retrospectives on each iteration, discussions on Slack.com
OPD	Rules and standards (Confluence, GitHub Wiki)
OT	Discussion on Slack.com
RSKM	SOTA, Risk List, Confluence, Jira
RD	QAS and Tactics, List of Requirements, Confluence
TS	Design Patterns
PI	Continuous Integration Manager
VER	Peer Reviews, Jenkins, Test Cases
VAL	Jenkins

4.3   Generic Practices of the Process Areas

Building on the insight gained with the first assignment it is now easier to understand the generic practices based on their relationship with the Maturity Level 2 process areas. An example of the results for two process areas is shown Table 2.

Table 2 Generic Practices for Project Planning and Project Monitoring and Control

	PP	PMC
Establish a Policy		
Plan the Process		Sprints were used and monitored using Jira
Adequate Resources	Jira to manage issues and tasks, Gantt charts to visualize planning	Jira, Gantt
Assign Responsibility	Project manager	The scrum master or project manager
Train the People		
Manage Configurations	Planning in Jira	Scrum planning and Jira issues. Gantt charts to monitor project status and are placed on confluence.
Involve Stakeholders	Professor and assistants	Professor and assistants
Monitor and Control	Review planning at the beginning of a new sprint	
Evaluate Adherence		
Review Status	Bi-weekly reviews	Bi-weekly reviews

Also in this assignment, students can rely on their own knowledge of the implementation of the practices. They are obviously allowed to contact other project team members to complete the results.

We intentionally avoid any attempt at rating practice implementation, even a coarse-grain classification. However, from the results it is possible to determine opportunities for improvement at a glance by looking for empty cells in the table. In our example there is obviously a lack in training and quality assurance.

4.4   Discovery of Artifacts and Dream Questions

The assignment to identify artifacts that are evidence of implementation of practices can build on the previously established insight in the methods and tools that are used. In an educational context we do not aim for completeness of coverage and ask for a small number of example artifacts.

We apply a variation of the "Discovery" approach to identify artifacts that provide objective evidence of the implementation of process area practice [2]. In a discovery approach objective evidence is discovered during interview sessions with members of the organization. In the verification approach, artifacts are collected as more reliable objective evidence in preparation of the interviews during which the evidence is verified.

The "Dream Questions" are typically asked at the end of appraisal interview sessions requiring each participant to respond. The questions are:

- If you would be allowed to change one element in the organization, what would that be?

- If you would be allowed to keep one element in the organization, what would that be?

The "element" can be a procedure, way of working, tool, organizational infrastructure, etc.

The preceding assignments create a context enabling students to respond in an informed way to these questions. They typically respond with process-oriented issues and not with people-oriented issues (team spirit, dedication, superior skills) as is often the case in the appraisal of low maturity organizations.

4.5   Action Planning

All preceding assignments are performed as a combination of individual home work followed by a classroom discussion. The final assignment is a team effort in the classroom. We are using the 5 Why technique to identify the root cause of an issue and define corrective and preventive actions. It involves the following steps.

- 10 minutes individual reflection to respond to the why questions

- Collaborative creation of a cause-and-effect diagram

- Identification of preventive measures

As an example we addressed the following issue, an answer to a dream question in the previous assignment.

Projects are requested to apply the Scrum method while some basic assumption to apply that method are not satisfied. The members of the team are not collocated and typically work individually with limited opportunity for direct interaction. They are not allocated full-time to the project but only work on it a few hours a week. How can the method be effectively applied in such a context?

Why is this causing problems? Communication is inefficient. Inefficient work due to too many context-switches. A typical sprint duration does not work with part-time allocation. To identify solutions we could take some benefit from a paper on contemporary peer review in open-source development [6] we had discussed earlier in the course.

We concluded the following action: Establish a good combination of synchronous and asynchronous collaboration. Organize a remote stand-up meeting at a fixed time every week (not daily) using e.g. Hangouts and allow for asynchronous work during the week.

5 Lessons Learned

Although all but the last assignment involve individual work, the weekly discussions in the classroom ensure intense interaction between all students. It can be argued that the students only acquire a superficial understanding of the model because they are not asked to dive into the details of even one process area. However, we believe it is more important to have a good understanding of the basic structure and purpose of the model than a detailed knowledge of the specific practices and sub-practices. With the foundational knowledge they can study the details on their own when needed. By requiring students to establish a broad understanding of all process areas they can more easily engage in discussions and keep focus on the objective of process improvement. As mentioned before, the answers to the dream questions consistently refer to process issues and not to people issues demonstrating that the approach helps to establish a process-oriented mindset.

The first exercise can already be performed in the second week of the course. With a modest effort of 1-2 hours students are able to relate the theory to practice. That creates a quick win and the momentum to engage with the more difficult next steps.

The quick pace of an assignment per week allows for correction and adjustment at any time. For example, the second assignment to identify the implementation of generic practices for Maturity Level 2 process areas was not fully understood by all students and the result were not of adequate quality. Early detection of that lack of understanding could be remedied by giving specific advice in the subsequent classroom session and allowing some students to repeat the exercise.

Even with the extra week to redo the second assignment, there is more time and a better foundation to perform an action planning. Without sacrificing educational value we have obtain more practical results than with the previous approach [1].

The exercise can be better integrated with the course. A high level introduction of the model is sufficient to perform the first assignment. A more detail explanation of the relationships between process areas and generic practices supports the following assignments. Sessions on e.g. root cause analysis and quality assurance later in the course support the action planning.

We believe that the proposed method provides a good foundation for students to start applying process improvement in their future work environment. It can be applied with minimal training by members of the organization without expert guidance. The approach leads to the identification of quick wins which may provide a stepping stone towards more rigorous approaches.

6 Next Steps

We still follow a traditional "waterfall" life cycle in software process improvement with sequential execution of an appraisal, action planning, implementation, verification of success and deployment.

We want to explore how our approach can evolve to become more agile. It should be possible to identify quick wins in the first steps of the appraisal process and already start executing improvements, e.g. by feeding the results into the retrospectives at the end of Scrum sprints. That will enable students to complete the full cycle from identification of opportunities for improvement to deployment in their own projects.

7 Conclusion

In this experience report we have presented a sequence of exercises to educate university students with little experience in commercial software development. We demonstrate that the aims to achieve practical results and the educational value of the exercises do not have to conflict with each other but can actually mutually reinforce each other. By achieving practical results, students are more motivated to engage in the exercises resulting in an improved the learning experience.

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9 Author CVs

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EXPERIENCE REPORT: IMPLEMANTATION OF ISO/IEC 20000 INFORMATION TECHNOLOGY SERVICE MANAGEMENT SYSTEM

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Abstract

This paper explains the experience of an IT company about the integrated management of the ISO/IEC 20000 In order to establish and execute an efficient and effective infrastructure, a companywide process improvement program has been conducted. The lessons that are learned from the execution of this process improvement program, key implementation practices and major challenges are shared in this paper.

Keywords

Process Improvement, Process Management System, ISO/IEC 20000, Service Management System, Experience Report.

1 Introduction

INNOVA Information Technologies Corporation is the Turkey's one of the greatest solution companies which provides solutions and products for its national and international clients.

INNOVA implements various quality management systems regarding customer expectations, legal liabilities and to gain competitive advantage. ISO 9001:2008 forms the main roof of the quality management system. ISO 27001 is used to establish the norms for the Information Technology – Information Security related activities, ISO 20000 is used to define the Information Technology – Service Management processes and ISO 15504 is used to establish, maintain, appraise and improve system and software life cycle related processes. The main objective of this paper is to share the integration and improvement experiences that were obtained during the ISO 20000 process improvement activities.

1.1 Motivation

INNOVA first established an ISO9001 [3] based quality management system which was later enriched by ISO 15504 [1] Organizational Maturity Level-2 certified software development processes [1].

Then ISO 27001 [2] and ISO 20000 [4] certification requirements achieved due to legal and competitive advantage motivations. Quality assurance group, as the primer responsible of maintaining and establishing these certification initiatives, defined and executed a process improvement program in order to build an integrated process management system.

2 Background Information About the Company

INNOVA performs its activities in two different geographical locations with seven major work branches. Due to the different natures of the sectors and customers targeted by these branches, various development life-cycles, organization structures and processes are in use.

ISO 27001 and ISO 20000 based systems are defined and integrated with the existing quality management system.

The following sections explain to how to decide implementing Information Technology Service Management System and faced and key implementation practices deployed in order to overcome these steps during the process of building the integrated process management system.

3 Decide to Implement Information Technology Service Management System (IT SMS)

3.1 Rapid Growth

INNOVA was founded as a small company 15 years ago and acquired by Turkish Telekom in 2007. Every year from then the number of staff doubled as well as the total income. As a result of such a rapid growth IT SMS is more important for control and manage this income.
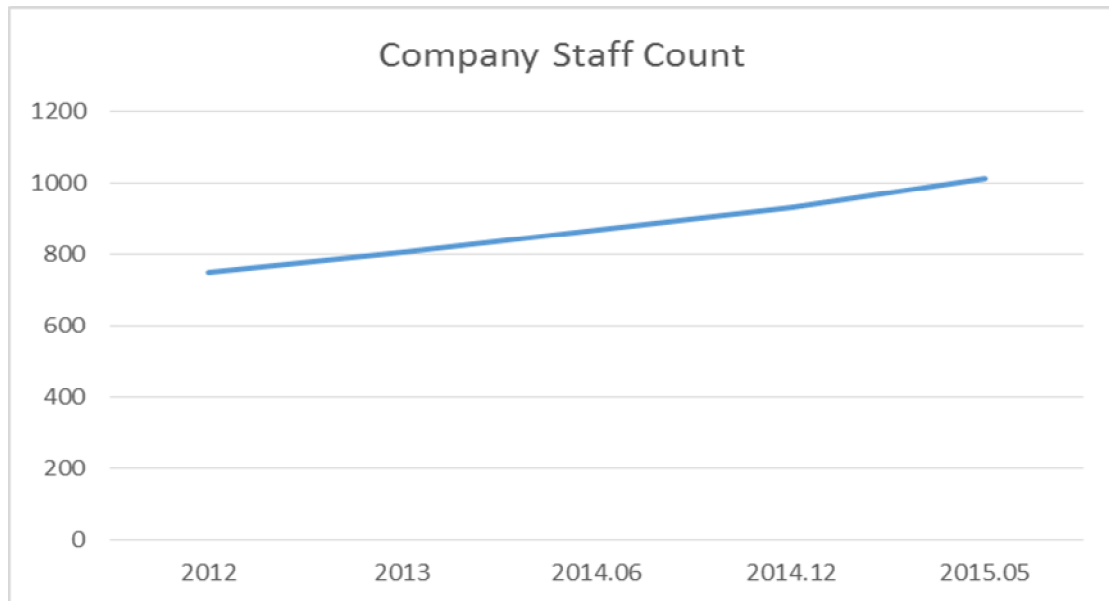
Figure 1 Company Staff Count per year between 2012 - 2015

3.2 Competition with IT Market

Technology, resources, infrastructure, objections, financial situation and cost changes faster than before at IT marketing contest. If any company needs to be at that contest they must use their resources efficiently by using management systems. Our company already has ISO 9001 Quality Management System and needs to build an IT based management systems.

3.3 Working on other Service Management Systems

INNOVA is certified IT system maturity with the certifications of ISO 9001, ISO 27001 and SPICE Level 2. That facilitated to initiate and agree on ISO 20000 compliance activities.

3.4 Using Internal or External Consultant Resources

An evaluation is conducted to see the advantages and threats of taking consultancy from inside the company or outside. Based on offerings evaluation in-house consultancy decision is given to get the know-how about the practices by trainings. Quality assurance team is selected as responsible of the work.

3.5 Yearly Continuous Improvement Projects

As a best practice, the top management give commitment to ISO 20000 committee to manage that work as an internal improvement project. From 2011 to today every year improvement projects are executed and progress is tracked via them.

3.6 Deciding External Audit Corporation

Main criterion to select the audit company for external audits was that the audit company should know us and worked with us before. This will be facilitating start up and agreement on main concerns. So that, one of them was distinctive among three. Coherent work of periodic audits provided additions into continuous improvement.

4 Steps of Implementing IT Service Management System

4.1   Establish a IT SMS Committee and Define Roles

Sponsor of the project is assigned from executive committee by the top management. The sponsor is also conducting committee leader activities. Stakeholders of the improvement activities whom will be actively involved from other departments and committee member assignments and roles and, responsibilities defined and published as a formal document. Hereby, stakeholders agreed on responsibilities and started the working. One of the purposes of the committee is also to feel and work as a teammate of this system and be more efficient.

4.2   Define Scope, Policy and Objectives for Service Management

Scope definition and agreement on it was the coercive issue after ISO 20000 ITSM system build decision was given. Each department's responsibilities and tasks identified and cost benefit analysis are completed to whether include them into the scope. Marketing researches showed that including all departments is risky and not easy to manage so that IT services is included into the scope.

The top management defined the business objectives of the service management based on company objectives. In order to achieve objectives policy is defined and published. Change is inevitable so objectives, policy and scope is being checked for update in periodically.

4.3   Determine and Provide Resources

IT SMS Committee's sponsor gives support to establishing, implementing and maintaining the IT SMS by providing all resources. Awareness education meetings prepared for new and old staff periodically.

4.4   Create Process Asset Library

Processes were collected under central location such as Process Asset Library (PAL). As a result staff could access processes rules determined at "document control process".

Company prepared Process Asset's for IT SMS listed below table. It also includes SPICE level 2 maturity Quality Assurance documents.

	Processes	Template	Form	Guide
IT Operation	13	12	12	4
Quality Assurance	9	11	20	3
Human Resources	6	NA	52	5
Law Department	2	NA	5	NA

Table 1 Departments Process Asset Library

4.5   Define Key Performance Indicators (KPI) for Processes

Process improvement team (PIT) defines Key Performance Indicators (KPI) for achieving to IT SMS

scope and target at 2011. KPI's are controlled and improved at internal/external audits, committee meetings, management reviews and changes on objection between 2011 – 2015 showing with Process Performance Summary Report. After motivation of taking certification, improving KPI's and more efficient targets are more important. Because every year count of staff of our company and work issues are rising and it'll be more difficult to manage a huge system.

	IT Operation	Quality Assurance	Human Resources	Law Department
KPI count	35	13	5	2

Table 2 Count of KPI based on department at 2015

4.6   Operating, Checking, Controlling and Improving Processes

4.6.1   Documentation management

Our Company's quality management system is based on the ISO 9001. ISO 27001 and ISO 20000 systems are defined and integrated with the existing quality management system for Documentation management process and record control process. Documentation requirements are managed with Microsoft SharePoint Library system.

PIT was created service policy and objectives for service management, service management plans, service catalogue, SLAs, service management processes.

4.6.2   Internal audit

Audit programs were planned, scheduled and, announced at yearly Improvement Project. Internal auditors selected from Quality Assurance team but Auditors couldn't audit their own work. We solve that problem by using and auditor from consultant team at another department while auditing Quality Assurance section. While taking auditor educations our purpose is our auditors have established a connection to the intersystem ability.

Internal audit findings till 2011 trend are shown below in Figure 2. As shown, there is continuous decrease on findings in spite of moving to the new version, ISO 20000:2011 on May 2013.
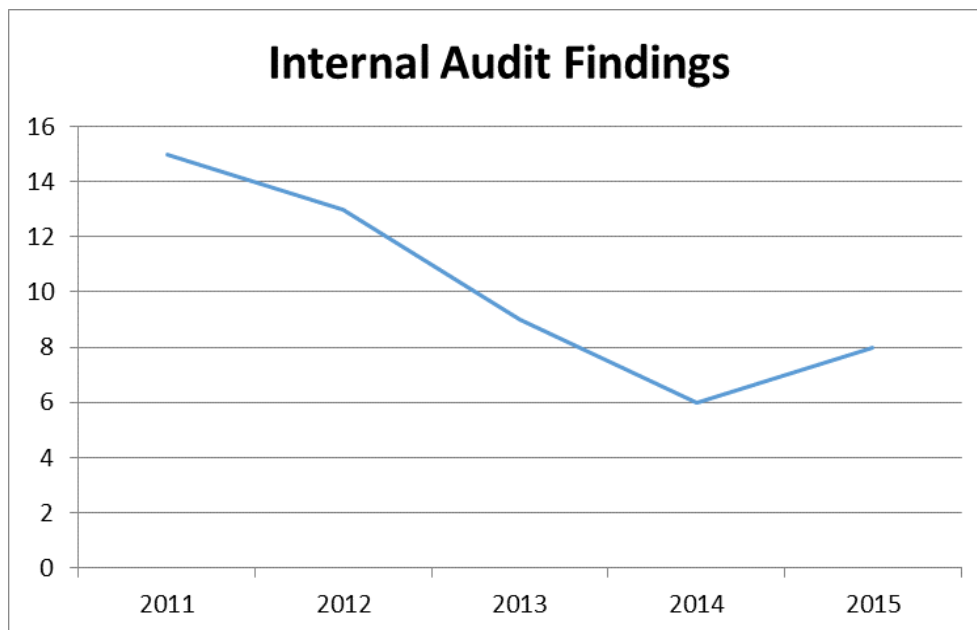
Figure 2 Internal Audit Yearly Trend

4.6.3 Management review

Top management reviews were made periodically. This reviews responsibility appointed to IT SMS Manager. IT SMS Manager prepared an report for; "customer feedbacks, service and process performance and conformity, current and forecast human, technical, information and financial resource levels, current and forecast human and technical capabilities, risks results and follow-up actions from audits, results and follow-up actions from previous management reviews, status of preventive and corrective actions changes that could affect the SMS and the services and opportunities for improvement. The IT SMS and the services at planned intervals to ensure their continued suitability and effectiveness" and follow-up actions from new management reviews.

At the beginning of IT SMS system top management reviews were more difficult. Certification motivation is the biggest effectiveness but then it's more meaningful to coordinate which you spend money. Bringing IT SMS committee together periodically, taking their several hours and improvement suggestions. After years they were asking time of top management review and giving effective improvement suggestions, talking on service objectives.

4.6.4 Design and transition of new or changed services

Our company prepared a "INNP.BT.12 IT Service Catalogue Management Process" for all new services and changes to services with the potential to have a major impact on services or the customer. "INNF.47 IT Service Request Form" was prepared for all new, changed or removed services. This form includes all requirements of "ISO 20000-1:2011 5 Design and transition of new or changed services" section. Service requests will come from e-mails, SM tickets, actions of IT SMS committee or changing technologies. IT SMS Manager manages this form and presents to IT SMS committee meetings. 9 big services were activated by using this form between 2011-2015. This was a complex subject at the beginning. It's very hard to implement this system because it's the easiest way only fill forms but not understand why we use them. Motivation of certification and short schedule is affected this. After years all staff understood importance of this service.

4.6.5 Service Level Management and Business Relationship Management

At the beginning of IT SMS customers couldn't find point of contact. IT SMS manager responsible for the customer relationship and customer satisfaction after requirement come from ISO/IEC 20000:2011. At the beginning of IT SMS only signing SLA's were seems enough, they thought that when they show signatures its enough for certification audits. But after taking certification SLA agreements were more meaningful for both sides.

PIT is prepared catalogue of services with IT SMS manager. This catalogue includes 57 categories defined under the 20 main services. And each service had sub services. We couldn't define catalogue of services with the customer because defect of awareness.

PIT created SLA agreements on behalf of requirements from ISO/IEC 20000-1:2011. Our Companies services and SLAs controlled with the customer at planned intervals. At these meetings we monitor trends and performance against service targets. After these meetings customers awareness increased and change requests come for service catalogue and SLA breach times.

4.6.6 Service Continuity and Availability Management

PIT created Service Continuity and Availability Plans for IT SMS. Periodically this plan controlled and improved by using disaster plans and reports feed backs. Awareness is increasing about service up times. Before the IT SMS no one can know up time of IT system and what'll be happen after a disaster.

4.6.7 Budgeting and accounting for services

Before the IT SMS establish there were concerns about systems cost. And after establishment of IT SMS IT SMS Manager could manage and measure service costs for each customer. Any improvements at IT SMS can be calculated per each department. At the beginning of IT SMS showing calcula-

tions enough for certifying but after these years it's more important where system spends.

4.6.8 Capacity management

Capacity management plan was created periodically. This plan includes projects and improvements capacity calculations, storage, memory, line, server, backup, network switch capacities and change management effects. After creating that plan we can manage time-scales and thresholds, and it causes less costs.

During the certification year we're trying to understand what's our capacity. After years we learn how we manage and improve them.

4.6.9 Information security management

4.6.9.1 Risk Management

Risk assessment guide is prepared by PIT and formula is (Risk = f(Assets, Probability, Impact)). This formula and guide was prepared for ISO 27001 requirements but changes at ISO 20000:2011 version expectance was manage service risks. By the way service risks were calculated periodically and if there were some risks improvements and changes were implemented.

Before the certification we saw our risks when risk held. It's very difficult to implement this system at first. After dominate the system we'll see our risk's before held.

4.6.9.2 Information security incident management

One of the benefits of certified ISO 27001 was some ISO 20000 practices already implemented. Information security incident management was created since 2011. Security incident tickets were increasing yearly as shown at figure. Reason of this situation was customers' awareness increases every year. Last 2 years tickets were consist of virus attacks and behavior incompatible with policies and procedures like sharing personal information.

While at the beginning of certification we were trying to open tickets by to many communicate between our customers. Taking tickets were difficult despite motivation of certificate. But after customers' awareness increases it's easier.
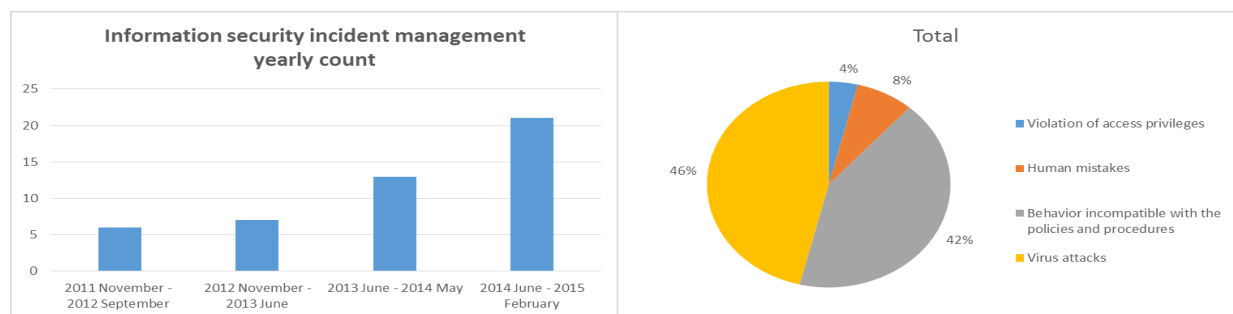
Figure 3 Information security incident management count and last 2 years analysis

4.6.10 Supplier management

Supplier management was a practice based on ISO 9001. Evaluating suppliers already done periodically. But alignment of SLA breach times, basis for charging, service targets, and interfaces between service management processes operated by the supplier and other parties and define relationships between suppliers newly added to contracts. We were developed contracts with our law department. After measurement of this procedure we give up with working one of our suppliers.

4.6.11 Incident and service request management

Before implementing IT SMS there were still incident and requests too. They came from phone calls, face to face or e-mail posts. Every request was important and urgent for customer. Broken mouse will be big issue for customer and this causes confusion. Every IT staff had overloaded work and couldn't show what they did.

After implementing IT SMS PIT wrote incident and service request process. First step is clarifying urgency and important issues shown at below table.

Urgency	Impact Area			
	Company (1)	Department (2)	Users (3)	User (4)
Critic (1)	1	1	2	2
Major (2)	1	2	2	3
Minor (3)	2	2	3	3

Table 3 Impact/Urgency table

Major incident at ISO/IEC 20000:2011 was defined in our company as critic. We implement this calculation to our service manager tool and also gave our SLA times impact for each service from this table. Then an incident calculates as 1 it was really important and urgent for technical to solve.

We had nearly 300 incident and 500 request tickets every month, these is our max KPI and they ride near the line. Example of other our KPI is not exceed totals shown at table below.

For Incident	For Request
1- <%5 total incident count	1- <%1 total request
2- <%20 total incident count	2- <%10 total request
3- >%75 total incident count	3- >%89 total request

Table 4 KPI of incident and request issue types

4.6.12 Problem management

Incident requests were being tracked uniquely without root cause analysis in problem management process before getting in compliance with ISO 20000. Beyond establishment of the system, incident records assigned with a problem are being started to control from Known Error database whether any existing issue before. If there is no issue then they never recorder into the Known Error database until workaround and permanent solution is provided. Thus, a shared knowledge base made available to personnel working different locations.

4.6.13 Configuration management

There is an existing asset inventory as the output of ISO 27001 execution, after ISO 20000 CI information of description, location, status and changes were more clear to manage. In ISO 20000, every CI can be accessed easily, complete information can be retrieved. Change requests coming to the CI can be managed with easy tracking. Most of the operations are being done with online search but still there are a few CIs tracked manually.

4.6.14 Change, Release and deployment management

Changes, release and deployment activities were being done manually without planning. With the power of the system planning started, test development carried on and back out methods written. Urgent change, release and deployment are defined with agreement on customers, and activities carried based on that agreement.

4.6.15 Service Manager Tool

Service Manager tool is being used as an interface to get requests and manage for 4 years. Search

and reporting is not fast as expected. Choosing a sercive manager tool is too important and Motivation of certification is and short schedule will affect negative.In addition it does not have a user friendly interface so that our company planned to move a new one.

5 Conclusions

In this paper we shared our process improvement experience in an IT company complying with service management systems.

Completed works for compliance on ISO 9001, ISO 27001 and SPICE maturity level 2 is showed that those are also stated in ISO 20000. Prior works indicated that ISO 20000 certification can be held with little additional effort.

Employees had a perception that all work is done for certification but it changed in a time manner. Roles and investments to them were key factors for changing the perception. That increased involvement and redirected being proactive.

Measuring the KPIs periodically and corrective actions for measurements far from objectives improved the system.

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Software Quality Assurance Approach to the Software Development Life-Cycle in a Defence Company

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Abstract

Since ASELSAN REHİS (Radar and Electronic Warfare Systems) Business Sector has been certified as per CMMI-DEV ML3, AS9100C, AQAP-2310 and ISO 20000; design, development and related quality assurance activities are improved as well as all other processes. A quality assurance approach is subjected to this paper, namely: SDPAs (Software Development Process Appraisals), those are determined to improve effectiveness of the software quality assurance activities. SDPAs will be synchronized with the SDLC (Software Development Life-Cycle). The purpose of these quality assurance activities is to detect possible nonconformities, initiate and complete corrective actions earlier. Regarding the quantitative analysis of the case study which is conducted, software quality assurance effectiveness is expected to improve. The evaluation result of the case study shows that this quality assurance approach will be considered for the system and hardware development processes respectively.

Keywords

Software Development Process Appraisal, Software Quality Assurance, Software Development Life-Cycle, Functional Configuration Audit, Physical Configuration Audit

1 INTRODUCTION

ASELSAN REHİS DQA (Design Quality Assurance) team conducted several software, hardware and system FCA/PCAs (Functional and Physical Configuration Audits) so far. In the first quarter of 2014, SDPAs are determined as a supplementary quality assurance activity in ASELSAN REHİS Management System. Main objective of the SDPAs is to identify possible non-conformities, initiate and complete corrective actions earlier. DQA team performed these appraisals with the participants from respective Radar and EW product development teams (system, software and test engineer/lead engineers), and their positive reaction led the DQA team to conduct SDPAs. This paper determines ASELSAN REHİS design quality assurance approach and the specifics of these appraisals. The motivation of this study is to register this approach to ASELSAN REHİS software development process. As a result of this improvement study, SDPAs are introduced and performed prior to the conduct of FCA/PCAs. The distinction between an SDPA and an FCA/PCA is primarily that of focus. The former focuses on the techniques, tools, intermediate work products and processes through which a set of systems requirements becomes an SCI (Software Configuration Item), while the latter focuses on the functional and physical configuration of that SCI. Our primary objective with these appraisals is to improve the software quality assurance effectiveness while assisting project design teams in improving software quality from an independent QA perspective.

This paper is organized as follows; literature is investigated and illustrated in the context of software quality assurance in section 2. Section 3 depicts the background of the improvement study with respect to ASELSAN REHİS Management System. In section 4, SDPA specifics are explained. Finally, case study is evaluated in section 5 and future works are summarized in section 6.

2 LITERATURE SURVEY

Software quality assurance is a key aspect in SDLC. Audits conducted by the QA team are one of the effective ways to manage the compatibility between the actual development and the defined one in early phases. Software audits are conducted to "provide an independent evaluation of conformance of software products and processes to applicable regulations, standards, guidelines, plans, specifications, and procedures" [1]. In the literature there are many studies trying to establish an effective and efficient way for QA. Most of the studies in this area are similar to ours; except having numerical results about expected improvements. For instance, in an experiment paper that handled at Boeing, the authors define software process management and audit process to increase the companies' competitive capabilities however the studies are not based on any case studies [2]. In another study that was carried out at STR LLC, establishment of QA function including different activities and its integration with SDLC is given [3]. However this focuses primarily on QA process establishment which has already being conducted in AT&T Bell Laboratories for years and does not provide numerical data showing the results. [4, 5] are other examples which establish for software audits. In addition to defining an audit process, some studies also state the lessons learned from various quality assurance experiences [6, 7, 8]. Being different from these previous ones, our study establishes an additional appraisal mechanism to improve the software development process and gives metrics for further analysis.

3 BACKGROUND

As ASELSAN REHİS Software Development Process is determined per ref ISO/IEC 12207, J-STD-016 and CMMI-DEV v1.3, Quality Assurance Department's approach is also compatible with these model/standards. Upon this improvement proposal which is subjected to this paper, the software FCA/PCAs had been performed prior to the product acceptance tests (that takes place right after system integration tests). In ASELSAN REHİS Management System, quality assurance team may appraise or audit a project at any time during the project lifecycle, but if done early enough, the corrective actions (those are taken to eliminate non-conformities) can be applied earlier which improve the quality of the product being developed.

In Figure 1 ASELSAN REHİS processes are depicted throughout the project life-cycle. The processes are divided into three main process groups: Management, Product Realization and Support. As it is depicted in the figure below, software development process takes place among development and verification stages of the project life-cycle which is the focus of SDPAs [9, 10].
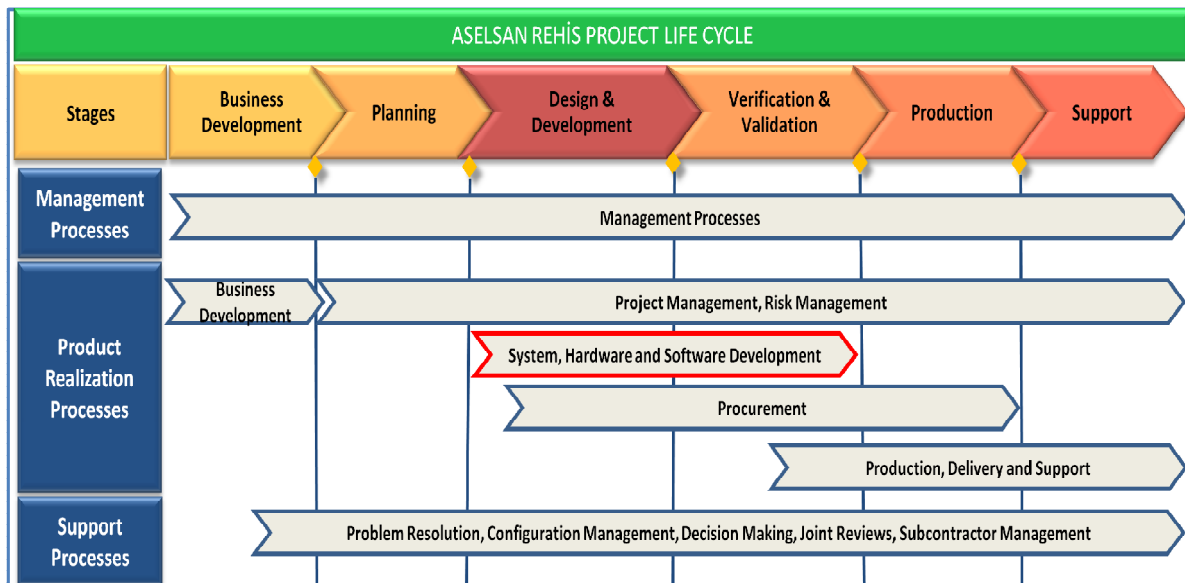
Figure 1: ASELSAN REHİS Project Life-cycle

Current software quality assurance activities can be summarized as follows;
- Preparation of the Software Quality Assurance Plan
- Conducting FCA/PCAs
- Review of requirements, design, test documentations and design and configuration management related plans
- Attendance to the qualifications of the products acquired from design subcontractors.

Since our purpose is to detect possible non-conformities, initiate and complete corrective actions earlier, synchronization of the software quality assurance activities with the software development process is found valuable as a result of the literature investigation.

4 SOFTWARE DEVELOPMENT PROCESS APPRAISALS

The SDPAs are synchronized with the software development process. While the software development process steps are applied by the software development team, DQA team carries out these appraisals. DQA team's main purpose is to detect the weaknesses and strengths of the applied software development process as soon as possible.
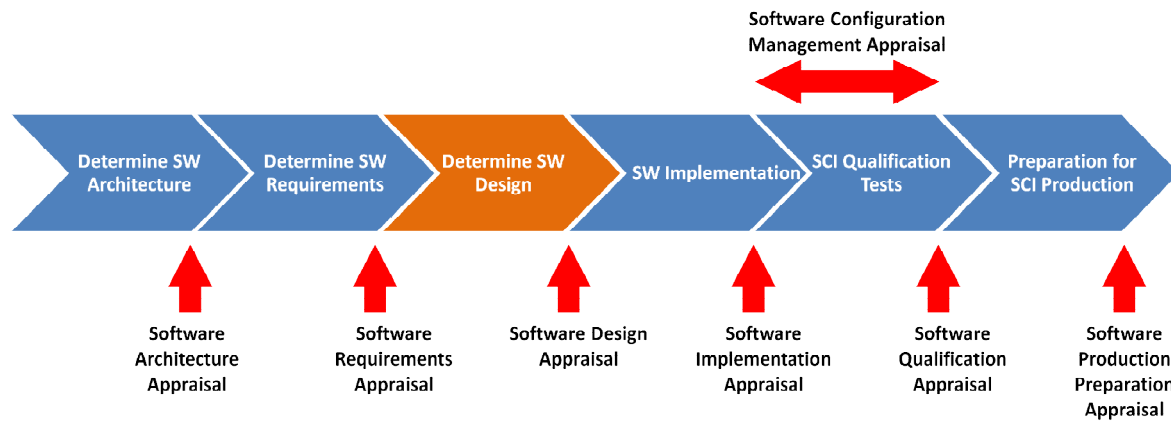
Figure-2: Software Development Process and SDPAs

SDPAs consist of the following phases:

I. Planning

An appraisal plan is prepared to plan the software development process appraisals in each quarter. In the plan, the goals and objectives of the appraisal are clarified and required efforts for each SDPA are estimated. A preliminary version of the appraisal plan is reviewed by the QA manager. Once the project design schedule update takes place it is reflected to the appraisal plan, besides this information is announced to the relevant stakeholders (project design team and their managers).

II. Preparation

An SDPA team consists of 2-3 staff; depending on the size of the project's software products. One person is designated as the lead appraiser. Each team member has experience and expertise in process audits, software development, and software quality assurance. Additional experts may be involved, as necessary. The team analyses the software development methodology (e.g. waterfall, incremental or agile) applied in the project. Each appraisal should be customized with respect to the particular constraints of the project. The pre-requisite questions are answered in this phase (See Figure-3 Sample Checklist Section A).

III. Evaluation and Reporting

In this phase, evaluation questions are answered (See Figure-3 Sample Checklist Section B). SDPA team would discuss the evidences and evaluate their adequacy regarding the software development process. The appraisal interviews are held in an environment isolated from design team offices, to prevent interruptions and encourage people open up more. Appraisal checklists can be used to guide interviews. A sample checklist that is used in software implementation appraisal is given in Figure-3.

SOFTWARE IMPLEMENTATION APPRAISAL			Objective Evidence	Answer	Find-ing/Improvement Suggestion	Due Date
Work products	Software Media, Source Code and Executable Packages					
Stake-holders	Software Team Lead, SCI Developer(s)					
Inputs	SDP (Software Development Plan), SRS (Software Requirements Specification), SDD (Software Design Description, (if applicable) DBDD (Database Design Description), Software White-Box Test Form					
A. PRE-REQUISITES	1	Are the nonconformities -which are detected in the previous SDPAs- closed?	SDPA Non-conformity List			
	2	Are the software development activities planned per ref Software Development Process?	SDP			
	3	Are the software requirements developed, managed, base-lined and technically reviewed by all stakeholders?	Requirements Management Tool, SRS, Technical Review Automation Records			
	4	Is the software preliminary detailed design made and techni-cally reviewed by all relevant stakeholders?	SDD, DBDD (if applicable), Software Design Tool			
B. EVALUATION	1	Is the software labelled and software media, source code and executable packages prepared for the SCI to be released?	Software Media, Source Code Package(s), Executable Package(s)			
	2	Is the release compatible with the software release plan?	Software Release Plan			
	3	Are the packages and labelled media announced to relevant stakeholders?	E-mails, Project Design Directory			
	4	Is the implemented code compatible with the coding stan-dards that are referred in the SDP?	Source Code, Coding Stan-dard(s), SDP			
	5	Are the code blocks reviewed that are selected by the project design team?	Code Review Logs/Records, SDP, M oM (Minutes of Meeting)			
	6	Are the white-box tests performed for the SCIs (in which requirements qualification level is given as "SCI")?	White-Box Test Form, SRS			

Figure-3: Sample SDPA Checklist

SDPA team selects a set of SCI among the project SCIs as per sampling standard MIL-STD-105E. The team examine the SCI's fitness-for-use in development activities; inspect compliance of the prod-ucts to the referred standards and/or models. When multiple appraisers review the same set of docu-ments, they would need to negotiate and make a consortium among their comments. The appraisal team's findings should be evaluated together and documented in an appraisal report. The appraisal team members should obtain additional information and seek clarification on issues that do not have the team's consensus. SDPA report involves strengths as well as the weaknesses and/or improve-ment suggestions. Weakness findings are classified as "major"and "minor";

- *Major:* Any non-conformity per ref applied standards and/or models.
- *Minor:* Any non-conformity per ref software development related process assets that do not have an impact to the referred standards and/or models requirements.

In the SDPA report, not only the problems but also their reasons and suggested recommendations are stated with caution. The preliminary draft version of the appraisal report should be reviewed by the lead design engineer as a prerequisite of the finalization. The final version of the report is distributed to the design team, their manager and QA manager.

IV. Follow-up

Relevant stakeholder's (project design team and their managers) suggestions and/or feedbacks are considered while following the action items. In the follow-up phase, DQA team evaluates cost-effectiveness of the SDPA. Lastly, SDPA performance is evaluated to improve the SDPAs planned for upcoming quarter.

5 CASE STUDY

As the SDPAs were determined in May 2014; four projects were sampled from Radar and Electronic Warfare domains. Case study is conducted to evaluate the effectiveness of the SDPAs.

A measurement is made to evaluate the effectiveness of the SDPAs; compared to the FCA/PCAs those had already been applied. Firstly, historical data has been collected from previously reported non-conformities. The non-conformities are grouped as depicted in the horizontal axis of Figure-4. And vertical axis represents the average closure days.
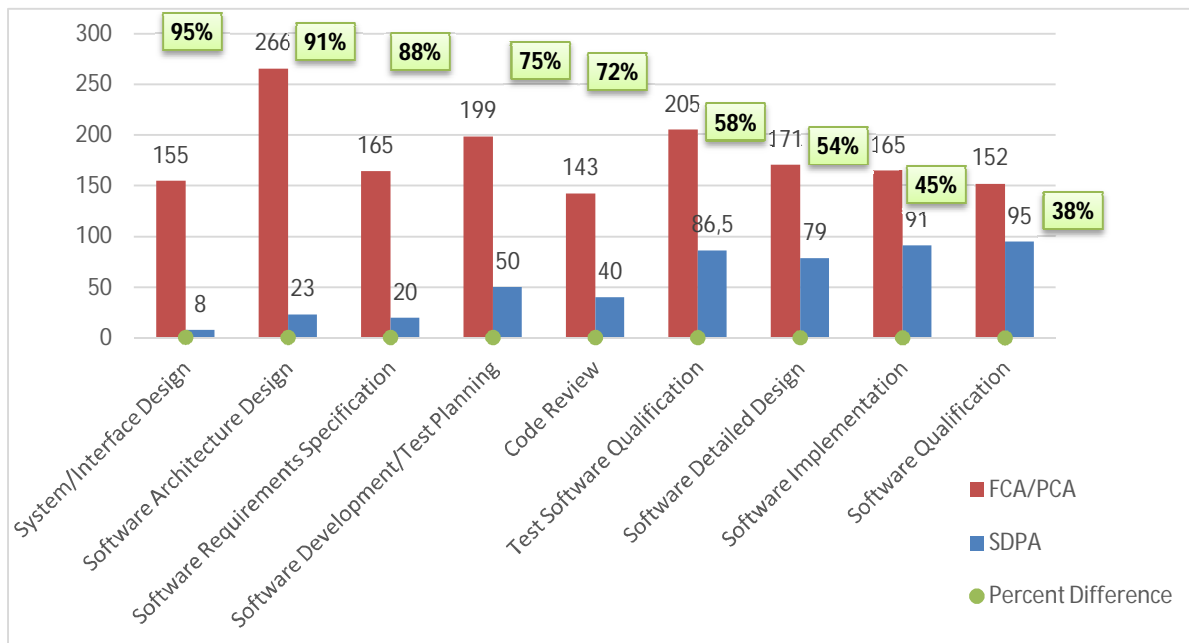
Figure-4: Comparison of Action Item Closure Rates

Analysed data depicts that the action item closure rates of SDPAs are better than FCA/PCAs. The percentage differences are also demonstrated in the figure above. The improvement is in 75-95% interval for the initial steps of software development process, on the other hand it varies in 38-58% interval for the last steps of the process. The reason can be explained as follows; SDPAs were conducted in parallel with the software development process, however FCA/PCAs were conducted as the process is finalized [11]. The case study showed that since the quality activities were synchronized with the software development process, these activities added value to the planning and monitoring of design activities. The design team is charged to various projects; therefore it takes time to rollback and respond to the quality findings when they are reported at the last phase of the project. In Figure-4 the closure rates of the SDPA action items are improved especially for software detailed design, soft-

ware implementation and software qualification. SDPA action items are closed throughout SCRUM sprints and they are used as inputs for sprint backlogs.

The other advantage of SDPAs is that it provides earlier detection of nonconformities than the FCA/PCAs. Figure 5 shows how many days earlier on average, the non-conformities are detected in SDPAs compared to FCA/PCAs for the software development phases shown in Figure 2.
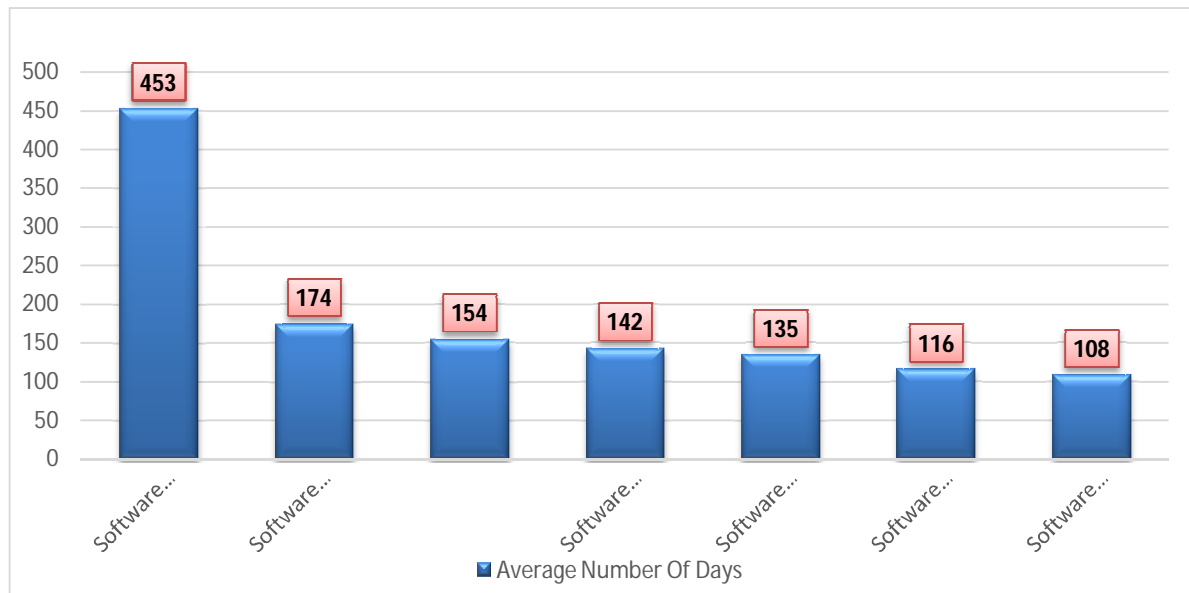
Figure-5: Improvement in Non-conformity Detection

The improvement in "Action Item Closure Rate" and "How Many Days Earlier on Average of Non-conformity Detection" led the DQA team to make a consortium that SDPAs add value to the ASELSAN REHİS Management System.

6 CONCLUSION

As mentioned in Section 5, SDPA and FCA/PCA are categorized in to the same groups. DQA team had a chance to make quantitative analysis, in this way. The non-conformity categories are over-lapped with the software development process outputs. In the context of the analysis, FCA/PCA non-conformities are inspected in more detail as well as the SDPA non-conformities. The analysis results show that the non-conformities of the software development process (i.e. software/software test planning, software architecture design and test software qualification) initial phases are closed in more than 200 days. By means of the SDPAs, this duration is decreased to nearly 50 days. This case shows that early detection of the non-conformities has a positive impact on the closure rate of triggered action items. As a result, it can be claimed that software quality assurance effectiveness is improved.

It is considered that DQA team's presence is found non-threatening since design and quality management benefits of the SDPAs is understood by the project team. Therefore, they play a supportive active role in SDPAs. Regarding the case study results, DQA team evaluated that it would be valuable to institutionalize this software QA approach and apply it to the system and hardware development processes further. A couple of design subcontractor software products were selected for the case study. The non-conformities are recorded and monitored till closure. The results showed that SDPAs provide close communication with the subcontractor and improve the quality of acquired products. For that reason, SDPA checklists will be customized to use for subcontractor activities.

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ITMark as an ISO29110 profile: building an experience factory

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Abstract

Since its release in 2011 several ISO/IEC 29110 industrial experiences have been reported and some research works summarize industrial experiences. Building an experience factory helps VSEs during initial assessments in order to compare them between others. ITMark has been used as a reference model in 74 assessments worldwide, and this paper reports this experience and it demonstrates its adequacy for VSEs. In fact, a mapping between ITMark and ISO/IEC29110 is defined and applied.

Keywords

ISO/IEC 29110, industrial experiences, experience factory

1 Introduction

Since its release in 2011 several ISO/IEC 29110[1]–[4] industrial experiences have been reported [5]–[8]. Some research works summarize industrial experiences such as [9] and [8]. Other research works such as [10] are focused on how to measure the impact of this standard. Variability is one of the biggest issues applying a standard in a company [11]. And in general there is a need to report more experiences performing and analyzing ISO/IEC29110 in practice.

Experience Factory term was introduced in [12] and it refers to empirical approaches and on the idea of creating a knowledge base from experiences. The Experience Factory packages experience by "building informal, formal, or schematised models and measures of various processes, products, and other forms of knowledge via people, documents, and automated support"[13].

Very Small Entities (VSE) require this kind of databases in order to compare them and to share experiences applying quality models.

This paper provides an industrial experience assessing ITMark in VSEs, and which purpose is to create a knowledge base from these experiences. In addition this paper reports a method to assess ISO29110 based on ITMark. The knowledge base is built from 74 assessments worldwide [14], and we identified the following industrial research questions:

- IQ1: Can ITMark be used to assess the ISO/IEC29110 basic profile?
- IQ2: What is the coverage degree of ITMark over ISO/IEC29110 basic profile?
- IQ3: Based on these assessments, what is the tendency during initial assessments?

This paper is structured as follows. First a background on the reference models used in this industrial experience. Second a research method is defined. Third section includes the main results. And finally a conclusion section ends this paper.

2 Background

2.1 ITMark

ITMark (http://it-mark.eu) is a certification scheme especially designed for small and medium enterprises (SME). ITMark was conceived to provide a lightweight method in order to assess SMEs, and it was designed based on best practices carried out by successful companies. SMEs must demonstrate not only benefits for the achievement of a relevant position in the market but also they need to improve different areas within the organization. Nevertheless different quality models used nowadays covering some important aspects most of them do not cover all areas of organizations and their business as whole. Organizations aiming to improve their business through quality cannot be only focused on improving a small part of their business. They need to provide a holistic view of the organization's areas as well as their business aspects. ITMark is flexible enough to be applied by VSE, and it takes into account three base standards.

2.1.1 Business Processes Model

ITMark business processes model is based on Business Management and it has been divided in 10 specific categories: Market, Management, Products&Services, Sales, Marketing and distribution, Strategy and committee, Financial analysis, Customer's profile and analysis, Investment factors, Development and production, and Industry and macro environment. Each category is composed in its turn by 10 important elements. Therefore this model contains 100 elements for characterizing business aspects.

2.1.2 Software, Systems and Services Engineering model

Software and systems development process model is based on CMMI® [15] structured in several process areas as it is shown in table 1. This assessment method is mainly focused on the following CMMI process areas: CM: Configuration Management, PPQA: Process and Product Quality Assurance, MA: Measurement and Analysis, REQM: Requirements Management, PP: Project Planning, PMC: Project Monitoring and Control and SAM: Supplier Agreement Management.

2.1.3 Security Management model

Information security is not only related to protect our systems from external attacks, but also to protect from internal attacks mainly due to human errors, hardware and software fails, and disasters. There are several security attributes contributing to a holistic security model. However we have considered as main attributes: confidentiality, integrity and availability based on ISO/IEC27000 [16]. In fact ITMark adapts these ISO requirements to SMEs (Small and Medium Enterprise). There are 61 aspects analyzed, and an excerpt is shown in Figure 1.

ITMark ID	Reference to standard clause
A1. There is a basic inventory of assets	7.1.1 Inventory of assets"
A2. Assets have their owner formally identified-	7.1.2 Ownership of assets"
A3. There is a policy for information classification-	7.2 Information classification"
A4. There are procedures for information classification-	7.2 Information classification"
A5. Some roles and responsibilities have been assigned -	8.1.1 Roles and Responsibilities"
A6. Security responsible have received specialized training on security	8.2.2 Information security awareness, education, and training"
A7. There is a physical security	9 Physical and environmental security perimeter"
A8. There are uninterruptible power supply equipments	9.2.2 Supporting utilities"
A9. There are utilities for the secure disposal of information-	9.2.6 Secure disposal of re-use of equipment -10.7.2 Disposal of media"
A10. Each user has an unique identifier	11.5.2 User identification and authentication"
A11. Permissions are assigned on users'roles and responsibilities	11.2.2 Privilege management-11.2.3 User password management
A12. Personal firewall protect local machines services	10.6.2 Security of network services-11.7.2 Teleworking"
A13. User desktops and laptops are periodically updated	10.1.2 Change management-12.4.1 Control of operational software - 12.5 Security in development and support processes -12.6 Technical vulnerability management"
A14. Server machines are periodically –0.1.2 Change management	12.4.1 Control of operational software-12.5 Security in development and support processes -12.6 Technical vulnerability management"
A15. There are mechanisms to protect-against malware"	10.4 Protection against malicious and mobile code"
A16. There are procedures to backup" and restore data"	10.1.1 Documented operating procedures" 10.5 Back-up"
A17. A plan for backups is set and"carried out"	10.5 Back-up"
A18. Backup copies are labeled and" stored in a secure place"	10.5 Back-up"
A19. Backup copies are tested" periodically"	10.5 Back-up"
A20. Networks controls are configured" and deployed"	10.6 Network security management", 11.4 Network access controls"
A21. The organisation has identified an" information security responsible"	6.1.3 Allocation of information security responsibilities"
A22. Employees sign confidentiality" agreements"	6.1.5 Confidentiality agreements", 8.1.3 Terms and conditions of employment"
A23. The organisation signs" confidentiality agreements with" clients and providers"	6.1.5 Confidentiality agreements"
A24. The organisation knows applicable" legislation"	15.1 Compliance with legal requirements"

Figure 1. Excerpt of ITMark security aspects

2.2 ISO/IEC29110

This standard and its related set of standards such as [1]–[4] are focused on Very Small Entities (VSE). Industrial experiences have been reported [5]–[8] highlighting some novelties. There is a wide diversity of papers in this context, and some research works such as [10] are focused on how to measure the impact of this standard. Variability is one of the biggest issues applying a standard in a company [11]. Even sentiment evaluation [17] has been also studied and it can contribute to identify the key aspects for succeeding during an ISO/IEC29110 assessment from a management point of view. Industrial experiences such as [9] and [18] provide pilots implementing this standard.

2.3   Experience Factory

As stated by [12]: "*The experience factory supports project developments with direct feedback by analyzing and synthesizing all kinds of experiences gathered from projects as well as other state-of-the-practice notions and acting as a repository for such experiences.*" The experience factory has been used for building software competences[19], and recently used with the ISO/IEC29110 [20]. Our purpose is to create this repository of experiences, and to make them available to the general public. In addition the Experience Factory should be able to provide indicators and measures in order to help organizations to compare between them.

3   Research method

3.1   Method

In order to set up an experience factory we need to define a method. Therefore we performed the same approach as described in [13], and which is drawn in Figure 2.
We analyzed a wide set of software engineering related projects in VSE, and which purpose was to improve their quality. These organizations are listed in [14]. At Tecnalia we acted as project support, and we packaged these experiences in a database containing best practices, performance logs, and indicators.
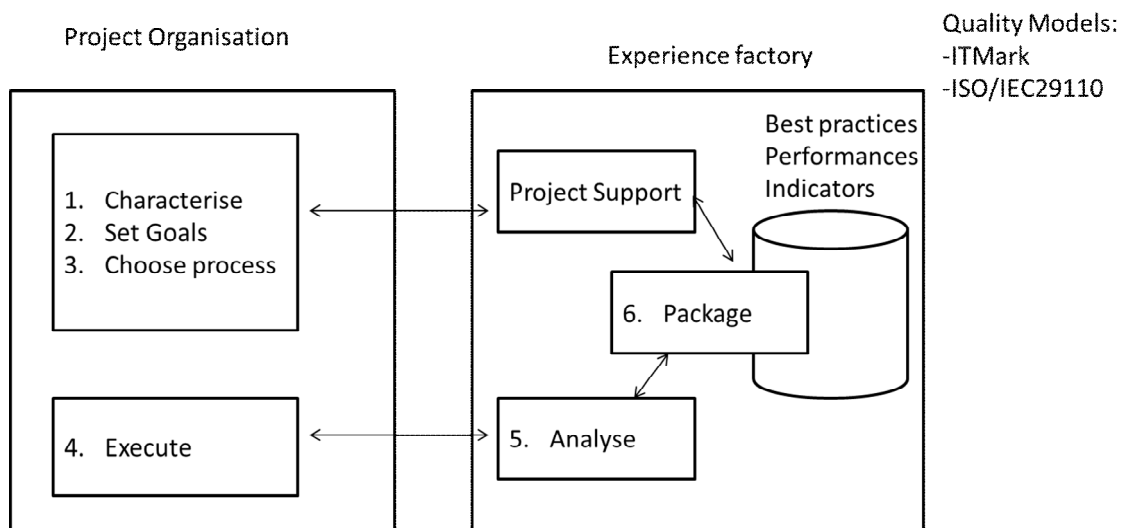
Figure 2. Extension of Experience Factory Method [13] for generating a VSE quality models experiences.

ITMark helps organization to gather the appropriate data and work products. During the assessments work products were categorized according to ITMark schema. This categorization provides a way to univocally identify work products and evidences in a project. These evidences are used during the mapping between ITMark and ISO/IEC29110.

3.2   Statistical analysis

The statistical analysis carried out in this industrial experience is focused on analyzing the number of occurrences of a repeating fact or event. These elements are going to populate our experience factory database. Different analysis such as trends analysis for each specific area can be performed, but at

this stage we just want to analyze their frequency and standard deviation. This paper just shows their frequency.

4 Results

4.1 Software, Systems and Services Engineering model

We analyzed 74 assessments based on Software, Systems and Services Engineering process model which is based on CMMI level 2 process areas. Figure 3 represents the frequency of Software, Systems and Services Engineering process area coverage during the initials assessments of these 74 VSEs. The result follows a normal distribution and which mean is 46,99%, and which standard deviation is 0,15. These values indicate that most of the initial assessments are similar and VSE falls most of the times on the same problems. In terms of ISO/IEC29110 basic profile areas these problems come from Quality Assurance, Change Request, Software Configuration and Verification and Validation.
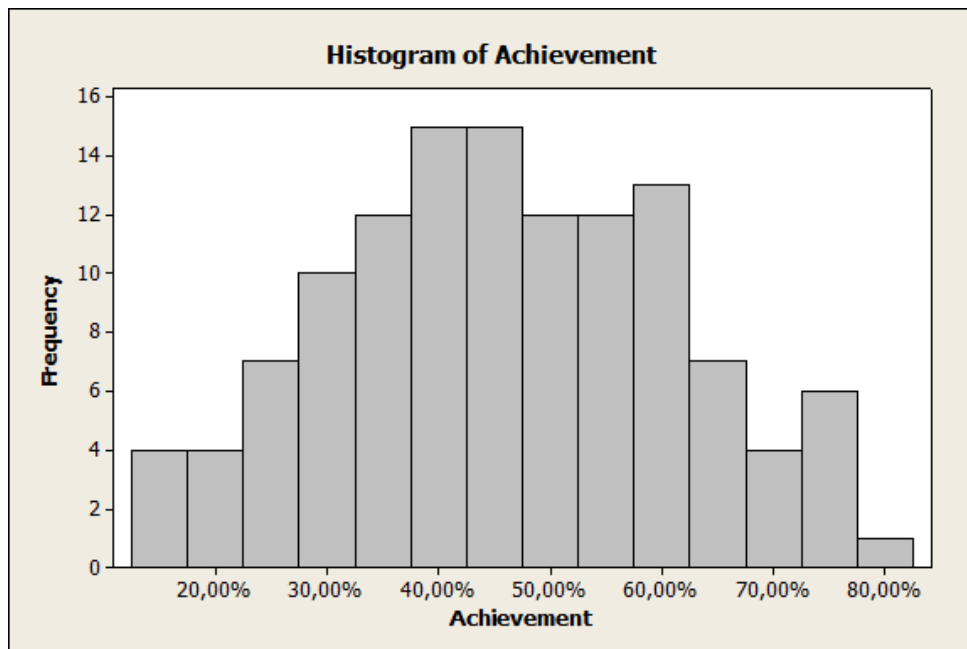
Figure 3. Frequency of achievements for Software, Systems and Services Engineering

4.2 Mapping ITMark and ISO/IEC29110 basic profile

In order to assess these VSEs we follow a similar approach as described in [21], [22] where some mappings between standards are defined. This approach requires a deep analysis of the reference models being mapped. In this sense we analyzed each ITMark specific area and we mapped it to the ISO/IEC29110 basic profile areas. For this situation we mapped just specific practices and we set aside the generic practices. It is worth mentioning that Measurement and analysis is a transversal area and it must be taken into account in several areas of the basic profile.

Figure 4 provides a mapping between ITMark specific practices described in the left column, and the ISO/IEC29110 basic profile areas described on each column. Each ITMark practice is related to each column using an 'X'. The areas related to supplier management (SAM) are not included in the ISO/IEC29110 basic profile, and therefore these lines do not include 'X's. Other areas related to engi-

neering in the basoc profile are not included in our ITMark assessments, but they are taken into account in higher levels of ITMark.

		Project Management Process							Software Implementation Process						
		PM.O1. The Project Plan	PM.O2. Progress of the project is monitored against the Project Plan and recorded in the Progress Status Record.	PM.O3. The Change Requests	PM.O4. Review meetings	PM.O5. Risks	PM.O6. A software Version Control Strategy	PM.O7. Software Quality Assurance	SI.O1. Project Plan.	SI.O2. Software requirements	SI.O3. Software architectural and detailed design	SI.O4. Software components	SI.O5.Test Cases and Test Procedures.	SI.O6. A Software Configuration	SI.O7. Verificatio n and Validation
		100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	10,00%	10,00%	25,00%	100,00%	25,00%
DEV_CM_SP0101	41,20%						X								
DEV_CM_SP0102	73,51%						X								
DEV_CM_SP0103	50,69%	X					X		X	X	X	X	X		
DEV_CM_SP0201	47,67%													X	
DEV_CM_SP0202	54,17%													X	
DEV_CM_SP0301	51,50%													X	
DEV_CM_SP0302	18,13%													X	X
DEV_MA_SP0101	38,33%		X	X				X						X	X
DEV_MA_SP0102	41,13%		X	X				X						X	X
DEV_MA_SP0103	33,51%		X	X				X						X	X
DEV_MA_SP0104	31,49%		X	X				X						X	X
DEV_MA_SP0201	41,78%		X	X				X						X	X
DEV_MA_SP0202	34,15%		X	X				X						X	X
DEV_MA_SP0203	35,92%		X	X				X						X	X
DEV_MA_SP0204	40,85%		X	X				X						X	X
DEV_PMC_SP0101	46,99%		X												
DEV_PMC_SP0102	61,11%		X												
DEV_PMC_SP0103	34,89%					X									
DEV_PMC_SP0104	37,04%		X												
DEV_PMC_SP0105	51,26%		X												
DEV_PMC_SP0106	54,37%				X										
DEV_PMC_SP0107	42,50%				X										
DEV_PMC_SP0201	61,11%		X												
DEV_PMC_SP0202	56,94%		X												
DEV_PMC_SP0203	41,34%		X												
DEV_PP_SP0101	57,29%	X													
DEV_PP_SP0102	51,39%	X													
DEV_PP_SP0103	61,42%	X													
DEV_PP_SP0104	47,22%	X													
DEV_PP_SP0201	54,54%	X							X						
DEV_PP_SP0202	54,17%					X									
DEV_PP_SP0203	57,78%	X							X						
DEV_PP_SP0204	67,22%	X							X						
DEV_PP_SP0205	63,54%	X							X						
DEV_PP_SP0206	57,29%	X							X						
DEV_PP_SP0207	50,69%	X							X						
DEV_PP_SP0301	50,69%	X			X										
DEV_PP_SP0302	63,43%	X			X										
DEV_PP_SP0303	67,80%	X			X										
DEV_PPQA_SP0101	30,20%							X							
DEV_PPQA_SP0102	22,60%							X							
DEV_PPQA_SP0201	28,96%							X							
DEV_PPQA_SP0202	30,32%							X							
DEV_REQM_SP0101	61,46%									X					
DEV_REQM_SP0102	73,61%									X					
DEV_REQM_SP0103	57,99%			X										X	
DEV_REQM_SP0104	47,22%			X						X	X	X	X		
DEV_REQM_SP0105	50,35%			X						X	X	X	X		X
DEV_SAM_SP0101	70,00%														
DEV_SAM_SP0102	75,71%														
DEV_SAM_SP0103	62,86%														
DEV_SAM_SP0201	60,00%														
DEV_SAM_SP0202	58,57%														

Figure 4: Mapping among CMMI specific practices and ISO/IEC29110 basic profile

4.3   Business and Security as extensions to the profile

During these years we realized a need to assess business and security aspects in every organization. Therefore ITMark includes from the very beginning early assessments on business and security aspects. Business aspects are grouped in 10 categories, and each category is included in our Experience Factory. Each category provides a frequency of the assessments. For example, Figure 5 provides a frequency for business development which includes 8 areas to be assessed. In this case, organizations used to fall in the first aspect which is related to business plans. These aspects can be included as a new profile or an extension of the ISO/IEC29110 basic profile.

For security aspects, we analyzed 61 aspects and we stored these assessments results in our experience factory database. One of the main conclusions from these initial assessments is that none of the security areas are satisfied. In addition we can identify the weakest security areas such as A4 and A9 related to information classification and disposal information. All these results can be obtained by us-

ing our experience factory.
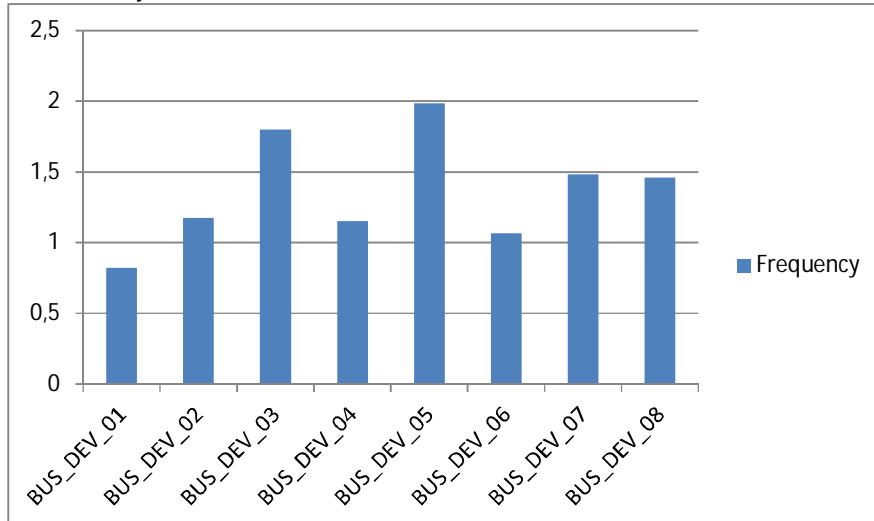
Figure 5. Frequency for Business process area: Development&Production
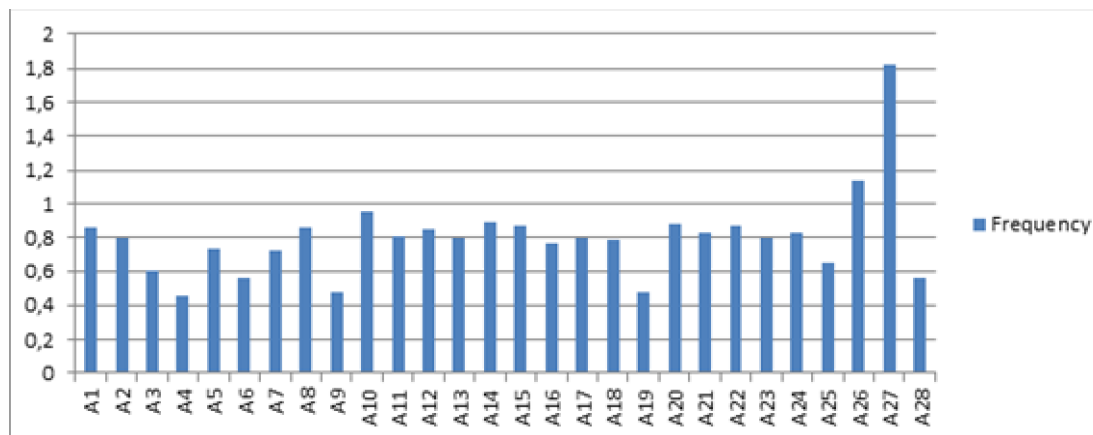
Figure 6.Frequency of a Security aspect

5 Discussion

This paper reveals that ITMark can be used as a method for assessing VSE based on ISO/IEC29110. However the ITMark areas reported in this paper do not include engineering aspects. Therefore the current mapping does not cover 100% the ISO/IEC29110. This means that for example "*SI.O3. Software architectural and detailed design, SI.O4. Software components, and SI.O5.Test Cases and Test Procedures"* from this standard are not covered 100%. ITMark has different levels depending on each organization, and the engineering aspects can be included. Due to space limitations we have not include each standard deviation for each specific practice but this information is stored in our experience factory.

Measurement and Analysis process area is transversal to the ISO/IEC29110 basic profile. While we are defining "quality assurance" or "change request" or "progress of the project monitored against the project plan and recorded in the progress status record", we require the definition of some measurements and indicators. Therefore this practice is not taken into account explicitly. However it is assumed implicitly.

In addition there is plenty of published literature discussing quality models but we would like to mention that in some cases these studies are not up to date or appropriate. For example in [23] authors reference ITMark indicating that this model is not focused to VSE. However this paper and our experi-

ence demonstrate that it is possible and appropriate to implement ITMark in VSEs. Our experience is carried out in more than 74 VSEs around the world [14]. For the sake of simplicity this paper just reports 74 assessments but an extension of this industrial experience is expected to be reported. Our experience factory includes not only frequencies and standard deviations from each specific practice but also this mapping to ISO/IEC29110.

6 Conclusions

The main conclusion from this industrial experience is that ITMark can be used as method for assessing VSEs. In fact, we have used ITMark and a mapping to ISO/IEC29110 basic profile to assess VSEs. Obviously there are some gaps in this mapping but most of the areas are covered and thus ITMark can be used for assessing ISO/IEC29110 basic profile. Therefore this paper demonstrates that the first industrial question (IQ1) is satisfied. In addition this paper provides a summary of experiences providing an average of coverage of the basic profile areas (IQ2). Finally this paper also highlights some indicators such as frequency in order to provide a basic indicator to compare situations for VSEs. Therefore we can identify some trends while assessing VSEs (IQ3). All these data are stored in our Experience Factory which can be used by VSEs.

According to [24] seems to be reasonable to perform an analysis of VSEs related to critical systems. In fact, we are currently in the process to define and validate a profile in the automotive domain taking as a base standard the ISO26262 standard [25].

Acknowledgment

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Software Development Practices in Small Entities:
an ISO29110-based Survey

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Abstract

Small and medium-size enterprises (SMEs) involved in software development often experi-ence problems in mastering their development process, especially smaller companies. This can result in a decreased efficiency leading to problems such as time/cost overruns or failing to address functional and non-functional requirements (reliability, performance, usability, etc.). Globally, this can reduce significantly the customer satisfaction and hamper the enterprise growth potential.

In this paper, we report about a survey conducted in Belgium to assess more precisely which and how SMEs are affected by these problems. The survey was driven by the ISO29110 lightweight standard focusing on very small entities (VSEs) developing software whose inter-nal IT department is less than 25 people. This represents a very large portion of SMEs in business. In particular, survey results highlight the most frequent issues and how they are linked to some organisation/project characteristics. The survey is based on a free online self-assessment consequently, in addition to identifying issues encountered by enterprises it is also possible to infer a set of quick-win recommendations to solve these issues. We could also cross-check the relevance of ISO29110 recommended tasks and activities in comparison with those already in place at companies participating to the survey. Our results are also compared with those reported by other surveys targeting both large and small companies.

Keywords

Software process improvement, project management, ISO29110, SME, VSE, industrial survey

1   Introduction

Developing software is challenging for small and medium size enterprises (SMEs), especially to ensure the quality with respect to the constraints of timeliness, budget and in general, customer satisfaction. The lack of maturity in these 3 aspects can also be related to a number of factors such as failure to identify the degree of importance of problems, lack of internal expertise to address certain problems or simply resources and priority/constraints.

To understand more precisely the nature and extent of problems across various kinds of SMEs, we decided to conduct an industrial survey with the aim to answer to following high level questions:
- What are the main issues leading to customer dissatisfaction?
- What are the main issues leading to software development team dissatisfaction?
- How do problems relate with key SME characteristics such as size, sector and project management practices?
- To what degree are recommended activities and tasks (from ISO29110) most often overlooked?

To structure these considerations, our survey was designed as follows. After an introductory section to identify SME characteristics, the survey asks about causes of external (customer) and internal (development team) dissatisfactions and about the extent to which practices are performed. In this work, practices are equivalent to the set of activities and tasks found in the ISO29110 lightweight standard described hereafter [1][2]. Questions on dissatisfaction allow for four types of responses (never/sometimes/often/always). Purposefully, the lack of median value forces participants to take a stand on every question. In addition, Questions on practices expect yes/no answers.

The survey is built on the top of a self-assessment tool thus it is not just limited to asking a set of questions. At the end of the survey, based on answers, it identifies activities and tasks with weaknesses and it provides a set of recommendations to participating companies. Firstly, providing recommendations is used as a motivating factor to encourage SMEs to perform the survey and possibly trigger some initial awareness or even quality improvement actions from participating SMEs. Secondly, the assessment is also designed to identify software development activities and their tasks already performed by participants. The survey was currently only disseminated in the French-speaking part of Belgium through key local IT channels[1]. Consequently, all results reported are only intended to be applicable to SME in this area. However, many other areas with ICT economies mainly provided by SME should be encouraged to use this self-assessment tool to further study if statistics in Belgium French-speaking side tend to validate elsewhere.

This paper is structured as follows. Section 2 gives some background on the ISO29110 standard used as driver for our survey. Section 3 presents a detailed analysis first detailing the participating SME and then giving a global ranking of problems. A more detailed analysis is presented where problems are related to SME characteristics and to specific software and project management activities and tasks found in the ISO29110 standard. Section 4 compares our results with other large scale surveys, which did not focus specifically on SMEs. Finally Section 5 draws conclusions.

2   Background: an overview of ISO29110 standard

ISO29110 is a recent lightweight standard "Systems and Software Life Cycle Profiles and Guidelines for Very Small Entities" [1][2]. It is developed with the objective to assist and encourage SME in the assessment and improvement of their software processes. It proposes a set of profiles increasingly helping SME with more complete and extensive processes. Currently, the lightest profile, named Entry, and the second profile, named Basic, have been published [2]. The self-assessment tool used to build the survey is based on the Entry profile. This profile defines two processes, project management and software implementation. Both processes identify a set of activities, each of which is refined in a set of tasks. In particular, the project management process is composed of 4 activities: project planning (PM1), project plan execution (PM2), project assessment and control (PM3) and project closure (PM4). While the software implementation process is composed of 6 activities: software implementa-

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[1] We warmly thank Infopole [3] and Agence Wallonne des Télécommunications [4] who help to relay this survey to their members.

tion initiation (IMPL1), requirements analysis (IMPL2), architectural and detailed design (IMPL3), construction (IMPL4), integration and tests (IMPL5) and finally product delivery (IMPL6).

This standard emerged from a number of national initiatives, more specifically Belgium contributed to it based on its experience with the OWPL (Observatoire Wallon des Pratiques Logicielles) tool [5]. This precursor tool was structured into 10 processes (requirements management, project planning, project tracking and oversight, development, documentation, testing, configuration management, subcontracting management, quality management, and experience capitalization process).

The survey based on the "entry" profile covers 39 tasks of the software implementation and project management processes. The self-assessment is based on checking if these 39 key tasks are performed and if their expected input/output artefacts are produced. For example in the software implementation process, the *requirements elaboration* task is said to be performed if it takes a project plan as input and it generates a requirements document as output. However, the self-assessment tool recognises that SMEs in particular small ones do not always understand well the jargon used in standards related to software development lifecycle processes. Consequently, instead of directly confronting participants with process jargon, the self-assessment tool first asks about problems generally encountered during software development project. The list of problems used in the survey is described in the next section. Subsequently, the self-assessment tool narrows down on problem causes by asking question on practices performed during software projects. Practices refer to activities, task and work products from the ISO29110 Entry profile. To avoid asking unnecessary questions and keep the self-assessment focused on issues important to a participant, the self-assessment tool only narrows down on causes when necessary.

3   Survey analysis

The analysis first reviews the characteristics of SMEs who participated to the survey in Section 3.1. Second, the list of problems encountered is ranked in Section 3.2. We then identify relationships between problems encountered and SME characteristics in Section 3.3. Sections 3.4 and 3.5 present statistics on the list of recommendations on activities and tasks for the complete set of participating SME in French speaking community of Belgium. Finally, Section 3.6 identifies threats to the validity of the survey and explains how threats are mitigated to produce reliable results.

3.1   Characterisation of the participating SMEs

Reported results are based on a set of 36 answers. A larger number of answers (more than 50) are available but some are filtered out when the survey is not fully completed. The collected answers are representative with a quite good sampling of the enterprises in terms of size (from less than 5 up to 50 employees: see Figure 1), of sectors (public, manufacturing, health, banking, pure ICT: see Figure 2).
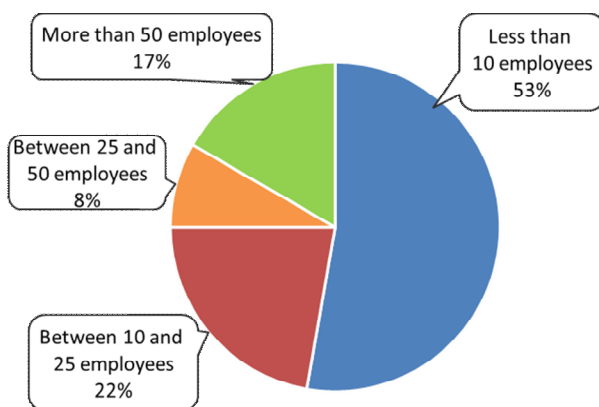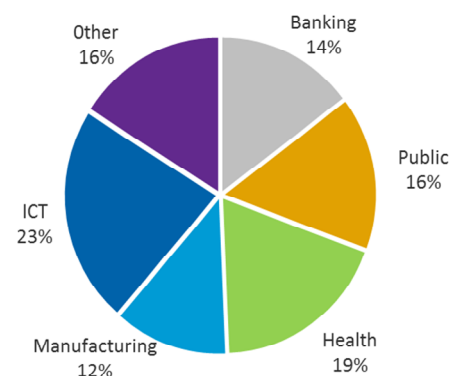

Figure 1. Sizes.

Figure 2. Sectors covered.
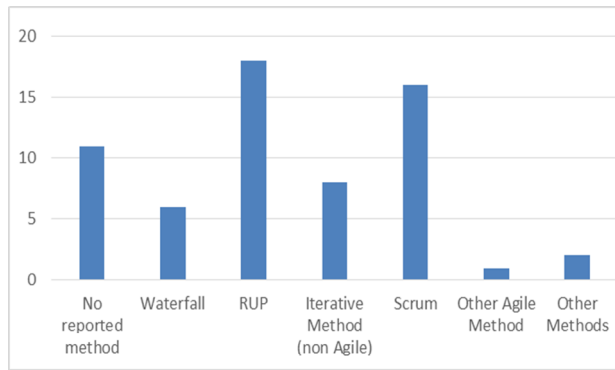
Figure 3. Used development methods
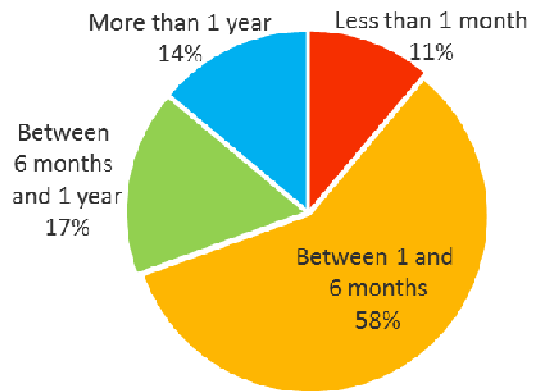
Figure 4. Average Project duration.

For the majority of the answering companies, the mean duration of their IT projects is about 6 months. (see Figure 4). Figure 3 also provides information on development methods. As expected in SMEs, it is interesting to observe that while Agile methods are now well integrated, few SMEs indicate the actual agile methods used. This could indicate yet a misunderstanding on what agile methods are. Out of 36 participants it is also worrying that nearly 1/3 (11) explicitly state using "No particular Development Method". Further enquiry behind this answer would be needed to understand if participants mean that they can switch methods according to project or if they actually do not know the methods they use.

3.2   Ranking of the reported problems

The initial part of the survey asks questions on common problems encountered in software development projects from a set of 12 common problems related to customer and development team satisfaction themselves influenced by cost, time and features issues.

Table 1. Reported problems ranked by severity.

#	Short problem description	Concerns	Never	Sometimes	Often	Always	Mean severity
1	Delays overruns (>5% duration time) in the project execution	Customer	8%	31%	47%	14%	3,0
2	Reported inefficiency in tasks related to project management or software implementation	Team	0%	56%	33%	11%	2,6
3	Cost overruns (>5% initial budget) in the project execution	Team	17%	39%	31%	14%	2,4
4	Customer satisfaction w.r.t. project documentation	Customer	6%	28%	42%	25%	1,9
5	Customer satisfaction w.r.t. project follow-up (i.e. regularity/clarity of project meeting/project status)	Customer	3%	28%	58%	11%	1,9
6	Many bugs reported by the customer	Customer	22%	58%	17%	3%	1,4
7	Discussion with customer of adjustment to timing, cost or functionality	Customer	3%	22%	31%	44%	1,36
8	Tasks not clearly defined for team	Team	22%	61%	14%	3%	1,33
9	maintainability and the capability of evolution of software	Team	0%	19%	42%	39%	1,19
10	Customer satisfaction w.r.t. project non-functional features (as performance, reliability, security,…)	Customer	0%	11%	72%	17%	1,16
11	Team satisfaction w.r.t. development environment available	Team	0%	9%	58%	33%	0,92
12	Customer satisfaction w.r.t. project functional features	Customer	0%	6%	61%	33%	0,83

Problem Severity Score (PSS): a weighted sum over all answers is used to establish the order of problem frequency severity reported in Table 1. To clearly mark a distinction between positive and negative answers, the survey only offers 4 possible answers hence prevents selecting a median answer. The weights of the 2 negative answers are respectively 0 and 1 while the 2 positive answers' weights are respectively 4 and 6. It is also worth noting that depending the phrasing of problems pre-

sented to participants, the negative answers may be *never* or *sometimes* and in other cases, it is *always* or *often*. In other words, the weighing scale is assigned one way or the other according to the phrasing of the question. This is one of the means to prevent systematic answers from participants. Table 1 shows the ranking of all the reported problems from the most severe to the less severe according our measurement method.

Unsurprisingly, cost, delay and inefficiency in project tasks rank as the top 3 problems. All 3 problems can actually be observed internally (by the development team members) and externally (by the customer). Those factors are fully aligned with factors reported by international studies such as the CHAOS report [6]. A more detailed comparison is presented in section 4.

More interestingly, internally perceived inefficiency (#2 in Table 1) is ranked well before product quality issue reported by client (#6). This suggests a good level of awareness and also a focus on minimizing external impact of quality problems, which may explain increased delay and cost overrun risks.

Looking at the less severe problems on the customer side, there is a global satisfaction about the delivered features both functional and non-functional (note however this is reported by the software development SME on the behalf of their customers and not directly by customer themselves). On the development team side, the available development tools seem to meet expectations.

In order to build a benchmark of participating SME, a **global problem severity score (GPSS)** is assigned to each SME. It is computed as the sum of the PSS on all criteria. Each SME can then view how it benchmarks against other participating SMEs. For anonymity reasons, we may not publish data related to this benchmarks. However, we may globally mention that SMEs generally obtain a fairly low average: The highest rank SME obtains a score of 56 while two thirds of SME score between 10 and 30. This trend confirms that a majority of SME are facing several problems and need recommendations to improve processes of their development lifecycle to address these problems properly.

3.3   Relating problems to SME characteristics

This section analyses possible correlations between SME characteristics and reported problems, focusing mainly on the top-3 problems directly relating to the cost-delay-quality triangle.

- About the size of the company, Figure 5 shows a significant relation between size and problem occurrence: The smaller the company, the higher the frequency. Companies with less than 10 people report problems about five times more often than SME with more than 50 people.
- About the impact of the sector, Figure 6 shows some variation but far less than the impact of the size of companies. Manufacturing, banking and public sector seem less impacted (about half the maximum rate). Report [7] presents statistics on these sectors in Wallonia.
- About the impact of the project duration, Figure 7 shows that the longer the project is, the higher the reported GPSS is, which is coherent with a higher risk.
- About the impact of the quality team size on GPSS, surprisingly Figure 8 shows that they are quite independent.
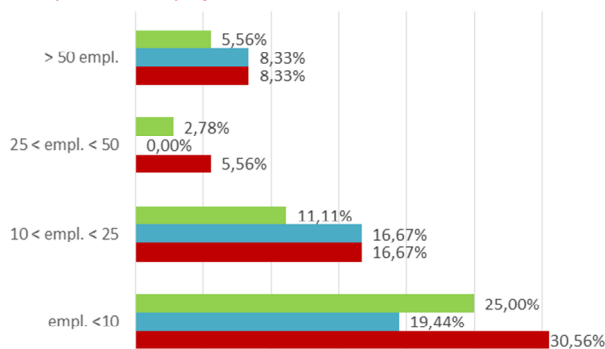
Figure 5. Impact of company size.
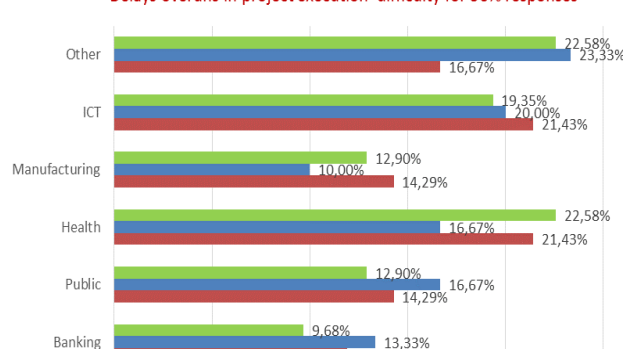
Figure 6. Impact of company sector.
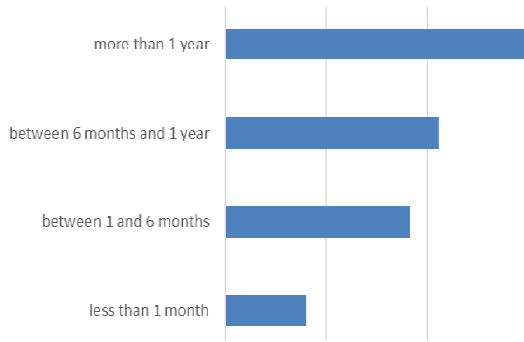
Figure 7. Impact of project duration on average GPSS.
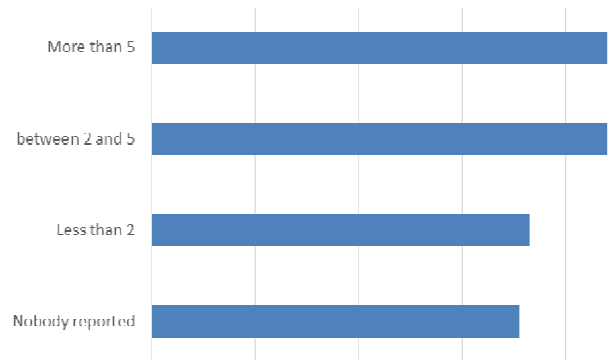
Figure 8. Impact of size of quality team on average GPSS.

3.4   Analysis of ISO29110 recommended activities

After surveying problems encountered, the next batch of questions is related to process activities found in ISO29110 Entry profile mentioned in section 2. It is important to highlight that participants are not asked questions on all 10 activities. Indeed, the survey is built on the top of an online self-assessment tool. This tool only covers questions for activities related to problems mentioned by each participant, i.e., problems and statistics mentioned in section 3.2. For instance, most participants expressed no problems on customer satisfaction on functional and non-functional aspects of software (see entries #8 and #10 in Table 1). Therefore, in most cases, the self-assessment tool does ask questions related to testing activities in particular, entries #9 and #10 in Table 2 show that only 3% of survey participants are asked questions on testing activities. Conversely, the top 4 ISO29110 activities in Table 2, related to requirement or planning, are frequently asked to participants (81 to 97% of participants are surveyed on these questions). The reason is that the self-assessment tool is built on the assumption that problems related to cost of delay (top most problem in Table 1) are usually due to requirements not sufficiently documented or to issue with project planning.

Table 2. More and less frequent recommended activities

#	Activity	Related ISO29110 activity	ISO29110 activities related to problems (Table 1)	Activities performed asked in survey	Inferred global % of activities performed
1	Establish the description of client requirements	IMPL2	97%	77%	78%
2	Document progress reports during project execution	PM2	92%	67%	69%
3	Control regularly project progress vs planning	PM3	92%	82%	83%
4	Establish project plan	PM1	81%	69%	75%
5	Organize project kick-off	IMPL1	64%	87%	92%
6	Formalize the delivery and acceptance of software by the customer	PM4	56%	40%	67%
7	Create and update the list of components	IMPL3	6%	100%	100%
8	Write the delivery modalities of software	IMPL6	8%	100%	100%
9	Describe tests	IMPL5	3%	100%	100%
10	Realise tests	IMPL4	3%	100%	100%

The 2 right most columns of Table 2 present the following information:

- *Activities performed asked in survey* – percentage of participants who are actually asked the question on the given activity and answer that they are performing it during their software projects.

- *Inferred global % of activities performed* – percentage of participants who are performing the given activity even if not asked the actual question on the given activity. Given that participants not asked the question on an activity initially answered not to have encountered problems related to this activity, it seems fairly safe to infer this percentage. In the end, we observe that there is little different in percentages between the 2 right-most columns of Table 2.

The activity most surveyed is about requirements. Poor requirements are frequently reported as key factor in project failure [6]. The next 3 entries relate to project management issues (project planning and progress monitoring). Combining percentages from these companies, 70-80% of participants surveyed on these 3 activities claim to perform it. This means that the remaining percentage (between 20-30%) do not perform enough planning and progress reporting during their software project.

A deeper analysis on the first 4 activities highlights the following. First, we know that the self-assessment tool only asked questions on these 4 activities only to participants who initially indicated encountering problems (in Table 1) related to delay, cost or inefficiencies in project tasks. Second, 70-90% of participants surveyed on these four activities mention that they are performing them. However, they also mention suffering from problems on delay, cost and task inefficiencies. We may therefore infer that for a large majority of these participants, they are not efficiently performing some of these four activities. For instance, they may write and share a requirements specification document with customers but the content of that document may not be complete. Regarding planning and plan monitoring, many SME perform these activities but sometimes in very informal ways and then fail to react or adjust the plan. In other words, it justifies that the survey needs the next and final steps where participants are further asked about the ISO29110 tasks performed under each activity. This information is presented in section 3.5.

Finally, at the end of Table 2, it is worth noting that the testing phase seems under control as few problems and activities related to testing are systematically reported as being problematic. It is worth noting that CETIC devoted a significant effort a few years ago to raising SME awareness in the field of testing. A survey reported as part of this effort appears in [8]. In addition, CETIC has coached various regional SME on how to improve their verification and validation practices at different stages of software development project.

3.5   Analysis of ISO29110 recommended tasks

Following questions on activities of ISO29110 Entry profile, the survey continues with ISO29110 tasks found under each surveyed activity in ISO29110. Table 3 lists tasks most frequently surveyed participants. As for activities in section 3.4, the self-assessment tool does not systematically ask questions about all 39 tasks of ISO29110 Entry profile to all participants. The question filtering process by the self-assessment tool is however different than for activities. Questions on tasks are only asked if participants previously indicate that the activity is performed. Indeed, if a participant answers not to perform an activity then there is no need to further asking question on finer grained tasks under this activity. It is safe to assume that the given participant does not perform any tasks under that activity.

It is worth noting that first tasks in Table 3 mostly relate to project management activities. Conversely, the least frequent recommended tasks relate to software implementation activities in particular test related tasks.

We can also notice that even if nearly 80% of participants indicate producing a client's requirements document in Table 2, based on Table 3, 92% review this document with their customer (Task #6 in Table 3). Transitively, 8% write a client's requirements document only for use by the development team. Furthermore, Task #5 and #2 respectively show that 80% allow for updating to the requirements specification and 85% evaluate and track change request from the client. Thus the remaining 20% and 15% do not. A finer analysing per participant shows that one not performing one of these three tasks (#2, #5 and #6) does not perform the other two. Clearly, this is a good recipe for project failure.

A similar observation applies for tasks #1 and #3 in Table 3. 85% of companies surveyed on these two tasks indicated monitoring project progress and assigning requirement analysis task to project team. Inversely, this means that 15%, often the same 15% of participants do not assign requirement analysis task to project team members hence clearly this impede on their ability to monitor project progress.

Table 3. More and less frequent recommended tasks

#	Task related to activities	Related ISO29110 activity	Proposed ISO29110 tasks	Performed tasks by companies from proposed ones
1	Evaluate progress against the project plan	PM3	75%	85%
2	Evaluate and track changes from the client	PM3	75%	85%
3	Assign tasks to project team for analysis of software requirements	IMPL2	75%	85%
4	Establish measures to correct deviations or to solve problems and monitor them	PM2	75%	78%
5	Document or update the specification of requirements	IMPL2	70%	80%
6	Validate the requirements specification with the customer and obtain approval	IMPL2	70%	92%
7	Control the execution of the project plan and document the progress in the progress report	PM2	61%	73%
8	Organize review meetings with the client	PM2	61%	86%
9	Identify and document the list of tasks required to complete the project	PM1	56%	95%
10	Establish the project team composition and assign roles and responsibilities	PM1	56%	85%
11	Identify and document the list of resources (human, material, equipment and tools)	PM1	56%	70%
12	Write the project plan	PM1	56%	75%
13	Identify and document the list of risks that could affect the project	PM1	56%	40%
…	…			
35	Assign tasks to project team for delivery of software	IMPL6	8%	33%
36	Establish or update the test cases and test procedures	IMPL4	3%	100%
37	Perform unit testing and correct defects until success	IMPL4	3%	100%
38	Perform integration testing and document the results in a report test	IMPL5	3%	100%
39	Deliver the software according to the project plan	IMPL6	3%	100%

Unlike Table 2, at this point, it is not possible to infer global percentages for Table 3 on tasks. This is due to the compound and opposite logic in the self-assessment tool when initial filtering questions first on activities (based on problem encountered) and then filtering questions on tasks (based on activities performed). Future work will investigate how to extract results in order to distinguish between such scenarios to be able to infer accurate global percentages for tasks.

3.6   Threat to Validity

To produce reliable results, we identified a series of threats related to our survey and then designed an approach for conducting the survey and filtering results to limit the error factor. The main threats identified are:

1. The sample selection of participants is not representative.
2. Participants do not want to reveal the truth and answer positive results.

3. Different people appreciate a situation differently hence potentially leading to different people who worked on the same software development project to answer a given question differently.
4. Participants could use different email addresses and answer the online survey several times.
5. Participants are not ready to answer long complex questionnaires hence covering 12 problems and 39 tasks is too long for most SME.
6. Participants in SME in particular very small enterprises such as start-ups are not necessarily well versed on the jargon of software process standards.

Regarding the first threat, the 36 SME surveyed as described in Section 3.1 are a representative sample for the French speaking community of Belgium, which is majorly constituted of SME. Although our results are only intended to target Belgian SME, we believe that analysis results could be further studied in other areas of the world to identify potential more global trends. However, until other surveys are conducted in other areas of the world, results are only intended to apply the Belgian context.

To address the second threat on veracity of answers, the following mitigation actions are used. First, after the survey, participants receive recommendations on set of activities and tasks where improvements are needed. Being too optimistic in answers will then only results in receiving fewer recommendations. Second, the survey is not fully anonymized. We promise not to reveal the names of people or organisation publically but company information and a personal email (to which the recommendations are sent) are collected at the beginning of the survey.

To address the third threat on variety of opinions, we recognise that not all people answering to the survey have the same history in their organisation. The list of people invited to answer the survey was established not merely by researchers contact but also by CETIC business staff who have frequent interactions with enterprises in Belgium. Thus people invited to answer the survey were selected based on prior relationship with CETIC staff member. In addition, the survey provides simple question with always 4-option answers (Never, Sometimes, Often and Always). Standardizing questions and answers helps to reduce the degree of subjectivity in answers.

To avoid many answers from the same participant (threat 4), IP filtering is performed at the beginning of the test and a participant can participate to the survey only once every 24-hour. On the result filtering aspect, only a single survey participation per organisation is considered and the vast majority of the participants revealed their organisation name as we keep it confidential.

To simplify the questionnaire, the survey is based on self-assessment tool for the Entry profile. This tool conditionally selects questions about activities and tasks based on problems encountered by participants. Consequently, the survey can be answers in four one-screen web pages and average number of 25 to 30 simple questions, which can generally be answered in less than 10 minutes.

The sixth threat is solved in two ways. First, the survey build on top of a self-assessment tool which initiates the exercise by surveying general problems encountered during development projects. Anyone behind an SME would understand these problems independent of knowing the jargon of software process. Second, the survey is based on the ISO 29110 Entry profile, the concepts covered in this profile are fairly simple and most companies would likely understand them. Furthermore, this profile only involves 2 processes hence, there is no complex interactions potentially hidden between processes as it may happen in ISO 12207 or CMMI.

4 Related work

Table 5 shows the comparison of our survey results with some other very large surveys as the CHAOS survey [6], GARTNER report [9] and SAUER study [10]. CHAOS results are conducted among 60% US based projects, 25% European and 15% the rest of the world with half of companies working on large projects, 30% midsize projects and 20% small size projects. The GARTNER survey was conducted with 150 participants in organizations across North America, France, Germany and the United Kingdom. The Sauer and Cuthbertson study conducted in 2003 is based on a web survey of 421 IT projects in UK, investigating the state of project performance.

Regarding their outcome, projects are globally more challenged. If we dig into key dimensions, time and costs overruns issues are significantly present. Although the evaluation criteria might hinder the

comparison, this suggests SME are more challenged than the whole IT sector. However it is worth noting that less failed projects are reported and that feature coverage is better, maybe because of a good level of adoption of Agile techniques by our participating SME (50%). Over the years, it is worth noting a significant positive evolution related to problems on "features coverage" in Table 5 from 41% in 2003 to 100% for SME in 2015.

Table 5. Comparison with other surveys/studies.

	CHAOS report (2012)	GARTNER report (2011)	SAUER study (2003)	CETIC survey (2015)
Project outcome				
Successful	39%	25%	16%	20%
Failed	18%	25%	31%	10%
Challenged	43%	50%	53%	70%
Key dimensions				
Time overruns	74%	44%	45%	92%
Cost overruns	59%	42%	49%	83%
Features coverage	69%	57%	41%	100%

5   Conclusion and Next Steps

So far the survey has confirmed previously reported factors explaining why SME are challenged in mastering the maturity of their IT developments. It has also more precisely highlighted interesting facts. It also tends to show that SME are quite aware of their maturity level and are willing to improve it (a large majority of SME asked to be kept informed although it was not mandatory).

A current limitation is the relative small number of answers, which is also bound to its relatively small current geographical scope. Our plan is now to extend our survey to other countries and, based on the larger set of answers, to study if the same observations are confirmed or need to be revised.

The survey is available in French and English at this URL: http://survey.cetic.be/iso29110/survey.php. It takes about 15 minutes to complete and provides quick win recommendations. We warmly encourage you to spread the information to any SME you know that might be interested.

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7 Biographies

Annick Majchrowski holds a computer science Master's degree obtained in 1987 from the Catholic University of Louvain-La-Neuve. She also holds a degree in Mathematics obtained in 1985 from the same university. Her areas of expertise involve Information Systems analysis and quality management. Annick has also followed trainings on project management methodologies such as Prince II and on the COSMIC functional size measurement methods. Annick has participated in many consultancy projects with the public sector at regional and federal level.

Sanae Saadaoui has a PhD in Computer Science (University of Namur 2007). She has extensive experience in managing, securing and modelling of information systems and improving software development processes. Her areas of expertise are requirements engineering based on KAOS and on the COSMIC functional size measurement method. Sanae also received a certificate for the initial PRINCE 2 project management training.

Christophe Ponsard is leading the Software and System Engineering department at CETIC. He holds a master in Electrical Engineering and Computer Science. His main area of expertise is software engineering, more specifically requirements engineering, model-driven engineering (including formal methods), security and safety critical systems. He has a strong experience in the development in model-driven engineering tools, especially targeting (goal-oriented) requirements engineering and the design phases using formal methods.

Jacques Flamand graduated in Electronics Engineering in 1975 at the University of Liège. After 2 years as an assistant in the Computer Science Department at the University, he worked as a developer, project leader and Product Line Manager in Siemens Software Laboratories, become Océ Software Laboratories in 1999. Since 2009, parallel its Product Line Manager at Océ activity (now part of the Canon group), is a research engineer in the software Quality team CETIC. His main expertise is software engineering, especially software quality and quality of the software development process. He is currently responsible for the development of assessment tools in order to help companies evaluate and improve their software engineering practices.

Jean-Christophe Deprez has been at Centre d'Excellence en Technologies de l'Information et de la Communication (CETIC) in Charleroi, Belgium since 2005 where he is Scientific Coordinator. He received his doctorate from the University of Louisiana in Lafayette in May 2003. Since 2008, Dr Deprez is an ISO representative for Belgium in various ISO/IEC JTC1 Subcommittees, namely, SC7 on Software and System Engineering, SC27 on Security, and TR215 on Health Informatics. Prior to joining CETIC, Dr. Deprez was an assistant professor at Pace University, New York, USA (2001-2005). From his initial steps in Research, his research have been dedicated to improving the quality of software through the coupling of static and dynamic analyses of software project data not only at the code level but also other data to discover evidence of software process execution by human stakeholders.

Lessons learned from four years empowering Project Management with TALAIA OpenPPM

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Abstract

Knowledge and experience is not the only prerequisite for a successful project, well performing team using proper tools and techniques ensures efficient project management. Good tool is essential to support decision-making in any of the business units be managed. TALAIA OpenPPM is an open source solution for managing projects, programs and portfolios. SM2, founder of TALAIA OpenPPM, after four years of experience of the tool implementation in companies from different sectors, came to a conclusion that the adoption of the tool depends on the maturity level of the project management processes established in the organization. Also, this article derives lessons learned by SM2 in expansion and opening of a new business line in international market.

Keywords

Project Management, Open source tool, PMBOK[®]

1   Introduction

Currently, more and more companies use the project-based management to plan, implement and control activities which are not day to day operations. Project is defined as any temporary effort that has a limited budget and resources, should finish in a limited period and obtain a unique result, product or service. These assignments are more demanding than the daily operations and require a well organised management structure.

Some organizations are naturally project based, its business is to perform projects one after another for their clients, and those companies which are not, organise their tasks as a "project" to generate new products and services, achieve strategic goals, and expand their business or to implement new technology.

Organizations in any sector, large or small require resources with specific skills and knowledge for using project management support systems. Moreover, companies implementing a large number of ongoing projects involving large number of resources, have problems with fulfilling strategic aspect of projects in company. Strategic project management goes beyond efficient project implementation towards area of anticipated cancelation of project being implemented and strategic evaluation of projects being initiated. In order to achieve this objective company should focus on management of project programs and portfolios, rather than on solely management of projects. Objectives of managing a portfolio and program are different. Regarding the distinction between portfolio and program, PMI® (Project Management Institute) speaks about *Portfolio manager* as the position of manager, linked to governance, while the *Program manager* is a position related to management.

On the other hand, many Project Managers, who have many years of experience, very good theoretical knowledge in project management fundamentals and excellent resources in their project teams, do not have adequate tools which would properly integrate all the resources and knowledge in a cohesive whole. A Project Manager needs to manage a project, not a tool. He especially needs to manage expectations of all stakeholders, to use an effective and efficient communication mechanism, to provide information in the right form, at the right time, with the appropriate impact and only with necessary information. A company needs successful delivery of projects regarding scope, time, cost and quality, despite not having the proper tools (none of the tools, with different features, or partially covering successful delivery). The project success depends less on the tools than how are they used. In Project Management, the focus should be the opposite, from what we observed in the tools currently available in the market: It should not be the case that company has to fit to the tool, but the tool should be flexible enough to be used in the right and easy way by the company.

Tools to manage the project portfolio are called Project Portfolio Management (PPM) tools. Globally observed there are many open systems products and initiatives in project management, but unfortunately there aren't PPM products. They are commercial alternatives but they require high investment, training and configuration and, in most cases, they don't fit to SMEs (Small and Medium Enterprises). Many products are pursuing a project management implementation model similar to products such as ERP (Enterprise Resource Planning) business management. Generally, these products require the company to change its processes and roles to suit the tool. They have high cost of licensing software that centralizes all management, consulting needs to adapt the organization to the tool, heavy recurrent costs in maintenance and adaptations and updates over the years. However, satisfaction with these products is low: many customers accept this effort and cost because they find value in adapting these products, but they fail to implement them or take years doing it.

In 2009, SM2 Software & Services Management, a project-oriented company started the development of TALAIA OpenPPM, an open source solution for managing projects, programs and portfolios. According to the PMBOK® Guide [1], published by the PMI®:

- A *project* is a temporary endeavour undertaken to create a unique product, service or result.

- A *program* is a group of related projects, which his coordinate management brings more benefits and control than if managed individually. May include work outside the scope of individual projects (e.g. operations).

- A *portfolio* is a collection of projects, programs and other portfolios or other works, which are grouped to facilitate effective management of such work in order to achieve strategic business objectives. The components of the portfolio do not need to be interdependent or directly related.

The first version of the tool was obtained in 2011 and from the lessons learned from each successive implementation, it has been continuously improved. This paper presents TALAIA OpenPPM (section 2). Section 3 gathers the most important considerations from the implementation and use of the tool. Section 4 summarises the lessons learned from the four years of TALAIA OpenPPM. Finally, section 5 concludes the paper.

2   TALAIA OpenPPM

TALAIA OpenPPM provides a complete management perspective of the company, providing many features and emphasizing the importance of integrated portfolio management for the entire corporation. It was designed with two main objectives:

- To allow flexible and effective work of the Project manager and other stakeholders (Team member, Resource manager, Project manager, PMO, Stakeholders, Sponsor, among others).

- To provide global visibility and perspective to the business Portfolio managers or Project managers as well as to CEO, Financial director, Human resources and Operations.

The main objective of TALAIA OpenPPM is that project managers are able to apply their knowledge based on project management standards (Figure 1). The tool does not require changing the business processes. It adapts to the organization by optimizing its daily operations in project management.

TALAIA OpenPPM is a multi-company tool. This means that a single instance can securely manage information for more than one company. It is an entirely web application. Users are able to start the application only with a username and password. It is designed to integrate with other tools (planning tools, issue tracking or ticketing, management risk, cost management, staff evaluations) and it is enhanced to be intuitive and ready to use.

Figure 1: TALAIA OpenPPM Project management

2.1   The developer company

SM2 Software & Services Management is a consolidated Spanish based company, leader in IT business, with the required capacity and alliances to provide "end to end solutions". It counts more than 150 professionals and delivers quality services with more than 25 years of experience in projects and consulting services, integration systems, outsourcing services and software products. SM2 has strong expertise in the sectors of Tourism, Finance, Public Administration and Health.

SM2 is an established company that has among its shareholders the multinational Atos, the world leader in information technology and the financial institution BMN. Both companies provide on one hand, technological support and industry knowledge, and on the other, solvency and business continuity.

2.2   The origin

TALAIA OpenPPM was born in the context of an investment project financed by the Ministry of Industry, Tourism and Trade of Spain, Avanza2 Plan 2009. The first version of the tool, called OpenPPM, was developed with the aim of providing companies an open source product, consistent with the standards of project management good practices, as defined by PMI[®].

Following this initiative, TALAIA OpenPPM becomes the brand name of the SM2 professional services offers around open source product OpenPPM.

2.3   TALAIA OpenPPM consistence with Project Management standards

TALAIA OpenPPM is consistent, by design, with the standards of good practice in portfolio, program and project management developed by the PMI[®], ISO 21500 [2] and ANSI-EIA 748-C for Earned Value Management Systems [3]. According to the PMI[®]:

- **Project management** must follow the ANSI/PMI 99-001-2018 standard [1], known as the PMBOK[®] (Project Management Body of Knowledge) Guide. The fifth version defines 47 processes, in 10 knowledge areas (Integration, Scope, Stakeholder, Time, Human resource, Communications, Cost, Procurement, Risk and Quality) and 5 groups of processes (Initiating, Planning, Executing, Monitoring & controlling, and Closing). TALAIA OpenPPM allows managing the following management areas according to the PMBOK[®] Guide.

- **Program management** must follow the ANSI/PMI 08-002-2008 standard [4]. The second version defines 47 processes, in 9 knowledge areas (Integration, Scope, Time, Communication, Risk, Procurement, Financial, Stakeholder and Governance) and 5 process groups (the same as for the PMBOK Guide). Programs have a life cycle composed by 5 sequential phases: Pre-program preparations, Program initiation, Program setup, Delivery of Program benefits and Program Closure. TALAIA OpenPPM allows program management and exploring information at both project and investment levels (Figure 2). The Program Manager can control investments and projects belong to his program.

- **Portfolio management** must follow the ANSI/PMI 08-003-2008 standard [5]. The second version has 14 processes, 2 areas of knowledge (Portfolio governance and Portfolio risk) and 2 groups of processes (Aligning and Monitoring & controlling). TALAIA OpenPPM offers the possibility to manage Portfolios, Programs and Investments. The Portfolio Manager can control investments that belong to his portfolio. TALAIA OpenPPM shows the last summary report of each project. The Medium-High profiles (Portfolio Manager, Program Manager, Functional Manager and PMO) may drill down into projects details to reach the same level of information as the Project Manager (read only access).

Figure 2: TALAIA OpenPPM Investment management

2.4   TALAIA OpenPPM features

Some of the most important features of TALAIA OpenPPM are:

- **Investment and project management**. Managing an organization means monitoring of investments, projects and portfolios. This implies separated but again interconnected management levels. TALAIA OpenPPM helps supporting these levels through use of different roles.

- **Risk and change management**. Companies are performing in an ever growing complex environment. Therefore TALAIA OpenPPM includes a risk and change management module to analyse current and possible future scenarios in order to manage project uncertainty. Working with Key Performance Indicators (KPIs) ensures real time compliance with all requirements and effort levels associated with each project.

- **360º overview**. TALAIA OpenPPM provides an overview of all ongoing projects, reporting real time progress and outcomes. It covers the complete project life cycle, from ideas of possible investments until closing or cancelling projects and projects portfolios. At any time it is possible to check initial planning versus actual situation, being able to dill down in more projects history details (issue log, risks, changes, status report, etc.). In closed projects, stakeholders can measure deviation between expected and performed project activities.

- **Monitoring project execution**. Team members follow a workflow. They are aware at all time if they have been pre-assigned, assigned or released from a Project. When incurring hours and expenses, the approval workflow always involves the Project manager.

- **Bottom-up information**. The method used by TALAIA OpenPPM offers both a 360º overview and an end-to-end vision based upon a bottom-up feedback from the Team members to the Project managers and ongoing to Program managers, PMOs, Functional managers and Portfolio managers. Thanks to the data process requirement tool, TALAIA OpenPPM provides efficient and quality/effectiveness follow-up reports, ensuring necessary information availability at all company levels to successfully complete each project.

2.5   Roles supported by TALAIA OpenPPM

A single user can access TALAIA OpenPPM up to 10 different roles, depending on the department to which is connected and the function to be performed:

1. **Investment Manager (IM)**: Responsible for managing the projects pending approval, or investments, providing tracking information. Investments have 3 phases: initiation, execution and closure.

2. **Project Manager (PM)**: It is the main role, responsible for managing the projects approved, leading the project team and provide tracking information. Supervises TMs.

3. **Team Member (TM)**: A person assigned to the project team, a source of direct costs, responsible for allocating hours and expenses.

4. **Program Manager (PgM)**: Responsible for managing programs. Supervises PMs. The program has 5 phases: preparation, initiation, configuration, execution and closure.

5. **Resource Manager (RM)**: Responsible for ensuring the availability of human resources as planned, the capacity management and training.

6. **Sponsor (SP)**: Responsible for project funding, helps ensure that projects achieve planned objectives.

7. **Project Management Office (PMO)**: Define processes and quality standards, monitors the performance of programs and components, centralized administrative support and provides information for decision-making.

8. **Functional Manager (FM)**: Director of the Performing Organization, responsible for the alignment with strategic objectives, is part of the monitoring committees, helps in the overall supervision and controls the performance of programs and components. Supervises PMs, IMs, PgMs.

9. **Portfolio Manager (PfM)**: This role usually corresponds to the CEO, who has high-level visibility on all projects of the organization. Typically is reported by the Functional Managers (heads of department), Program Managers (responsible for project lines) Investment Managers (or administrators of the application).

10. **Stakeholder (SH)**: Any person involved in one or more projects, or whose interests may be positively or negatively affected by execution or project completion.

2.6   Service portfolio associated to TALAIA OpenPPM

SM2 has developed a complete service portfolio associated to TALAIA OpenPPM, giving access for customers to the latest version of the tool combined with the guarantee of an optimal use and implementation of the product:

SM2 also provides a range of advisory and consulting services for companies looking for improving their processes, investment control, portfolio management, resource management and working methodology:

- **Implementation**: Consulting, elicitation of the implementation requirements, configuration and initial set up (users, profiles, organizational process assets, etc.), initial data & project load, technical set up & tool deployment, training.

- **Maintenance & Support**: Gold (Functional and technical support, response rate with less than 4h, access to customer site and TALAIA OpenPPM Community, hosting included, +60 hours for customization), Silver (Bug reporting, functional and technical support, software & documentation upgrades & patching, +20 hours for customization) and Bronze (bug reporting, Software and Documentation patching).

- **SAAS**: Software set-up, technical support service & Service Level Agreement (SLA), version updating, hosting service (cloud): availability, monitoring, communication, data backup.

Finally, a new initiative called "TALAIA OpenPPM University" has recently been created to provide universities with the possibility to experience the latest version of the tool, allowing students to put in practical knowledge gained during their Project Portfolio Management courses.

2.7   TALAIA OpenPPM recognitions and awards

In September of 2012, SM2 received the Certificate of Technological innovation for the project "OpenPPM" by the ACIE (Certification and Innovation Spanish Agency) in the sub-discipline and UNESCO code 1203.18 "Computer science, Information Systems, Design of components". Two years after, in February of 2014, SM2 was awarded with the special distinction "Innovative Technology" by the CAEB (Confederation of Business Associations of the Balearic Islands).

3   Implementation and use of TALAIA OpenPPM

This section gathers the most important considerations after four years of experience implementing TALAIA OpenPPM. Firstly, it is worth mentioning that the tool hardly has learning curve for Project managers with experience and knowledge of the PMBOK® Guide best practices. However, it is highly recommended that organizations provide training in project management good practices to their Project managers before adopting the tool.

In most of SMEs, roles can be shared by more than one person, and a person can have more than one role. For example, a Project manager that manages multiple projects can be, in turn, a Program manager and a portfolio Manager can in turn be PMO. The decision to allow a single user to hold more than one role has been crucial for TALAIA OpenPPM to become accepted by SMEs.

In TALAIA OpenPPM business managers have an overview of the proposed investments and of the budget and the resources needed for their implementation, so they can balance the launch of new projects based on production and outsourcing capabilities and, as result, they can execute the investments involving a greater benefit for the organization.

TALAIA OpenPPM has no license cost and it is provided with all the functionality, but its use is progressive, it depends on the maturity of the organization and it is extended as the level of knowledge and adaptation of project management processes progresses. The eight stages of maturity observed in SM2 customers are:

1. Investments, including the planned start and end dates, scope and budget are reported. The investment monitoring during execution is based on recording the time deviation, the percentage of completion and a fortnightly or monthly executive status report. The customer has an overview of all investments, both proposed and in execution, and uses the project charter to formally authorize the project.

2. Human resources are managed. The customer manages the human resources involved in the projects, with an allocation cycle and an hour approval cycle, including sick leaves and holidays. The customer has a vision of its resource pool, production capacity and real execution capacity.

3. Project managers manage risks and incidents, and during the planning stage they take into account assumptions and exclusions to better define the scope. The customer can analyse the evolution of risks and compliance with the assumptions made to budget investments.

4. Project managers perform an integrated change control and also a stakeholder management. Project managers use the log to record chronologically the most relevant events of the project. The customer can more accurately predict the additional cost and time deviations with clear knowledge of the causes and factors involved, and also with a better management of stakeholders' expectations.

5. Suppliers and subcontractors are managed. Customers manage acquisitions and involve their suppliers in the use of the tool, spreading good practices among their collaborators, who can use the tool to charge not only time but also to manage their projects as part of a whole.

6. Monitoring by Project managers is complemented with Earned Value Management (EVM), other indicators and metrics adopted in the organization. The customer tracks global and specific KPIs, aligned with organizational processes (e.g. ISO 9001) and strategic goals.

7. Program Management. The customer groups projects requiring joint management by applying Scoring methods to prioritize resources.

8. Portfolio Management. The customer applies top-down versus bottom-up strategy. Risks are reduced and the productive capacity is maximized with gap reduction and greater anticipation.

To sum up, TALAIA OpenPPM is used in organizations with maturity levels 1-6 to track the decisions already taken (Do the things right). In organizations with maturity levels 7-8, it is used to take decisions and innovate (Do the right thing).

3.1   Evolution of TALAIA OpenPPM

SM2 has adopted TALAIA OpenPPM as the internal PPM tool and it is the first to experience and evolve the product with its own needs. TALAIA OpenPPM has allowed SM2 not only to improve portfolio management, but also to improve the established processes consistently with ISO 9001, to anticipate the new needs of ISO 9001:2015 and to prepare for the ISO 21500 future certification.

Other decisions taken by SM2 that have made the product to evolve were propitiated by customers' demands. TALAIA OpenPPM is offered at no cost to the end customer and can also be freely downloaded and used. SM2 had to find a balance between investment in products and services providing business results: implementation, development of custom adaptations and additions, PPM consultancy, training and post-implementation support.

It should be noted that TALAIA OpenPPM was not designed for a low-level management. However, in order to meet customer requirements, functionalities related to Demand management and Portfolio management had to be enhanced, as well as integration mechanisms with specific tasks management tools as JIRA® and REDMINE®.

Customers need a wide range of comprehensive reports and charts Out of the Box (OOTB). During the early adoption of TALAIA OpenPPM they usually invested in the development of custom reports and documents. However, one year after implementation, most customers integrate, with the support of SM2, their own Business Intelligence (BI) solutions for data mining.

There is also an increasing demand for mobile and responsive solutions to access information from mobile devices and tablets. The graphical interface developed in the first version of TALAIA OpenPPM had to be redesigned after a year of launching the product to meet the user expectations.

Customers demand functionalities that allow each user to customize the visibility of information and notifications generated and received. The TALAIA OpenPPM roadmap has been greatly influenced by this need since 2014, and it will be necessary to continue investing in this type of utilities over the next two years.

Although the SM2 philosophy is not to reinvent TALAIA OpenPPM but to integrate with existing tools, customers demand more third-party functionality in order to stop using other products and stop paying licensing costs of these products. A very significant example is the scheduling tool, on which dependency management and critical path functionalities are requested and have been incorporated into the product 2015 roadmap.

4   Lessons learned from the four years of TALAIA OpenPPM

Throughout the four years of tool implementation in companies in different countries and operating in different sectors, SM2 had to make some changes in its internal structure in order to maintain its productivity and, at the same time provide better service to its customers. The main changes SM2 has undergone are:

- Initially SM2 was not a product-oriented company. Launching a new business line as TALAIA OpenPPM made Strategic goal and financial analysis become independent from the rest of the services in the company. This was done to measure the results of the investment in the short and medium term, without undermining the decision making in other areas of the company.

- SM2 was initially a local service company in an island (Mallorca) with some clients nationwide. The commitment to internationalize TALAIA OpenPPM and the services associated with its implementation has led to the creation of a new department and the adaptation of some of the internal processes to provide global services worldwide:

  - Adopt English as the official language.

  - Generate or translate all documentation related to the tool.

  - Prepare the product for multi-language, multi-currency environments with multiple format masks adapted to different languages and cultures.

  - Periodically redefine and adapt our prices and service level, because perception depends on client country and culture.

  - Design a proper business model that can go from 100% to a mix of direct/indirect investment, depending on the client situation and business need such as distributor, service partner, etc.

  - Train staff and prepare it for internationalization of the product.

  - Establish a network of partners to have a local presence in the country of our clients, because it is very important for the client to have presence of a distributor in person.

  - Define a communication strategy.

- Regarding SM2 infrastructure, it has been required an investment in video conferencing systems and in the implementation of asynchronous communication management systems.

4.1   Commercialization of TALAIA OpenPPM

From the point of view of the commercialization of TALAIA OpenPPM, it has been observed that each location requires different sales plan and that, as a general rule, it is desirable to have local partners who know the market well. For this reason, a network of local partners in Spain and another one in Latin America have been already established. Currently, a new network of partners in Europe and another one in Asia are being developed. Having a wide network of partners does not guarantee an increase in the number of sales, but increases the capillarity and contributes to improve market positioning. However, it is important to note that a lot of effort to attract, motivate and train new partners for selling such a specialized product is required.

In order to attract non-local customers it was necessary:

- To design a website and provide it with information and explicit content.

- To strengthen presence in social networks, blogs and specialized publications.

- To create a demo environment for pre-sales teams with intuitive data sets accompanied by simple manuals that allow the use of real examples from beginning to end.

- To facilitate direct tool evaluation to potential users. To do that, the code was released in a specialized platform so that it can be freely downloaded and used.

- To conduct periodic free webinars, conferences and lectures in specialized forums.

- To promote the use at universities and business schools with TALAIA OpenPPM University.

The product roadmap is alive and must feed on the experiences and expectations of current and future users. Communication between delivery, pre-sales and sales is the key for the consolidation of the roadmap, which should be checked periodically.

Against all odds, the IT customer is very complex since its maturity in project management is much lower than in other engineering or construction sectors.

The PPM products should be directed to market as "service" rather than "product". Moreover, we have found that the open source model is aligned with the current trend of companies aimed at minimizing software investments. SM2 customers remain reluctant to take key business data in the cloud and opt for a model of implementation in their own infrastructure that, on the other hand, facilitates integration with other tools in the organization and global data exploitation.

Lean, Zero Footprint and Low Bandwidth approaches have been a success since they are aligned with the current trend aimed at minimizing investment in hardware and network and communication infrastructure. Customers are looking for simple solutions, easy to implement, aligned with Agile methods and easy to integrate with other complementary tools.

5   Conclusion

This paper presents the potential benefits for a company to implement TALAIA OpenPPM, an open source tool that supports the establishment of good practices for portfolio, program and project management. Moreover, it collects the lessons learned by SM2 after four years implementing the tool.

TALAIA OpenPPM consistency with the PMBOK® Guide allows adopting a common language among project managers, business managers and department directors, standardizing the indicators used to measure variations and achieve objectives.

The adoption of a PPM tool as TALAIA OpenPPM has to be gradual and evolve according to the maturity of the organization, starting with the most prepared departments and then, slowly unfolding it throughout the whole organization. Forcing the process to a higher maturity level if the company is not ready, could lead to immediate dropout of using the tool in the company.

It is very important that Project managers have sufficient authority to carry out their work. Without that, the progress and evolution of the company towards excellence in management would not be possible.

There is a great difficulty to transmit the value and usefulness of PPM software. The customer expects a product that performs the management by itself; however, the product is obviously a project management supporting tool. The Project manager has to make decisions and exercise his role, and use the tool to facilitate his work.

6   Literature

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Enabling Delivery Excellence through Impactful Risk Management

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Abstract

A traditional risk management process in an IT company has a flow starting with risk identification, risk management consisting of mitigation[1] / contingency[2] action identification & implementation, and risk governance as part of the project' SDLC (Software Development Life Cycle). However this model does not cater to the needs of risk management at Program level where the magnitude of projects ranges from 1000+ FTE (Full Time Equivalent) to a one member project. With the changing times in IT industry & business moving towards digital markets there is a strong demand for establishing a robust risk management & governance right from early stages of the projects. Hence the new risk management process needs to do the following

- To help delivery identify risks at early stages of the projects development lifecycle
- To capture the learning' of previous escalations thereby enabling the organization to take more complex risky projects for execution
- To provide transparency on the critical risks to customer to enable a strong risk governance
- To enable a culture of risk based program management to provide deeper risk insights right from 1000 FTE projects to 1 FTE projects
- To help organization adopt the culture of no customer escalations
  Thus this paper talks about the effective and efficient risk governance by making changes in approach, tooling and other implementation practices towards creating an automatic & robust risk management process within our organization. The key highlights of this presentation will include:
- Transformational journey of improvements in Risk Management process in last 10 years
- Tool based definition of risk cycle leading to automatic risk alert mailers to the respective stakeholders
- Leveraging technology for automation of risk governance across various levels
- Quantitative(RPN[3] – Risk Priority Number) based Risk Escalation process
- Key metrics to ensure organization wide risk tool adoption
- Rich risk repository catering to the need of organization to assess its ability to handle risky projects
- Details of challenges faced , benefits reaped & way forward

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[1] Mitigation – Action taken by the project manager to prevent risk before it happens
[2] Contingency – Action taken by the project manager to cure risk after it happens.
[3] Risk Priority Number, or RPN, is a numeric assessment of risk assigned to a process, or steps in a process, as part of Failure Modes and Effects Analysis (FMEA), in which a team assigns each failure mode numeric values that quantify likelihood of occurrence, likelihood of detection, and severity of impact.

1 Transformation to Risk Automation – Business Need

Most of the Tier1 / 2 organizations adapt Quality management models like CMMI, ISO, or its internal equivalent, there is an underlying strong focus on risk management process. The Delivery Manager is an integral part of it and along with the multiple of tasks that he performs; the risk management ends up being another business as usual task. His focus gets restricted to large complex projects than long-tail project' (e.g.: 1 FTE staff augmentation projects) where potential escalation occurs. Will such low focus add value to the organization?

For a delivery team, achieving higher revenue & profitability, defect free production, zero customer escalation and better resource utilization are the key goals. How can a single person responsible for a huge critical portfolio showcase the expected value-adds to businesses? Is his cost adding value back to organization as well? To answer "yes", we wanted to go to the next level on the way of articulating the values in the way business demands.

The leadership team feels good when the delivery manager adds business value & prevents customer escalations. The fundamental for this entire thing is that a delivery manager understands the clients current & future business & their risk appetite, his / her organizations current risk appetite and address the gap efficiently.

When a delivery manager pins the delivery management's attention along with what the client wants through strong integrated risk governance then they will pave the way for the excellence to happen during the entire SDLC of project execution leading towards a success story in the end.

So this paper depicts our transformation journey started way back 10 years before with a goal to add business value. It covers how delivery excellence can be reaped with a focused vision of adding value to the business through the following:

- Creation of specialized experts group within delivery organization to bring focused attention towards creation of client specific quality assurance charter with a focus on delivery risk management.

- Strengthening of risk based program governance with strong focus on projects with associates less than 3

- Customization of the risk escalation process leading to better customer connect

- Altering risk management cycle to bring in an early alert system

- Defining key measures to ensure organization wide risk tool adoption

- Developing risk repository catering to the need of organization to assess its capability to handle large, complex, risky projects from start

- Learning' from challenges faced , benefits achieved & define future course of action

2 Transformation #1 – Quality Assurance Charter

A focused group of experts was formed to support all types of projects right from development to testing only kinds. The vision for this group is to ensure delivery excellence across all the departments. The Voice of Business (VOB) – department head – was captured and formalized into quality assurance charter One common VOB was that they getting know the issues very late in the development life cycle and many a times these issues gets converted as an escalation rather than a pro-active alert from the delivery. Hence 'Delivery Risk Management' became a key focus area in quality assurance charter for this group.

With a view of creating value to the business and the end customer this group was constantly demanded to share what could be the potential risk failure points by the delivery team while responding

to proposals specially in the area of emerging markets such as social, media, cloud, & analytics – Digital arena. With the lack of single source of system based data being a huge constraint, the team had to reach out to multiple people, multiple sources to provide meaningful and right information within the stipulated time. Right information became critical for key decisions such as costing model, team profile & structure, onshore / offshore based delivery model, right SDLC etc... In proposal response there was an ever growing demand on early visibility of risks from critical projects right from delivery director level to department /sub department heads up till executive leadership team.

The traditional way of risk identification was to get the risks identified at a project level and is only through management review spanning for ~1.5 hrs. But with the quantum of the projects increasing by 25% annually per business department, 100% coverage became challenging.

Thus the need for robust risk management process with focus on strengthened governance, automatic tool based alerts to right stakeholders along with meaningful management information reports to be generated with click of a button.

3 Transformation #2 – Risk based engagement governance

One of the key challenges that the delivery team faced was to share a complete project engagement status to the senior leadership team both at offshore & onsite. Hence visibility into the risks for projects which were managed by customer and by other business departments was a constraint. Due to this any complaints / escalation from the customer were a sure surprise for all. Also whenever a new project was started within the same account but by another business department, the risks, experiences obtained, best practices, challenges could not be shared at the start of project leading to reinventing of the wheel again.

In this scenario we came up with a solution of institutionalizing an inclusive quality assurance strategy involving onsite project counterpart & customers – Global Kick-off & Program Governance Board(PGB)

Global Kick-off: Any new projects that started with a project high value deal, with more than one business department involved, having service level agreements or penalty for delayed delivery or defective delivery has to have a global kick-off involving various business department head, account managers, deliver director, leadership team, technical subject matter experts etc..

The Global kick-off meeting ensures cross sharing of applicable best practices, learning's from due diligence   (investigation   of   a   business   prior   to   signing   the   contract) w.r.t commitments signed in the contracts, associated potential risks & issues, risks occurred in the past projects within the account along with the mitigation & contingency & related risk costs, strategy for year on year improvements and opportunities for innovation.

Program Governance Board (PGB): Any kicked-off project by default becomes part of PGB review. In order to facilitate PGB (program governance board) reviews project health information related to scope, schedule, cost, quality, total value, pricing model, technology category, SLA (service level agreement), resource pyramid structure, account with escalation and associate skill set with corresponding RAG (Red, Amber & Green) status are collected in 'Delivery Run Book'(collection of project review journal). Each project journal is mapped to its associated risks from organization risk portal (raised by the project manager and various auditing groups along with the RPN -Risk Priority Number) to give a complete view to any reviewer..

Then the review of the risks happens by the various service line leaders within the accounts, In the Program Governance Board reviews involving senior leaders, the reviewer understands the progress of the project based on the parameter in Delivery Run Book along with the project stakeholders. Then projects with critical risks are marked for any of the following further actions:

- Detailed technical review,
- Deep-dive project assessment
- Critical Project Review involving customer

Also in these reviews, the reviewers also decides which of these project critical risks are to be taken up for review with next level – business department head, senior leaders, executive leadership to avoid surprise escalations from customer.

4 Transformation #3– Tool based - automatic risk governance

Risk is the probability of suffering harm or loss.[4] With stronger expectation of risk identification from leadership team, quality audit methodology had to change from 'compliance check only' perspective to proactive risk identification along with the regular compliance assurance. As a result risk identification started having 3 major components[5] - context, condition, consequence – 3C concept became the way of articulation for any non-conformances / observation.

Secret formulae for a successful engagement, is stronger connect with the customer and with the customer facing internal groups like BD (Business development) teams, Account Manager (AM) etc. The business department quality assurance team's major focus is to identify the customer expectations and risks in engagement through their interaction with account manager & customer.

Also various entities like auditing group, project manager and account manager identifies risks at project level through audits and reviews with the development team. Thus a collaborative critical risk review is organized which focuses on systemic analysis of risks (raised by auditing team, project manager, account manager) in relation to an engagements & project's objectives. This way it is better suited to managing risks in complex, distributed onshore –offshore model.

The elaborate risk solutions (detailed in risk section in this paper) can be used to manage risks across the project development lifecycle, enabling decision makers to more efficiently engage in the risk management process. It also helps them to navigate through a broad tradeoff space (including performance, reliability, safety, and security considerations, among others), and strategically allocate project's limited resources when and where they are needed the most.

Engagement Reviews: The quality assurance team facilitates engagement reviews where audit findings, dependencies on customer, project issues/risks and performance (metrics, cost, utilization) get reviewed to enable closure of any risks / potential escalation foreseen at the earliest.
The flow for the engagement review involving the various business units is depicted below:
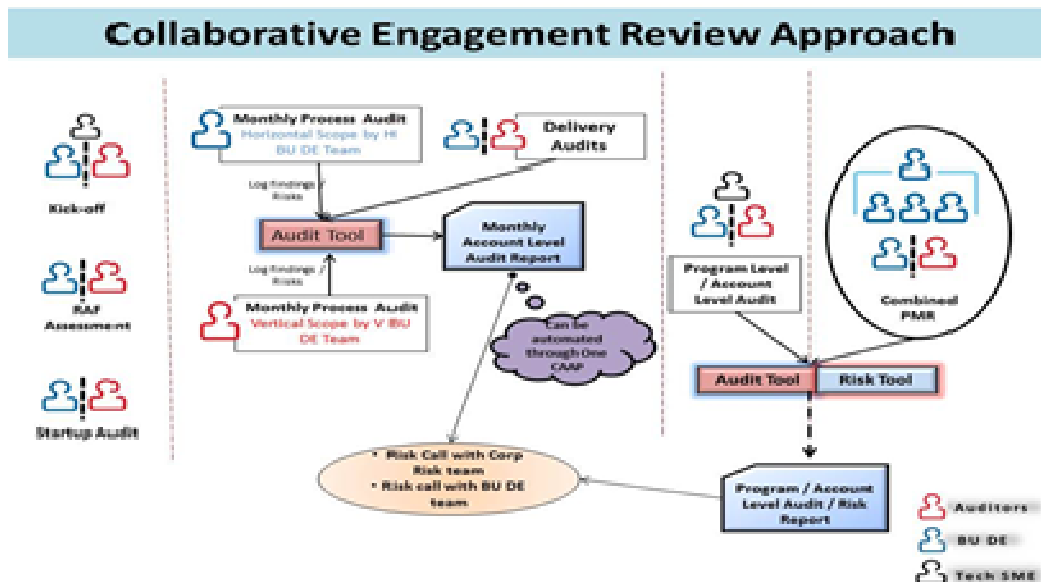
Figure 1: Collaborative Engagement Review Approach

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[4] This definition is derived from the definition used in Dorofee [1996].
[5] Mission Risk Diagnostic (MRD) Method Description- SEI Report - TECHNICAL NOTE - CMU/SEI-2012-TN-005- Christopher Alberts , Audrey Dorofee

Any organization risk program is developed on the assumption that a disciplined and systematic method of managing project risk is necessary and feasible to control the quality, cost, & schedule of the projects at an account level. Its approach, based on a stylized model of management problem solving, addresses the full range of activities to effectively manage risks.

Auditing & process facilitation teams, identifies risks through audits and assessments across various stages of project developmental lifecycle. These risks get shared as an early risk alert to the project managers and the delivery directors involved in the engagement. Such various risks at the project level across the engagement gets rolled up, which then gets discussed as part of account level risk calls where quality teams and the department leadership teams are involved.

All the critical risks then get promoted to the organization risk dashboard which gets shared to the CEO of the organization.

Figure 2: Risk Management Process - The flow
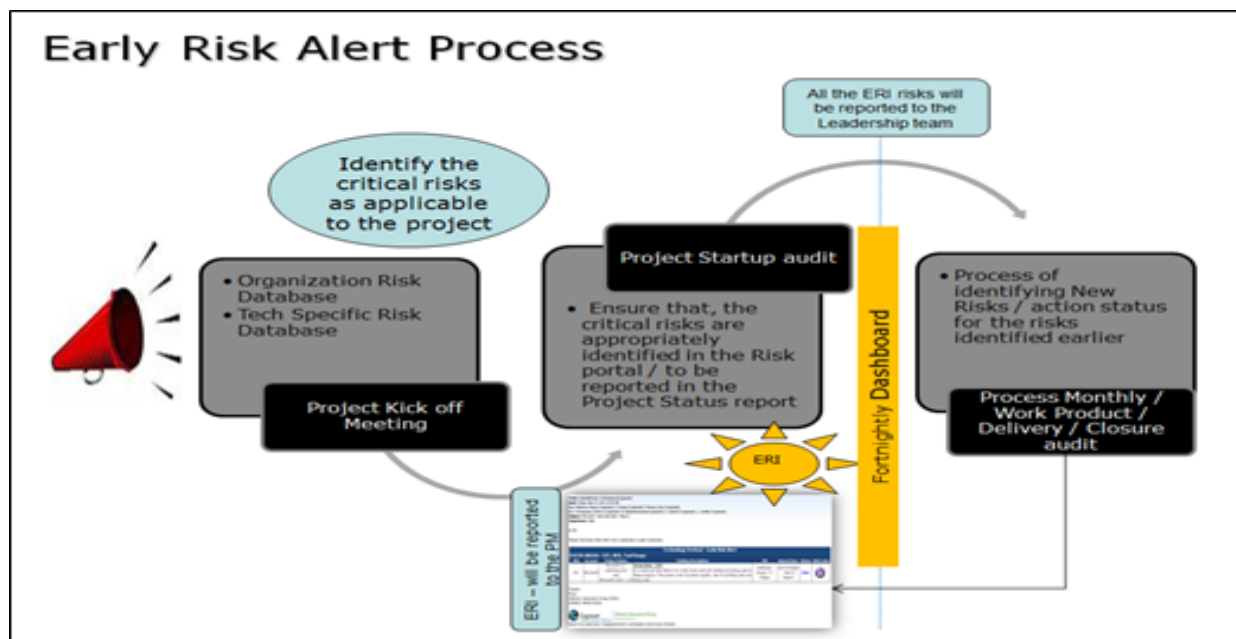
Figure 3: Early Risk Alert Process

5   Transformation #4 –Automatic Risk ManagementLiterature

A robust tool was developed which rich features enabling automatic risk management and robust risk governance. This insight tool talks to various other organization tools thereby pulling the already available project demographics, relates risks in terms of risk details, contingency, mitigation, risk priority number, target risk closure date etc., and project's delivery performance measures.
This tool thus enables the following – risk governance to risk management effectiveness

- Program Governance Board review
- Critical project reviews
- Risk heat map[6] – risk ageing Vs RPN(Risk Priority Number) –to focus the reviewers attention on high critical and long open risks
- Analytics Reports
   - Top risky projects across various departments in a organization
   - Top 20 risky projects
   - Phase wise / category wise / ageing wise risk trends
   - RPN trending analysis
- Account wise risk view
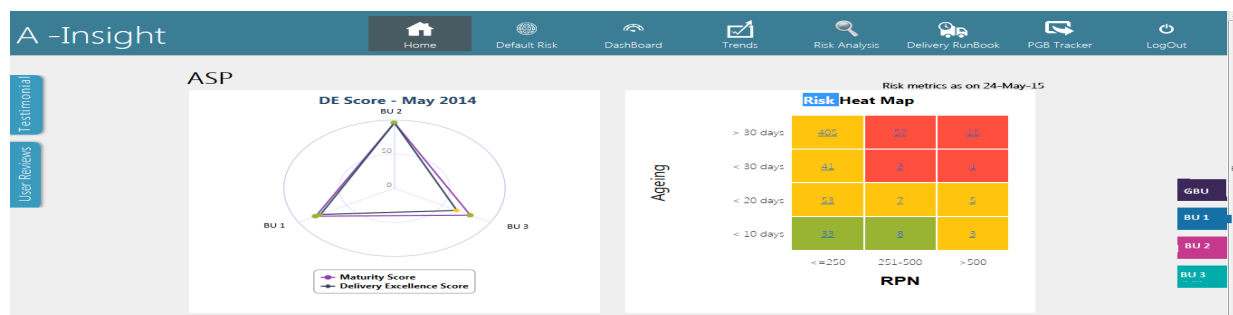
Figure 4: Risk Management Tool

6   Roadblocks & Secret Formulae for Successful Transformation

Key Challenge 1: Top Management – "Zero Surprise Escalations"

Success Formulae: To reduce the risks we primarily focused on the following:

➢ Reusing the Innovations / best practices adopted by the peers where the similar work was performed using less people, involving less cost, focus on more automation
➢ Taking help of corporate team to automate basic data quality check and risk – mitigation / contingency inferences and raise the deviations in terms of non-conformances
➢ Robust, automated & quantitative criteria based risk escalation process
➢ Roll-out awareness & trainings with the help of training department globally through virtual means - Live meetings & webinars

Key Challenge 2: Another challenge faced when we rolled out this new way the project manager community came back telling us – "Our plate is full, we do not have any extra effort to take up this initiative" (No adequate timelines available for the respective project manager to focus on additional initiatives)

Success Formulae: The global picture of what is available out of this transformation was presented to all Leaders within business department and how the automation & tools leverage will reduce their non-

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[6] Risk heat map is a 3X3 matrix consisting risk ageing as y- axis and risk priority number as the X-axis. This view helps the senior leaders to focus their attention on risks with higher risk priority number and has been open more than a month.

value added activities resulting in 30% improvement in productivity and strengthening of the engineering / project management processes.

Along with that the business department transformation activities were rolled out to volunteering project teams, benefits tracked and the results were published to entire business unit.

Key Challenge 3: Project Team – "Yet another initiative …….?"

Success Formulae: We adopted the 'AAA' approach of "Announce, Adopt & Adhere" where the announcement of the initiative launched from the Executive management with potential benefits and key expectations from the business unit. As part of Adopt, the pilot success stories including the customer feedback achieved will be socialized across all business department.

Also the pain areas towards institutionalization will be addressed by the business department transformation core team to ease the roll-out. As part of Adhere, top adoption & high effectiveness business department were publicized and rewarded at the appropriate forum bringing in the necessary pride & attention

7 Transformation Results

The new process helped in complete elimination of manual reporting of early risk alerts to the right stakeholders. Also it helped in bringing critical and long open risks for review with senior leaders thereby ensuring right focus within their limited time availability. Thus new process helped providing different views for different stakeholders(project level risk view, account level risk view, business department level risk view and organization risk view) automatically. Due to this new way of focused review ensured improvement in the risk articulation and identifying right mitigation / contingency actions.

When we analyzed the results from the last two quarters of 2014, the following inferences were seen.
- ✓ 80% reduction in customer escalation in a single business unit
- ✓ 22% reduction in customer escalation in the area of deliverable quality
- ✓ Tools leveraging program resulted in 9% productivity improvement and 70% reduction in defect density, without any additional effort expended towards it.
- ✓ 67% of the risks and escalations were alerted by quality assurance through audit findings / risk identification
- ✓ Quality assurance alerted risks in 769 projects covering 366 accounts across all the business units
- ✓ We identified that 7% projects have contractual related risk

8 ISO 31000 versus new risk process

ISO 31000 was published in 2009 as an internationally agreed standard for the implementation of risk management principles. We wanted compare our new risk process against the ISO 31000 to see whether all the standard recommended elements were covered by our new risk process. The below figure depicts the comparison between ISO 31000 enterprise risk management process against the automated risk process.

New Risk Process

Elements of ISO 31000

Risks written in 3C format
– Context, condition and
consequence by the risk
identifier

Establish context

Risk assessment

Communication and consultation

Risk identification

Risk analysis

Risk evaluation

Monitoring and review

Risks are identified by
projects/quality teams
and updated in
automated tool

Risks are analyzed in tool
by team with
appropriate contingency
and mitigations plans

Risks are evaluated by
PGB (Program
Governance Board)

Automated process

Risk treatment

Risk treatment
monitoring & review
happens through
automated tool

Communication of risk
happens through
automatic risk alerts from
the tool

Figure 5: ISO 31000 vs New risk process

9 Way forward

Going ahead, the focus would be to institutionalize the finalized tool and best practice across the entire business unit and to automate, decentralize the routine business as usual activities. Create a residual risk repository tagged to an customer thereby enabling intelligent insightful information during the new project proposal solutioning.

Specialized groups for doing core activities and drive focused innovations to continuously improve the alignment towards business transformation leading to a transformed relationship with our customers.

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Towards A Knowledge Ecosystem of Software Industry

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Abstract

To seize the new opportunity of the emerging networked knowledge era, a knowledge-driven strategy is designed to support long-term sustainable development of software industry. The main target is to build a knowledge and innovation ecosystem supporting knowledge sharing and co-creation among all stakeholders, in which intellectual resources in the cyber space are effectively integrated through internet of knowledge (IoKs) and Internet of People (IoPs) to formulize synthetic power for peer production and innovation. Active knowledge services, BoK-Based knowledge organization schema and crowd knowledge engineering methodology are proposed as implementation methods. This proposal also means to make a radical improvement in knowledge acquisition and service process, a vital basis of SPI.

Keywords

Networked Knowledge, Knowledge Ecosystem, knowledge service, IoK, IoP, SPI

1 Tamping down The Foundation

As software has become the prime industrial differentiator and basis for innovation, the role of software industry as a driven engine for economic growth has been more clearly recognized.   It is timely and critical for us to study how can take the new steps in software development to maintain its impulse and increase the competitiveness.

Experiences have shown the human factor is the most influential one in any successful project. Nine system failures out of ten, in the final analysis, are attributed to the human factor. Software process is mastered by people with proper knowledge and skills. Therefore, a robust development process needs right people playing right roles. Total System Maturity should be a plus of people maturity and process maturity. To improve the core competence in software services from the root, we must migrate our attention from just process maturity to people maturity. For knowledge-intensive software industry, a smart strategy for sustainable development is to devote every effort in increasing its total knowledge capital.

The top management guru Peter F. Drucker said: "Knowledge has become the key economic resource and the dominant–and perhaps even the only–source of competitive advantage. …Now that knowledge is taking the place of capital as the driving force in organizations worldwide." [1] How can fully exploit the value of these resources and enhance our core competitiveness is still short of effective action.

In the industrial age, in order to tap underground natural resources, we have to do resource survey first and draw up the geological resource map. Why we often miss a similar step while exploring important knowledge resources?   In the field of knowledge management, knowledge audit is a recommended practice in which the enterprise analyzes the knowledge requirements according to its own strategic objectives and draws the knowledge map to make clear about what knowledge gap is and how to manage it. For software development, we need similar preparation for knowledge resources, i.e. to clear knowledge requirements, check the resource stock on hand, know what kind of resources really needed, where can find them and how can easily access them. In our viewpoint, knowledge is not have to be only a resource/asset passively waiting for mining, but also could be an active service, to directly send the required knowledge resources into hands of requesters. Such kind of active services rely on purposeful organizational activities and supported by a team of professional knowledge service workers through an IT-enabled process. Knowledge as a Service (KaaS) is emerging as an interest research topic and has been listed by IDC as top 10 tech predictions in 2010 [2]. Similar to other High-Tech business, the software industry also has a special need from the support of such an active and well-organized knowledge service.

2 Seize The Historic Opportunity

While standing at a new historical starting point to realize the Chinese Dream of a great rejuvenation of the Chinese nation, it coincides with a new turning point in human history while knowledge entering into the network (new media) era [3], that means the knowledge will spread with network speed and its influence and value will grow exponentially with network scale abide by the Metcalfe [4], Reed [5] and Beckstrom [6] law respectively. To seize this rare opportunity, we proposed to adopt a more active spirit for knowledge services in organizing 'Too Big' and scattered knowledge resources into a powerful intelligence-driven engine for sustainable economic development, relying on future Internet technology. The networked knowledge services support system to be built will be a vital smart infrastructure and think net in the knowledge economy and society.

Herbert Spencer said: "Science is organized knowledge". Knowledge is systematic and high interrelated, forming an organic collection. Only synthetic knowledge can create much higher value. On the contrary, unorganized and scattered ones would come down to the information level and are hard to embody the value of knowledge. Therefore, 'Knowledge as a Network' [7] is becoming a logical conclusion. As a valued knowledge service, it is required to be a goal-oriented knowledge organization activ-

ity.

3   The Solution in a Connected World

EuroSPI The connectivity power of the Internet can bring novel solutions for knowledge services. The 2008 European Future Internet Assembly Meeting Report proposed the future internet will have four pillars [8] (Fig.1), besides the Internet of Things (IoT) that we have well known, the rest are: Internet of Contents and Knowledge (IoK), Internet of People (IoP) and Internet of Services (IoS). Recently the Cisco company further put forward the concept of "Internet of Everything" (IoE) [9]. Here the intention is very clear, that is, to give full play to the power of the Internet high connectivity to link all available resources together and achieve a high integrated value and advantages. These include IoK-based contents and knowledge integration, IoP-based collective wisdom advantages as well as IoS-based combination of service value chain. The solution proposed in this paper is attempting to study how explore the value of other three Internets (IoK, IoP, IoS), except the IoT, to build the so-called "Networked Knowledge Service Support System" being targeted by us.
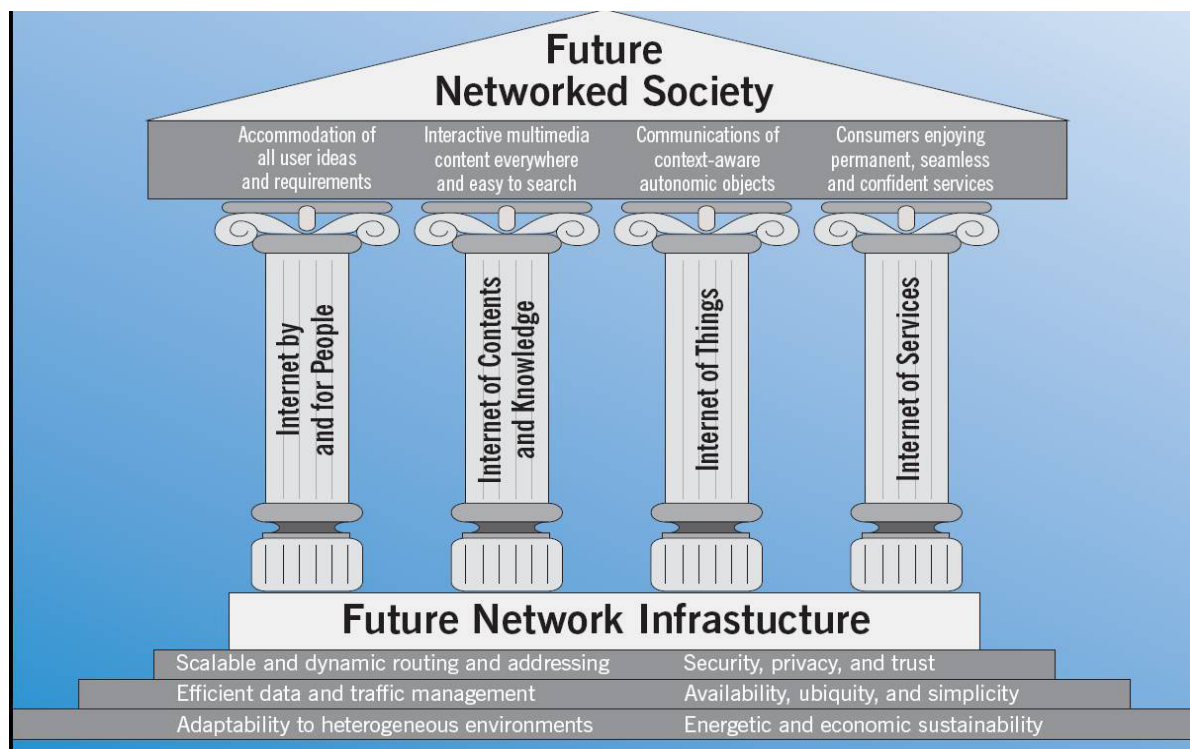
Figure 1: Pillars of Future Internet

IoKs can be used to implement the goal-oriented knowledge organization. For example, based on specific strategic objectives a complete knowledge map can be drawn through the analysis of knowledge requirements and then a corresponding IoK system can be formulated by discovering and linking associated resources. To serve the need of specific industrial transformation, the domain body of knowledge (BOK) is always a recommended framework for knowledge organization to ensure its integrity and scientificalness.

By this way, IoKs will turn scattered knowledge resources over the internet into a real networked knowledge. Originally feeling "too big" resources have been clearly organized and classified according to meaningful subjects. Guided by the domain BOK or knowledge map, the user can quickly find the interested knowledge point and easily access the linked resources behind it just by a simple screen hit. Moreover, all these resources accessed have high relevance and recommended value, without lot of garbage information as in the case of using popular search engines, because they have been filtered by professional service teams and validated by previous network users. As an open and neutral principle is insisted in collection of knowledge resources, which allows coexistence of different per-

spectives and give readers more freedom to make their own judgment and selection, that better embodies required characteristics of networked knowledge.

The IoK can better reflect the network characteristics of knowledge. With its connectivity, the knowledge expression will be borderless and endless, and can be expanded at any time and any point to link more new discoveries. Networked knowledge is featured by its high openness and public property, can be shared and commented by more people. The discovery and creation of knowledge are not limited to only few authors as in the paper-media era. Everybody has possibility to be a contributor and join in a co-creation. The knowledge creation not relies on only individual thought but more often a collective process. The networked knowledge always displays high timeliness as a good idea can be published without waiting for a final conclusion. The learner will get more benefits from studying the knowledge discovery process than just knowing the conclusion.

4   BoK-Based Knowledge Organization

As an authoritative knowledge source, the IoK development must have robust backup expertise to cover enough broad spectrum and degree of depth in its knowledge resources. Therefore, in the knowledge support layer of the IoK, it should have the participation of domain experts, either direct or indirect. In addition, a dedicated professional team, called 'Professional Knowledge Service Workers' (PKSW) is a must. The PKSW is also a kind of knowledge workers whose responsibilities are to discover, organize and maintain the related BOK, identify, collect, organize, disseminate, update knowledge resource and provide best knowledge services for other knowledge workers. The PKSWs are just like workers working in different domain-specific shops in the 'Knowledge Factory', whose main tasks are to assemble originally scattered knowledge resources (papers, reports, books, web pages, video courseware etc.) into well-organized knowledge packages.

Fortunately, in the software engineering domain there are some ready-made BoKs defined by authoritative domain experts that can be straightly used as the knowledge organization reference framework of respective IoKs. Table 1 gives a list of the SE IoK prototype systems developed by us so far.

Table 1. SE IoK Prototype Systems

BoK	Publisher	Resources Linked	Printed Books	e-Documents
SWEBOK v3	IEEE, ACM	3825	2468	1357
PMBOK	PMI et al.	655	488	157
SQuBOK	JUSE	427	270	157
ISO/IEC 29119	ISTQB	927	427	500
SPIBOK	IISP	722	422	300
Agile (ADBOK)	CASDA	506	295	211

IoK implementation will create a friendly user-interface for domain-specific professionals in accessing resources of digital libraries, which reflects a user perspective on resource collections. Large digital repository plus online access is just a first step for building digital library as the resources are still scattered and unorganized without additional efforts. The IoK proposed by us will be a last mile knowledge services to make professional users much more close to valuable resources with reduced learning curves. Moreover, it can exploit more advantages from high resources integration in digital libraries. Mutiple domain-Specific IoKs create a vast space for knowledge exploration with various professional demands and can support on-demand knowledge acquisition to meet the need of interdisciplinary innovation.

To align with the state strategy "Innovation Driven, Transformation Development" in China , we have also developed a series of prototype IoKs for supporting the strategic emerging IT industries listed in the national development plan, including: Cloud Computing, Internet of Things, Smart Grid, Mobile Computing, Data Science/Big Data, Crowd Software Engineering etc. For those emerging technological areas with rapid development, the hardest challenge is lack of shaped BOK in the IoK organization. According to our experience, however, for any specific domain there exists objectively a body of knowledge (BoK) awaited to be discovered and made it explicit through a team effort of domain experts. In view of its high potential value, there will be many even fragmented knowledge frames being

revealed gradually (e.g. in published books or training materials) during the knowledge discovery process. Therefore, it is still possible for us to identify some temporary framework for the IoK knowledge organization which will be dynamically evolvable as time goes by. It would be an invariant truth, any domain BoK will be constantly evolutionary as the new knowledge is continuously emerging. "No best, Only better"- this will encourage us to make a bold trail as needed in developing domain IoKs getting incremental service value with progress.

To support development of modern service industry, two IoK prototype systems have been added in our catalog either. One is the "Service Science, Management, Engineering and Design" (SSMED) put forward by IBM and another is based on the new "Service Computing BoK" released by IEEE as a vital IT basis for service implementation.   The expanding capability of IoK service repository will be conductive to help software professionals keeping in step with the rapid technological development.

5 From BoKs To Knowledge Ecosystem

The concept of knowledge ecology and ecosystem stem proposed originally as a methodology for knowledge management. Since 1997 the KE ideas caught on as an academic topic [10]. Just like the food chain living things depend in the natural ecosystem, the knowledge analogizes with oxygen and nutriment required in human intelligent activities. A knowledge ecosystem can be looked, through a "Bi-focal" lens, simply as a network of conversations plus knowledge repositories. It can also be considered as a triple network of "People- Knowledge- Technology", as see Fig. 2, i.e. supported by underlying technology, the people network (communities of practice) continuously shares and creates the knowledge network through interaction to generate business and social value [11].
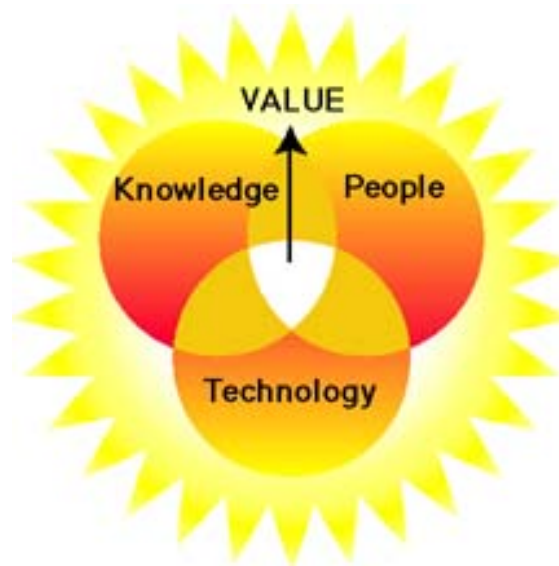
Figure 2: Knowledge Ecosystem

Emerging networked knowledge era makes the knowledge ecosystem with more significant value. It can be extended to a vast space, beyond the enterprise and organization, covering the ecological scope of whole society and economy, thus creating a much higher economic and social value. Building knowledge ecosystem will be considered as a vital infrastructure in the knowledge society.

In 2010 the US largest research park RTP published a forecast research report with the title "Future Knowledge Ecosystems: The Next Twenty Years of Technology-Led Economic Development" [12]. The most worth seeing of this report is to show a crucial trend: The model of self-contained research/industrial parks and incubators that dominated the last fifty years of technology-based economic development is being challenged and will shift to future knowledge ecosystems. This report described 14 emerging trends which will make deep impacts on the future strategic decision making in technology-led economic development. In the past time, it was used to consider the benefits of regional cluster. However, in the networked time we have new options in developing "Virtual Cluster".

There is an obvious need to develop new business models for technology-led economic development efforts. The first-generation and second generation models in use today are mainly driven by revenue from real estate development, sales and leasing and government subsidy. Potential new models are more likely to be built on venture investments, knowledge brokering and event management. The overall shift will continue to evolve rapidly from products (buildings, sites and infrastructure) to services (research "hotels", incubation, technology transfer, knowledge commons). The new model should be carefully planned with grand visions in long-term strategies to put focus on making know-how sticky, cultivating a regional knowledge ecosystem, establishing leadership for the "Long Now", and from managing dirt to managing activity and chance.

In pace with the coming networked knowledge era, we must seriously investigate its real impact on economic development to seek for a proper model and platform in development support. In our viewpoint, it would be the "Networked Knowledge Ecosystem" as recommended by many experts, which is a cyberspace without border limits, meantime, with wide connection and rich resources shared.

The knowledge ecosystem has a close correlation with knowledge networks [13]. The IoK-based knowledge ecosystem schema proposed by us has good correspondence with George Pór's triple network model, as shown in Fig.3. The underlying technology selected is cloud-based future Internet technology. The knowledge layer is composed by domain BoK-based IoKs and the active participants in ecological activities are IoPs made up by Communities of practice (CoPs). Through knowledge services and co-creation, new knowledge are continuously discovered, integrated, shared and exploited to generate high economic and social value and promote a sustainable development of the ecosystem. This will be a virtual and borderless S&T and Industrial Park, a research cloud supporting open innovation to generate unceasingly new knowledge-based products and services.
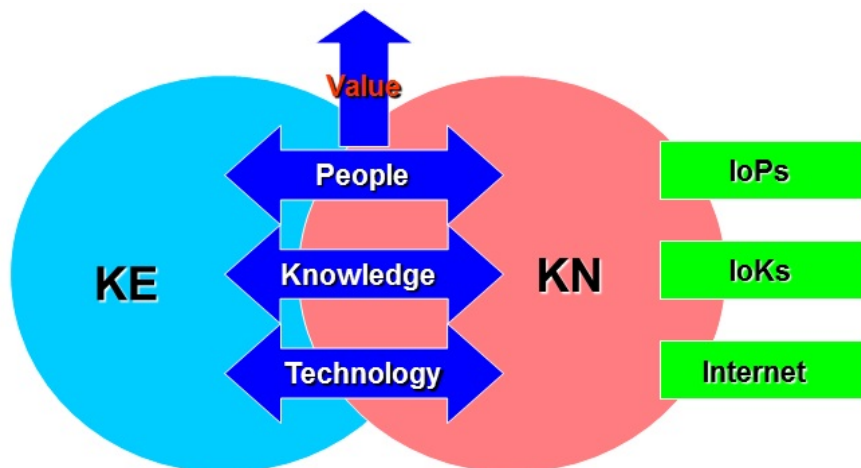
Figure 3: Knowledge Ecosystem & Knowledge Network

The public library, as a junction point for a variety of communities, should be a natural keystone host platform of this kind ecosystem in view of its plenty of resources and knowledge service mission and experiences. An ecosystem is made up all the organisms that share the same habitat or platform and keep interdependency of mutualism and co-evolution through interaction. To remain the ecosystem balanced and stable, an effective feedback system is necessary to aware and response to any change in environment and dependence. The library as an ecosystem also contains many dependent actors, including readers, service user institutions, publishers, vendors and authors etc., that formulate a complete value chain of information/knowledge services in which the library acts as a central coordinator, just like a "Knowledge Middleware" or "Knowledge Logistics Manager".

6   Crowd Knowledge Engineering Methodology

It will be a great challenge to develop a public knowledge ecosystem to meet the needs of whole society and economic development as covering so wide domains. To seek an actionable solution for this

needs some support from an effective methodology. For that, we can draw some inspiration from principles of knowledge management, such as, "knowledge seeks community" and "No one is in charge" [14]. Building knowledge ecosystem should be a social process.

This methodology proposed here was enlightened by studies of software ecosystems. Recently eight US professors jointly published a paper discussed and gave a prospect on "The Future of Crowd Work" [15] and the Chinese academician Wei Li has initialled a research program in "Crowd software Engineering" [16] to take full advantages of collective wisdom via crowdsourcing. For our ambitious knowledge service engineering project mentioned before, which requires wide public engagement, the only smart choice is to adopt a strategy so-called "Lets Crowd Do All Possible" instead of "Try Do Everything All by Oneself". We called that methodology: "Crowd Knowledge Engineering", that is, to build a co-creation platform for knowledge ecosystem which provides an online editing tool for defining and revising domain specific knowledge organization frameworks and APIs for resource linkage to facilitate collaborative participation in co-creation of domain IoKs. This is also a smart strategy to greatly change the world by utilizing collective creativity in the Internet "Generosity Age" as advocated by Clay Shirky [17].

Fig.4 gives an illustration about the conceptual model of the library knowledge ecosystem and the co-creation platform supporting the crowd knowledge engineering.
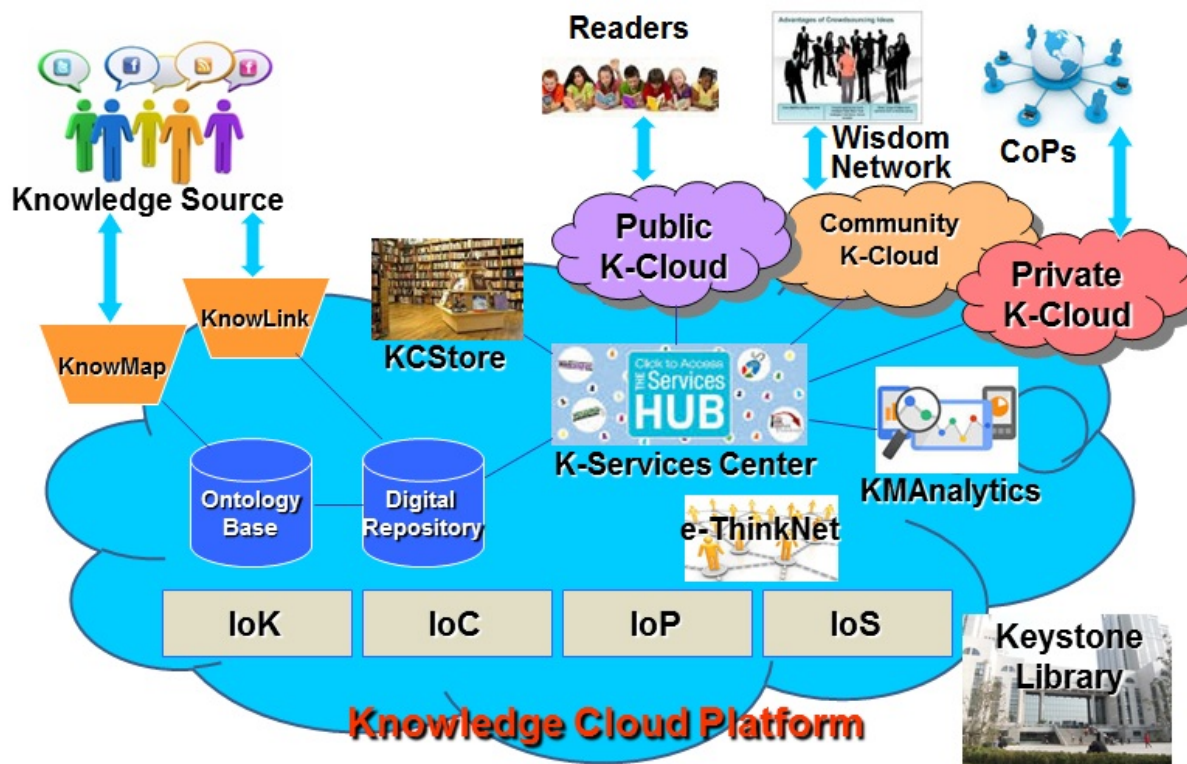
Figure 4: Library Ecosystem and Co-Creation Platform

The whole system is built on a keystone library platform which is based on the knowledge cloud platform and supported by IoK, IoC, IoP and IoS technology. As a co-creation platform of the knowledge ecosystem, external domain professionals and experts from different knowledge sources can define and revise their domain BoK or goal-oriented knowledge organization framework by using the online knowledge map editing tool KnowMap. The revised version will be stored in the ontology base. The related knowledge resources can be recommended and linked to corresponding knowledge point or area through the KnowLink interface. The well-defined domain IoK can be released into public through the online knowledge cloud store. The users of the knowledge ecosystem can be guided, via the K-Services center, by the interested knowledge map to easily discover and share the available resources, including from the public knowledge clouds and private knowledge clouds oriented to enterprises, communities or individuals based on their specific development objectives. The KM Analytics software can provides service improvement indications through interaction data analysis, and identi-

fies expertise location (know-who and know–where) to promote the development of IoPs and think nets as a basis for high value services in consulting and decision supporting.

7 Some Trail Practice

As mentioned before, we have proposed a novel solution to meet the challenges of the coming networked knowledge era and seize the rare opportunities either. It demands a concerted effort to reach such an ambitious objective. As a result, we have initialed an interdisciplinary alliance for the knowledge service engineering project. The member comes from different institutions, including ECUST, Shanghai Jiao Tong University, Shanghai Library and Zhoushan Library, and maybe more will join in soon.

As the first step, the idea proposed above has been adopted in the design of new Zhoushan Ocean Digital Library to enable active knowledge services and domain IoKs as a main intelligence engine for supporting sustainable development of marine economy. Based on its existing resources, the Shanghai library has initiated a new service idea in developing the "Industrial Libraries" for which the domain IoKs will be able to accomplish much. The first prototype released was a "Design Library" to meet the need of constructing a "Design Capital" targeted by the Shanghai city. An IoK prototype based on the "Industrial Design BoK" has been developed by us as a follow-up step.

To achieve a more ambitious dream in "Library Ecosystem as Economy Engine", our KS alliance has actively participated in study of the Front-end Major Research Issues for the State Thirteenth Five-Years Plan. As a kind of fundamental support, it found that the solutions proposed by us can be widely applied to obviously support at least 10 major issues among 25 issues listed in the state catalog. We have submitted a whole research report illustrating how to deploy concrete solutions for all these issues. This fully demonstrates comprehensive availability and power of our proposal.

Recently Shanghai has drafted a strategic plan to build city as a technological innovation center with global influence. As a key measure of promoting the "Innovation Driven and Transformational Development" policy, the state government has also announced a new so-called "Internet+" strategic action plan and called for "Mass Entrepreneurship and Innovation". Undoubtedly, Software development will act a vital role in integration of cyber and physical systems. In some sense, the "Internet+" can be interpreted as "Software+", i.e. a gateway to the cyber space. As an important driven force, the software industry has an inescapable responsibility to take a leading upgrade action. That is why we proposed an initiative to build "Virtual Software Park" as a step towards the knowledge ecosystem of software industry as stated in this paper.

In Shanghai Library, an open "Innovation Space" was established as a gathering place for "Crowd Makers". Insisting on the market-driven principle: "The demand is our service target", a just-in-time "Internet+" IoK prototype with 1700 linked books has been developed as a starting point for public engagement to turn the "innovation Space" to be a "Problem Study Space" and a "Book Reading Space" to stimulate a multi-perspective discussion on current hot-topic "Internet+" for broadening and deepening its understanding, thereby, promoting a co-innovation for it.

The shared platform can also be shaped as an innovation ecosystem. How to support knowledge-based innovation can be depicted as an "innovation iron triangle" as shown in Fig.5. Knowledge is a vital premise for knowledge-based innovation. The chief champion of innovation is people who is equipped by knowledge services. The IoK- , IoP-, and IoS-based communities create a broad space for open innovation.
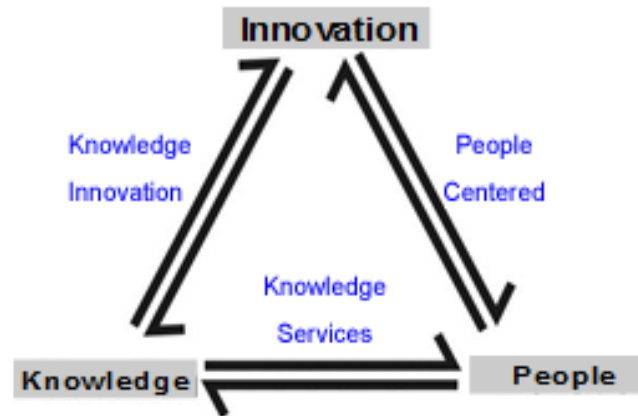
Figure 5: Key elements of Knowledge-based Innovation

8 Conclusion

To increase development efficiency and productivity, enhance software quality and reduce lead times, the software process needs to keep a continuous improvement. As a fundamental support, the knowledge acquisition and service process is required for a continual improvement as well. The approach proposed by us shows a tentative exploration in this direction. Facing with a massive demand in professional development from millions of knowledge consumers in China, it is mandated to provide a world-class connection and contents in knowledge services. It explains why we adopted an "Internet + Knowledge" schema, by utilizing high connectivity of Internet and giving full play to the value and power of knowledge, to formulate a so-called "Knowledge+" infrastructure enabling well-organized knowledge resources as a real driven engine for industrial development.

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Successfully Initiating a Global Software Project

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Abstract

Global software projects involve the collaboration of team members that are distributed among different locations and belong to different organizations. To avoid process-related problems, they require a distributed development process that is tailored to the context of the project. In this paper, we use an industrial global software project of German and Indian organizations as a case study to illustrate the difficulty of timely coming up with a process that covers all necessary areas, that is sufficiently documented, and that is fit for purpose. We propose to tackle these difficulties by defining the distributed development process together with the project team, adopting the LAPPI technique, an approach to collaboratively identify process issues for process improvement. We explain how the approach was successfully applied in the project to derive a distributed development process, where a previous non-interactive attempt failed and propose future extensions to the LAPPI technique.

Keywords

Global Software Development; Distributed Development Method; Offshoring; Process Definition; Method Engineering, The LAPPI technique

1   Introduction

An increasing number of companies thrive to tap the benefits that near- and offshore development offers, being competitive pricing, availability of resources, and technical knowhow [1,2,3,4]. Often, the development cannot be outsourced completely, because, e.g., the requirements engineering or backend development have to remain onshore, either with the client company or with some onshore third party organization [5]. This results in distributed teams that are spread over different locations on- and offshore [6]. Especially in iterative and agile projects, a negotiated and streamlined distributed development process is essential in order to reduce "friction" due to miscommunication and missing alignment of activities [7,8].

Defining such a distributed process is difficult, as it has to take into account the established processes on all organizations, as well as the characteristics of the new project and its distributed team. Often, the documentation of the established process is either too high-level, not reflecting the practice, or missing completely [9]. This results in the threat that the new distributed process is defined top-down by project managers without sufficiently taking into account the differences to the existing practice and the know-how and characteristics of the distributed team [6].

Challenged with similar problems of setting up a distributed development process and struggling with a definition created top-down by management in a previous at-tempt, the team of our case study reached out for a more light-weight and collaborative approach. During an on-site visit with the off-shore partner in India, the LAPPI (A light-weight technique to practical process modeling and im-provement target identification) technique [10] was used. LAPPI is designed for the related domain of software process improvement and it has been used in over 30 companies with good results [10,11,12]. With two interactive half-day workshops, the project team of our case study was able to derive a well-received proposal for the distributed development process.

In this paper, we use the case study to illustrate the challenges of defining a dis-tributed software de-velopment process. We describe the experience with the use of the LAPPI technique that is shown to help in deriving the distributed process when starting to plan and implement global software develop-ment projects. Based on our study, LAPPI can be said to help in creating essential common under-standing of the project and ways of work in it. Further, this mutual understanding is created in a practi-cal and lightweight way that seems to work at least in European and Asian cultures.

This paper is structured as follows. In Section 2, we provide background information about the project that serves as the case study. In Section 3, we then highlight the challenges of deriving a distributed development process. In Section 4, we characterize a collaborative and visual approach to process definition together with the team. We provide background about the LAPPI technique, illustrate its use in our case study, and summarize the experience with LAPPI as well as its benefits. In Section 5, we present our conclusions and discuss future work to make LAPPI even better suitable for initiating global software projects.

2   Project Background

In this paper, we use an ongoing industrial, distributed development project as a case study. We use it to illustrate the challenges of defining a distributed development process and the benefits of doing it with the LAPPI technique.

The project is situated in the financial domain. It has the goal to develop an online portal that provides self-service and reporting capabilities to end customers using a web application framework. The first phase of the project is scheduled for roughly one year of development and its goal is to deliver the initial version of the portal.

The organizations that are mainly involved in the project are the Client (a bank), the Onshore Partner (an IT company), s-lab (the s-lab – Software Quality Lab), and the Offshore Partner (an India-based company). The Client, the Onshore Partner, and s-lab are all set up in different locations in Germany within two hours of traveling. **Table 1** provides an overview of the team members from the different organizations that are mainly involved in this project.

Table 1. Project Organization

Client	Onshore Partner
1 Business Owner	1 German Project Manager
2 Domain Experts	1 Architect / Infrastructure Manager
1 Test Manager	1 Backend-Developer
Indian Offshore Partner	
1 Researcher	3 Portal Developers
1 Indian Project Manager	1 Portal Architect
1 Requirements Engineer	1 Tester
s-lab – Software Quality Lab	
1 Requirements Engineer / Process Engineer	

The portal development is carried out by the Indian co-located team members. The Client is involved in the requirements gathering, their prioritization and in user acceptance testing. The Onshore Partner manages the project and is responsible for the integration with the backend systems. s-lab supports the requirements management and is consulted for process-related questions of the software development.

The organizations had experience in working together on a bilateral basis, but have not worked jointly on a project before. The Onshore Partner developed many IT systems that are in use at the Client site, while the Offshore Partner mainly developed automated tests and reports for this particular Client. However, this project is the first of its kind, where the onshore and offshore partners collaborate with the Client to deliver an IT system that is mainly developed in India. In order to setup the responsibilities and to coordinate the planned activities, the partners had to set up a distributed development process as part of the project start-up phase.

3 Challenges of Deriving a Distributed Development Processes

Software projects with vague start have a high risk of failure [13]. Thus, a project should have a well-defined startup phase, where among other things the development process should be defined [14]. Establishing a suitable development process can compensate for the additional coordination-, communication- and development-related issues of global software development projects [2],[6]. Development processes described in literature, e.g. agile development processes that are specifically designed for larger projects or organizations [15],[16], cannot be used directly, because every process requires tailoring due to restrictions imposed by the project [17]. For example, in the project of the case study, the German Project Manager requested the use of an agile approach with frequent deliveries, in order to gain acceptance for the project and reduce criticism. Agile approaches advertise a self-organizing team of cross-disciplinary experts [18, 19]. However, the resources of the Offshore Partner are used to hierarchies and are highly specialized, such that this had to be considered explicitly by differentiating roles and responsibilities.

In the following, we use the case study to first explain how distributed development processes are typically derived in a top-down manner by project management. Afterwards, we explain the challenges of defining such a distributed development process and then illustrate the consequences of a flawed process, based on the project experience.

3.1 Defining a Distributed Development Process

The distributed development process is typically discussed during the project initialization phase, in which the overall contractual, organizational and content-related setup is made [20]. The project initial-

ization phase is often characterized by limited face-2-face time of team members of the involved organizations and time pressure to finish the preparations in time before the scheduled development start. In our project, face-2-face time was limited as the Indian Project Manager and the Indian Business Analyst visited Germany for a two-week on-site-visit to set up the project. The next on-site-visit followed not before a few months later. There was time pressure, because defining the development process was scheduled to be negotiated during this on-site-visit and the development had to start promptly afterwards.

Often, e.g., due to the time restrictions and lack of knowledge to do it differently, the distributed development process is negotiated with limited involvement of the project team and not discussed and documented sufficiently [9]. In our project, the project managers discussed the development process based on previous projects during a couple of consecutive presentation sessions. They used presentation slides and created documents from these projects to support their presentations. While the Indian Project Manager and most of the German team members attended, the sessions were presentation-centric. The project managers created an org-chart with responsibilities, a communication diagram, and a bullet-point list for the most important activities of a development iteration, based on their ideas for the distributed development process for the project. At the end of the visit, they documented their result in presentation slides and distributed them among the team. During the process definition, the project managers faced several challenges that led to a flawed process and consequently issues in the first weeks of development as illustrated in the following sections.

3.2   Challenges to Defining a Distributed Development Process

Defining a suitable distributed development process is a difficult task for the involved organizations as reflected by various publications about the problems of global soft-ware development projects, e.g. [1],[3],[6],[9]. In the following, we discuss the major challenges faced by the project managers during the on-site-visit of the startup phase in our case study that lead to the use of the LAPPI technique:

Missing experience with defining distributed processes: In our project, the project managers were responsible for defining the distributed development process and it was seen as part of the organizational set-up. Both project managers had experience with managing IT projects in the past, but they were not explicitly educated as process or method engineers [21], especially not for global software development pro-jects. Therefore, each project manager had only a limited view on how the development and the project team should be organized.

Missing and incomplete definition and documentation of as-is processes: Existing as-is development processes serve as a foundation to derive a distributed process. However, the development process of the Onshore Partner has not been defined and documented, because in previous projects, the teams were usually co-located, small, and rather self-organizing. As the members of the Onshore Partner were not following a specific process, they were not able to quickly illustrate their roles, artifacts, and activities. The Indian Project Manager presented an agile process the Indian organization used before. However, some important development activities were missing from the process, e.g. creating technical prototypes and architecture activities in general. The missing documentation of the existing processes made it more difficult to com-pare the existing development processes. In addition, the gaps had the consequence that some activities were overseen and not sufficiently coordinated in the first weeks of the development.

Heterogeneous experience with existing processes: The Indian Project Manager was able to lay out an existing agile process that seemed to be suitable for our project. However, it was based on previous projects, not an organization-wide standard and therefore, several Indian project members were not experienced with that approach, however, this was not noticed before the first development iterations.

Difficulty to determine required detail of process definition: There was only limited time to define the to-be process during the on-site-visit in Germany and it could be discussed only on a very high level of abstraction. For example, communication paths were defined in terms of "who should talk to whom?", but not based on the actual activities in terms of "who should talk about what to whom and when?" In addition, it was discussed that a ticket system had to be used, but who specifically and how the tickets

should look like, was not discussed. Another example is the work of the requirement engineers, where the division of roles and responsibilities between the German and Indian engineers was not clearly defined.

3.3   Consequences of a Flawed Process

During the first weeks of the development in the project, process-related issues surfaced. In the following, we list the reasons and explain how they became apparent:

Missing big picture: The way the development process was documented, it did not provide an overview of the defined process activities, their order, and their relationship. Therefore, the team members did not understand the importance of their activities for other down-stream activities. For example, requirements descriptions for a sprint were too detailed for their purpose and could not be finished in time.

Uncertainty about the scope of responsibility of team members: The work of some team members was not clearly defined as part of the distributed process. This resulted in uncertainty about their actual work and how it would be integrated into other activities. For example, the activities of the architects were not defined and it was thus not clear what architectural decisions would have to be discussed and coordinated.

Unsuitability of activities and artifacts: The gaps in the process definition led to avoidable bureaucratic overhead. For example, the documents that were created by the German Requirements Engineer were not reused for the Indian requirements documentation. Instead, because of the gap in the process description, the Indian Requirements Engineer stuck to the format of previous projects resulting in additional effort and consistency issues.

Misfit between responsibilities and skill sets: Some team members were lacking the required skills to fill in their role accordingly. For example, although the distributed process was proposed by the Indian side, based on former agile projects, several Indian team members were not familiar with agile development approaches. Consequently, they carried out their activities in the usual manner, resulting in documentation overhead and schedule overruns.

4   *Deriving A Distributed Development Process Using LAPPI*

Based on the process-related challenges with the distributed development project, described in Section **Fehler! Verweisquelle konnte nicht gefunden werden.**, it was decided to discuss the distributed process again during the next on-site-visit. This visit was a two-week visit of the Requirements and Process Engineer (in the following termed Process Engineer) and the German Architect to India. As other topics had also to be discussed, the time for the discussion of the process was again very limited. Therefore, the Process Engineer was looking for a more collaborative and more visual approach in order to improve the utilization of the face-2-face time together. In the following section, we describe the requirements for such an interactive approach. Thereafter, we explain the LAPPI technique that fulfils these requirements and then illustrate the experience made with LAPPI as a means to derive a distributed development process.

4.1   Characteristics of an Collaborative Approach to Derive an Distributed Development Process

Based on the experience with defining the distributed development process during the first on-site-visit, the project team was looking for an approach that would improve the utilization of the face-2-face time and consequently improve the documented distributed process. Therefore, it was looked for an approach with the following characteristics:

Inclusive and interactive: The approach should foster the involvement of the available project team members, such that their opinions, experiences and views would be part of the discussion and could be taken into account. The approach should initiate discussions among the team members and enable multiple people to be active at the same time. This was especially important as some Indian team members were not used to actively state their opinion during meetings, if not specifically asked for it.

Visual: The approach should help the project team members to visualize the process in order to create a common big picture and to understand the flow of information and artifacts and to make gaps visible.

Easy to learn and low ceremony: In order to improve the utilization of the available time and to foster the involvement of the team, the approach should be easy to learn and easy to apply. The required preparation and overhead of the approach should be low enough to allow its use with only two half-day sessions available.

Quick results: The approach should allow to quickly create an overall view that can be refined with further details later on. For the on-site-visit, deriving a coarse-grained overall view was more valued more than a precise, but partial description.

4.2   Background on LAPPI

The LAPPI technique is developed to provide an easy to use, lightweight tool for process modeling and improvement target identification [14]. LAPPI is developed in collaboration with software industry and academia, the history and evaluation of the technique can be found in [14]. Using LAPPI, the process, roles participating in it, and information moving between these roles can be made visible in practical and cost-effective way. It helps a company to understand their current processes and the organizational interactions, and to create a process description baseline [14].

In previous studies, LAPPI has been used to model various different processes [10,11]. The technique has proven to be useful in, for example, requirements engineering, testing and general software development process improvement initiatives. The developers of the technique have a strong interest in improving it and applying it in different domains. For example, customer support process improvement that was initiated using the LAPPI technique, showed that LAPPI is suitable in this area also and can bring benefits to customer support functions [11]. In this study, instead of process improvement, LAPPI was applied for the initial process definition with promising results.

The main activities of the LAPPI technique are two workshops: I – Roles and information flows and II – Process modeling. In workshop I, the roles and information flows are modeled using a wall-chart technique. The roles are listed in diagonal of a wall-chart and the information moving between the roles is modeled vertically and horizontally in between the roles to create a map of all the roles participating in the process and visualizing the information needed by these roles to do their tasks. For an example of the role and information flow wall-chart, see Fig. 1.
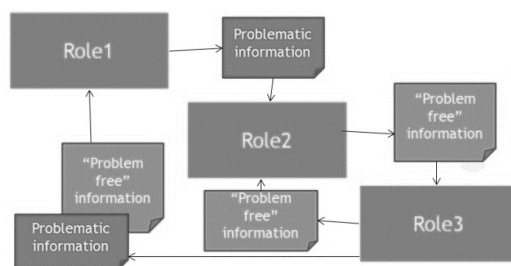
Fig. 1. LAPPI workshop I – roles and information flows

Workshop II of the LAPPI technique focuses on making the process steps visible. Here also, wall-chart technique is used due to its easy understandability. The process steps are written on post-it notes and arrows are used to mark the sequence of the process steps. For a simple exemplar visualization of the marking used in workshop II, please see Fig. 2.
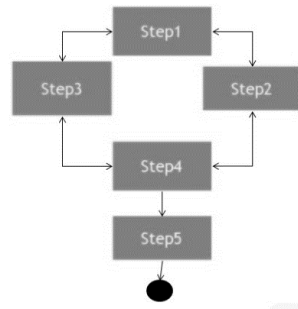
Fig. 2. LAPPI workshop II – process modelling

Combined result of these two workshops is a process overview, including the process model, roles participating in the process and information moving between them and the problematic areas of the process. Based on the process overview, the company can start planning the next steps of their SPI initiative. In contrast to the intended use of LAPPI for process improvement based on a common process in use, in this study, the two workshops of the LAPPI technique where performed to come up with an initial definition of the distributed development process.

4.3   Applying LAPPI to Derive a Distributed Development Process

As described in the previous section, the LAPPI technique was originally developed for the purpose of understanding the current processes and organizational interactions during process improvement. However, it was applied in slightly different context to help with the definition of an initial distributed development process, as there was no existing definition of the complete process and no coherent and common understanding of it.

In our case study, the LAPPI technique was used during the second on-site-visit. This was about one to two months after the beginning of the development, when issues with the distributed development process became more and more apparent (c.f. Section **Fehler! Verweisquelle konnte nicht gefunden werden.**). In two consecutive half-day sessions, the two workshops of the LAPPI technique were conducted in order to help with reaching common ground with the development process and quickly deriving a visualization for it. There were eight participants from the Offshore Partner and the Process Engineer as the representative of the German organizations (c.f. Fig. 3). While the Process Engineer had participated in a half-day workshop about the LAPPI technique before, the other participants were not familiar with the technique.

Fig. 3. Indian team members collaborating based on the LAPPI technique

4.3.1 *Workshop 1 - Roles and Information Flows.*

At the beginning of the workshop, the Process Engineer provided a quick introduction to the aim of the workshop and the LAPPI notation. As minor changes to the original workshop, the focus was not so much on differentiating problematic and problem free information, but rather documenting the information flows in general.

Fig. 4. Indian Team members during Workshop I defining Roles and Information Flows

At first, there was only little participation by the team. After some encouragement by the moderator and the Indian Project Manager, the participants started to be more proactive and shortly after, the whole team was engaging in the workshop (see Fig. 4). Due to the high parallelization, everybody could prepare his post-its without waiting for other participants and the team had a mostly complete picture after an hour. However, it also became obvious that there were gaps that nobody had thought of before. For example, due to the missing information flows, the Indian Project Manager joked that he was happy that he had such a simple job, as nobody seemed to require information from him. The team members seemed to be more focused on what they had to deliver, but not so much, on what they required for that. The team was able to fill in some of these gaps before the time for the session was up. The participants decided to stick to the model derived so far and to continue with the second workshop.

4.3.2 *Workshop 2 - Process Modeling.*

This workshop was again moderated by the Process Engineer, who quickly introduced the purpose of the workshop and the LAPPI notation for the process modeling. As a deviation from the original, beside the activity steps themselves, the artifacts that were created by these steps and the responsible roles were added at the corner of the activity post-it (c.f. Fig. 5). In addition, the team created a grid that marked the days of a development iteration and added the activity step post-its to the according lines.

With the experience from the first workshop, the participants were active from the beginning on. Again, the participants were able to prepare and add their post-its in parallel to speed up the effort, so that the group was able to engage into discussions early on. For example, one of the discussions was about the right way of testing as the Indian Tester feared that bad experiences from earlier projects could repeat themselves. Beside the documentation of the discussed process, there were two major results from this workshop. First, the workshop uncovered that the Indian team members expected that the requirements were refined *before* the start of the development iteration, while the German team members thought that this would be part of the development iteration itself. Second, the participants defined the point in time, where the specifications should be frozen and not change anymore.
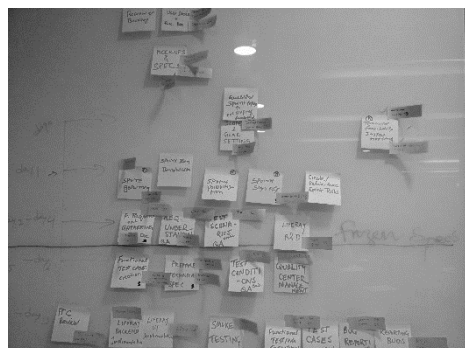
Fig. 5. The development iteration defined during Workshop II for the process modeling.

4.4   Overall Reception and Results of Applying LAPPI

After the workshops, the participants were asked for their opinion about the LAPPI workshops and the results. The feedback was very positive. The participants liked the interactive and inclusive nature of the workshops and that the LAPPI notation was easy to apply. The Indian Project Manager explained that he found the approach to be more productive than upfront presentations and discussion rounds. Improvement suggestions or critique were not mentioned.

The achieved results support this feedback. In two half-day sessions, the participants were able to document the distributed development process including activities, roles, artifacts and timings. Based on the spontaneous adaptations of the original notation, the developed process model provides a visual overview and improved the overall transparency. In addition, the workshops fostered the exchange of positions and discussions. For example, the project team learned about the different expectations regarding the preparation of requirements. The developed process model was the foundation for the implementation of the distributed process using a ticket system that is still in use.

The reception and the results suggest that the LAPPI technique fulfills the characteristics described in Section 4.1. The approach is inclusive and interactive and the provided visual notation is easy to learn and easy to adapt as also stated in previous research on the technique [10]. Therefore, the approach allows to quickly derive useful process-related visualizations that are understandable by the whole team.

5   Conclusions and Future Work

In this paper, we used an industrial global software development project of German and Indian organizations to illustrate the necessity of defining a suitable distributed development process and the challenges in doing so. These challenges are the missing experience of project managers to timely define such a process, the challenge to consider current as-is processes and the available skills of the team members, and the challenge to document the distributed development process it in sufficient detail. In order to better cope with these challenges, we characterized a collaborative approach for the process definition that would need to be interactive, visual, easy to learn, and easy to apply. We then explained the LAPPI technique that incorporates these characteristics and showed how it was used in the case study to derive a process definition collaboratively. We explained that with LAPPI the project team derived are more complete, more consistent, and visual process model in two half-day work-shops, while the same failed in a previous top-down attempt driven by project managers.

As further improvements of LAPPI for the area of initial process definition, we see two possible directions. First, there could be a set of heuristics or rules that help in deriving the process model based on the roles & information flow model or the other way round. Maybe artifact states, as used in ticket-based processes, could be derived from the combination of role & information flow model and process model. Second, the LAPPI workshops gain from the participation of team members that are representative for the project in terms of roles and organizations. Therefore, in a distributed setting the question arises how the locally scattered team can be supported in applying the LAPPI technique, either by adjusting the LAPPI technique itself or by using supporting communication technologies.

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Creation of an IEC 62304 compliant Software Development Plan

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Abstract

Organizations engaged in medical device software development are required to demonstrate compliance with a set of medical device standards and regulations before the device can be marketed. One such standard IEC 62304, Medical device software - Software life-cycle processes, defines the processes that are required in order to develop safe software. Demonstrating compliance with IEC 62304 can be problematic for organizations that are new to or have limited experience in the domain. The standard defines what processes must be carried out, but does not state how. In a review of a number of such organisations it was found that the development of a software development plan proved to be a difficult task. In this work we have created a software development plan template to assist organisations with this arduous task.The software development plan template will be validated with these organisations as part of the future work.

Keywords

Regulatory compliance, Software Process Improvement, Software Process Improvement Roadmaps, IEC 62304, Medical device Software Development Plan

1 Introduction

Medical devices have been around for centuries but it is only in the last decades of the twentieth century that software has become widespread in the operation and control of some kinds of medical devices [5]. It is because of the critical nature of medical device software and due to the increase in the number of recalls of medical devices arising from software failures that regulatory bodies acted to try and rectify this growing trend.

To address these issues international standards organisations have developed a number of medical device standards which aim to regulate how organisations implement medical device software. These standards outline what organisations must do to ensure the development of quality medical device software processes, however they do not specify how they should do it. Existing software process improvement frameworks such as MDevSPICE® (formally known as Medi SPICE) allow organisations to examine their existing processes in light of these standards but do not provide specific detail on how to implement the processes.

In previous work, an IEC 62304 implementation roadmap has been developed [8] and is currently being prepared for validation by industry experts. Through contact with software development organisations, the first element causing a major difficulty was the creation of a software development plan as described in Section 5 of IEC 62304. These organisations did not have the experience to develop such a document. This paper describes the development of a software development plan template that complies with IEC 62304 and would be suitable for small to medium size medical device software development organisations.

2 Related Work

2.1 Medical Device Software Quality

Wallace and Kuhn [5] describe how in the years, 1983 to 1991 6% of the recalls registered with the FDA were due to software failures and how for the years 1994 to 1996 this had risen to 10%. ANSI/AAMI/SW68 Medical device software - Software life cycle processes [6] was adopted in 2001 and its stated purpose was to reduce the time required for regulatory review of medical device software by reducing the material that must be reviewed while providing a development process that will consistently produce high quality, safe medical device software. IEC 62304 was introduced in 2006 and is based on ANSI/AAMI/SW68 with a number of significant additional requirements. IEC 62304 has been adopted by the ANSI as an US national standard (replacing ANSI/AAMI/SW 68). However the number of medical device recalls registered with the FDA that related to software issues has continued to increase. Alemzadeh et al.[7] describe how 33.3% of Class I (presenting a high risk of severe injury or death to patients) recalls between 2006 and 2011 were software related. The standards state clearly what is required by medical device software development organisations, but do not tell the organisation how to implement these requirements.

The development of safe medical device software requires quality management, risk management, and good software engineering [1]. The purpose of IEC 62304 Medical device software — Software life-cycle processes [2] is to define the lifecycle requirements for medical device software development and to establish a common framework for medical device software life cycle processes. IEC 62304 also requires a medical device software development organisation to have a quality management system in place that demonstrates the ability to provide medical device software that consistently meets customer requirements and applicable regulatory requirements. ISO 13485 Medical devices - Quality management systems - Requirements for regulatory purposes [3] is one such standard. IEC 62304 also requires that a risk management process complying with ISO 14971 [4] be applied to the software development life cycle processes.

2.2   Roadmapping

The roadmapping process is established and proven in the technology domain and continues to be adopted in many other fields of endeavour. Phaal [9] lists over 2000 public domain roadmaps organized by topic including chemistry, construction, defence, energy, transport and many more. A number of large companies use roadmapping to develop their strategic planning going forward. NASA embraced roadmapping in 2005 [10] arising out of a number of cost overruns in their development budgets.

Within the SPI domain, the number of published roadmaps is limited. McFeeley et al., [11] have developed a high level process improvement roadmap and describe how their roadmap is intended to provide an organization with a guide to forming and carrying out an SPI program.

Höss et al., [12] launched a pilot project to acquire skills in implementing IEC 62304 in a hospital-based environment (in-house manufacture). They concluded that the pilot project carried out at their facility clearly demonstrated that the interpretation and implementation of IEC 62304 is not feasible without appropriately qualified staff. They recognized that it could be carried out by a small team with limited resources although the initial effort is significant and a learning curve must be overcome.

It can be seen that applying the roadmapping process to IEC 62304 and generating a roadmap that will aid medical device software development organizations in the implementation of IEC 62304 is a necessary and justified step.

Flood et al. [13][14] have already applied the roadmapping process to ISO 14971 and IEC 62366 and these roadmaps have been validated with industry experts. A roadmap has also been developed for traceability in the medical device domain leaving the development of an IEC 62304 roadmap as the last piece of the puzzle.

IEC 62304 is not a standalone standard and the manufacturer of a medical device is responsible for ensuring compliance with the other relevant standards. Irrespective of the lifecycle model chosen, the processes defined in the standard must form part of the model and be implemented during the development of the medical device software. One method organizations have of doing this is through mapping the standard to their particular life cycle model. The IEC 62304 implementation roadmap will remove this step in the software development process as the requirements of IEC 62304 are already mapped to the defined processes, identified as Activities and any gaps that exist in the organizations processes will be detected.

2.3   General Software Development Planning

The Institute of Electrical and Electronics Engineers (IEEE) produced Standard 1058:1998 Standard for Software Project Management Plans [15] to specify the format and content of software project management plans. When ISO/IEC/IEEE 16326:2009 Systems and software engineering — Life cycle processes — Project management, which harmonised ISO/IEC TR 16326:1999 and IEEE Standard 1058:1998, was introduced, software development plans were identified as separate entities. Section 5.9 Additional plans (Clause 9 of the PMP) states "*For projects dealing with software intensive systems or software products, these additional requirements are usually documented in two additional plans created at a lower level of abstraction than the PMP. These additional plans are the system engineering management plan (SEMP) and the software development plan (SDP).*" These standards state what must be contained within a plan but do not give examples of such a plan. McConnell, in his Software Project Survival Guide [16], details a software project development plan template, based on IEEE 1058 – 1998. One of the main features of this plan is that it separates the managerial processes, the technical processes and the work packages, schedule and budget.

3   A roadmap for IEC 62304

The definition of a Roadmap for the purposes of applying the roadmapping process to this and the other standards in the domain is *"A series of Activities, comprised of Tasks that will guide an organization through the use of specific "How To's" towards compliance with regulatory standards"*.
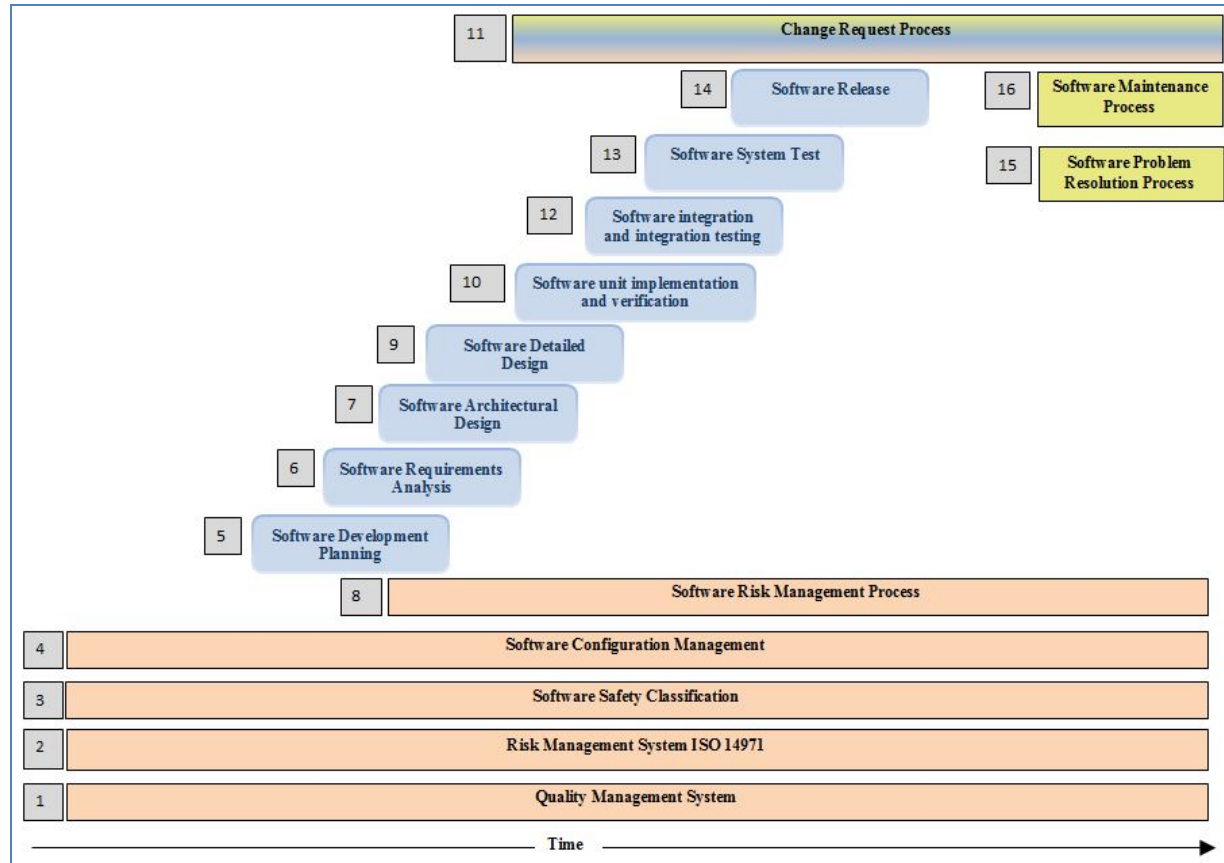
Figure 1 Metaphor for Roadmap

A roadmap for the implementation of IEC 62304 has been developed and the metaphor detailed in figure 1 was developed to aid organisations in the visualisation of the activities that were required and also to give an indication of the timeline associated with the implementation of the processes required by IEC 62304.

It can be seen in this figure that a number of the required processes are on-going right throughout the development of the project and in some cases, right to the end of the life of the product. These processes have been defined to ensure the safety of all users of the medical device, including operators, patients and healthcare professionals.

The roadmap outlines the stages at which each process should be introduced into the organisation and these processes may be performed multiple times through the life of the project. As can be seen organisations must first start with the implementation of a quality management system and a risk management process compliant with ISO 14971. The organisation must then establish the classification of the device and ensure that for all artefacts produced as part of the project are controlled and uniquely identified, including all modifications and revisions.

At this point the organisation would be in a position to begin the development of the medical device software. The first stage in this process is to plan the software development process including all of the necessary stages from requirements analysis through to releasing the process.

4 Research Method

The aim of this work is to assist organisations with the implementation of IEC 62304. To meet this aim we began by examining the current software development practices of two organisations new to the medical device domain in light of the IEC 62304 standard. This work revealed that the most prominent issue was a lack of a software development plan.

To assist these organisations in the creation of the software development plan the following research method was undertaken.
1. **Examine current software development practices within the medical device organisations:** The first stage in the implementation of the roadmap was to examine the organisations existing processes and determine which elements were most urgently required. This examination revealed that the most prominent issue faced by these organisations was the lack of a software development plan.
2. **Examine general Software Development Plans and compare them with the requirements of IEC 62304:** The requirements of IEC 62304 were mapped into the template and a comparison made between the contents of the template and the requirements of IEC 62304. Details from the annexes were also included so that the rationale behind the requirements were understood and could be easily referenced by the authors of the actual medical device software development plan.
3. **Develop Generic Software Development Plan template which satisfies the requirements of IEC 62304:** The outcome of the comparison process was a generic medical device software development plan that encompassed all elements of the original project plan, elements derived from best practice, the requirements of IEC 62304 and the rationale from the annexes of the standard.
4. **Examined the organisations existing planning documentation in light of the template:** Once the template was developed the organisations existing planning documentation was examined to determine if additional elements were required to complete the software development plan template developed in Stage 3.

5 Results

5.1 Examination of Current Software Development Practices

As described previously, contact was made with two software development organisations who were planning to enter the medical device software development domain. Organisation A is a small software development house with approximately fifteen employees. They are specialists in the mobile application market. Organisation B is an organisation who as part of a multinational company has experience of manufacturing medical devices and some limited experience in developing medical device software but who have identified the need to set up a separate division to take responsibility for the development of medical device software that will form part of any medical device that they manufacture. Both organisations have already begun their journey on the road to IEC 62304 compliance by investing in a quality management system complying with ISO 13485 [3] (QMS) and a risk management system complying with ISO 14971 [4] (RMS). Their question was "what do we have to do now?"

Both organisations had commenced Activities 1 (QMS) and 2 (RMS). The software safety classification of Class C is assigned at the start of the project (Activity 3) and remains as such until the software risk management process (Activity 8) is commenced and the results of this process are established. The software configuration management process (Activity 4) was established in both organisations to a certain degree, established enough for them to commence planning the software development (Activity 5). Both organisations had difficulty with this stage. Reviewing their existing documents established that Standard Operating Procedures (SOP) were the methods employed to detail, describe and record the processes carried out by their staff. These procedures were not robust enough and did not cover all the requirements of IEC 62304. Neither organisation had what could be described as a Soft-

ware Development Plan (SDP) as required by IEC 62304. This is the point where the "How To" element of the roadmap was required.

5.2 Comparison of general Software Development Plan with IEC 62304

There are a number of software project development plan templates available. Most of these are based on the IEEE standard. Because standalone software can be a medical device in its own right [17], a decision was made to base this software development plan template on the software project management plan template. The template refined by McConnell was used because of his standing in the software engineering world. Medical device software development organisations operate in a business environment as well as a safety critical one. The sections and references to budget were retained to reflect this reality.

Using the template detailed by McConnell, a comparison was made with IEC 62304 to identify any limitations that were apparent. Section 5 of IEC 62304 is titled Software Development Process and Sub-Section 5.1 (Software Development Planning) contains eleven sub clauses, 5.1.1 through 5.1.11, that detail the requirements for the software development planning stage. These are included in the roadmap under the Activity Title - Software Development Planning and grouped into five tasks as detailed in Table 1:

Table 1 Tasks associated with Activity 5 – Software Development Planning

Task	Description
5.1	Establish a Software Development Plan
5.2	Update the Software Development Plan
5.3	Ensure that the plan includes references to or plans for the following elements. (Task 5.3 references thirteen separate elements required by IEC 62304).
5.4	Identify the supporting items used to develop the medical device software, which could impact the medical device software.
5.5	Plan to place configuration items under documented configuration management control before they are verified.

These five tasks reference seventeen elemental requirements from Sub-Section 5.1.

The limitations identified to the software project management plan described by McConnell included a limitation related to the question of risk. In the general software engineering world, risk to the project is a concern whereas for the medical device domain IEC 62304 requires that the software risk management process "identify software items that could contribute to a hazardous situation identified in the medical device risk analysis activity of ISO 14971". Safety to the patient, the user and the environment are of paramount importance. Section 3.3 was retitled to Software Risk Management, mapped to IEC 62304 section 5.1.7 Software risk management planning, which in turn references the Software Risk Management Process described in Section 7 of IEC 62304.

A second limitation of the generic plan was that Section 1.1 Project Overview did not highlight the importance of safety and producing safe software as an objective. Reference to safety is a major element of this section in the template, so that from the beginning of the project, safety is to the forefront.

5.3 Generic Software Development Plan template

These requirements were mapped to the most appropriate headings in the revised template above. As an example, IEC reference 5.1.7 details the requirements with regard to software risk management and this was mapped to the heading 3.3 (Software Risk Management) in the software development plan. This mapping of each of the requirements of Sub – Section 5.1 to the template ensures that the plan encompasses all of the requirements of IEC 62304. The software safety classification associated

with each requirement is also mapped. It is important to note that the plan is a "living" document and will be continuously reviewed and updated during the software lifecycle process.

The requirements of Section 5.1 of IEC 62304 were mapped to the template to ensure that all requirements were included in a particular section of the template.

The final template reflects the requirements of a software development plan for the medical device domain and by the addition of elements from current best practice, the template now comprises the following sections:

Title Page
Signature Page
Revision History
Preface
Contents
List of Figures
List of Tables
List of Definitions, Abbreviations and Acronyms
1. Introduction
    1.1 Software Project Overview (referencing main project if appropriate)
    1.2 Software Project Deliverables
    1.3 Schedule and Budget Summary
    1.4 Evolution of the Software Development Plan
    1.5 Reference Materials
2. Software Project Organization (referencing main project if appropriate)
    2.1 Process Model
    2.2 Organizational Structure
    2.3 Organizational Boundaries and Interfaces
    2.4 Project Responsibilities
        2.4.1 RACI Matrix

3. Managerial Process
    3.1 Management Objectives and Priorities
    3.2 Assumptions, Dependencies, and Constraints
    3.3 Software Risk Management
    3.4 Monitoring and Controlling Mechanisms
    3.5 Staffing Plan
    3.6 Measurement and Analysis
4. Technical Process
    4.1 Standards, Methods, Tools, and Techniques
    4.2 Software Documentation
    4.3 Project Support Functions
5. Work Packages, Schedule, and Budget
    5.1 Work Packages
    5.2 Dependencies
    5.3 Resource Requirements
    5.4 Budget and Resource Allocation
    5.5 Schedule
6. Additional Components
7. Index
8. Appendices

This template is easily tailored to match the requirements of any medical device software development organisation. The plan can be tailored by means of including elements of their processes under specific headings or in the Appendices. IEC 62304 only requires as a minimum that the SDP references the plans to be included. Therefore the organisation is able to identify the elements of the plan that will be required going forward and be able to adequately plan for and resource these processes.

5.4 Review of Organisations Documentation

The organisation's existing planning documentation was reviewed and a comparison made with the template. A number of elements were identified as either lacking in detail or were non-existent. Further follow up interviews elicited more information on the existing processes being used and the outcome of the review noted the following elements that required action:

- **Safety** - the main driving force behind the development of the standards for medical device and medical software development is to identify the processes that are required to produce safe design and maintenance of medical devices and software. The need to keep safety at the forefront of all discussions, designs and implementations is the element that needs to be included and highlighted within the SDP.

- **Maintenance** – The last process identified in the roadmap is that of Maintenance, but nonetheless a very important feature of medical device software development. Small organisations entering the medical device software development arena need to identify and plan for this

process.

- **Language** – the medical device domain requires a whole new lexicon. It is not expected that developers become medical experts, but they need to understand the basic definitions and treatment methods associated with the device being designed. Understanding acronyms, units of measurement and dosage levels for instance could be crucial. The training requirements of the staff engaged on the project are required to be identified in the SDP.

- **Error handling** – in the general software development domain designing what happens when an error occurs will probably not cause harm to the user. In safety critical domains the results of error handling can be life threatening. The importance of error handling and the need to consider a much wider set of circumstances and implications is crucial in safety critical domains.

6 Discussion

IEC 62304 is an important and substantive standard. The purpose in developing an implementation roadmap is to guide medical device software development organisations of all maturity to regulatory compliance. Organisations who want to enter or who have just started their journey in entering the market find it difficult to decide how to undertake the processes necessary or even adapt or improve the processes that they have in place so that they can comply with all the requirements of IEC 62304. The roadmap, when complete, will contain a repository of the "How To's" necessary to guide such organisations.

IEC 62304 defines the processes required for the development of safe software for the medical device domain but does not tell the organization "how to" carry out the processes. The generated roadmap when completed will fill this gap. The experienced gained so far in generating the roadmap and interacting with organisations operating in the medical device software development domain has been invaluable in the understanding of the needs of these organisations and the best manner in which these needs can be fulfilled.

7 Conclusions

Organizations that are engaged in or wish to become engaged in the medical device software development domain are placed under a high level of scrutiny by the regulatory bodies tasked with ensuring that the medical device organization is compliant with all the standards. These standards identify the requirements the medical device organization must satisfy without telling them how to achieve compliance. This can hinder both the development of new medical devices and existing software houses entering the medical device domain due to the range of methods available for implementing the standards.

Building on the previous work in developing the IEC 62304 implementation roadmap this paper has described the development of the first "How To" that will form the first block in the repository of "How To's" for the roadmap. These "How To's" are the essential ingredient that an organisation needs in starting the journey on the road to IEC 62304 regulatory compliance.

8 Future Work

The fourth stage of this work is to validate the roadmap through expert review. A number of experts will be recruited for the validation from a diverse range of back-grounds including those who work in the medical device domain and use the standards on a regular basis, assessors who regulate organizations using the standard, academics with the appropriate expertise, and members of the standards committee.

It was envisioned that the fifth stage, the identification of the "how to's" for the achievement of the Tasks defined in the generated roadmap and the building of a repository to house them would only commence following validation of the roadmap. However, as is the case in many endeavours, "there is a tide in the affairs of men, which taken at the flood, leads on to fortune" (Julius Caesar Act 4, scene 3), it was decided to take the opportunity when it arose to work with both organisations in developing an SDP template. The plan template is currently being evaluated by the organisations and the results will be evaluated in due course. Further "How To's" will be developed through interaction with organizations that are close to regulatory compliance and by assessment of their processes. This will enable the development of a robust repository of "How To's" and future implementations of the roadmap in medical device organizations.

9 Acknowledgement

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11 Author CVs

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Dr Fergal Mc Caffery is a Science Foundation Ireland (SFI) Principal Investigator. He is a Senior Lecturer in the Department of Computing and Mathematics, Dundalk Institute of Technology (DkIT). He is Director of the Regulated Software Research Centre in DkIT and the Medical Device Software Engineering competency area in Lero. He has been awarded SFI funding through the Stokes Lectureship, Principal Investigator and CSET Programmes to research the area of medical device software. He has published over 170 peer-reviewed conference and journal papers and is on the editorial board/programme committee for a number of leading software engineering conferences and journals.

EXPERIENCE REPORT: IMPLEMENTING REQUIREMENT TRACEABILITY THROUGHOUT THE SOFTWARE DEVELOPMENT LIFE CYCLE

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Abstract

The developed traceability model in development life cycle is essential in helping project members, project managers, customers; both understand the product and maintain the integrity of the design information. In order to maintain the traceability it is essential to have a good development environment support [1]. This paper describes how requirements traceability are supported in INNOVA, an IT Solutions Provider company, with integrated tool infrastructure, the transformation of the tool infrastructure and the challenges that were faced during the transformation.

Keywords

Software Process Improvement, Configuration Management, Application Lifecycle Management, Requirement Traceability

1 Introduction

INNOVA Information Technologies is an IT solution provider which develops IT oriented software products and services for the national and international customers. INNOVA IT Solutions consist of various business directorates, all of which give services to national & international customers.
As there are many long term and maintenance projects, requirement traceability and impact analysis are essential factors to reduce cost and time to implementation in the Application Life Cycle Management.

1.1 Motivation

Traceability of requirements through the software development lifecycle (SDLC) is essential in the development of software. Many projects' traceability efforts simply focused on satisfying regulations but do not leverage the many benefits of traceability. Traceability, if fully implemented is an important tool for managing system development [1]. Traceability allows tracking whether the customers' requirements are being met, which requirement each task or design item is related to, and the origins and motivation of a requirement. Though the maintenance and use of traceability change management and impact analysis can be utilized for the companies advantage in lowering the development and maintenance cost. [2]

Before the beginning of the infrastructure improvement and integration, the tools that were used in the company were Enterprise Project Management (EPM), JIRA, Team Foundation Server (TFS), Quality Center (QC), Enterprise Architect, SVN and Eclipse. During the use of these large amount of toolsets that can each be considered as an Application Lifecycle Management (ALM) Tool, no rules to specify which tool is used for which purpose and almost no integration existed. Thus, projects and their management would differ dramatically, with difficulties and sometimes manual management in requirement traceability.

In order to downsize the number of tools as much as possible, specify the tool purposes and integrate them to simplify and uniform traceability, an infrastructure and process improvement was started.

2 Background Information

2.1 INNOVA the Company

INNOVA is a leading software developer and integrator in Turkey, which provides innovative software solutions and services, covering the entire project lifecycle from consulting, design, application development and integration to support.

Established in September 1999, INNOVA serves its bluechip client base from main offices in İstanbul and Ankara, a manufacturing facility for kiosks in Istanbul, as well as support offices in 12 cities in Turkey.

Areas of business in INNOVA include OSS/BSS Systems for Telco operators, Financial Transaction Applications, ERP, CRM and BI systems, portals, custom software development IT systems management and infrastructure, IT security and kiosk systems.

With more than 900 people serving its clients, INNOVA has delivered solutions and services to customers in 33 countries to date. Major customers of the company are fixed line and GSM operators in Turkey and abroad, banks, as well as other prominent organizations in the manufacturing, public and service industries.[4]

2.2   INNOVA Configuration Management Team

Configuration Management Team was established in 2015 with the goal of having an independent support staff in projects to make sure configuration management practices are applied. The team gives support in maintaining and keeping the tool infrastructure available to the appropriate project members, performs configuration management activities, such as management planning, identification of the configuration items with the project team, configuration control, status accounting, audits and also gives support in release management activities.

3 The Tool Infrastructure

Each tool was selected for specific use with the consideration of its capability, the company's culture, experience in the previous projects, making the software development life cycle tool infrastructure specialized for the company.

For the application life cycle management several tools such as TFS, JIRA, Enterprise Architect and SVN were selected. All of the tools selected are adequate for their using purpose. In the process of tool selection in order to minimize the cost, already acquired and partially used tools were considered. Also during the selection process, integration factors as well as company's experience in the tools were valued.

For Project Management, Requirement Analysis and Test domains TFS, for the Design and UML diagrams Enterprise Architect, for source code traceability JIRA and SVN were selected to be the management tool. The final setup of the tool infrastructure and the plugins used for tool integration is shown in Figure 1.
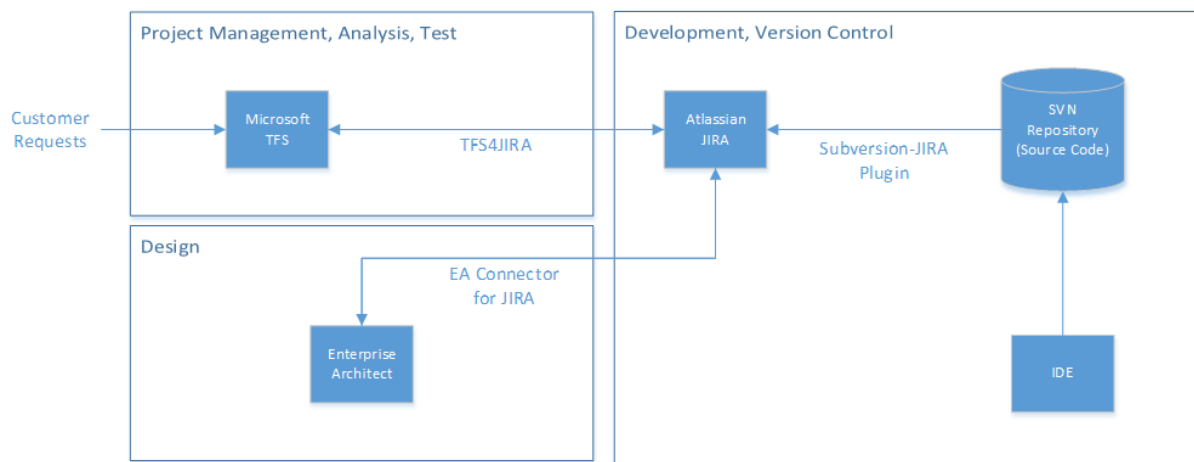
Figure 1 INNOVA Software Development Life Cycle Tools Model

The project work item and workflows in the TFS were based on the TFS Project Template: MSF for CMMI Process Improvement 6.2.

With its flexibility in work item, fields and work flow setup TFS is very capable in managing customer requirements, task and test management. In the tool setup it is planned to have the Project Managers, Analysts and Test Specialists manage their domains on TFS, where every item is linked to the relative customer requirements. Software requirements are maintained on TFS but a copy of the requirement set is imported in to Enterprise Architect through JIRA and the requirement-design traceability is maintained in both EA and TFS.

Since Enterprise Architect is a strong suite for design, and several groups have been using it for UML modelling it is decided to be utilized in the design area. In the Requirement-Design traceability between TFS and Enterprise Architect, JIRA was utilized as a seamless integration tool since TFS and Enterprise Architect has no integration directly.

JIRA is very strong in its integration capabilities with other tools such as Enterprise Architect, version control systems and continuous integration tools. Thus, JIRA was used as a bridge with TFS, Enterprise Architect and SVN. Currently SVN is used as a version control system which integrates with Eclipse development tool used by most of the development teams in the company.

3.1   Integrating TFS with JIRA

In order to minimize the licensing costs and utilize the existing tools, Enterprise Architect was used for design modelling which introduced the challenge of establishing traceability between the requirements and the design. As mentioned in Section 3, JIRA was used as a bridge with TFS and Enterprise Architect. In order to integrate TFS and Enterprise Architect, TFS4JIRA Plugin was utilized which automatically synchronizes TFS work items with JIRA items and vice versa. TFS4JIRA integration is shown in Figure 2.
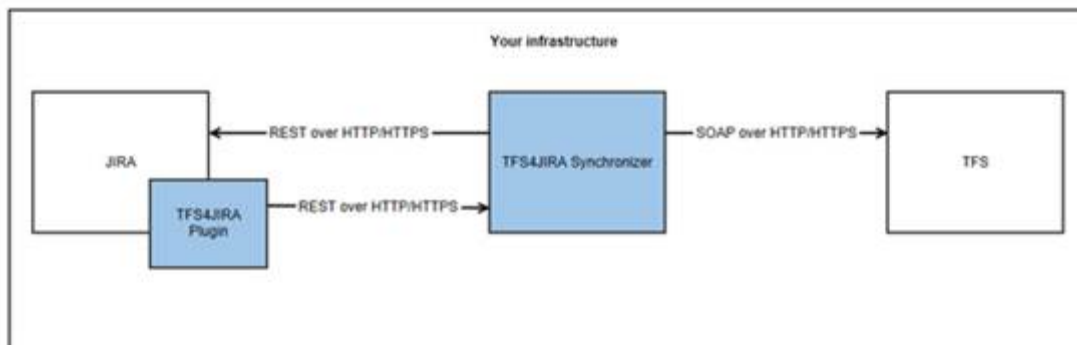
Figure 2 TFS4JIRA JIRA Server and TFS Structure

During the integration, work item types, states, fields are mapped using TFS4JIRA successfully.
As TFS4JIRA does not synchronize links, using both TFS and JIRA for requirement management and managing traceability could not be accomplished. Thus, viewing and managing traceability from JIRA was not possible. It is decided to use TFS for managing traceability with requirements, task, test case and EA for managing traceability with design issues and requirements.

3.2   Integrating Enterprise Architect with JIRA

In order to integrate Enterprise Architect and JIRA, EA connector for JIRA was utilized which is an add-in for Enterprise Architect to provide bi-directional integration between the Enterprise Architect and JIRA.

The integration is achieved by manually exporting artifacts from Enterprise Architect, which are created as issues in JIRA, and importing issues from JIRA to Enterprise Architect, which are created as artifacts in that tool.

It is possible to map the entities to be handled in the import and export processes, as well as the fields of the entities themselves that will be exchanged.

During the test for integration, import and export processes gave an exception for every requirement item to be imported or exported. Since the exception was given per requirement item and each project has a large set of requirements this issue was critically affecting the usability of the integration. For resolving the exception the company that was providing the EA connector for JIRA Version 6.5.1.0 plug in was contacted by creating the relevant JIRA issues on their site. With the detailed bug report provided and the support the company have given the exception issue was fixed. Although TFS4Jira cannot synchronize the links between items, EA connector for JIRA has the capability of synchronizing item links between Enterprise Architect and JIRA. In order to utilize this functionality linked issues from JIRA were sent with a field where a scripted field in JIRA were created and mapped with a new cus-

tom field in work items. Thus, traceability between Requirements and design issues could be accessed from TFS.

3.3   Integrating JIRA with SVN

SVN is the main source control tool that is used in INNOVA. TFS 2012 does not support SVN as a version control system. Developer Teams could not use TFS' own version control system as the Company develops its software products with java. As planning the infrastructure change, developing issues are ongoing with very compressed schedule. During this transformation, it is very difficult to export the repositories with the full commit history in to the TFS. Thus, company decided to continue using SVN and manage the integration through JIRA by using JIRA's free Subversion Plugin.

Subversion Plugin reads the commit messages from the repository and if commit message has valid JIRA issue id then commits appear in the JIRA as shown in Figure 3. Commits to the SVN are done through Eclipse by development team.

Figure 3 Subversion commit messages shown in JIRA

3.4   Simple Example with Screenshots

A simple example of the requirement traceability with the implemented tool infrastructure can be seen in Figure 4 and Figure 5. The traceability can be followed by the same underlined labels with same color.
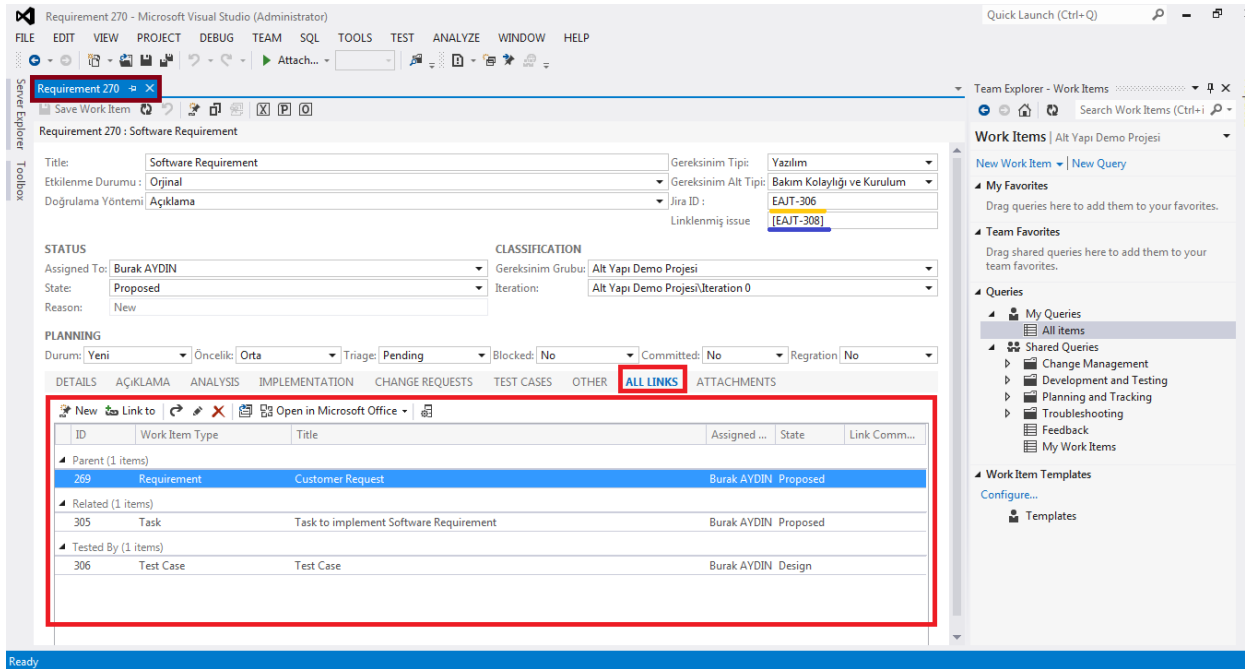
Figure 4 Looking From TFS
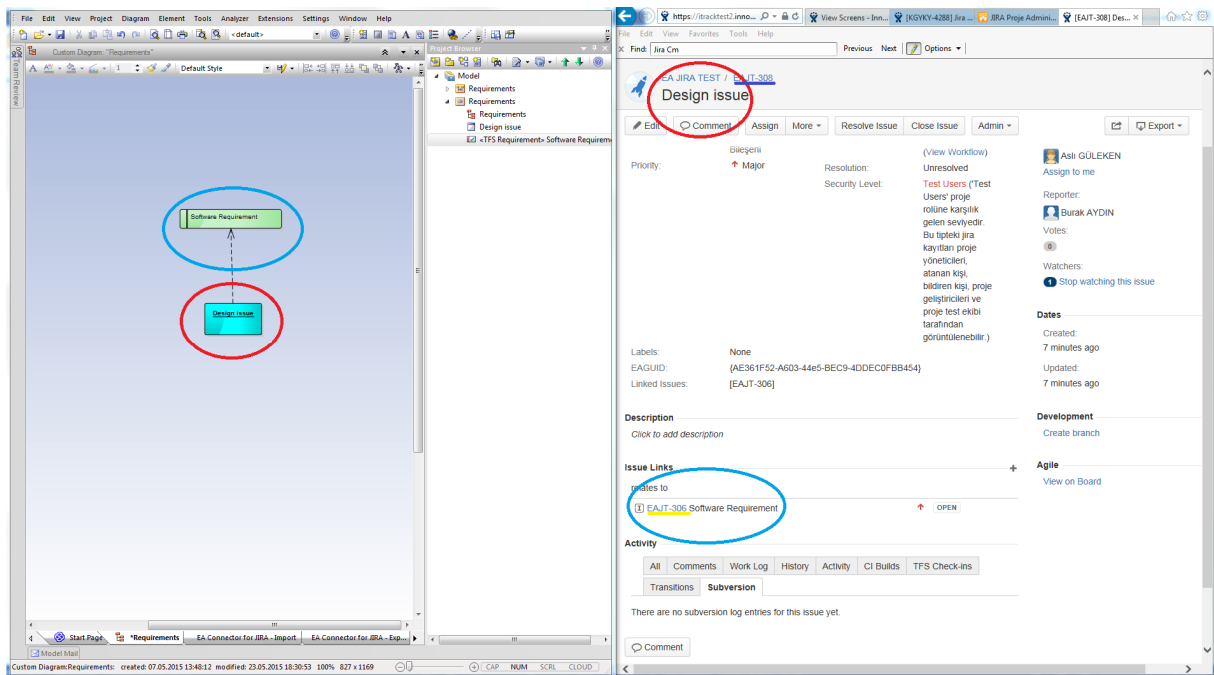
Figure 5 Looking From EA and JIRA

4 Conclusion

The requirements traceability support in development environments is essential in helping project members, project managers, customers, both understand the product and maintaining the integrity of the design information (especially in large, complex systems). Although it is preferred to use a single tool throughout the Application Lifecycle Management, cost factors, company culture and experience may prevent a single tool to be used. By supporting requirements traceability as described in this paper, our implementation model provide the flexibility to work with many different tools that are used in

product development life cycle as well as providing the appropriate level of support for the development process chosen by the product development team.

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6 Authors CV's

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Suha AKMAN is currently Configuration Management Team Leader at INNOVA IT Solutions. He is also responsible for the Configuration Management Process area in Process Improvement Project of the INNOVA TELCO Branch. He holds BSc. in Computer Engineering and MSc. in Computer Networking degrees from North Carolina State University, NC, USA. He took part at many projects as software developer, designer and systems engineer in the defense and telecommunication industry. He is interested in Quality Management, Process Improvement, System Engineering, Configuration Management and Continuous Integration.

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A Method to Realize Traceability in Development Processes

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Abstract

The SoQrates Working Group "Traces" develops methods for documenting a continuous flow of information and takes into account the transparency of the activities of the different disciplines. Particularly the level of detail, accuracy and completeness of the interfaces are considered. These methods consider also the required traceability demanded by different standards. By using the developed methods, a platform development with reusable components is possible. In combination with an efficient variant management, existing components can be combined to new customer products in a very short time (design to market). The closed traceability approach increases quality and safety veritably without additional resources. This paper describes the current results of the SoQrates Working Group "Traces" as a method description with best practice examples of the participating companies and research institutions.

Keywords

Traceability, Automotive SPICE[®], Functional Safety, Software Lifecycle, Re-use

1   Introduction

"Traceability" is one of the most unpopular buzzwords in embedded development. In spite of the fact that the development of complex devices and systems requires the interaction of different disciplines – starting from the management of requirements through design until testing – the establishment of the traceability is very often connected with a lot of effort that has to be spent. Therefore many companies are leaving audits and assessments with the finding, that a complete and consistent traceability is not available.

Single engineering disciplines are largely established in companies as separate processes and many best practices are available. A continuous coordination of these processes allows a successive opti-

mization of the entire development. The lessons learned from these companies are a very useful input for discussion and knowledge exchange, which is one of the most important goals of the working groups in "SoQrates".

SoQrates consists of several working groups with companies from different domains, e.g. Automation, Automotive, Finance and Medical. These companies are collaborating in identifying best practices for process activities in development areas like requirements management, architectural design, testing, functional safety, security, model comparison and traceability.

The SoQrates Working Group "Traces" develops methods for documenting a continuous flow of information and takes into account the transparency of the activities of the different disciplines. Particularly the level of detail, accuracy and completeness of the interfaces are considered. These methods consider the required traceability demanded by standards like ISO 15504 / ISO 330xx (SPICE) or ISO 26262.

By using the developed methods, a platform development with reusable components is possible. This results in reduced development costs and shorter development cycles (time to market). Furthermore, a distributed development across companies and national boundaries will be supported by unique component interfaces. In combination with an efficient variant management existing components can be combined to new customer products in a very short time (design to market). The closed traceability approach increases quality and safety veritably without additional resources.

Based on the requirements defined in different standards (chapter 3), the benefits of traceability will be described in chapter 2. Chapter 4 introduces an engineering model for single products using structural diagrams from UML. Based on this model an extension for multiple products will be defined in chapter 5. Chapter 6 gives an example how to implement this new model in projects and organizations.

2   Benefits of Traceability

Traceability offers a lot of benefits which will be described in the following key points:

Completeness
- Through traceability it can be demonstrated that the delivered system meets all requirements of the customer.
- Traceability allows the proof of completeness starting from requirements via design and implementation until test implementation (e.g. for security and safety evaluations).
- Traceability is the basis for discipline-spanned metrics.

Dependencies
- Traceability allows the systematic, structured analysis of causes for errors that have been occurred (Root Cause Analysis, Derivation Analysis).
- Traceability allows the systematic, structured impact analysis of requirement changes (Impact Analysis).
- Traceability supports effort estimation (e.g. cost and time) for changes, problem resolutions and follow-up projects.
- The number of traces is an indicator for the complexity of a product.
- Traceability supports the re-use of existing components through direct acquisition of the component itself and the linked discipline-specific information.
- Traceability allows the product- and project-wide error analysis.

Process
- Traceability is an indicator for the maturity of a product or project, because there must be a structured approach for requirements, architecture and tests.
- Traceability is a prerequisite for a successful maturity check for Safety, Security, SPICE or CMMI.

3 Traceability in Standards

The traceability between work products is required by several international standards. This chapter contains some examples, whereby the list does not claim to be exhaustive.

3.1 ISO 26262 – Road Vehicles - Functional Safety

The international standard for the development of Functional Safety relevant road vehicles [1] demands a complete traceability over all levels of requirements. In part 8 of the standard it is defined that safety requirements shall be traceable with a reference to

- each source of a safety requirement at the upper hierarchical level,

- each derived safety requirement at a lower hierarchical level, or to its realization in the design,

- the specification of verification.

This is important especially for an impact analysis if changes are made to particular safety requirements, and for the functional safety assessment.

3.2 Automotive SPICE®

The Automotive SPICE® Process Assessment Model [2] comprises a set of indicators for process performance and process capability. For process performance the so-called "Base Practices (BP)" require a traceability between associated work products.

In the updated version 3.0 of Automotive SPICE® [3] the traceability requirements have been extended and more detailed. In addition the difference between bidirectional traceability and consistency is highlighted (see Figure 1).
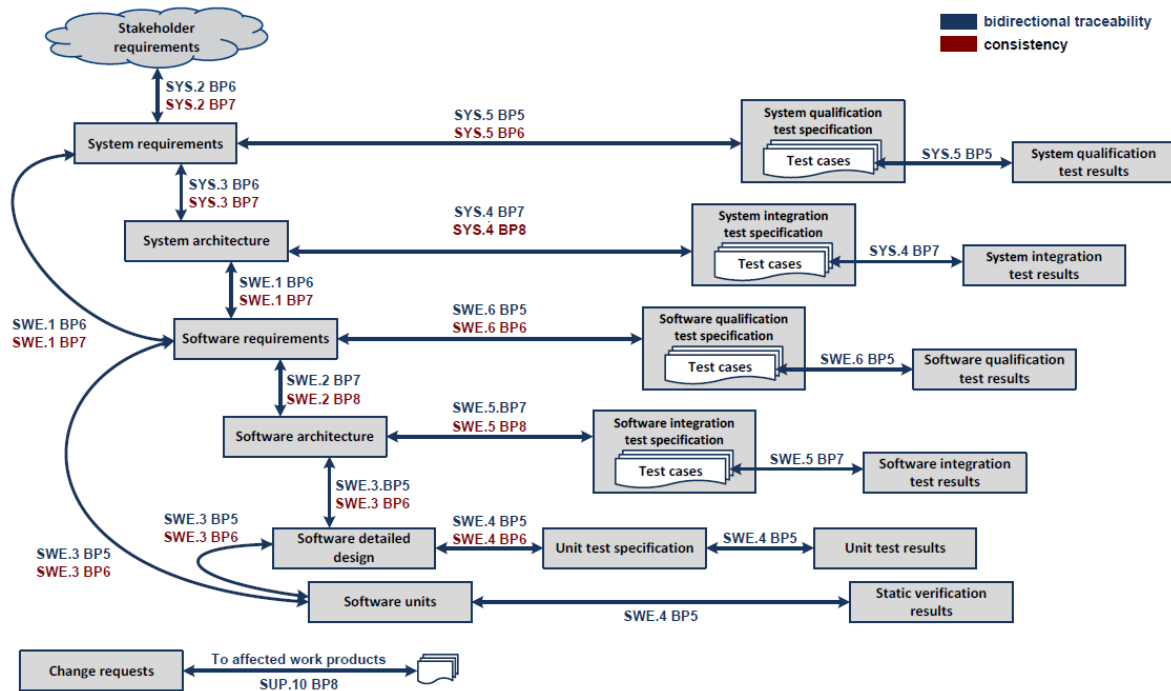
Figure 1: Bidirectional Traceability and Consistency in Automotive SPICE® v3.0 [3]

3.3 ISO/IEC 12207

The International Standard ISO 12207 [4] defines software lifecycle processes for systems and software engineering. It contains processes, activities and tasks that are to be applied during the development of a software product or service. Figure 2 shows the traceability graphically.
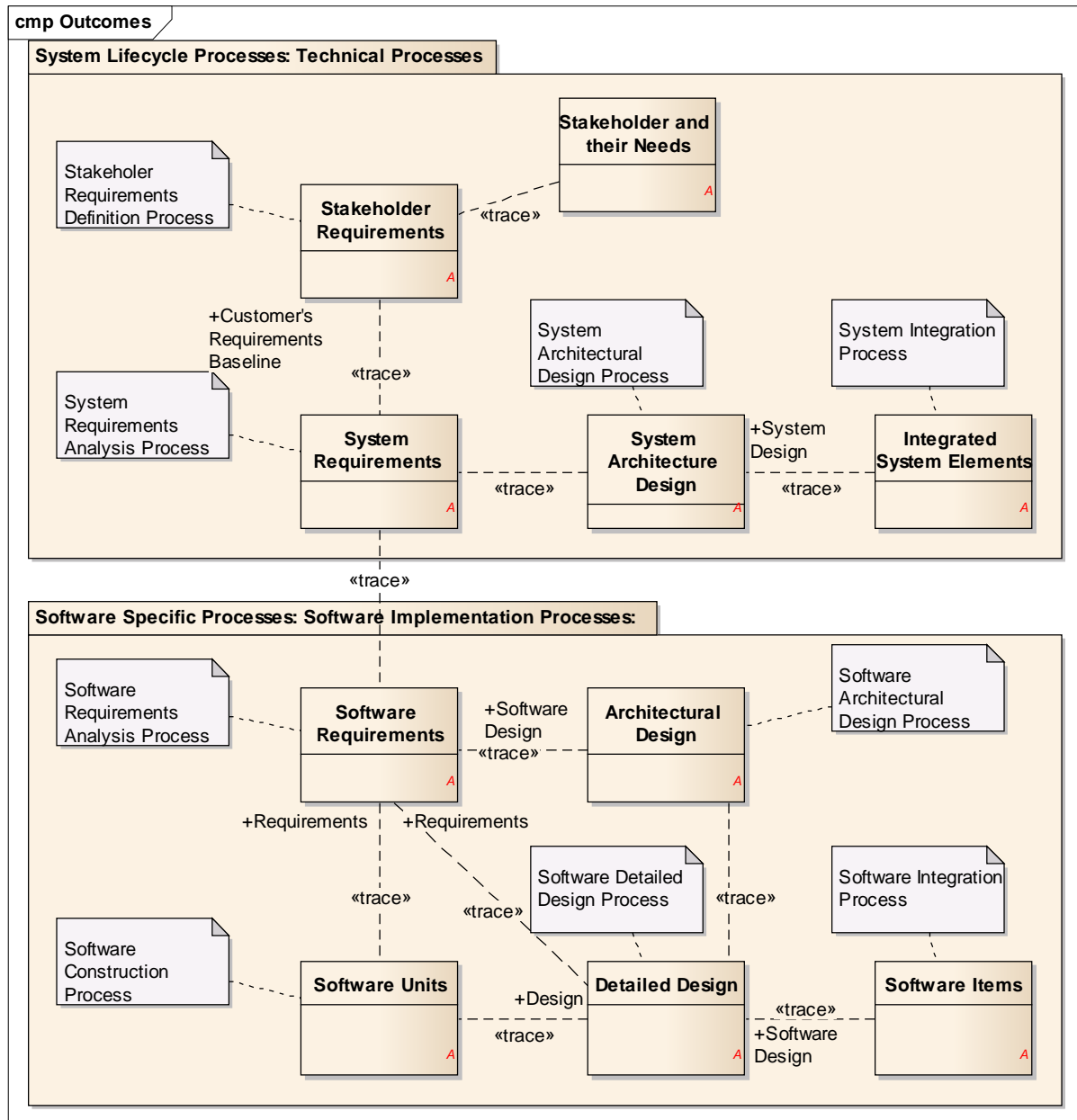
Figure 2: Traceability of Process Outcomes in ISO/IEC 12207

4   *Engineering Model for a Single Product*

In the following chapters UML structural diagrams are used to visualize the meta model for the traceability. This method is chosen for a consistent approach.

Very often processes specify the development of one single product and do not consider the derivation of variants from the product. The variants from the product are handled as a new single product. This use case can be described with a meta model.

4.1 Meta Model

Work products are usually structured hierarchically. For example, a document contains chapters; a chapter may contain sub chapters, and finally, each chapter contains sentences. A meta model illustrates this approach (see figure 3).

The meta model is used for artifacts of various engineering disciplines. The element ***ItemType*** is an enumeration and defines the discipline like requirements engineering, architectural design, implementation, test engineering or test execution.
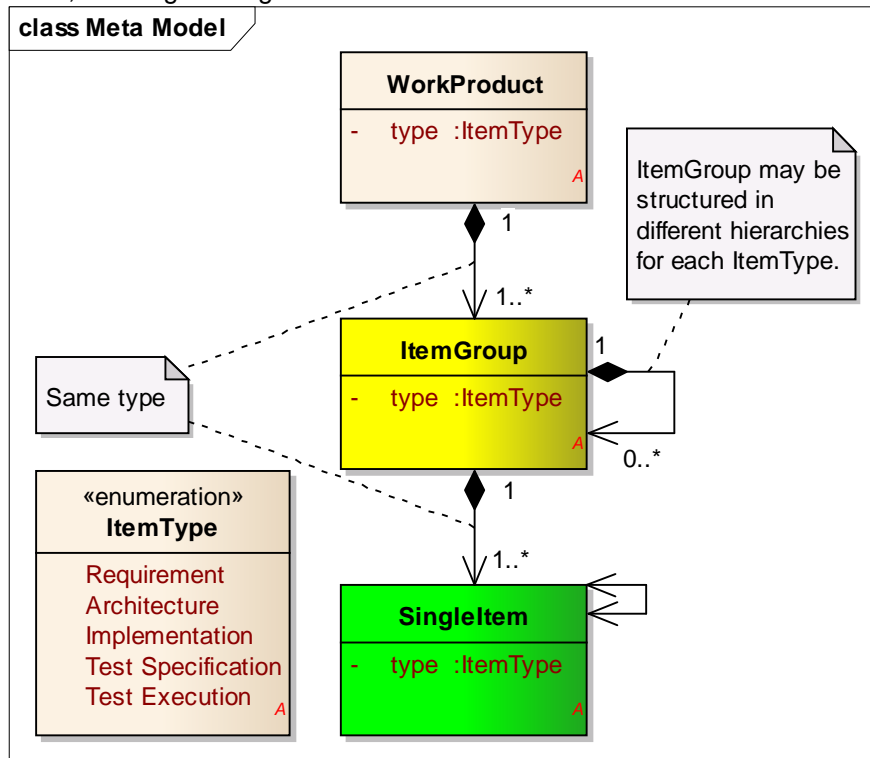
Figure 3: Class Diagram Meta Model

The element ***SingleItem*** contains the atomic information. It represents the leaves when the document is structured as a tree. For example a single item is a requirement or a class in an UML class diagram.

The element ***ItemGroup*** is a collection of single items or item subgroups of the same item type. It is useful for structuring documents and creating hierarchies. One item group is composed of at least one single item. One item group may be composed of several other item groups. An example for an item group with single items is a requirements module with requirement objects or a UML class diagram with classes. An example for an item group with item subgroups is a major requirement group with subsidiary requirement groups or a UML package diagram with packages.

The element ***WorkProduct*** is a complete and self-contained document. It consists of one or more item groups of the same item type. For examples a work product is a requirements specification consisting of several chapters or modules or an architecture model in UML containing several diagrams.

Same type means that the work product, item group and single item are of the same type i.e. a requirements specification consists of chapters for groups of requirements and these chapters contain requirements.

4.2 Engineering Disciplines

The meta model is applied for work products of engineering disciplines. The packages represent the engineering disciplines. The classes represent the elements of the work products. The relationships between the engineering disciplines are denoted by the dependency arrows (see figure 4).

Requirements Engineering

- The ***Requirements Specification*** specifies WHAT the product shall do. Only one requirement specification exists for a product. This requirement specification contains all requirements and

shall be structured to the needs of the platform development. Usually it is divided into separate documents (Requirements Group) for stakeholder specifications and system and discipline specifications.

- The ***Requirements Group*** is used to structure the requirements specification. A requirements group may contain the stakeholder specifications with subsidiary requirements groups containing the customer requirements, internal requirements and legal requirements. Another requirements group may contain the system specifications with subsidiary requirements groups containing the system and subsystem requirements and the discipline requirements for software, hardware and mechanics.

- The ***Requirement*** is on the highest level of detail with attributes containing all necessary information. It may be a requirement on stakeholder, system or discipline level. For realization of the traceability the requirements have links to other elements of the same level of detail e.g. to a test case. Usually a requirement has at least one link to one test case.
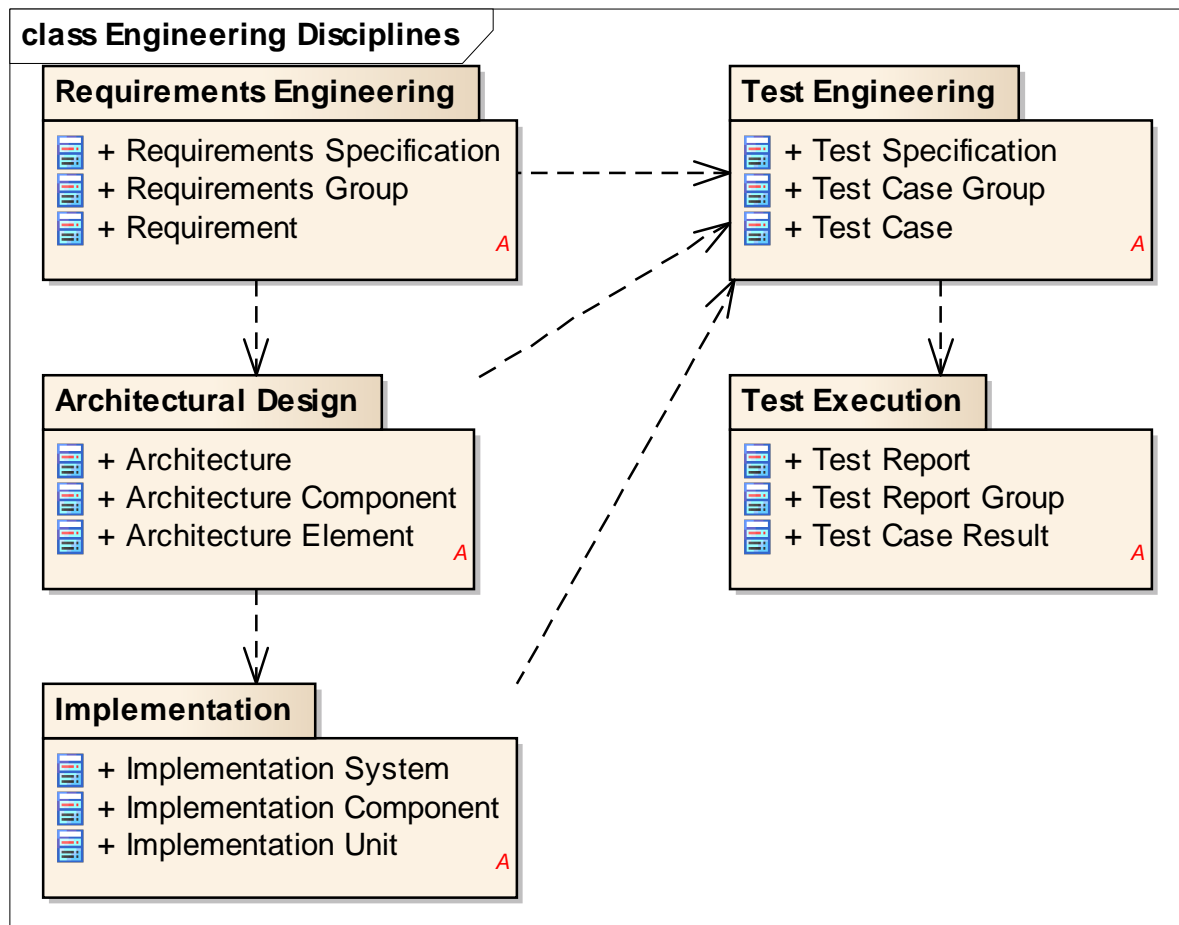
Figure 4: Class Diagram Engineering Disciplines

Architectural Design

- The ***Architecture*** specifies HOW a product is realized. Usually it is a model (e.g. SysML, UML) with a collection of architecture components. It may be a completed ARC42 template [5].

- The ***Architecture Component*** is used to create the hierarchical levels of an architecture. On a high level it is the system or the software architecture; on a low level it may be an UML diagram, a package or a detailed design like a description of a SW unit or HW design.

- The **Architecture Element** is on the highest level of detail. It may be a class, a sequence diagram or an interface.

Implementation

- The **Implementation System** represents the system under development i.e. the product to be delivered. Usually it is embedded in a context and it has interfaces to this context.

- The **Implementation Component** represents a part of a product like a system element. It is a discrete part of a system that can be implemented to fulfill specified requirements. A system element can be e.g. hardware or software. It contains implementation units and may contain other implementation components.

- The **Implementation Unit** is on the highest level of detail. It is an atomic part of the system and will not be subdivided e.g. HW circuit, software item with source code, object code, control code etc.

Test Engineering

- The **Test Specification** specifies all tests for an implemented system.

- The **Test Case Group** contains test cases or other test case groups.

- The **Test Case** specifies a single test with inputs, predicted results and a set of execution conditions for a test item.

Test Execution

- The **Test Report** contains the results of all tests. A summary of the results is helpful.

- The **Test Report Group** groups several test case results to one report.

- The **Test Case Results** contain the result of a test case e.g. passed, failed, skipped. Each time a test case is performed a new test case result is recorded.

4.3 Engineering Layers

Another view of the same engineering disciplines' elements is a layer model (see figure 5).
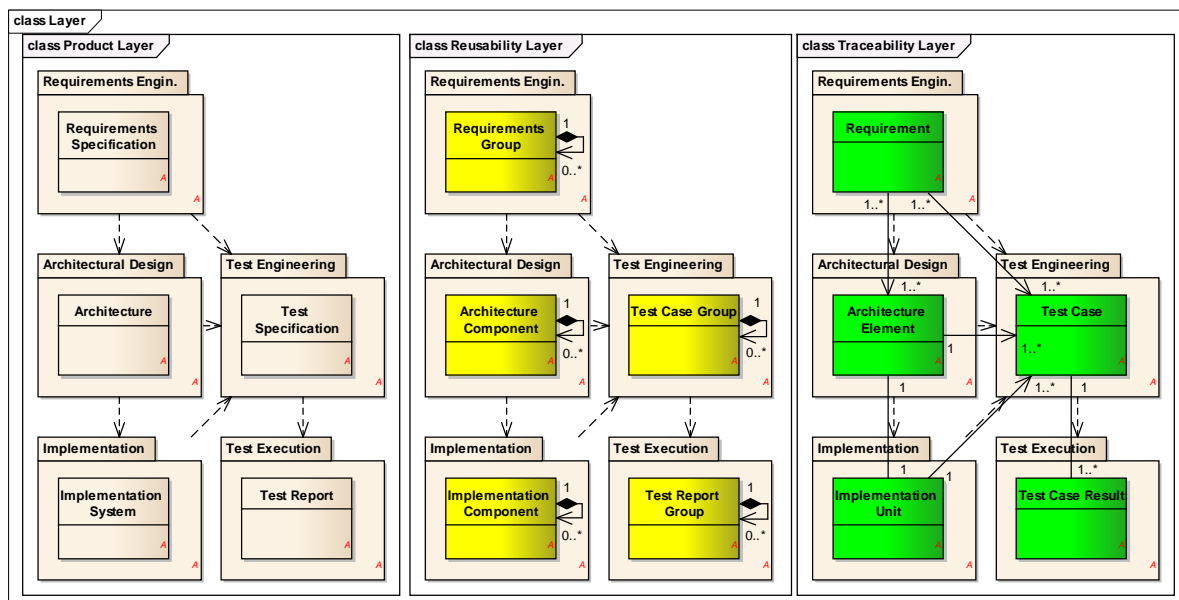
Figure 5: Layer for Product, Reusability and Traceability

The **Product Layer** is the highest level. The work products belong to a product and they are identified by a naming convention. There is no traceability between the work products on this layer.

The ***Reusability Layer*** contains groups of elements predestined for reuse and variant management. However these groups may be product specific.

The ***Traceability Layer*** contains elements on the highest level of detail. These elements shall be traceable between the Engineering Disciplines. In this layer links between single items are realized, e.g. a link from a requirement to a test case or a link from a customer requirement to a system requirement.

5   *Engineering Model for Multiple Products*

Usually an organization does not construct only one single product, but it constructs multiple products. This may be variants with a major common part and minor specific parts or new products based mainly on previous products. However the development process should consider multiple products.

5.1 Model for a Product Component

The meta model with product component is an enhancement of the meta model described in the previous chapter (see figure 6).

The element ***ProductComponent*** is used for reusing a component of a product. The product component should be capsulated and modular and may need application parameter for configuration. It needs attributes for unique identification and tags for grouping.

The product component consists of a collection of item groups. In contrast to a work product the product component consists of an item group of each item type, i.e. a requirement item group, architecture item group, implementation item group, test specification item group and test execution item group. Within the product component the item groups match one to one. The item groups may be stored on different locations or Configuration Management Systems.
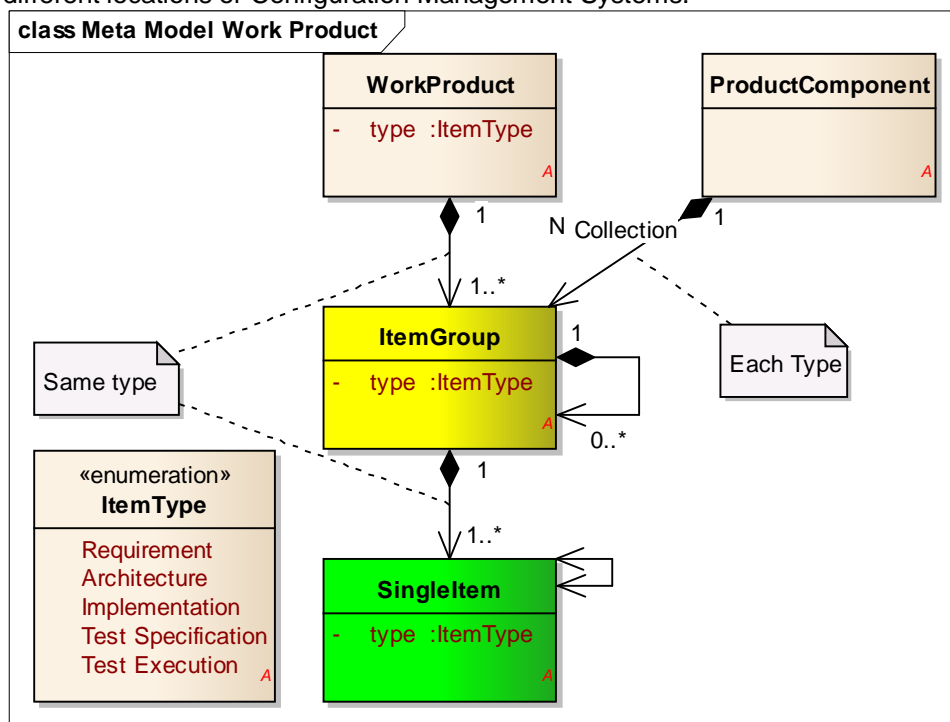
Figure 6: Class Diagram Meta Model with Product Component

Reusing a product component means that not only implementation components are reused. Also the associated item groups like requirements, architecture, test specification and module test results are reused including the traceability of the single items. Only integration tests have to be performed. However an item group may stand alone without belonging to a product component. Therefore the cardinality is set to "0..1" (see figure 7).
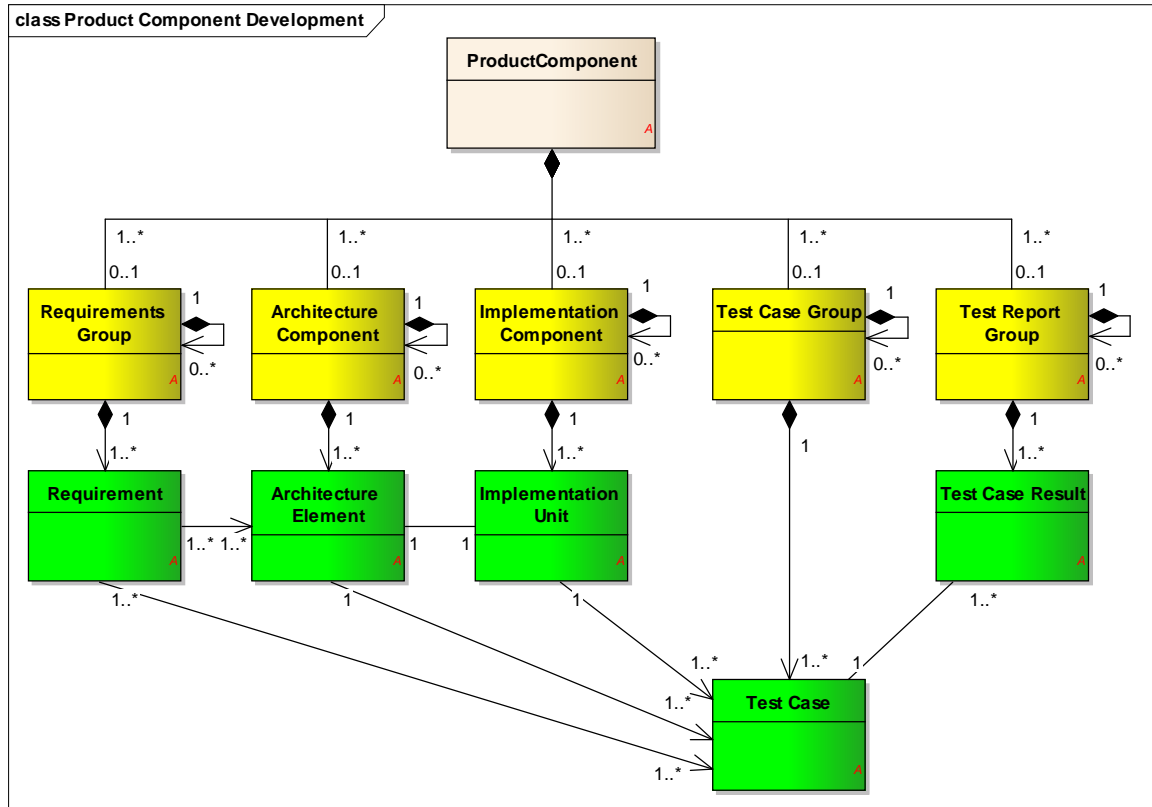
Figure 7: Product Component Development

5.2 Product Composition

Figure 8 shows an approach for development of multiple products.
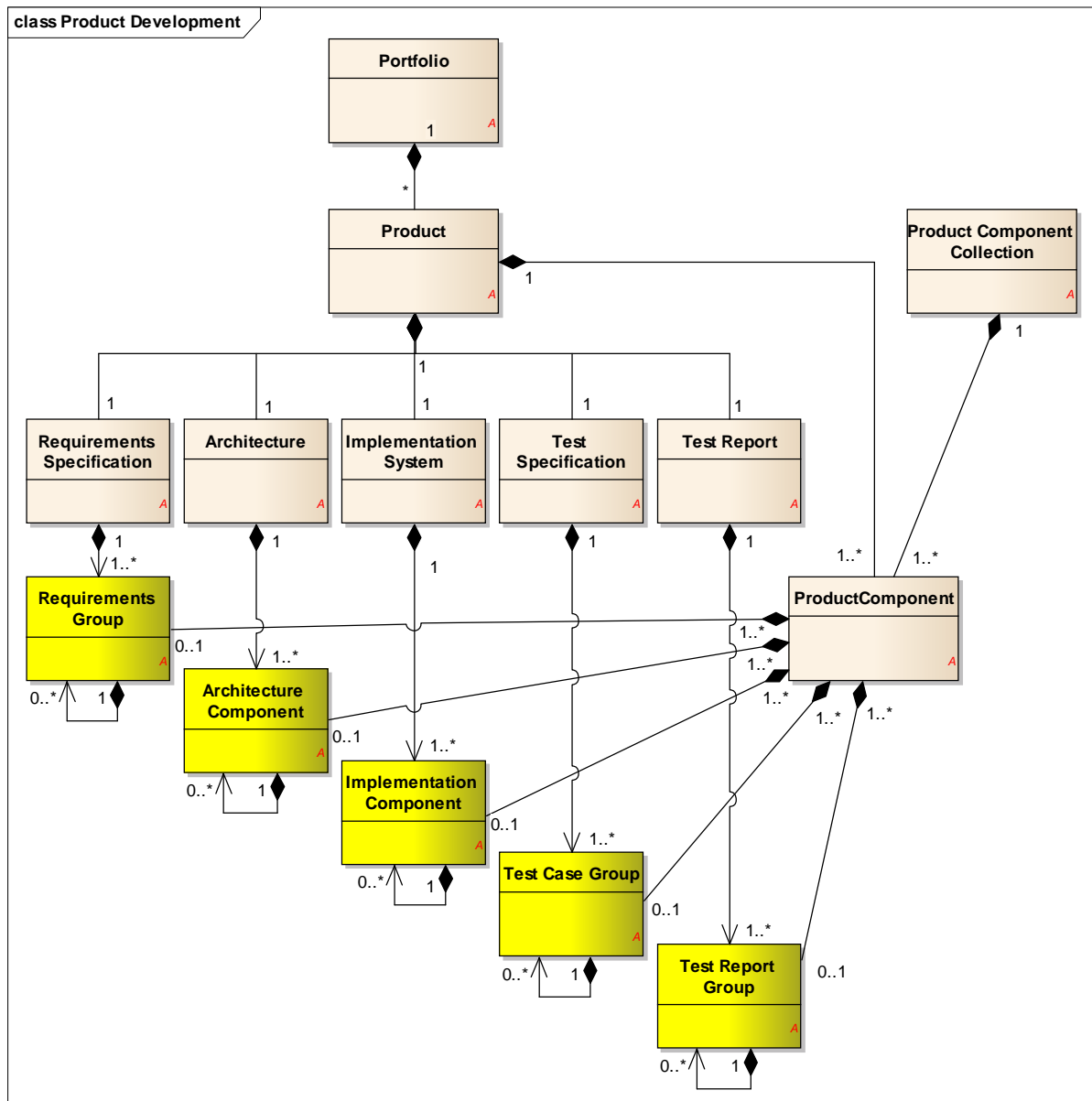
Figure 8: Multi Product Development

The **Portfolio** is a set of several products. These products are different but use similar components.

The **Product** represents one product to be delivered to a customer including the complete specification and documentation. Each product is defined by its work products, one work product of each item type. The work products consist of item groups.

The **Product Component Collection** represents a collection of all available product components. These product components should be reused in different products as much as possible. It is needed by the portfolio for identifying the product components for reuse.

6   Example: Calculator

An example demonstrates the model. A simple calculator with variants can be modeled with different views which show the relations of dedicated aspects. In this paper only one view is shown with associations of only one variant of the product.

The portfolio consists of two products: a standard calculator and a professional calculator. Both calculators are similar but the professional calculator uses parts with a higher performance (see figure 9).

object Example

```
pf :Portfolio

professionalCalculator :        standardCalculator :          pcc :Product
Product                          Product                       Component Collection

r ProfCalc :    a ProfCalc :    i ProfCalc :    s ProfCalc :Test   x ProfCalc :Test
Requirements    Architecture    Implementation  Specification      Report
Specification                   System

r Body :        a Body :        i Body :        s Body :Test       x Body :Test        Body Chassis :
Requirements    Architecture    Implementation  Case Group         Report Group        ProductComponent
Group           Component       Component

r CPU Float :   a CPU Float :   i CPU Float :   s CPU Float :      x CPU Float :       CPU Float :
Requirements    Architecture    Implementation  Test Case          Test Report         ProductComponent
Group           Component       Component       Group              Group

                                                                                       CPU Integer :
                                                                                       ProductComponent

                                                                                       Memory Dynamic :
                                                                                       ProductComponent

r Mem Dyn :     a Mem Dyn :     i Mem Dyn :     s Mem Dyn :        x Mem Dyn :
Requirements    Architecture    Implementation  Test Case          Test Report
Group           Component       Component       Group              Group              Memory Static :
                                                                                       ProductComponent
```

Figure 9: Calculator Example

The product component collection contains

- One product component for body chassis used for both calculators
- Two product components for CPUs, one float CPU for the professional calculator and one integer CPU for the standard calculator
- Two product components for memories, one dynamic memory for the professional calculator and one static memory for the standard calculator

The professional calculator consists of the three product components body chassis, float CPU and dynamic memory. These product components contain the item groups for the work products requirements specification, architecture, implementation system, test specification and test report. As mentioned above these product components also contain the traceability between the single items.

The standard calculator reuses the product component body chassis as it is, i.e. the work products of the standard calculator contain the same item groups including the traceability. This approach reduces the development effort especially by reusing the traceability.

7   *Conclusion*

In the daily business many of different basic specifications shall be reused very often in different portfolios or products. In the classical way of requirements engineering only the structured requirements can be reused. If the given rules in this paper are fulfilled, it is additionally possible to reuse different item types, e.g. architecture, implementation and test consistent and in one step as a product component. Variants can be handled, e.g. by different sets of items in the item groups of a product component.

The presented method for documenting a continuous flow of information and respecting the transparency of the activities of the different disciplines is only one part of a wider discipline. Especially the problem of handling different variants is not sufficiently solved, yet. Other topics for the future may be platform development, parameterized items, metrics and key performance indicators. The model can also be extended to management disciplines like project management, change management etc.

The work on this model for traceability and reusability has not finished yet and will be continued. It is always a benefit to use the experience of experts from different domains and companies to discuss the possible views of a problem, and the members have the interest to include more views and aspects.

8   Literature

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5. ARC42: arc42 contains a template for development, documentation and communication of software architectures: www.arc42.org

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Rainer Dreves began his business career as a hardware development engineer for digital satellite receivers. In 1999 he changed to Continental and developed embedded software for complex chassis

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After receiving his PhD in theoretical solid state physics Mr. Haunert is working since 18 years in various positions at Giesecke & Devrient. He was able to collect experience in patent work, software development and software testing, as well as in project management. In the past years, Mr. Haunert was engaged in the definition and implementation of a systems engineering process. His main focus is on the integration of various tools available on the market in order to get an end user easy to use tool chain.

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Bernhard Sechser graduated at the Friedrich Alexander University Erlangen-Nuremberg as a computer scientist in 1996. He began his business career as a software developer at Siemens. In 1997 he changed to Continental, where he developed embedded software for the automotive industry. Starting in 2001 Bernhard increasingly managed the quality assurance activities of a business unit at Continental. In 2008 he became the global head of the Quality Management System Integration department. He was responsible for planning and implementing a quality strategy for the entire system and software development and conducted numerous SPICE assessments. In 2009 Bernhard Sechser joined Method Park, where he passes on his knowledge and experience as a Principal Consultant for SPICE & Safety and intacs Principal Assessor.

Safety and Software Metrics in Safety Critical Applications: Towards a Meta-Analysis

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Abstract

Software components are key elements in safety critical applications. Our daily activities rely on a proper functioning of these components, and metrics are widely used in industrial sectors such as automotive, avionics and railway (e.g. electronic hand-breaks) in several ways. In order to ensure that a critical application is safe, we need to set up mechanisms to analyze each application domain. Metrics are key elements, and we need to identify them as a previous step to develop, analyze, assess or certify any kind of safety critical applications. This paper provides a systematic literature review of safety and software metrics used in safety critical applications during their development phases, and a statistical analysis of these metrics in safety critical applications.

Keywords

safety metrics, software metrics, systematic literature review

1 Introduction

Nowadays the role of metrics is becoming more relevant in industry especially in safety critical contexts which are increasingly relying on software components for their appropriate operation. This kind of contexts such as critical infrastructures, au-tomotive, avionics or cybersecurity contexts have reported the use of metrics for different purposes. For example cybersecurity can be mitigated by using metrics [1], and in automotive or avionics contexts, metrics are used to control safety from a general point of view [2]–[5] These application domains use a wide set of techniques such as FMEA (Failure Mode and Effect Analysis) [6] or FTA (Fault Tree Analysis) [7] or QFD (Quality Function Deployment) [8] to minimize failures in the resulting products. One common aspect to these techniques is that they rely on measurements and at the end on metrics. The identification of metrics is a key aspect that we need to know when we are analyzing a safety critical application. However there is not a consensus on what are the metrics appropriate for each specific situation.

Software engineering has quite well defined metrics [11] allowing to assess a soft-ware engineering project. Some metrics concepts from the software domain can be reused to other domains [12], but it is not considered a common praxis. Measurement methods [13] have been widely discussed in litera-ture, and they have been applied to these domains to ensure that a system is safe.

Safety metrics are the main building blocks for setting a safety management sys-tems [14] which is required for assuring safety critical applications. The usefulness of indicators are difficult to assess: "For safety indicators with their long-term effects, diagnosis is even more difficult" [15]. An appropriate identification of safety metrics helps us to measure not only product properties, but also to analyze the safety during an assessment or certification of a component. Therefore there is a need for setting a measurement framework from a general point of view in safety critical systems such as in [16] where authors define a framework for measuring software safety risks. This is especially relevant during the certification process of safety critical systems [17]. Thus it is relevant to identify what are the most important metrics in a certification process [18] or in safety critical applications in general. Literature reveals several techniques and approaches used in different application domains.

A meta-analysis study as explained by Wholin et al.[19] provides a synthesis of a topic based on sta-tistical methods. Several efforts have been devoted in this sense such as [20] where authors analyze the effectiveness of pair-programming. Some of these analyses rely on systematic literature reviews (SLR) [21], and our approach is also based on SLR. This research aims at providing a meta-analysis of safety and software metrics inside the reported literature. Therefore a systematic literature review on safety metrics in the context of safety analysis for safety critical applications is carried out in this paper. Additionally our systematic literature review (SLR) which is based on [21], improves the limitations described in [22] by adding three cycles of the systematic process.

This paper is structured as follows. First a background on safety and software met-rics is provided in order to introduce the main challenges. Second a research method and strategy is defined for our SLR. Third section includes the main results of this systematic literature review and on our meta-analysis results. And finally a conclusion section ends this paper.

2 Background

2.1 Safety metrics

This paper goes deeper in the analysis of safety metrics, but in short there is a wide set of papers referring to the safety metrics concept. Some of them are used for safety monitoring [23] or test suites [24]. From a theoretical point of view, a safety metric temporal logic has been proposed [25] for exam-ple. From an industry perspective, several research works have reported on safety metrics such as in

robotics surgery [26], road transport systems [27], and recently in cyber-physical systems [28]. Reliability [29] is an aspect widely discussed in safety critical applications, and several research works have been proposed [30]. But this study on metrics it is not just focused on this aspect. Instead we consider safety and software metrics in a broader sense for safety critical software systems.

2.2   Software Metrics

In the software engineering discipline there are several metrics which have been defined and reported. Khan [31] gathers different approaches and some software metrics which are used in industry. Cruickshank, Michael, Shing, [32] define a validation metrics framework in order to validate safety requirements. Kitchenham [33] provides a mapping study on software metrics and it identifies trends in this context. As results she stated that there are several limitations of empirical studies in software metrics such as its context or the implications of linear relationships. In fact she stressed the challenge to aggregate this kind of results into an empirically- based body of knowledge. Therefore there is a need to understand how software metrics are used in different contexts such as in safety domains.

2.3   Motivation and objectives

There are several papers related to systematic literature review in general [34], but it is hard to find a study with this approach related to software and safety metrics. In fact recently Aman Jatain and Yukti Mehta [35] reported a comparative analysis of a set of models in the context of software reliability. Our motivation is to understand what are the main reported metrics and techniques, what has been reported until now, and to analyze the relationships between studies related to software metrics and stud-ies related to safety metrics. We have identified the following set of research ques-tions for this study:

- RQ1: What is reported in the peer-reviewed research literature about safety and software metrics in safety critical software applications?

- RQ2: Is there any relationship between these metrics?

- RQ3: What metrics and techniques are the most reported?

3   Research method and strategy

3.1   Research strategy

The research was designed to be a systematic literature review [21], and improving the limitations described in [22]. This paper presents all activities described in the following Figure 1 which describes our systematic review strategy. This strategy starts by defining a research area and limiting the scope which has been described in "motivations and objectives" section.
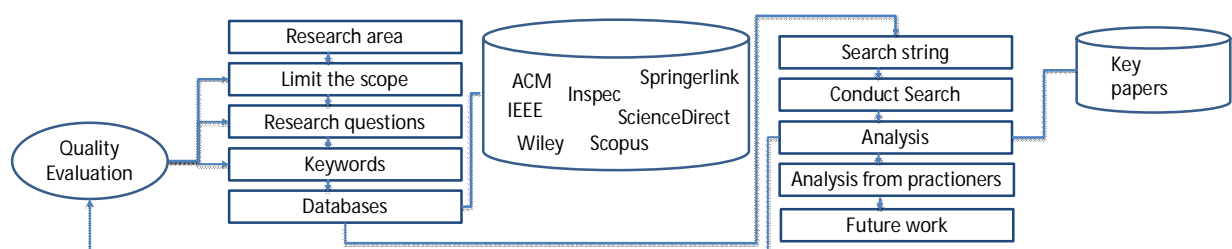

Figure 1. Systematic approach

3.2 Data source

Our strategy starts by defining a research area and limiting the scope to safety metrics in safety critical applications. This approach helps us to identify a set of research questions stated in the next section. A set of key words are derived from these questions and they are based on previous research works such as [36], and a set of well-known databases are selected such as ScienceDirect (http://www.sciencedirect.com/), SpringerLink (http://link.springer.com/), IEEE Explore (http://ieeexplore.ieee.org/Xplore/home.jsp), ACM Digital Library(http://dl.acm.org/) and Wiley InterScience (http://onlinelibrary.wiley.com/), Web of Science (http://apps.webofknowledge.com/) and Scopus (http://www.scopus.com/).

3.3 Data retrieval

We have designed three cycles for data retrieval according to each search string in order to refine and to limit the scope for our study. We have included a quality eval-uation step into this SRL approach. The search results are just limited to English papers. The first search string is defined as "safety metrics". As result of this step we have obtained 338 papers from the data sources identified related to safety metrics in computer science. The main problem of this string is the scarce contextual infor-mation for safety metrics in safety critical software applications scenarios. Due to space limitations we have not included tables describing their distribution among the years.

The second search string is structured in a way to include such contextual infor-mation for this kind of safety critical scenarios. The second string is defined as (X1 OR X2 OR …) AND (Y1 OR Y2 OR …) AND (Z1 OR Z2 OR …) AND (W) where X includes application domain, Y includes safety areas where safety metrics are used, Z includes safety cases concepts and W refers to safety metrics concept. The resulting second string is *((("critical software" OR "critical system" OR "critical systems" OR "critical equipment" OR "critical application" OR "critical applications" OR "em-bedded system" OR "embedded systems" OR "embedded software") AND ("safety certification" OR "safety evaluation" OR "safety assurance" OR "safety assessment" OR "safety qualification" OR "safety analysis" OR "safety stan-dard" OR "safety standards" OR "safety requirement" OR "safety requirements") AND("safety case" OR "safety argument" OR "assurance case" OR "dependability case") AND ("safety metrics"))*). As result we obtained 22 papers.

The third string uses the same values for X, Y, Z but we use "software metrics" for W. The resulting third string is *((("critical software" OR "critical system" OR "critical systems" OR "critical equipment" OR "critical application" OR "critical applica-tions" OR "embedded system" OR "embedded systems" OR "embedded software") AND ("safety certification" OR "safety evaluation" OR "safety assurance" OR "safety assessment" OR "safety qualification" OR "safety analysis" OR "safety standard" OR "safety standards" OR "safety requirement" OR "safety requirements") AND ("software metrics")))*. As result we obtained 43 papers.

3.4 Research process and inclusion of papers

The research process's steps taken to extract the final set of studies are structured in three cycles. As stated before we proceeded with three strings covering searches on safety metrics in general, safety metrics in safety critical applications and finally on software metrics for safety critical applications. The results coming from these three sources sum a huge number of papers, and some of them are not available. So we proceeded such as Jalali and Wohlin [37], and we discriminate some of these papers as "relevant", "irrelevant" and "maybe relevant". This discrimination process is the same for these three search strings, and there is a common set of steps. Firstly a basic search is performed based on each search string. Secondly following Petersen et al. approach [34] we select papers which are Eng-lish written, and which titles, keywords and abstracts are framed in the computer science domain.

This process is carried out by both researchers separately in order to reduce potential bias. Each pa-per was voted by each researcher, and the following rules were applied in order to decide on its

inclusion into the final list: Include paper if reviewer A "relevant" and reviewer B "relevant", or reviewer A "maybe relevant" and reviewer B "relevant" or vice versa, or reviewer A "irrelevant" and reviewer B "relevant" or vice versa, or reviewer A "maybe relevant" and reviewer B "maybe relevant". And do not include paper if reviewer A "irrelevant" and reviewer B "irrelevant", or reviewer A "maybe relevant" and reviewer B "irrelevant" or vice versa.

3.5   Classification and Data extraction

A well-known classification schema defined by Wieringa et al. [38] for determining the research type it is adapted and used for our purpose. These categories are:

•   Evaluation research: Investigation of a problem and it reports techniques in practice.

•   Proposal of solution: A solution technique is proposed and argued.

•   Validation research: Investigation on properties of a solution proposal.

•   Philosophical paper: This kind of papers set a new way to look things.

•   Opinion paper: This kind of papers include authors opinion, and they argue about their position

•   Experience paper: Focused on author's personal experience emphasizing what instead of why. MS Excel was used for data collection. Our improved SLR approach consists of 3 cycles, and finally 43 candidate papers were selected for the final analysis. From this set of papers 36 were fully read, and 6 were excluded because they were redundant or they did not provide value for the study

3.6   Statistical analysis

Our statistical analysis represents an initial step of a more detailed analysis of these metrics. There is no consensus on what are the steps in a meta-analysis study. In fact the authors in [20] provide a depth statistical analysis which is appropriate for studying the topic subject of the study. In [39] the author states:
Meta-analysis, or the analysis of analyses, can support investigations of important hypotheses and provide researchers with a powerful way to quantitatively summarize a field of inquiry.

Our purpose is to analyze what has been reported in metrics in safety critical contexts, and the relationships between studies. This statistical analysis is not meant to provide a depth analysis but rather identify a path towards a deep meta-analysis of the role of metrics in safety critical scenarios. Our analysis is mainly focused on correlation (Pearson factor).

4   Results

4.1   Results of literature review

Our SLR approach is structured in three cycles corresponding to each search string. Figure 2 shows these three cycles with the results for each search string.

The first search generates 338 papers related to safety metrics by analyzing au-thors, titles and abstracts [21]. The resulting papers are too generic for the study but they were analyzed over the years. As result we obtained 338 references which demonstrates that safety metrics in general are increasingly having interest. This is an initial result of our first cycle analysis. We refined our search excluding papers which are more related to other disciplines such as chemical and biological areas. As result we have 227 papers covering a wide variety of aspects, not just safety critical applications. A

second cycle is performed for identifying safety metrics for safety critical applications. Due to space limitations we have omitted this table but it demonstrates that there are too few publications on this topic and that they are spread among the last years. A further refinement was defined for the third cycle which is focused on software metrics in safety critical applications. 43 papers were selected and 36 were considered for the analysis because we avoided duplicated papers, and we followed the inclusion process described previously.
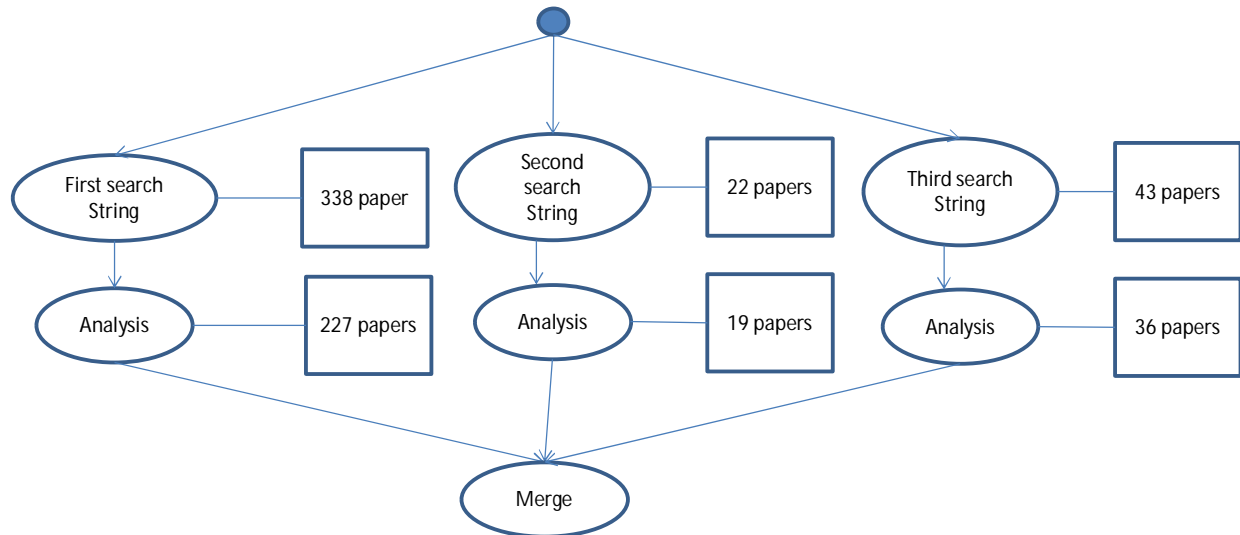
Figure 2. Three cycle data retrieval results

4.2   Software metrics and successful applications

This paper is focused on software metrics in safety critical software applications so we concentrated our efforts on the results of the third cycle. The previous two cycles are interesting to identify trends from a more global perspective and we identified correlation between these metrics. We classified the results of the third cycle (36 pa-pers) according to Wieringa et al. [38], and we represented them in Figure 3. We fol-lowed Jalali et Wohlin approach [37] for considering successful cases. Figure 4 repre-sents metrics frequency and
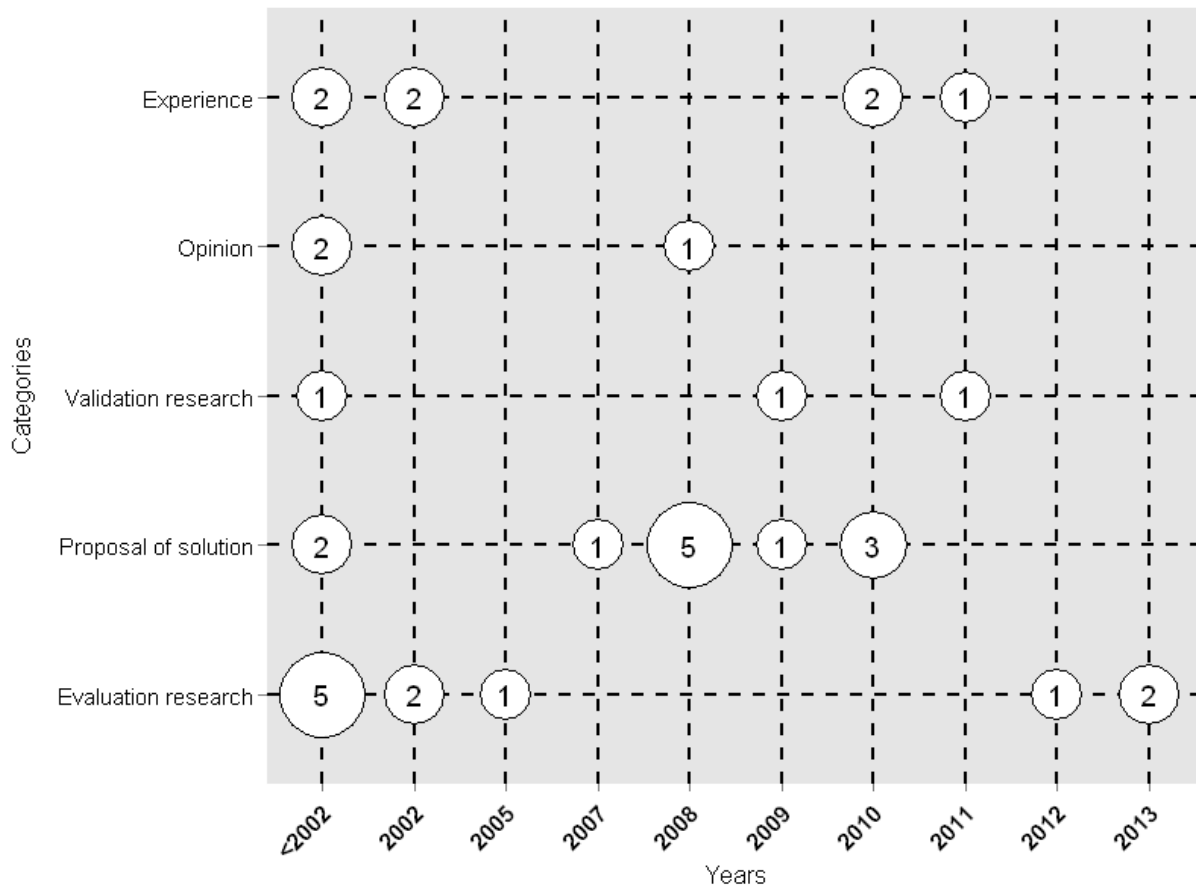
Figure 3. Distribution of research types over the years for software metrics in safe-ty critical applications
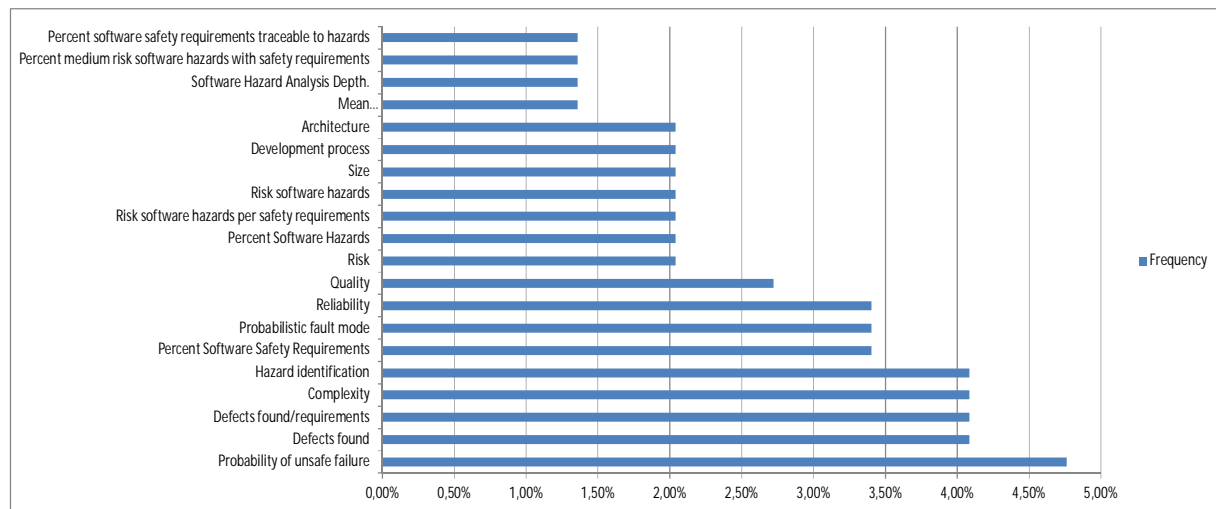
Figure 4. Frequency of metrics used

Probabilities are an important factor and metric to be considered and obviously it appears in the first position. These papers are classified according to Wieringa et al. [38] classification schema (Figure 3), and the distribution of papers according to this classification is the following: Proposal of soluti-on:33,33%, Evaluation research 30,56%, Experience: 19,44%, Validation research: 8,33%, and Opini-on: 8,33%.

4.3   Techniques used for software metrics

The main techniques reported are in the following in the following order: Bayesian Beliefs Networks, Hazard identification, Safety cases, Quality, GQM, Size, Continu-ous time Markov chains, FTA, FMEA, Multi Criteria Decision Aid (MCDA), and Software Hazard Analysis Depth. Figure 5 represents with a solid line safety metrics in safety critical applications, with a dashed line safety metrics and with a pointed line software metrics.
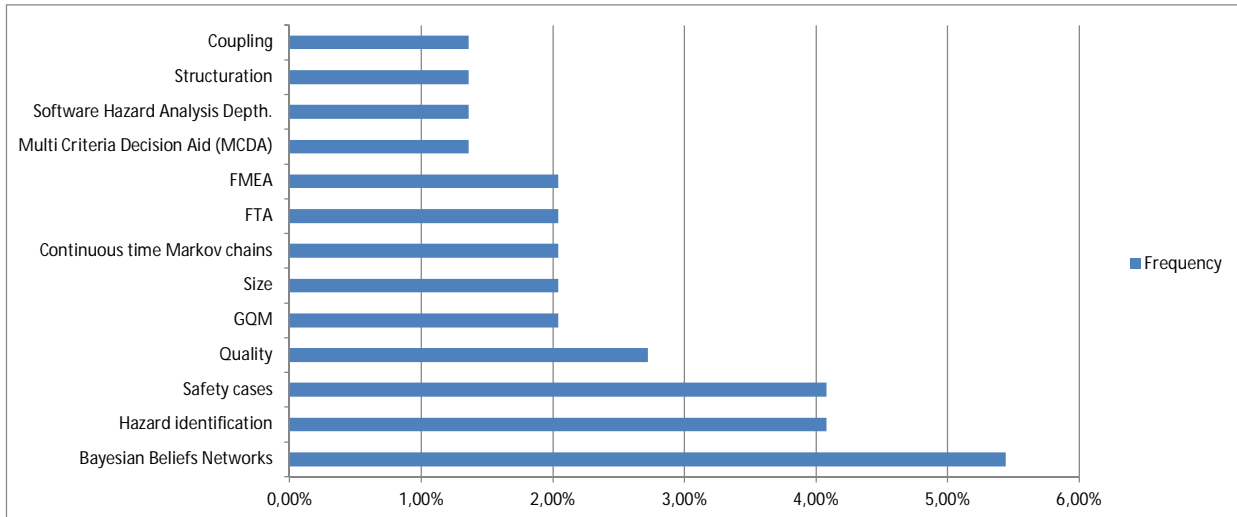
Figure 5. Frequency of techniques used.

4.4   Correlation among metrics

As stated previously our SLR approach is structured in three cycles, and it helps us to identify correlations between these data sets. In fact a correlation analysis of these data sets is defined as follows (correlation coefficient and Pearson):

- Safety Metrics – Safety Metrics in Critical Applications: 0,658, and Pearson factor: 0,64828562

- Safety Metrics – Software Metrics: 0,741, and Pearson factor: 0,7197

- Safety Metrics in Critical Applications – Software Metrics: 0,3618, and Pearson factor: 0,336
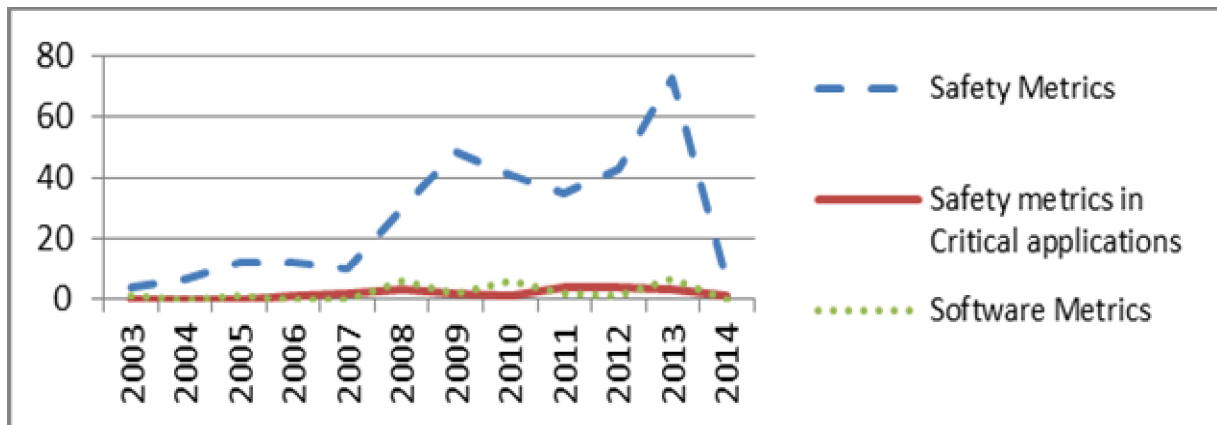
Figure 6. Distribution of the studies from 2003 to 2014

5 Discussion

Safety metrics and software metrics are huge domains where different approaches, metrics and techniques are used. This paper represents a systematic study showing that metrics are reported in different ways and they are applied to different domains making this analysis difficult. In this sense contextual information can be used to analyze where a specific metric is used or recommended from these reports in one domain or situation. However we do not get enough information, so we cannot conclude anything in this sense. We obtained data about the context reported in these papers but in an unstructured way. This concept is a relevant aspect to be considered when we need to identify metrics. Some papers refer to a specific development phase but there are other papers which phase information is missing. Therefore they are not taken as reference this classification, and they cannot be included as result of this paper.

From this study we can identify that the main software metrics used (Figure 4) are related to probability of unsafe failures, defects found and complexity. Surprisingly the naïve metric called "defects found" is still predominant on these papers. Hazard identification and risks are also relevant aspects which should be measured, but there are no standardized and detailed metrics for capturing hazards and threads. In addition there are several techniques (Figure 5) which are used in a wide set of domains. The predominant technique is related to Bayesian Beliefs Networks which are really complex to implement in real scenarios. In this sense safety cases analysis and hazard identification as technique are used to analyze threads and hazards in general.

Our data extraction process is inspired from Petersen [34], and it contributes to our systematic literature review (SLR) which is also based on [21]. Our three cycles im-proves the limitations described in [22], and we have reduced the potential bias during the evaluation process. However we have not completely eliminated the inherent potential bias.

Finally our three cycle approach shows that there is an interesting relationship be-tween these three cycles. In fact we can appreciate a correlation between safety met-rics and software metrics. In this sense we do not take into account what specific metrics are used, and if there is a correlation between them. This is a common problem in SLR approaches which are based on the results of the search strings. A second correlation is between safety metrics and safety metrics in critical applications. This indicates that most of safety metrics are used in this kind of safety critical applications.

6 Conclusions

Software and safety metrics are relevant elements to be considered when we are developing and analyzing a system, especially in safety critical applications. This paper defines three research questions, and we have provided an answer to each of them:

RQ1: What is reported in the peer-reviewed research literature about safety and software metrics in safety critical software applications? A systematic literature ap-proach is defined in three cycles including specific searches for each case.

RQ2: Is there any relationship between safety metrics and software metrics? A brief correlation analy-sis is provided, and we can conclude that the studies on safety metrics and the studies related to soft-ware metrics are aligned to some extent.

RQ3: What metrics and techniques are the most used? Our SLR provides a snap-shot of the metrics used and the techniques reported in literature based on a systematic approach.

This paper defines a novel SLR containing three cycles which are used to evaluate how the research works are reported in general and specifically on this domain. There are thousands (338) of reported safety metrics, and their study must be refined to a particular domain because they include a wide range of applications. All these metrics have different degree of definition. Some of them are really detailed and in other situations their definition is uncompleted. Therefore a standardized way to report metrics should be defined in future works in order to compare and contrast metrics. Even it should be considered to include a way to report experiences of using metrics. In addition this paper discusses

some limitations of the SLR and the inherent complexity to extract information related to classification criteria. Metrics are applied to different phases of the development process, and in some research works this information is missing. Each software development phase should be related to a set of metrics.

Further analysis on specific metrics and on their calculations must be performed. In fact we are currently analyzing how these metrics can be configured in a measurement framework for assuring safety critical applications. Some of them can be automatically generated but in most of the cases they require a human interaction to calculate a final value for the measurement. Another aspect with a huge interest in industry is what and how metrics can be used for certifying a system or a component. In addition it would be useful to re-certify a system or a component to be reused in another domain.

Acknowledgment

7 Literature

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Refactoring Technical Support to Reduce Interrupts of Developers

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Abstract

In this paper an analysis of a technical support data with the goal of identifying process improvement actions for reducing interrupts is presented.

A technical support chat is established and used to provide internal developer support to other development teams which use the software code developed by a core team. The paper shows how data analysis of a 6 months support time helped to identify gaps and action items for improving the technical support process to minimize interrupts from other developer teams.

The paper also shows effects (advantages and drawbacks) of refactor actions taken based on this analysis.

Keywords

1 Introduction

Classical management and process improvement frameworks use measurement as a tool for continuous improvement. Upper levels of widespread SPI approaches such as CMMI or (Automotive) SPICE recommend quantitative management of work products and processes [1], [2]. These approaches focus on "what" to be done, and they intentionally do not provide further guidance on "how" to analyse data or "from where to collect useful data".

This paper shows how action items of a process improvement were identified at a core automotive software development team supporting a high number of projects (and high number of other developers) based on simple analyses of data extracted from a modern messaging application.

As a trigger of this analysis, management of a business unit at NNG LLC. requested a root cause analysis to investigate why technical support time was high at a core team. The initial root cause analysis was broken down to several sub-analyses, including the analysis of how interrupts of developers could be reduced. The scope of this paper is to focus only on reducing interruptions and on identifying process improvement opportunities related to the reduction of interruptions and to review effects of improvement actions taken. It is not in the scope to describe the whole root cause analysis performed at the core team.

NNG is a global leader of automotive navigation software, has 700+ employees in different locations, most of them in 5 different buildings in Budapest, Hungary. After several discussions with the management representatives and interviews with the technical staff it came out that one main channel of technical support requests is a Skype chat, having members from all over the organisation including the members of the investigated core team.

From development point of view support chat requests (messages) are considered interrupts. Drawback of developer time interrupts has been investigated by multiple researchers and it was shown that interrupts can have negative effects on software development performance and the cost and effects (e.g. recovery time after an interrupt) can be quantified [3], [4]. Due to the negative effects of interrupts it was considered relevant to perform the analysis and identify action items accordingly.

Section 2 describes the approach used in this paper, section 3 presents the data collection and data preparation, section 4 shows the data analysis on collected data, and section 5 provides a brief summary of improvements based on analysis results. Section 6 describes the effects of the improvement actions taken. The paper ends with limitations in section 7 and conclusion in section 8 respectively.

2 Approach

The question to be answered in this paper is: "How interruptions from technical support chat could be reduced based on chat log analysis?"

In order to answer the question the following steps were identified:
   I.   Interrupt data collection and data preparation (discussed in 3),
   II. Interrupt data analysis (discussed in 4),
   III. Identification of process improvement actions based on data analysis results (discussed in 5),
   IV. Discussion of the effects of process improvement actions taken (included in 6).

3 Data collection and data preparation

In order to perform the organisation-related data analysis of a support chat, two data types were identified: (1) the logs of the chat and (2) organisation related data such as roles and composition of teams.

The following steps were performed during the data collection and data preparation phase:

1. Data collection from support chat

   A 6 months chat log was provided by the team leader involving 140+ active days which was considered sufficient for the analysis. Data from Skype has been collected by making use of SkypeLogView tool [5].

2. User data collection from internal database

   At NNG, list of employees, teams and various contact information including Skype are stored in a database. Skype IDs of active users of the support chat were used as a search key in the internal database.

3. Data preparation

   Data preparation consisted of merging user information collected from the internal database with the data collected from support chat log. All activities were considered as message sending (broadcasting) and end-line characters were removed from multi-line messages (considered as one message). Messages sent with the same timestamp by the same user were considered as single, multi-line messages.

4 Data analysis

According to the SPI Manifesto [6], involvement of the people started at the very beginning, metric candidates were identified in a brainstorming: total number of users, number of active users in a period, number of inactive users in a period, total messages, number of messages of the investigated team, external messages, total messages per user (most and less active users), total messages per role (most active role), average number of messages / day, average number of messages / hour and conversation length.

A period of **~6 months** has been analysed (2014.7.7-2015.2.11), including **218** days of which **144** were active days having 3529 messages in total. A day is considered active when at least one message is sent. Only partial data were available on the first and last days, therefore in some of the analyses these two days were excluded, taking into account only 142 active days (e.g. when calculating daily averages) with 3498 messages in total.
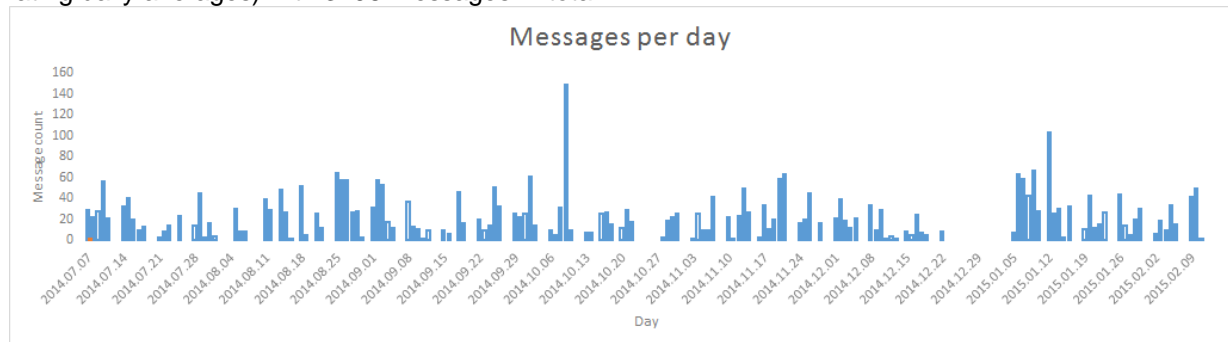
Figure 1 – Distribution of messages per day

The cost/benefit ratio of a measurement is always a central question. Therefore it was decided that only quick and simple measurements will be performed (and not all the possible analyses). For example "conversation length" was excluded because it could be difficult to measure real length of a conversation when multiple users interact in the chat room. Skype chats are working in a broadcasting mode: all members get all messages. Thus, it is difficult to identify attributes of conversations such as start time, end time, interrupts by next conversation start, all those which are needed to identify conversation lengths.

Taking into the account the metrics cost/benefit ratios the following set of the metrics were identified to be measured: messages per day, hourly distribution of messages, distribution of messages per weekdays, active versus inactive users, activeness of teams, activeness of roles and behaviours of top

active users. In this section these metrics are discussed.

1. Messages per day

In order to identify peak days, message distribution per active days was checked first.

Figure 1 shows the message distribution for the entire analysed period. The days with most messages had line counts of 149, 103, 67, 64, 63, 63, 61, 59, 59 and 58. For further information on the average and median of messages sent per day in this period see Table 4.

2. Hourly distribution of messages
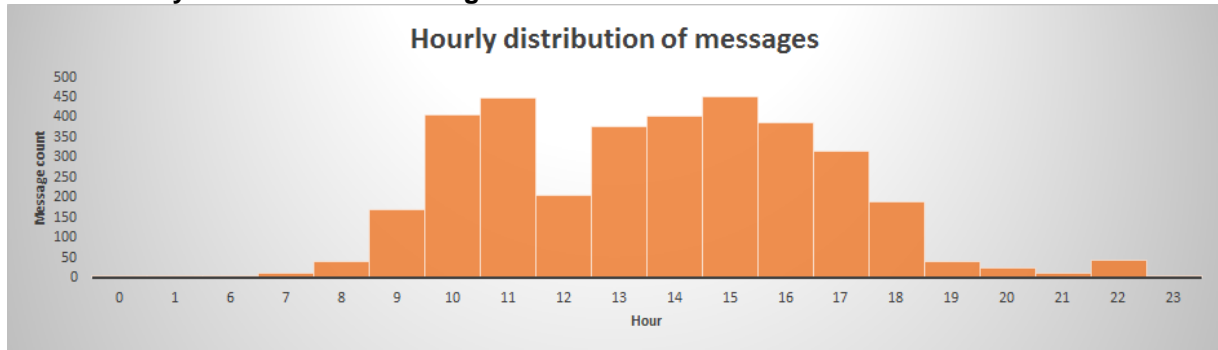
Figure 2 – Hourly distribution of messages

Measuring the peak hours of support time was in the scope of investigation. Figure 2 and Table 1 show the hourly distribution of messages. Peak hours are **15-16** and **11-12**.

Table 1 – Message distribution per hour

Hour	Messages	Average
15	452	3,18
11	449	3,16
10	405	2,85
14	402	2,83
16	388	2,73

3. Peak days

Similarly to peak hours it was investigated if there were peak days. Messages were distributed among weekdays as follows: Monday (709), Tuesday (713), Wednesday (586), Thursday (817), Friday (621), Saturday (49) and Sunday (3). It can be seen that (1) some messages were sent on weekends and (2) *there are no considerable differences among the number of messages sent on working days.*

4. Active and inactive users

Since messages are broadcasted, it was interesting to see what percentage of users were inactive in the period analysed. 23% of users (35 out of 154) were inactive in the analysed period. NNG has 700+ employees meaning that 22% of employees are member of this support chat of which 17% of all employees were active in the investigated ~6 months.

5. Activeness of teams

The analysis of activeness of teams showed, that out of the 3529 messages, 1154 (33%) were sent by the investigated team (9 people out of 18 team members) and the rest were sent by other business units and teams. The analysis also showed that even business units with up to 30 active members sent less messages.

6. Activeness of roles

It was also in the scope of investigation to see if employees with the right roles (developers) are sending messages on the chat. It came out that the majority of messages (68%) are sent by developers.

Distribution of messages per role was as follows: Developer (2386 messages sent, 68,21% of total messages), Project Manager (187, 5,35%), Team Leader (176, 5,03%), UI Developer (165, 4,72%), Technical Lead (131, 3,74%), Software Tester (87, 2,49%), Test Automation Engineer (65, 1,86%), Product Engineer (61, 1,74%), Architect (45, 1,29%), Other roles (195, 5,57%).

7. Top active users

Table 2 shows activeness of top 10 most active users based on message count. It can be seen that the most active user sent 315 messages in total which resulted in only 2,22 average messages per day. It also can be seen that top 4 active users are members of the investigated team.

Table 2 – List of top 10 active users

User Alias	Total messages	Avg. message / day	Team	Role
User 1	315	2,22	Investigated team	Developer
User 2	293	2,06	Investigated team	Developer
User 3	183	1,29	Investigated team	Developer
User 4	141	0,99	Investigated team	Developer
User 5	140	0,99	External team	Developer
User 6	111	0,78	External team	Team leader
User 7	107	0,75	External team	Developer
User 8	98	0,69	External team	Developer
User 9	93	0,65	External team	Developer
User 10	89	0,63	External team	Developer

5 Improvements identified based on data analysis

Table 3 shows the ID and metric number (column 1), results deducted from Skype chat log analysis (column 2) and gaps identified (column 3).

Table 3 – Analysis results and gaps

ID (metric)	Analysis result	Gap
S-F1 (1)	There are days on which support chat interaction is high. In these days it is common that 20+ messages are sent in peak hours, often resulting in an interrupt in every ~3 minutes (cases were checked). In case if users are listening, their day is practically lost on peak support days.	Developers are not protected from interrupts
S-F2 (1, 3)	It is unexpected when a peak support day occurs (no trend can be derived).	Developers are not protected from interrupts
S-F3 (2)	Peak support hours overlap peak developer hours (core office hours are between 10-16).	Developers are not protected from interrupts
S-F4 (6)	68% of interaction is by developers.	No support role exist for support tasks
S-F5 (observed, not in 4)	It is difficult to search in (Skype) support chat log and new users have no access to the skype log, same questions may happen in future.	There is no knowledge base
S-F6 (5, 6,7)	Top commenters send 0,6-2,2 messages per day and the investigated team members send 0,7 messages per day in average, there is no continuous need for all developers to listen the support chat.	Developers are not protected from interrupts (while they could be protected!)
S-F7 (4)	There are 154 users of the support chat. 23% of users were inactive in the last 6 months. Many of them may be interrupted, especially during peak support days (they may delete or mute support chat to avoid interrupts).	No support chat mute guide

Analysis results and gaps served as an input to the investigated team and to the quality management to identify process improvement opportunities (action items with responsibles and deadlines). Not all of them can be listed within the frame of this paper due to confidentiality reasons. However, most important ones (which can also be shared publicly) were: protect developers from interrupts by (1) defining a dispatcher service policy (2) with a weekly rotating dispatcher role, (3) developing and maintaining a knowledge base (FAQ page) to reduce the number of interrupts of the dispatcher and developers and (4) defining and institutionalizing a support chat mute guide for inactive users (with chat message keywords for activation). Another option for dispatching could be a non-rotating, full time dispatcher, however considering the average number of messages per day, dispatcher rotation was chosen.

6 Effects of actions taken

Effects of actions taken were assessed after 9 weeks of operation in the new settings (1) on a one-hour refactor retrospective meeting and (2) by measuring changes between investigated periods and measuring dispatcher activity.

Refactor retrospective Team members, the team leader and the quality manager attended the refactor retrospective meeting (in total 8 participants). The meeting focused on positive and negative aspects of refactor.

Positive aspects: According to the team feedback (1) the improvement project reached its goal: majority of the team members can work without interrupts, (2) a feeling of success - team members respond and others thank their service, (3) there is always one dispatcher, others do not need to continuously watch the support chat, (4) positive feedback from other teams, (5) since there is always somebody dispatching, response time decreased.

To be improved: (1) the team created a FAQ page, but its development is slow, (2) it is difficult for the dispatcher to find who the expert is in an area, (3) requests are not rated (e.g. based on urgency), (4) the dispatchers wish to solve all issues instantly, even if it is not needed by the policy, (5) some of the externals want bug fixes within the frame of support, (6) not everyone is suitable for the dispatcher role, (6) there are lots of meetings which the dispatchers has to attend and thus they has to be substituted on the support channel, (7) not all the team members use the mute guide.

Team members were also asked to estimate how much time the dispatching role requires in a week. The answer of 7 team members serving in dispatching role varied between 0,5 hours to 8 hours per week (0,5h; 1h; 1-2h; 3-4h, 3-5h; ~5h; 5-8h).

Measuring changes between investigated periods and measuring dispatcher activity

There was an increase in the average of support chat messages in the second investigated period. Table 4 shows a summary of major changes. These changes may be caused by external factors (e.g. organisational growth). Despite the increase in the number of messages and due to the refactor actions taken, team members experienced a decrease in time spent on support.

Table 4 – Comparison of major metrics in the investigated periods

	Both periods	14.7.8-15.2.10	15.3.2-15.5.3
Total messages	4973	3498	1475
Maximum nr of messages per day	149	149	99
Average nr of messages (all days)	17.70	16.05	23.41
Average nr of messages (active days)	27.02	24.63	34.30
Median of messages (all days)	10	9	15
Median of messages (active days)	21	20	28
All days investigated	281	218	63
Active days	185	142	43
Zero message days	96	76	20

	Both periods	14.7.8-15.2.10	15.3.2-15.5.3
Non-workdays	90	70	20

Table 5 shows message statistics of a 9 week "dispatcher-enabled" period in a weekly breakdown, columns are: week number, date interval, all number of messages sent, messages sent by the investigated team, number of messages sent by others (externals to the team), percentage of messages sent by the team, number of messages sent by the dispatcher, number of messages sent by non-dispatcher members of the investigated team, percentage of the messages sent by dispatcher (vs other team members) and dispatcher id. It can be seen that instead of 33% (first period), 57% of the messages were sent by the investigated team. Furthermore, ~49% of team messages were sent by dispatchers. Substitutions (when dispatchers had to attend meetings) are not counted. Some team members were serving as a dispatcher multiple times (see the last column), area expert dispatchers were providing more direct answers (e.g. dispatcher 2), while dispatchers with lower domain experience were asking the help of the team members (e.g. dispatcher 3).

Rest of the initially identified metrics were not re-measured, since no major conclusion would be drawn on the effects of the refactor.

Table 5 – Dispatcher activity in a weekly breakdown

Week	Date interval	All	Team	Others	Team (%)	Disp	Not disp	Disp (%)	Disp
W1	03.02 - 03.08.	52	23	29	55.77	14	9	60.87	Disp 1
W2	03.09 - 03.15.	83	36	47	56.63	23	13	63.89	Disp 2
W3	03.16 - 03.22.	153	61	92	60.13	10	51	16.39	Disp 3
W4	03.23 - 03.29.	137	56	81	59.12	33	23	58.93	Disp 2
W5	03.30 - 04.05.	270	119	151	55.93	65	54	54.62	Disp 4
W6	04.06 - 04.12.	229	108	121	52.84	53	55	49.07	Disp 5
W7	04.13 - 04.19.	104	48	56	53.85	34	14	70.83	Disp 2
W8	04.20 - 04.26.	206	87	119	57.77	52	35	59.77	Disp 6
W9	04.27 - 05.03.	241	94	147	61.00	25	69	26.60	Disp 3
Tot.:	**03.02 - 05.03.**	**1475**	**632**	**843**	**57.15**	**309**	**323**	**48.89**	

7 Limitations

Input data – only a half year log in the first period and a 9 weeks log in the second period were used. In order to gain a more holistic view (and to possibly refactor the support activities of other teams) a larger data input may be used.

In-depth analysis, further metrics to be analysed - there is room to define further, more complex metrics for the analysis (e.g. analysing behaviour of most active users, average response time, length of conversations etc.). However, with the scope of reducing interrupts and with the potential gain, the metrics investigated were considered sufficient.

Changes in roles and within organisation – a mid-size IT organisation, especially if it is transforming from a start-up to a multinational company has many changes even within a half-year period. These changes were not taken into account (e.g. there were multiple changes within the investigated team: role changes or changes among teams). Further changes occurred between the two investigated periods (e.g. the number of support chat members increased from 154 to 173 between the ends of the two investigated periods) which were not taken into the account.

8 Conclusion

The scope of this paper was to answer the question: "How interruptions from technical support chat could be reduced based on chat log analysis?"

In order to answer the question, 7 metrics were analysed and 7 conclusions were deducted, which helped in identifying 4 gaps serving the basis for identifying 4 action items.

The analysis showed that developers are interrupted many times during core developer hours by support chat requests. Data analysis showed that support chat interrupts at the investigated team could easily be reduced and developers could be protected by implementing action items identified in section 5, namely: (1) definition of a dispatcher service policy with a (2) (weekly rotating) dispatcher role, (3) development and maintenance of a knowledge base and (4) definition and institutionalization of a support chat mute guide.

With the analysis done and action items identified, the team started to implement the action items: they defined the dispatcher role, dispatching ideas were collected and summarized in a dispatcher policy - co-authored by the team and externals. When forming the dispatching service policy, ITIL [7] and the advantages of T-shaped people [8] were also taken into account.

After 9 weeks of operation in the new settings, support chat team members were asked to share their experiences with the new dispatcher service. Based on their feedback, it can be concluded that they experienced a clear improvement: despite the increased number of messages on the chat, their time spent on support varied between 0,5 to 8 hours per week for those weeks when they were serving as dispatchers, compared to the previous scenario when no one was clearly responsible for replying to the requests, but everyone was watching the chat and was interrupted. During the weeks investigated the team members did not need to watch the support chat (they were asked to help only in cases they were the experts of an area). The fact that ~49% of team messages were sent by dispatchers reflects that the new scenario is in place. A minor drawback is that the percentage of the messages sent by the investigated team versus all messages raised from 33 to 57.

We conclude that the way the problem was approached (dispatcher policy, dispatcher role, FAQ page and mute guide) can reduce the number of interrupts and requires a limited support time from the dispatchers. Further cases or higher amount of data may be studied before the generalisation of the approach. As a future direction, further techniques (e.g. data/text/process mining approaches, performance evaluation, formal methods, probability theory, polling systems or complexity analysis [9], [10]) and tools (such as ProM, ProM for RapidMiner or DISCO) could be involved to conduct a more detailed data analysis with the goal of understand underlying processes and analysing behaviour of support chats. Interrupts are not (and probably cannot be) fully eliminated as new problems may arise with the improvements (see section 6). As an additional future direction, the introduction of interrupt recovery techniques [11], [12] could also be investigated.

9 Acknowledgement

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11 Author CVs

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Controllability in ISO 26262 and driver model

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Abstract

The standard, ISO 26262, aims for functional safety of automobile E/E systems, and it provides "a framework within which safety-related systems based on other technologies can be considered." We focus on the hazard analysis and risk assessment (clause seven) in the concept phase of ISO 26262 part3. Usually, the risk is calculated from the probability of exposure and severity of harm, but in this standard we also have to consider the controllability of the driver for avoiding the harm. First of all, we'll present the DESH-G (driver, environment, software, hardware and goal) model as a framework. Then we show the driver model in detail, and it gives us the capability of the driver. We calculate the task demand from the situation-scenario matrix (SSM). If the task demand exceeds the driver capability or is in the neighbourhood, we regard it as the hazardous situation. Easiness of avoiding a dangerous condition is the controllability. The way to judge the degree of controllability is proposed using the driver capability and the task demand. In the system, such as the advanced driver assistance system (ADAS), the part of the driver's task is done by the system. It is harder to the design system to decide the behaviour at the border between computer and driver. Our idea is also effective in the development under such situations.

Keywords

Controllability, ISO 26262, DESH-G, driver model, driver capability, task demand, D-zone

Reference

KTM Functional Safety Environment – Break silos, ensure full traceability, modularity and automate reporting

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Abstract

This paper discusses how KTM AG Company addresses ISO26262 functional safety challenges internally and with its partners. KTM has identified four key resolutions to success. 1st - breaking the silos between safety and other departments, 2nd - ensuring traceability between development items to cover the norms, 3rd - accessing the modularity and reusability organisation to make the most of legacy knowledge, 4th - automating the reporting to ensure engineers focus on design (not on document generation). KTM targets an environment embracing Model Based Engineering and a repository of crosswise (work fields) design items. With a strong focus on system engineering, KTM's ambition is not to provide an ideal environment but to introduce one solving its current issues for its present maturity. The environment is implemented and operational on a major KTM project as a proof of concept for future KTM projects.

Keywords

Functional Safety, ISO26262, Model-Based Engineering, Model-Based Safety Assessed, system engineering, KTM

Reference

ECQA Governance Capability Assessor Skills for Managing Strategic Directions

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Abstract

ISO/IEC 15504 process capability assessments (or similar audit approaches) are widely used in specific industries and sectors, like automotive, medical, space, finance, etc. Most of these assessments are performed only at operational levels aiming up to level 2 (Managed) capability targets. The coverage of the governance objectives referred by the enabling processes of the Governance Model for Trusted Businesses helps to use the industry and sector specific process assessment models by establishing the applicable organizational contexts of level 3 (Established) and level 4 (Predictable) process attributes concerning to the operational and supporting business processes. The Managing Strategic Directions scenario - by adapting skills and processes from ECQA certified Governance Capability Assessor job role - helps the management to select and apply those governance practices which are relevant for improving and ensuring the better market recognition, the transparency and accountability of enterprise management, and the commitment to business excellence. This approach is also applicable for the key goals of future global innovation and networking aimed by the ECQA.

Keywords

Enterprise Governance, ISO/IEC 15504 (SPICE), ISO 31000 Risk Management, Enterprise Risk Management (ERM), Internal Control, Governance Capability Assessment, Assurance Management, Global Innovation and Networking, Business Trust and Transparency

Reference

ECQA Ontology and Terminology: Fostering Interoperability and Flexibility throughout the Network

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Abstract

Europe is heading towards a harmonized system of skills and qualifications for vocational and educational training. Professions, skills and competences need to be interconnected and streamlined at national, European and international levels. National qualifications frameworks in Europe have to be supported by an innovative and comprehensive approach.

The European Certification and Qualification Association (ECQA) is the result of several EU-supported initiatives taking place during the last ten years, with the goal of developing and maintaining a set of quality criteria and common certification rules to be applied across the different European and Non-European regions. The result is 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 test questions pool and exam systems, as well as a common set of certificate levels and a common process to issue certificates. Through the ECQA learners can attend courses for a specific profession in their country and perform a Europe-wide agreed test at the end of the course.

A new ontology approach would help to achieve more interoperability and flexibility throughout this network by giving access to participants to training programs from a new multidimensional view, allowing them to understand content and connections between professions and to design their professional curriculum in a more flexible way. This new approach would also give trainers and professionals a better vision of the interdependency between competences and qualifications, making easier to develop interdisciplinary curricula and to fill in educational gaps by creating dynamic portfolios of competences.

The harmonisation of existing syllabi and curricula by using a multilingual ontology methodology, reusable by other professions and job roles should also include the harmonisation of the ECQA terminology and its validation with the already existing European and international initiatives, qualifications programs and standards for vocational training.

Keywords

ECQA, ontology, interoperability, corporate language, competences portfolio, vocational training, harmonization

1 State of the art

Traditionally trainings are organized on the basis of a syllabus defining skills and competences. Facing the need of life-long learning, students continuously have to be able to have access to individual competences included in various syllabi across the barriers of individual professions and training providers.

It is obviously not sufficient any more to develop syllabi in the form of skills and professions, but to interconnect and streamline them at national, European and international levels. The development of national qualifications frameworks in Europe needs to be supported by an innovative and comprehensive approach. This needs to be fostered by harmonization of existing key activities in this sector.

ECQA is the most successful platform in the area of standardisation, unification and certification of skills and competences; also, providing training for these. It offers currently 30 professions, each of them built up according to the required skills of this profession. The training offer is steadily growing in terms of professions and also in the number of languages covered.

Nowadays, participants register and create an ECQA account where they can:

- Browse through the skills and competences for the different professions
- Perform the self-assessment with multiple choice test questions for a specific profession
- Have access to learning references
- Have access to online courses and trainings
- Collect evidences for learning and portfolio building
- Perform the exam and, afterwards get a certificate

Within the ECQA, all trainings are modular, based on learning outcomes as a minimum unit of modularity. The certified training organizations and trainers ensure that all courses worldwide are built according to the same structure and standards.

1.1 New ontology approach

All ECQA job roles are interconnected and they could well continue with further job roles and knowledge areas. This can lead to a few hundred more qualifications and thus support the valorisation in European research and industry.

In order for the users to efficiently search for and understand the content, its interdependencies and connections, related to this training offer, it is necessary to have a representation of all units and learning outcomes of all existing and future ECQA professions in an attractive graphical format. This could be achieved through innovative ontology based visualization and browsing and recommendation of training paths. The single categories of this representation would be linked to a comprehensive description of the units and learning outcomes.

The visualization of professional competences would make education and training much easier, allowing transparency and visibility of learning programs and courses. This initiative could reach an exceptionally vast international community of organizations and universities, through the ECQA community. Learners, trainers, national qualification frameworks, ECQA itself and the European community will directly benefit from a new tool and ontology methodology to guide them through competences, skills and professions in a multilingual and multidisciplinary way.

The idea is to develop, test and implement a multilingual ontology model to compare and visualize the skills and competences of successful ECQA job roles. This new tool would support national qualification frameworks (universities and training organizations) by providing a new procedure and methodology to approach the design of syllabi and professions and to help individuals find the training paths and related certifications that match the best their profile and preferences. The following elements/features should be drafted/developed:

- A study about the state of the art in competency and skill models, with a catalogue of specifications for the skill ontology and an analysis about the corpus for terminology development,
- An interface integrated in the ECQA system with the visualisation of the applied methodology to the set of models of the ECQA job roles,
- A comprehensive guideline for the users (ECQA community but also students, professionals).

The ECQA infrastructure is already supporting more than 6.200 exams, 5650 certificates issued and over 10.000 training attendees in Europe. The new ontology based competence interface will build a new innovative solution allowing to link competence modules of different job roles. This could lead to a cross – fertilization of the existing job role consortia in the ECQA community and a Europe wide exchange of good practice.

To further develop and improve the ECQA platform by a multilingual ontology tool for visualization and cross-accreditation of skill units and professional certificates will be a breakthrough that would serve as catalyst for other European initiatives.

1.2 Sharing skills to create a portfolio of competences

Each skill card for a profession has a modular structure consisting of units, learning outcomes and performance criteria. Overlaps between these elements across professions sometimes are necessary, as some professions call for similar skills (for example, Team Work, Communication Skills or Project Management). Students want to gain new competences. Competences in the form of learning outcomes are so far described only by the individual skill card for the respective profession. However, at the moment 80% of the attendees of ECQA courses and exams only attended one specific job role.

This new ontology approach would help students to find out, which qualification/competence they have already acquired and thus which parts of one profession are eligible for accreditation with another profession. This representation will not only help to systematize the content of future professions, skills and competences. The systematisation would help to define or re-define the scope of an individual units and learning outcomes to gain the big picture of needed and available skills. Double efforts by different Job Role Committees providing different job profiles and courses would be avoided. A clear/unequivocal communication between the different parties would be ensured and would facilitate the faster development of the training offer. The consequence is a support for the development of national qualifications frameworks in Europe and abroad.

A good example for this would be some of the core competences in the ECQA Certified Terminology Manager (CTM) – Basic that could be included in the skill card of other (if not all) job roles.

In the ECQA Certified Terminology Manager – Basic, following skills are defined and trained: CTM.U2.E3 (How to coin terms) where students/participants learn the principles of term formation and concept definition or CTM.U1.E2 (Why terminology management?) where students/participants learn about the applied principles and methods for terminology work and why terminology management is a key issue in companies and organizations.

These competences are multidisciplinary and necessary to organise, define and structure knowledge in all specialised disciplines. And, therefore, it would be worthy to consider the possibility of including them in the portfolios of competences in a multidimensional and interdisciplinary way.

In fact, this idea is already implemented in the ECQA CTM – Basic where we can find some cross-competences that are already part of other job roles (as for example Team Work and Communication Skills that can be found in the ECQA Certified EU Project Manager).

A full list of the trainings, skill cards and competences could be drafted, analysed and paired in order to create a list of transferable competences within the ECQA training, examination and certification system.

With respect to the examination and certification process, the idea behind is that, if one student has already studied and passed a specific competence (as for example, Team Communication for the ECQA Certified Terminology Manager – Basic), this could count it towards his/her certificate for other job role/profession (in that case, for example, ECQA EU Project Manager).

All ECQA certified trainers and training organisations would be trained to provide the same content for each learning element.

1.3   ECQA corporate language and terminology

Not only skills and competences in the ECQA framework should be aligned, but also the terminology behind, toward creating a knowledge management system.

Any organisation in the world has to manage its knowledge to be a player in the global market but, then, they will face the challenges of constantly updating, referencing, tracking and managing knowledge. Online information, guidelines, marketing material, presentations in conferences and software tools are only some of the examples of the media where the corporate language is present. And the ECQA is no exception.

The ECQA faces

- information available redundantly in different systems (ECQA website and platform but also in the website of different partners, job role members, training organisations and certified trainers),

- the necessity of maintaining data in various systems updated with the corresponding time and effort that this involves,

- and the risk of inconsistent or even incorrect data.

Many professionals and different organisations in different countries with cultural differences and several languages are involved in the ECQA working environment. ECQA works in a multilingual environment. All ECQA guidelines are translated into at least 3 languages (English, French and German), most of them into more than 3 languages and the website are translated into 12 languages (English, Bulgarian, Danish, Finnish, French, German, Greek, Hungarian, Italian, Polish, Romanian, Slovenian, and Spanish).

This multilingualism brings a lot of advantages (internationalisation, new market possibilities, better communication between the partners but also with customers…) but also brings disadvantages:

- Proliferation of terms for the same concept (as for example for training organization with ECQA Certified Training Organization, ECQA Training Organization, training organization and training provider) that can lead to misunderstandings and confuse users;

- The difficulty to maintain all information updated and available to all parties;

- And the risk that non-mother tongue speakers coin terms.

A first attempt to harmonise the terminology was ECQA Term. The aim of this project was to collect and analyse the core documentation of the ECQA with the purpose of creating a database with terminology findings (a selection of ca. 100 terms). The results of this project should represent a descriptive collection of the terms used in the association, a study of possible weak points in the terminology workflow and the base for further developments.

This work showed that the effort from the ECQA to make the information available in different languages is more than remarkable. The ECQA understands the importance of speaking the language of their members and users and has a big amount of documentation available at its website (partially in 12 languages). Issues linked to terminology management, multilingualism and translation/localisation in so many languages are not avoidable.

The harmonisation of the ECQA terminology should, therefore, include following aspects:

- The usage of American or British English (an example of this issue would be "certified training organization" vs. "examination and certification organisation").

- The grammar and orthographical principles of the languages should be taken into account when coining new terms. An example in English would be "self assessment" (self-assessment would be correct).

- Avoid the proliferations of terms for the same concept.
  For the concept in the case of "examination and certification organisation" where we can find these terms describing the same concept:
  1. exam and certification organization
  2. exam organization
  3. exam body
  4. examination and certification organisation
  5. examination body
  6. examination organization

- Revise the existing documentation applying this prescriptive corporative terminology.

- All stakeholders in the association should be included in the terminology policy planning and have access to this information.

On the top, the ECQA terminology needs to be aligned with European and international initiatives, qualifications programs and state-of-the-art standards for vocational training. Taking into account the fact that the ECQA is built by different projects since 1998, this is a never-ending task. From the first initiative in 1998 to the projects today in 2015, the European qualification framework has evolved and the ECQA with it. The ECQA terminology and corporate language changes hand in hand with the new developments in vocational training at European and international level.

At the moment, the ECQA terminology based on the ECQA Term work is only internally available. But an extended version of this work will be downloadable at the association website and accessible to all stakeholders. On the long run, the vision is to create an ECQA centrally managed knowledge base database that is easily accessible (online application), up-to-date, clear, comprehensible and traceable.

1.4 Conclusions

The European Certification and Qualification Association is *per se* one of the most innovative learning organizations in Europe. European studies 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. And this is one of the core specialities in the ECQA. Beside top management support, the studies outline that a positive learning culture (learning from mistakes, team learning, knowledge sharing, etc.) and a supporting organisational infrastructure is which helps with the implementation of a learning organisation.

ECQA and its training offer is growing fast, also in terms of languages covered. ECQA has 60 members in 24 countries, joining VET institutions and several thousands of professionals from all over Europe and abroad. Trainings for ECQA professions are offered currently Europe-wide each year to more than 300 participants. All of them will benefit from the new ontology model and methodology, the new approach for the competences portfolio and the corporate language strategy.

All these initiatives will promote the visibility and transparency in professional curricula, analysing intersection points between professions and offering the users all over Europe a tool to check, control and decide about qualifications to be acquired.

The European and international community will directly benefit from the new developments with new tools to guide them through competences, skills and professions in a multilingual and multidisciplinary way. This would be one step further in the mission to standardise the curricula and skills in the

European and international framework, making easier the communication between intuitions in the educational level, allowing transparency and visibility of learning programs and courses.

The proposed ontology/visualization of the skill set and learning outcomes will allow all partners and ECQA members (training organisations and trainers) to work and interact in a more efficient way, defining and structuring a pool of knowledge that will promote new cooperation strategies, reduce costs and resources and avoid that members work isolated in specific professional competences.

This new development in the ECQA will mean one step further in the mission to standardise the curricula and skills in the European framework. This approach is currently unique. There are no other training providers or VET institutions which have such a large set of professions and an ontology model behind them.

Basic qualifications, soft skills and key skill qualifications are considered to be transverse professional competences required to have access to the market. Students often have access to information about qualifications and syllabus in a very one dimensional way. With the ontology methodology in the background and the implemented ontology model, participants, trainees and professionals will gain a complete new and multidimensional point of view to the ECQA professions and their skill and learning outcomes. This will allow a transversal approach between the ECQA professions, the intersections between the core competences of each profession and the accreditation of them.

A learning organisation must enable everybody involved in development, innovation and learning to have easy and quick access to relevant information, to have all important facts available, no matter in which language, for which job role, which training/certificate, to track history of a trainings/developments and thus to prevent duplication of efforts, repetition of mistakes and higher costs.

A unified and harmonised ECQA corporate language would be an asset for the association to guarantee the quality of their documentation, help the users to understand the concepts, processes and functionalities and, at the end of the day, to save time and money. Bad or no terminology management can influence the quality of the services/trainings/certification and lead to misunderstandings and stakeholders (members, partners, students and users) dissatisfaction.

The potential developments of the ECQA related to language and terminology policies will set the path for a successful communication within the association and a better service for users and stakeholders.

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2 About the authors

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After pursuing an interdisciplinary bundle of studies with focus on Eastern European Languages and many years of scientific project management at the University of Vienna, Gabriele finished an intensive and innovative post graduate course "European Project Management (EUPROMA)". A pioneer in the field of professional preparation and management of EU funded projects, she successfully manages the International Network for Terminology since 2002. For the European Commission she acted as consultant to European eContent and 6th Framework Programmes. Gabriele Sauberer designed and performed many projects at European, regional, national and international level and developed trainings and seminars with focus on European and International topics.

From 2007 to 2010, Gabriele was teaching diversity management, intercultural management and project management at the Centre for Translation Studies of the University of Vienna.

In May 2011, Gabriele founded the TermNet Business Ltd (www.termnet-gmbh.at), a company owned by TermNet, the International Network for Terminology, and herself, in order to commercialise the results of national, international and EU-funded projects, and thus, to make the products and services of successful projects sustainable.

She is a certified quality auditor, EN 15038 lead auditor and expert in several standardization committees (Terminology, Translation, Human Resources, Diversity management, Corporate Social Responsibility).

Since 2012, she is ECQA Vice President and also accredited trainer for:
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Blanca Nájera Villar holds an university degree in translation and interpreting gained from the University Alfonso X, el Sabio in Madrid. She is highly skilled freelance translator, with strong experience in the profession after working as a project manager and in-house linguist with several translation agencies across both Spain and Germany. In 2012 she finished her postgraduate Master on Terminology at the University Pompeu Fabra, Barcelona, with a final master project on the ECQA terminology (ECQA Term).

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Innovation and Project Management in International Distributed Teams.
A Description of an Current Project Work

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Abstract

This project tried to combine students from different degree programs together in workgroups to get the best learning in communication within project teams with distributed teams. Students were given tasks weekly and reports were made continuously. Learning were made not only by programming for the companies, but also in information exchange of business-, media- and programming students.

Keywords

Reference

Towards an integrated Learning and Certification Strategy for Global Innovation

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Abstract

Innovation has become the lifeblood of every modern organization. The ISO TC 279 currently works on ISO ISO/AWI 50501 Innovation Management System Standard and ISO/NP 50502 Tools and methods for collaborative innovation – Guidance. These standards focus on innovation management systems and the assessment of these systems.
In the ECQA we elaborated since 2005 a vast set of skills and personal level certificates for innovation management competencies on a skill level. Innovation lives from the creativity of people, the networking of these innovative minds and the transfer into real products and services.
While both industries and universities agree on the necessity of specific competences for pushing and managing innovation skills, the education and professional training of such competences is still lacking behind the actual expectations.
While the ISO 5050x series will provide guidance about certifying innovation management systems, still for the personal competence level the recognition of acquired competences and experience on a personal level is very difficult.
This paper describes the strategy of the ECQA to integrate different innovation skills into a portfolio of competences for innovation.

Keywords

ECQA, innovation management skills, portfolio of skills, innovation, innovation management, certification, industry-university cooperation, knowledge triangle

1 Introduction

In the modern understanding, innovation has the following key characteristics:

• It is global and highly networked.

• It is open (outside-in and inside-out).

- It is interdisciplinary and diverse.

- It is cross-sectorial.

- It integrates products, services, and related processes (business, develop-ment, manufacturing, etc.).

- It demands continuous learning and un-learning.

- It is based on creativity, out-of-the-box thinking and inter-sectorial cross-fertilization.

Looking at these key characteristics it becomes evident that innovation concerns a large number of stakeholders in organizations rather than only a few experts and/or managers. Furthermore, apart from their diverse domain expert skills and competences, these stakeholders need to understand how to support the above listed characteristics by their own creative thinking, by their behaviour within an organization, as well as by their strategic thinking and planning [1].

We believe that teaching and practicing such skills should start from secondary school age and go on throughout the complete professional career. Young children are naturally creative, and do not yet suffer from thinking in a formatted way. Why not capitalize on this treasure, and teach them how to exploit their creative potentials, and keep or even enlarge them throughout their education and professional careers?

In general, education and professional training curricula are not at all complementary, and do not cover all the above listed innovation competence challenges. Even worse, there is no seamless ECTS and ECVET compliant certification scheme for the competences that characterize modern innovation management.

This article presents the key elements of the innovation management competence training and certification program strategy of the ECQA (www.ecqa.org), which is currently unique of its kind. Complementary EU-wide certified training modules have been built in the context of more than 30 certified professions over the last ten years. These modules provide the basis of a modular kit of certified learning modules which can be used on order to acquire the ECQA certification of learning outcomes that are related to modern global innovation management.

The article is structured as follows: Section 2 outlines the new portfolio strategy for innovation, and section 3 outlines key challenges of modern global innovation management which have to be reflected in education, training and certification programs. Section 4 maps the existing ECQA professions to these subjects, making visible the current coverage of innovation competence learning and certification by the ECQA. Section 5 gives a brief insight into the certification strategy adopted by the ECQA. The final section draws conclusions from this mapping and gives an outlook to the developments of the ECQA that aim at providing a modular kit architecture for the certification of innovation management competences in the near future.

2 New Portfolio Approach – Topic Clustering Strategy

All ECQA job roles are interconnected and they could well continue with further job roles and knowledge areas. ECQA plans to create so called clusters of knowledge where a critical mass of knowledge and certification options is provided for core topics driving the European Union skills development.

One of the portfolios (cluster of ECQA Job Roles Integrated) is the innovation management. Instead of having many different ECQA Job roles with each having a separate skill card we will have a set of core elements with an overall ECQA innovation vision for all different job roles in the innovation area and then a specialised set of elements per area of specialised competence (See Figure 1).
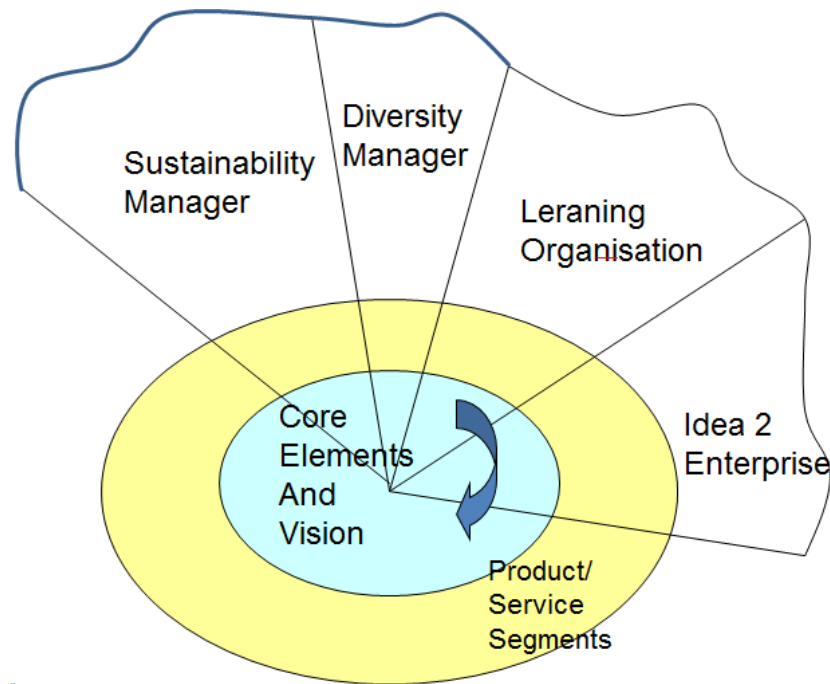
Figure 1: Core Elements and Specialized Segments for Innovation Competences

From each innovation related job role those will be marked as "core" which directly addresses one of the pillars of the ECQA innovation vision.

1) Creating a VISION and a Dynamic Network

   Nowadays businesses do not succeed without having a big, far-reaching vision. The vision is built on the market needs, the core competencies required, and a dynamic interaction and open communication with the market.

2) Creating a GLOBAL Community of TRUST

   Compliance: Setting standards or just "surviving" conformity assessments? Compliance in a complex world of all kinds of requirements and constraints is a megatrend and a hot topic for all businesses, organisations and industries.

   Diversity and Resilience: manage complexity and continuous change, use the full potential of your diverse work force; make your organisation resilient and your systems safe through diversity of design, benefit from post-traumatic growth and positive psychology.

   Sustainability: What makes businesses and business networks last and flourish? How to comply with international standards?

3) Preparing for Constant Change and being able to (UN)LEARN:

   The global learning organisation has replaced the local learning organisation. This requires new ways of creativity and innovation, as well as ex-novation of the useless.

4) Providing TRANSPARENCY of Rules and Business

   Almost every day new financial disasters are revealed. At their very origin is the missing transparency of the goals, the business, and the operations. In global business, however, transparency is a must that is reflected in international standards.

   Creating trust in business by transparency and Goal Setting: Business Compliance and Business Process Modelling;

The above 4 vision statements (see core vision in Figure 1) are used to select those elements which are integrated into the core set of elements. All other elements can be provided as an add-on depending on a specific customer interest.

This new strategy allows to integrate a number of job role committees under one vision, one umbrella, and creating a critical mass of joint activity.

3 Key Challenges of Modern Global Innovation Management

From our innovation consulting, coaching, training and research activities and com-munities, we derive that modern business organizations drive innovation based on the following key success factors.

3.1   Creating a Vision and a Dynamic Network

Nowadays businesses do not succeed without having a big, far-reaching vision that pushes strategists to think about ways to innovate every single day. This vision is built on the market needs, the core competencies required, as well as a highly dynamic networked interaction and open communication with the market. Cross-industry fertilization has become a key lever to push innovation beyond the limits of the horizons set within a specific sector. As businesses are getting more and more networked, industries not only have to collaborate but increasingly also to co-innovate. This can only happen in environments in which networked creativity based on effectively deployed ideation, selection and realization processes form an intrinsic part of the organizational culture. Building up such a culture requires investments and strategies that shall be guided by the company vision.

Once a vision is created and disseminated the network of supports and contributors can be used for building co-design partnerships or a critical mass of interested using modern web based networks.

3.1.1 Co-design of Products, Services, and Processes

As a response to global competition, industrial companies are increasing the introduc-tion of technologically sophisticated products as well as the adoption of advanced technologies and changes in organizational structure and processes. A company's competitive position is determined by the ability to innovate its product and service portfolio in the cycle time demanded by the markets that they address. However, they also have to assure their ability to ramp up to full scale production volume at the required speed and with the demanded quality. Therefore, for industrial companies, product and services innovations have to go hand in hand with innovations of the related processes.

For industrial companies innovations of the product system as well as innovations of the manufacturing processes are essential competitive factors. Due to technological facts there is a tight relationship between technical products and the processes implemented to realize these products, much less tight than in the software industry. Innovation management has to take into account the dynamics of the underlying product-process interactions and the resulting constraints [13]. This close coupling of products and the associated manufacturing processes has to be taken into account from the very early design phases of the product [14], leading to the need of integrated product-process design and innovation [15].

In the IT and software sector, there is clear trend towards providing software as a service (SaaS) rather than as a product that can be installed and used on a single computer. While this trend was initially mainly driven by technical arguments, new business models have come up which are based on the idea of selling the value of the product in use rather than selling the product itself. This allows the creation and selling of value-added services to customers all through the time they have access to the software services.

In increasingly many industrial sectors a very similar trend is to be observed. The economic target of companies is to support and be involved in value creation on customer side as long as possible, which implies that they have to conceive and support services strongly associated with the products that they sell, and which go far beyond maintenance and repair. Thus, in an economic sense, the margins that are achievable with all other kinds of services which can be delivered throughout the whole life cycle

have to be exploited. Products are becoming enablers of services, and their evolution is strongly linked all along the life cycle.

The need to co-design products and services introduces new challenges to design, and has led to a new field of close collaboration between industry and academia.

3.1.2 Capitalize on the Power of the Word Wide Web and Social Media

The World Wide Web and especially Social Media have become facilitators of innovation. They enable the engagement of vast communities in innovation activities via crowdsourcing and problem sourcing, and provide valuable data to guide and inspire the corporate innovation process.

3.2   Creating a Global Community of Trust

Numerous business scandals with mostly global impact lead to the fact that the mod-ern society is calling for trustful and transparent businesses. Transparency is strongly linked with the term compliance, which has become a key challenge and necessity for modern organizations operating in environments that are increasingly constrained by all kinds of requirements, constraints and standards. Innovative organizations find new ways of integrating all the latter in their products, services, and processes such that they become enablers for new architectures, functions, organizations, and business models. In this manner, the most innovative organizations not only adhere to and comply with standards and legislation, but they also advance them and define new ones by going beyond existing knowledge and practices.

3.2.1 Open up Innovation, create and get into Dynamic Networks

A global community of trust is also a prerequisite to open up innovation. At least since the publication of the Open Innovation concept by Chesbrough in 2003 [2], it is clear that modern innovation happens in networks rather than in closed environments. The idea is that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as the firms look to advance their technology. Both external and internal ideas are used to create value, and internal mechanisms are defined to claim some portion of that value. Open Innovation assumes that internal ideas can also be taken to market through external channels, outside the current businesses of the firm, to generate additional value. Ideas can also start outside the firm's own labs and can move inside. Open Innovation allows the recovery of overlooked innovations, which increases the chance for projects will find value in a new market or be combined with other projects.

Nowadays many industries are in transition between the two paradigms, e.g., au-tomobiles, biotechnology, pharmaceuticals, healthcare, computers, software, communications, banking, insurance, and consumer packaged goods. The locus of innovation in these industries is moving beyond the confines of the central R&D laboratories of the largest companies to start-ups, universities and other outsiders. In so doing, the company can renew its current business and generate new business, capitalizing on abundant distributed knowledge resources.

By its very definition, Open Innovation leads to networks of people, companies, and other different kinds of organizations. Several different kinds of initiatives are typical in such networks, such as contracting specialists, Joint Ventures with other companies, co-developing products with suppliers, subcontracting services, licensing technology, alliances with universities and research institutes, participating in broad networks to coordinate innovation, involving existing and future customers in idea and feedback networks, trend identification from semantic analysis of social and knowledge networks.

The management and coordination of such networks requires specific competencies which are not relevant in closed innovation organizations. Moreover, new metrics have to be found which allow the performance of such innovation networks in terms of several criteria. This is a very important subject of research in management and economy. An exhaustive overview of the state of the art is given in [3]. The Open Innovation paradigm is the basis of more specific derivatives like Coopetition [4] and Crowdsourcing [5], and has also become a key concept for tackling the challenges of economic crisis [6].

3.2.2 Embrace Diversity and Change

Diversity has become a keyword characterizing successful innovative organizations [7]. They embrace diversity in numerous dimensions, e.g. cultural and educational diversity of the workforce, diversity of the markets that they address, diversity of the industry sectors they investigate to get inspired, diversity of the design of products, services, systems, processes to maximize learning and functional safety. Also, change is natural for them, as there is no innovation without changes in behaviours, perceptions, habits, etc. Investing in change necessarily goes with investing in improving an organization's innovation culture. The SPI Manifesto [8] provides guidelines to man-age and accompany this change. We are using it in order to extend it to an Innovation Manifesto, which will provide a guideline on leveraging cultural change for a higher innovation performance.

3.3 Preparing for Constant Change and being able to (UN)LEARN

3.3.1 Be Open to Unlearn to be Able to Learn

Another key success factor for change is an organization's ability of un-learning. There is no doubt that the most successful and innovative organizations are those who achieve permanent learning on the organization level rather than on individual level only. Especially for disruptive innovations, the process of learning new paradigms implies un-learning of known principles and habits. Therefore, learning to un-learn is another key success factor of fast-moving innovators.

3.3.2 Turn Ideas into Reality by Entrepreneurship and Intrapreneurship

New ideas usually mean changing the existing way of work. Still ideas are the main source of innovation. Idea generation is an intrinsic objective of the ideation process. It is, however, not sufficient to contribute to innovation. Idea contributors have to stand in for their ideas, and market them within their organizations and/or to investors. This requires elaborating ideas and developing stories in order to "sell" them to gain promoters and convince decision makers. Consequently, entre- and intrapreneurship have become key levers to turn ideas into reality at the pace demanded by the ever shorter innovation cycles of numerous industry sectors.

Opening up and leveraging people's entrepreneurial spirit shall start at basic education levels, when young pupils and students are naturally creative and do not yet suffer from thinking in a formatted way. The mind-sets of young people have to be opened for innovation competencies to build the grounds for future European innovation. They have to be taught to think big to strive for new horizons that society cannot see yet [12].

3.4 Providing TRANSPARENCY of Rules and Business

3.4.1 Provide Effective and Transparent Models

Innovation processes require an innovation management system with defined innovation management processes. Processes need to be modelled using process modelling techniques which makes the organisational procedures transparent and controllable [19].

3.4.2 Demonstrate Business Compliance

Once a critical mass of interested people, a development partnership and a market has been created, the next step is to create trust in investors, and partners. International standards like COSO, COBIT, and governance standards help to create trust in the business [16].

4 Integrated Certification Strategy for Innovation Competences

Currently the ECQA certify competences and skills on a per-profession (job role) basis, i.e. they promote more than 30 job roles that are essential in several industry sectors. Exams can only be done in the context of a particular profession, and certificates can only be obtained per profession. The certification, however, is already modular, i.e., per skill element. Otherwise stated, one candidate can be partially certified for one particular profession (ECQA Summary Certificate).

As professional profiles on the job market are evolving more quickly than training programs and certification can follow, the ECQA has adopted a new strategy for certification which is explained here using the example of Innovation Management competences. Table 1 below shows a mapping from the modern Innovation Management competence challenges to existing ECQA certified professions.

ECQA Vision Statements		ECQA Certified Professions
1	Creating a Vision and a Dynamic Network	ECQA Certified Innovation Manager ECQA Certified Valorization Manager
2	Creating a Global Community of Trust	ECQA Certified Innovation Manager ECQA Certified Sustainability Manager ECQA Certified Social Responsibility Manager ECQA Certified Diversity Manager
3	Preparing for Constant Change and being able to (UN)LEARN	ECQA Certified Idea to Enterprise Expert ECQA Certified Researcher Entrepreneur
4	Providing TRANSPARENCY of Rules and Business	ECQA Certified Business Process Modelling Expert ECQA Certified Corporate Governance Assessor ECQA Certified Terminology Manager ECQA Certified Compliance Professional

Figure 2: ECQA Vision and Job Role Assignment

All the above cited certified training programs have underlying skill cards that are EQF-compliant in that they contain skill units, skill elements, and performance criteria. If a program is listed above in the context of a particular innovation management competence, this means that the skill card of the corresponding program contains one or several skill elements that are considered relevant for the respective innovation management competence.

As an example, Table 2 below shows the skill card of the current ECQA Certified Innovation Manager up to the skill element level.

Skill Unit	Skill Element
U1: **Innovation Domains**	U1.E1 Service Innovation U1.E2 Open Innovation U1.E3 Ideation and Entrepreneurship
U2: **Dynamic Learning** **Organizations**	U2.E1 Core Competence Analysis U2.E2 Learning Teams U2.E3 Multinational Learning Cycles U2.E4 Systemic Innovation Process Design
U3: **Supporting Processes**	U3.E1 Innovation and Social Media U3.E2 Innovation Networking U3.E3 Innovation Valorization and Change Management

Figure 3: Skill Card of the current ECQA Certified Innovation Manager

The new ECQA clustering approach means that each of the job roles identifies those elements that directly address one of the 4 main vision statements.

Skill Unit	Vision	Skill Element
U1:	3	U1.E1 Service Innovation
Innovation Do-	1	U1.E2 Open Innovation
mains	3	U1.E3 Ideation and Entrepreneurship
U2:	3	U2.E1 Core Competence Analysis
Dynamic Learn-	2	U2.E2 Learning Teams
ing Organizations	2	U2.E3 Multinational Learning Cycles
	4	U2.E4 Systemic Innovation Process Design
U3:	2	U3.E1 Innovation and Social Media
Supporting Pro-	2	U3.E2 Innovation Networking
cesses	2	U3.E3 Innovation Valorization and Change Management

Figure 3: Skill Card of the current ECQA Certified Innovation Manager mapping to Vision

In a further design step elements are identified which are directly overlapping with another job role. In this case only one joint element shall be maintained across all job roles.

For instance, innovation and social media, has a 100% overlapping with the job role ECQA Certified Social Media Networker. In this case a set of Social Media Networker Elements
    SIMS.U2.E1 Social and Business Networks
    SIMS.U2.E2 Blogging and Microblogging
    SIMS.U2.E3 Content Sharing, Recommendation and Collaboration + Education
replaces the element U3.E1 Innovation and Social Media and the Social Media Networker materials must also be updated towards innovation topics.

The idea is to create a core cluster of innovation elements which are shared and maintained across the innovation related job roles and are understood as the basis for supporting the 4 vision statements.

5 Conclusion and Outlook

This paper presents a unique European initiative aiming at certifying and training essential competences that are needed by managers and practitioners of modern global innovation in a modular yet holistic way. As these competences are highly interdisciplinary and transversal, the strategy is based on bundling competence elements from different specialized professions. In order to enable an incremental education approach of global innovation management competences from the early school age on, competence elements are covered by difference training approaches and materials, each having ECTS and ECVET equivalence values assigned to them. This facilitates the deployment of the innovation management education and training elements on an international scale.
The paper also pointed out a variety of innovation management competences that are typically needed in modern global innovation environments. Based on the needs and expectations of different industry sectors or education programs, the ECQA can propose different certificates covering a relevant selection of innovation management competences. These needs will be derived from interviews with Human Resource departments of major European industry groups for the industry certificates, and proposed to universities for adoption to their respective curricula. In this way, the ECQA will contribute to the transfer of education needs from industry to universities, and to adapting the latters' curricula and certificates to the needs of the modern job market.

This paper also outlines a practical approach to select, share and agree a core set of elements across different job roles, with each supporting a future ECQA innovation vision for Europe.

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Dr Andreas Riel has more than 18 years industry experience. He was Innovation manager at AVL List Graz. Then he moved to Grenoble Institute of Technology, France and became the coordinating manager of a FP7 project for innovation in manufacturing, which resulted in the foundation of EMIRacle. He is a lecturer at the Grenoble Institute of Technology and the FH Düsseldorf.
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Dr. Messnarz focuses on system architecture, functional (safety) design, requirements management and safety (ISO 26262) and Quality (ISO 15504) standards. He is an ECQA certified Functional Safety Manager and ECQA certified trainer. He is teaching Automotive Quality at the University of Applied Sciences, FH Joanneum, Graz. Dr. Messnarz manages EU initiatives to deal with Innovation, international standards and safety (www.eurospi.net) and he is the moderator of the German initiative SOQRATES,where experiences and best practices for traceability, requirement management, system and SW design, system test and safety standards are exchanged. He is vice president of the European Certification and Qualification Association (ECQA), and chair of EuroSPI.

Achieving sustainable development by integrating it into the business process management system

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Abstract

The purpose of the article is to present an approach how to integrate sustainability related topics into an organization's management system. As a starting point and connecting tissue, we use a process-oriented approach (BPM) for managing companies and then apply sustainability dimensions (economic, ecologic, and social) to it. Using this approach we do not change existing or already established management systems of companies, but we adapt it by modifying company vision, strategy and most importantly, management and core processes.
Integrating sustainability related processes into organization management system prevents "fire-fighting" and ad-hoc activities, which are performed by companies to comply with the increasing number of sustainability related standards.
In addition, we present two managerial trainings (business process management and sustainability management), which when combined, will enable managers to adapt to today's highly competitive business environment.
The concept presented here is a novel approach under the ECQA (European Certification and Qualification Organization), which will allow on-demand clustering of managerial skills and trainings (BPM and sustainability management).
The results presented are particularly useful for process analysts, quality managers, sustainability managers, social responsibility managers and similar professional profiles in order to improve their companies' activities and processes with respect to the sustainable development values.

Keywords

Leadership, business process management, sustainability, lifelong learning, certification, business analysts

Reference

Empowering Graduates for Engineering Jobs in the Automotive Industry

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Abstract

Training and Consulting Organisations from The Netherlands, Austria and France in very close cooperation with major automotive OEMs and Tiers, as well as the international ECQA certification association are currently developing a VET training that prepares recent graduates for successfully making their first steps in the automotive industry as an automotive engineer. The objective is to come up with a concise curriculum that delivers fundamental knowledge and skills that form the basis of the growing variety of engineering job roles in the automotive industry.

This collaborative activity has been inspired by major industry stakeholders who have been observing that engineering graduates without prior practical experience in the automotive domain have hardly any specific knowledge about the automotive industry, which is after all one of the key pillars of the European and worldwide economy.

Keywords

ECQA, ontology, interoperability, corporate language, competences portfolio, vocational training, harmonization

1 Introduction

The automotive industry has developed rapidly over the last decades. It was only "yesterday" that a car (literally) was delivered with a tool box! Nowadays a car is like a computer consisting of several networked electronic controls, almost a hundred in modern middle-class cars, and far more than that in luxury cars. This "computerisation" of cars has huge consequences on the variety of job roles in the modern automotive industry and their associated skills and consequences. In particular, the spectrum of relevant engineering skills has widened up significantly from purely mechanical engineering to electrics, electronics, and software engineering, as well as material engineering (lightweight construction), not to mention more traditional domains such as design and acoustics engineering.

Automotive industry – OEMs and Tiers alike – therefore recruit engineering graduates from an increasingly large variety of engineering backgrounds. Doing so, they report huge investments in delivering to these graduates the required basic knowledge about the automotive industry and related engineering skills. Therefore, if teaching the basic knowledge and the skills required in the modern automotive development and manufacturing processes were part of the students' curricula, they would have a significant gain in time and investment. This is even more necessary today as companies are striving for mastering the customer demand of a total life cycle care for their products in the form of value-added services, a tendency that widens up again the need for different job roles to have an understanding of the key processes in automotive industry.

Our goal is to bridge this gap by developing a consistent and concise VET training program that shall serve as a certified add-on qualification for recent university graduates and professionals alike. This paper introduces the related project initiative, and presents the key results of a needs analysis preceding the detailed development of the curriculum, training materials, and certification. To this aim, the article is structured as follows: section 2 describes the project's context and consortium. Section 3 summarises the main results of the needs analysis that has been carried out by project members under the involvement of key industry. Section 4 explains the planning of future project activities, while the final section concludes and gives an outlook.

2 Context and Consortium

In November 2014, a consortium of training and consulting organisations in the Netherlands, France, Austria and Ireland started a European project to develop a Europe-wide certified training programme for recent graduates and new hires with little or no knowledge of automotive engineering processes and standards. The curriculum will address the basic knowledge and skills for engineers working in the automotive industry with a strong focus on the European ecosystem. The Erasmus+ project is led by Symbol BV in the Netherlands, and is carried out in cooperation with automotive industry and education partners from four EU countries. The consortium members are the following:

1) Symbol BV, the Netherlands (www.symbolbv.nl): a training and consulting SME specialised in business and process improvement, and quality management for more than 10 years, with a lot of automotive clients.

2) ISCN, Austria and Ireland (www.iscn.com): a training and consulting SME specialised in automotive development process quality with a strong focus on software and electronics quality and systems engineering for more than 20 years.

3) Inno++, France: a training and consulting SME working very closely with ISCN with about the same fields of specialisation, for more than 2 years.

4) ECQA, Austria (www.ecqa.org): the European Certification and Qualification Association, an independent Europe-wide certification association for more than 20 years, currently promoting and certifying more than 30 job roles in various sectors (including automotive).

5) LSSA, the Netherlands (www.lsaa.eu): the Lean Six Sigma Academy, an independent Europe-

         wide certification association for Lean Six Sigma qualification levels (belts).

6) ROC Ter AA, the Netherlands (www.roc-teraa.nl): a well-established VET training organisation that is also the coordinator of the MBO Automotive Center.

7) ROC Summa College, the Netherlands (www.summacollege.nl): 22 schools for secondary VET with more than 22.000 students and 1.700 employees.

It is obviously not sufficient any more to develop syllabi in the form of skills and professions, but also to interconnect and streamline them on national, European and international levels. The development of national qualification frameworks in Europe needs to be supported by an innovative and comprehensive approach. This needs to be fostered by harmonisation of existing key activities in this sector.

The ECQA (www.ecqa.org) is the most successful European platform in the area of standardisation, unification and certification of skills and competences for modern job roles in industry. It offers currently 30 professional certificates, and promotes respective curricula and training materials that have been developed by international consortia. The certification and training offer is steadily growing in terms of professions and also in the number of languages covered.

Nowadays, participants register and create an ECQA account where they can:

- browse through the skills and competences for the different professions;
- perform the self-assessment with multiple choice test questions for a specific profession;
- have access to learning references;
- have access to online courses and trainings;
- collect evidences for learning and portfolio building; and they can
- perform the exam and afterwards obtain a Europe-wide recognised certificate.

Within the ECQA, all trainings are modular, based on learning outcomes as a minimum unit of modularity, and therefore compliant with both the ECVET and ECTS credit systems. The Job Role Committees (JRCs) associated with each profession ensure that all courses worldwide are built according to the same structure and standards.

In terms of certified curricula especially for the automotive industry, the ECQA currently promotes the

- ECQA Certified Functional Safety Manager [1], as well as
- ECQA Certified Automotive Quality Manager [2].

programmes, which have both been developed under involvement of leading automotive companies with experienced automotive industry professionals as the main target group. Despite their young ages, these programmes have already experienced remarkable success in Europe. The Automotive Engineer training programme that is the subject of this article can be considered as complementary to these programmes on terms of making available in very easily understandable form the essential notions that form the basis of the more specialised automotive job roles and related trainings. In addition to that, the consortium's aim is to establish a new job role "Automotive Engineer" in Europe, which provides a basis to assume more specific job roles in automotive downstream the engineer's career path.

3 Needs Analysis

Before the start of this project 12 global key players in the automotive industry supported applying for this European innovative project by sending Symbol a support letter that says bridging the aforementioned gap is necessary. They endorsed that finding people with a proper basic knowledge of automotive industry specificities was very difficult, and that consequently they had to invest significant amounts of time and money in training recent graduates and new hires. They also underlined the need for a Europe-wide certified training program for the job profile 'Automotive Engineer'. They also let the

consortium know that they would support this project by answering topic related questionnaires and interviews held by the consortium.

In the need for more kinds of support and input from the automotive industry, the project consortium spread a digitalised needs analysis to 74 automotive companies (OEMs and Tiers). Of course they also spoke with their business relations about the project and asked them the same questions as written down in the needs analysis.

The respondents from automotive industry confirmed in the needs analysis carried out in March 2015 that the wished recent graduates to be more prepared and educated when entering the automotive (engineering) industry environment. 34 companies replied to the needs analysis, of which 15% OEM, 60% tier 1, 60% tier 2, 12% tier 3 and 3% tier 4 (Please note that a tier can be both a tier 1 and tier 2 for example).

The study reveals that there is a particular gap between the current and required knowledge and expertise regarding:

- the knowledge of the automotive industry, its customers and its employees;
- standards, norms, and legislations relevant for the automotive industry; and
- approaches to product and process development.

In the following, we will summarize the most important results from this study, which provides the basis for the initial Automotive Engineer curriculum and certificate design. In a second phase, this design will undergo a more concrete and detailed review by experienced automotive industry professionals.

3.1   Knowledge about the Automotive Industry

43% answered that recent graduates have no knowledge at all. 42% say that they need recent graduates at least to be trained in the basics of the automotive industry at foundation level (EQF 4: remember, understand, etc.). Examples are the automotive supply chain, World Class Performance, and definitions/terms/abbreviations. 35% want recent graduates to be trained at practitioner level (EQF 5: apply, interpret, etc.).

3.2   Standards, Norms, and Legislation

The table below shows the opinion of the respondents according the level of knowledge and expertise of recent graduates concerning standards, norms, and legislation in the automotive industry.

Topic	Current level: No knowledge at all	Industry requires foundation	Industry requires practitioner
ISO/TS 16949	76%	56%	19%
ISO/IEC 15504	71%	50%	19%
ISO 26262	82%	69%	13%
APQP/PPAP	71%	50%	44%
World Class Performance	73%	63%	19%

Table 1: Needs analysis results for the topic area standards, norms, and legislation.

As the table shows there is a big gap to bridge for recent graduates to be able to perform at the required level.

3.3 Approaches to Product and Process Development

Like standards and norms the recent graduates' level of knowledge and expertise according to approaches in product and process development do not match the level the industry requires. The table below shows some findings of our needs analysis.

Topic	Current level: No knowledge at all	Industry requires foundation	Industry requires practitioner
Product Lifecycle Management	64%	71%	21%
V-model	61%	77%	7%
Functional flows	71%	62%	31%
Risk management (e.g. FMEA)	86%	69%	23%
Product Development Process	57%	69%	23%
Project management	29%	54%	38%
Lean Manufacturing	57%	62%	31%
Six Sigma techniques	64%	62%	31%
Systems engineering	71%	69%	23%
Problem solving (e.g. 8D)	71%	54%	38%

Table 2: Needs analysis results for the topic area approaches to product and process development.

The needs analysis shows that also in approaches used for product and process development recent graduates are not able to perform at a level the industry requires them to perform.

3.4 Why the Standards, Norms, and Approaches Are Mandatory

The laws which come up for Automotive industry are usually elaborated in national and international associations of car manufacturers who then propose the new laws to the state and even the United Nations (e.g. in case of the autonomous driving vehicle certain states of development and release were agreed between UN and car manufacturers associations).

One of the most influential laws is the product liability and safety law which has a big impact on the car industry and which is the basis for the fact that manufacturers sometimes have to recall thousands of cars.

The United Nations Economic Commission for Europe agrees product liability and safety requirements worldwide, the EU then created European directives and all member states have a time line to implement that in the national law.

Directive 85/374/EEC concerning product liability

Article 1:   The producer shall be liable for damage
                 caused by a defect in his product.

Article 6:   1. A product is <u>defective</u> when it does not provide the
                 safety which a person is entitled to expect, taking all
                 circumstances into account, including:

                    (a) the presentation of the product;

                    (b) the use to which it could reasonably be expected
                         that the product would be put;

                    (c) the time when the product was put into circulation.

> 2. A product shall not be considered defective for the sole reason that a better product is subsequently put into circulation.

Under European Product Liability Provisions the manufacturer has the burden of proof that the product was not defective. He has the full burden of proof.

Directive 2001/95/EC on General Product Safety – Main Focus on Consumer Protection

Article 1:

The purpose of this Directive is to ensure that products placed on the market are safe.

Article 3:

Producers shall be obliged to place only safe products on the market.

Article 5:

Within the limits of their respective activities, producers **shall provide consumers with the relevant information to enable them to assess the risks inherent in a product throughout the normal or reasonably foreseeable period of its use**, where such risks are not immediately obvious without adequate warnings, **and to take precaution against these risks**.

Where producers and distributors know or ought, to know, on the basis of the information in their possession and as professionals, that a product that they have placed on market poses risks to the consumer that are incompatible with the general safety requirement, **they shall immediately inform the competent authorities of the Member State thereof under conditions laid down in Annex I, giving details, in particular, of action taken to prevent risk to the consumer.**

Directive 2001/95/EC is the base for the market surveillance to ensure that only safe products are placed in the markets in the European Union.

Regulation 765/2008: Surveillance of product safety

This directive includes rules for national accreditation bodies e.g. for the certification of Quality management systems, **and a market surveillance in Europe „Rapex" which weekly publishes all dangerous products found in the European Union (recall, withdrawal).**

Article 16 (2):

Market surveillance shall ensure that products covered by Community harmonisation legislation which, when used in accordance with their intended purpose or under conditions which can be reasonably foreseen and when properly installed and maintained, are liable to compromise the health or safety of users, or which otherwise do not conform to applicable requirements set out in Community harmonisation legislation **are withdrawn or their being made available on the market is prohibited or restricted and that the public, the Commission and the other Member States are informed accordingly.**

The above directives effectively mean that if a problem arises which represents a hazard for the Automotive consumers the manufacturer must inform the public, must recall the cars and repair them or even withdraw the cars from the market and refund the users.
This law has a direct big impact on the quality and safety engineering required for the car industry. Therefore a growing number of quality management and functional safety standards is being implemented across all manufacturers and suppliers.
Meanwhile the European directives have been implemented in the member states.

When implementing the directives in the national law systems, the lawyers took a specific position towards international standards:

Norms are privately created standards of private organizations. They are only binding upon contractual understandings or by reference in statutory provisions (e.g. Harmonized European Norms created by CEN or CEN/ELEC and adopted by European bodies). ISO (International Standard Organization) is a private organization. ISO 26262 is a private norm.

However, established by the industries engaged in the subject matter of the norm the norm also gives evidence of the common understanding of the industries and thereby establishes what we understand as "State (standard) of the Art" or "Standard of Technology". Referring to this common understanding the norm constitutes the border line of common sense which cannot be ignored or reduced. Everybody can rely on this standard as a minimum standard. The half-life of minimum standards is always subject to further progress of science and technology.

ISO 26262 basically is standard knowledge since the first draft of 2008, not only since it official release in 2011.

ISO 15504 and Automotive SPICE basically are a standard knowledge since the first draft of 1998, not only since it official release in 2005.

All norms require the compliance with statutory provisions. Any neglect of statutory requirements is a violation of the requirements of the norm.

This statement by the lawyers means effectively that (1) norms and standards for quality management and functional safety must be applied, and (2) that the "state of the art" in engineering applies because standards are soon outdated. The term "state of the art" is a difficult issue for the car manufacturers and therefore associations of manufacturers and suppliers formed working groups to agree what e.g. is the current best practice in implementing a steering system at highest safety level.

Some norms listed are:

- **VDA – Standards**
- **AIAG – Standards**
- **Advanced Product Quality Planning (APQP)**
- **Production Part Approval Process (PPAP)**
- **AIAG Failure Mode and Effects Analysis**
- **ISO/TS 16949:2009**
- **Automotive SPICE 3.0 (ISO 15504)**
- **ISO 26262**
- **IEC 61508**

ISO 26262 rates the controllability by the normal driver when analyzing a hazard. An accident implies the assumption that something went wrong. According to statistics about 90% of accidents must be assigned to the driver of a vehicle. This is the challenge of applying ISO 26262. A system developed under ISO 26262 must anticipate the accident and the controllability by the driver as well.

Due to the increase of complexity in car design (caused by the integration of electronic, software, mechanics and vehicle functions spanning across components) more and more cases become visible because the law forces the car manufacturers to publish, repair and prevent problems which are safety critical.

Here are some selected messages:

Jaguar recalls 18,000 cars over cruise control software fault - car system upgrade needed, but no hardware affected

By Leo King | Computerworld UK | Published 10:23, 24 October 11

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On February 7, 2014, General Motors (GM) recalled about 800,000 of its small cars due to faulty ignition switches, which could shut off the engine during driving and thereby prevent the airbags from inflating.[1] The company continued to recall more of its cars over the next several months. As of June 30, 2014, GM has issued 45 recalls in 2014, which have involved nearly 28 million cars worldwide and over 24.6 million in the United States. GM says it expects to charge $1.2 billion against its second quarter earnings as a result of its ongoing recalls, and the charge could get worse as lawsuits and investigations continue.

https://en.wikipedia.org/wiki/2014_General_Motors_recall

This norms and legal background lead to a requirements that all young engineers from the start need to know to follow these standards and design and reliable systems.

3.5   Consequences for the Curriculum Design

The needs analysis clearly confirms that automotive industry requires recent graduates to perform at a higher level than they are trained at when they arrive in this sector. In order to respond to this demand appropriately, the consortium has developed two skill sets (curricula structured in compliance with the EQF [3]):

- one at the Foundation level (EQF 4), and
- one at the Practitioner level (EQF 5).

The Foundation level skill set is targeted at employees who are working in or preparing for testing, support design department, CAD engineering, measurement rooms, assembling test equipment, assembling production equipment, support test analysis, prototyping parts, production planning and preparing, supporting mobility concept innovation & traffic management, line supervision, and/or quality control.

The Practitioner level is targeted at employees who are working in quality, production, design, mechatronics, electrics/electronics engineering, mechanical engineering, test engineering, assembly line design, process planning, production planning, process improvement, project controlling, functional software development, data analysis, traceability and auditing.

These draft skill sets are currently undergoing a review by industry professionals in order to ascertain their content and structure. The results will be available by September 2015.

4 Further Project Planning

The project started in November 2014 and will deliver a number of results by its end in November 2016. Its key activities and/deliverables are the following:

- conducting a needs analysis;
- composing two skill sets;
- writing a book about automotive engineering in English, Dutch, German and French;
- writing an exercise book;
- creating training slides for training people at foundation level;
- creating training slides for training people at practitioner level;
- organising two pilot trainings (Train-the-Trainer);
- organising at least four student trainings with a minimum of 30 trainees each;
- organising automotive events in the Netherlands, Austria and France;
- writing exam questions; and
- taking exams (hard copy and on line).

The first pilot training will be a Train-the-Trainer event in the Netherlands, scheduled for October 2015 and planned to use the first release of training material. The second pilot is scheduled for January 2016, also the industry will attend this training. As of February 2016 at least two VETs in the Netherlands will have scheduled the new training courses for their students. From then, further pilot trainings will be organised outside the Netherlands by the project partners in Austria and France. Participation will be free of charge thanks to the financial support of the European Commission. More than 25% of the needs analysis respondents already announced they would like to attend one of these trainings themselves.

The training is expected to last four full days in total. Not only the key subjects of engineering and production will be part of this training but also more general knowledge about the automotive industry (its characteristics, customers, history and future), as well as continuous improvement.

5 Conclusion and Outlook

Like the project supporters from the automotive industry stated before the start of the project, the needs analysis shows that recent graduates, the automotive industry as well as VETs and higher education face a major challenge to let recent graduates perform like the industry feels they should.

This also might be a reason for the industry to become more involved during the education of their future employees. Strategic partnerships and collaboration between industry, VETs and higher education would be a big first step. Like the MBO Automotive Center (MAC) that signed the "Truck Academy" covenant with 10 truck OEMs, last July. Their goal is to enlarge the number of new automotive employees but also to improve the quality of their students' knowledge and expertise in VET and higher education.

We, the project consortium, do not only feel the need for change, our needs analysis show us the numbers that change is needed. For more information please contact the authors or visit our website www.automotiveengineer.eu.

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The 10 Must Haves for Global Innovation and Networking.
A new strategic approach

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Abstract

We all know and agree that innovation has become a critical success factor in any kind of business, in particular in saturated markets. Increasingly, we also agree that innovation, efficiency, effectiveness, quality and continuous improvement are not enough – that companies, organisations, networks, nations and societies need to excel, to reach excellence and leadership in their fields. But HOW to do that? What do we really need? In the past, we were talking about the „Ten Good Reasons for … (Innovation, Design Thinking, Sustainability, etc.)", addressing safety and security issues together with rational and economic thinking. In other words, we addressed our oldest part of the brain (the amygdala, i.e. our reptile brain) which identifies and re-acts to threats, fear and bad news. The paper introduces a new approach to global innovation and a new, thought-provoking way of thinking: It addresses those powerful "positive" emotions which are crucial to make people and organisations flourish – and which enable global innovation and networking in the 21st Century. The paper is based on and inspired by the research of Barbara L. Fredrickson [1], a renowned Professor of Psychology and principal investigator of the Positive Emotions and Psychophysiology Laboratory at the University of North Carolina at Chapel Hill.

Keywords

Innovation, Ex-novation, Diversity, ECQA Certified Diversity Manager, ECQA Certified Innovation Manager, Positive Leadership, Positive Psychology

Reference

A Practical Approach to Classification of Safety and Security Risks

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Abstract

Future automotive systems require more appropriate systematic approaches to support dependable development. Dependability is a superordinate concept regrouping different system attributes such as reliability, safety, security, or availability and non-functional requirements for modern embedded systems. These different attributes, however, might lead to different targets and the non-unified methods to manage these different attributes might lead to inconsistencies, which are identified in late development phases. More specifically, safety and security appear to be two contradicting overall system features which have been treated separately, but due to increasing awareness of mutual impacts, cross domain knowledge, and fine grasp of commonalities are becoming more important.

In the course of this document, an overview of system dependability analysis methods for safety and security attributes at early development phases is given. Target of this work is to provide a position statement for the discussion of available analysis methods and their practical applicability for safety- and security-related system development at early development phase.

Keywords

ISO 26262, HARA, STRIDE, automotive, safety, security, dependability analysis.

1 Introduction

Embedded systems are already integrated into our everyday life and the complexity and safety-criticality of these systems has grown significantly in recent years. For the automotive industry embedded systems components are responsible for 25 % of vehicle costs, while the added value from electronics components ranges up to 75 % for electric and hybrid vehicles [18]. Furthermore, recent trends aim towards highly integrated and automated vehicles. This requires the deployment of more advanced control strategies, thus providing additional benefits for the customer and environment. At the same time, the higher degree of integration and the safety- and security-criticality of these applications raise new challenges.

Future automotive systems will neither be perfect nor invulnerable. They will still fail due software defects, hardware breakdowns, or deliberate abuse and will also be target of malicious attacks by hackers or criminals. Nevertheless, these systems are essential components we depend on and entrust our lives, which makes failures becoming less and less of an option.

Therefore, appropriate systematic approaches to support dependable system engineering are required. This means, among other factors, applying combined approaches for system dependability features, such as safety and security. System dependability attributes have a major impact on product development and product release as well as for company brand reputation. Mutual impacts, similarities, and interdisciplinary values are in common and a considerable overlap among methods exists, but far too often different terminologies and processes obscure these similarities and hinder cross-fertilization of safety and security features. Standards, such as ISO 26262 [8] in safety and Common Criteria [9] in security domain, have been established to provide guidance during the development of dependable systems and are currently reviewed for similarities and alignment.

For this paper we provide an overview of available system dependability analysis methods (focusing on security attributes) and their practical applicability for safety- and security-related system development at early development phase. Furthermore, we present an approach which classifies the probability and impact of security threats using the STRIDE approach [12] and safety hazards using hazard analysis and risk assessment (HARA). This SAHARA concept [11] quantifies the security impact on dependable safety-related system development on system level.

This paper is organized as follows: Section 2 describes the initial situation when developing a safety- and security-critical embedded system, based on an automotive battery management system use-case. Based on this situation Section 3 analyzes the available works and standards dealing with (automotive) safety and security related topics. In Section 4 a description of the SAHARA method and its accomplishment to an early development phase safety-hazards and security-threat analysis is provided. Finally, Section 5 concludes this work with an overview of the presented approach.

2   Commencement of Liability

This section briefly describes the situation when developing an automotive battery management system (BMS). The BMS use-case is an illustrative material reduced for training purpose of both students and engineers. Technology-specific details have been abstracted for commercial sensitivity and the presented use-case is kept on a sufficient high level of abstraction intended to serve as a base for discussion of workshops.

Figure 1 depicts the general structure, main hardware components, and software modules of the high-voltage battery with BMS. The illustration shows the main features of a BMS:

- Power contactors - connection with vehicle HV system

- Interlock - de-energizing HV system when tripped

- CAN - automotive communication interface

- Relay - main contactor and output unit of the BMS

- Temperature sensors - feedback of actual cell temp

- Voltage sensors - feedback of actual cell voltages

- Current sensors - feedback of actual current flow

- Fuse - protective circuit breaker in case of fault

- Cells - electro-chemical energy storage

- BMS controller - monitoring and control unit

The BMS is a safety related system intended for installation in series production passenger cars and therefore within the scope of ISO 26262. For this reason, ISO 26262 aligned development is required. The ISO 26262 safety standard, among others (e.g. ICE 61508 [4]), provides guidelines and procedures for the development of safe electronic systems and is well-known and well-established in the domain. Starting point is a company where safety responsibilities and processes are well-established and concept development phase of the BMS is about to start in accordance to ISO 26262 requirements.
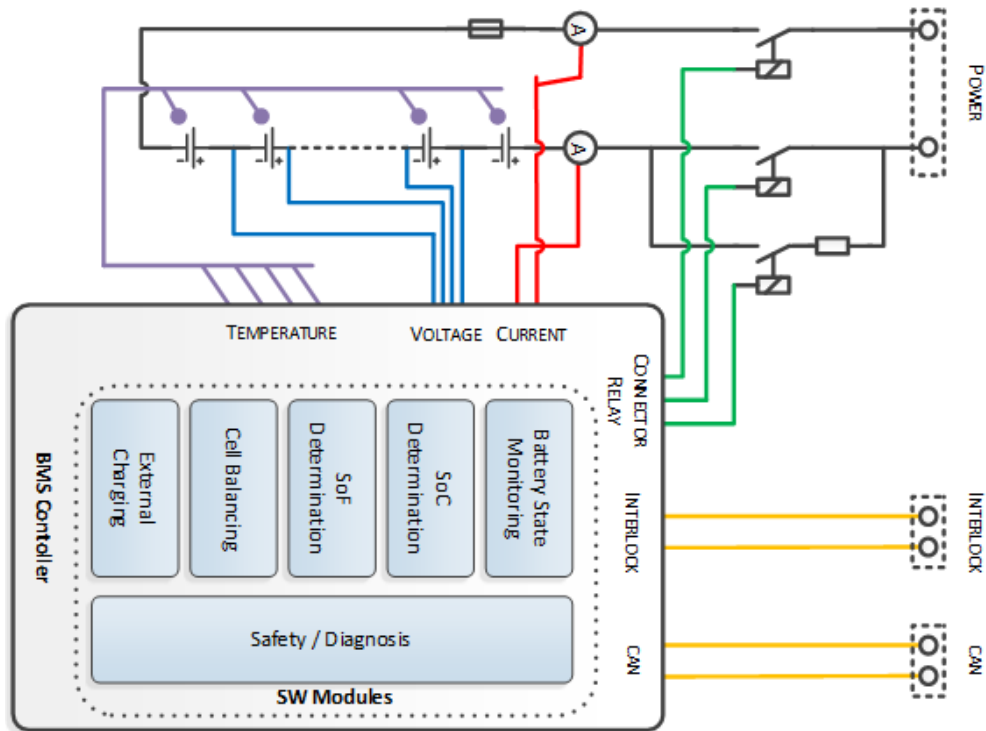
Figure 1: BMS Structure with main HW elements and SW modules

Due to the fact that more and more integration and communication between vehicle and off-board systems (Car2X) is required, defenses against intentional attacks (security considerations) are required. As stated by Firesmith [2] safety and security engineering are very closely related disciplines and could mutually benefit from another if their similarities are recognized and adequate interactions are established in a correct manner. Therefore, the following step is the analysis of available works and standards and how safety and security engineering interactions can be established.

3 Analysis of Options

Safety and security engineering are very closely related disciplines and could greatly benefit from another if adequate interactions are defined. Both disciplines focus on system-wide features and should be integrated into the development process from initial phase on. Safety engineering is already an integral part of automotive engineering and safety standards, such as the road vehicles – functional safety norm ISO 26262 [8] and its basic norm IEC 61508 [4], are well established in the automotive industry. Safety assessment techniques, such as failure mode and effects analysis (FMEA) [5] and fault tree analysis (FTA) [6], among others, are specified, standardized, and integrated in the automotive development process landscape. Nevertheless, security engineering practices and methods are not yet that settled in the automotive domain.

IEC 61508 Ed 2.0 provides a first approach of integrating security requirements. Security threats are to be considered during hazard analysis in form of a security threat analysis. However, this threat analysis is not specified in more details in the standard and Ed 3.0 is about to be more elaborated on security-aware safety topics. Also ISO 26262 Ed 2.0, which is currently in progress, is likely to include recommendations for fitting security standards and appropriate security measure implementations. In aeronautics domain ARP4754 [15] provides guidance for system level development and defines steps for the adequate refinement and implementation of requirements.
Security concerns in aeronautics industry are tackled by the Common Criteria [9,20] specification.

Other standards, such as IEC 62443 [7], or guidelines, such as SAE J3061 [21], are not applicable in practice for the automotive domain in their current state. An analysis done by SoQrates Security AK[1] indicates that the available standard are frequently fragmented or incomplete, and typically assume that their open issues are covered by other guidelines or standards. For this reason, also several researchers and research projects have recently made efforts and publications to combine security and safety engineering approaches.

The work of Gashi et al. [3] focuses on redundancy and diversity, and their effects on safety and security of embedded systems. This work is part of the SeSaMo[2] (Security and Safety Modeling for Embedded Systems) project which focuses on synergies and trade-offs between security and safety in concrete use-cases.

A security-informed risk assessment is mentioned in the work of Bloomfield et. al [1]. Focus of this publication is a `security-informed safety case' and the impact of security on an existing safety case.

Kath et. al [10] state model-based approaches as a promising approach to guarantee safety and security feature implementation. The authors present a model driven approach to security accreditation of service-oriented architectures in their work. Schmidt et. al [16] present a security analysis approach to identify and prioritize security issues, but solely providing an analysis approach for networked connectivity.

The work of Ward et. al [22], on the other hand, also mentions a risk assessment method for security risk in the automotive domain called threat analysis and risk assessment, based on HARA. This work identifies potential security attacks and the risk associated with these attacks. The work also describes how such a method has been developed based on the state-of-the-art HARA method.

The works of Roth et. al [14] and Steiner et. al [19] also deal with safety and security analysis, but focus on state/event fault trees for modeling of the system under development, while Schmittner et. al [17] present a failure mode and failure effect model for safety and security cause-effect analysis. This work categorizes threats with the help of the STRIDE threat model in focus of an IEC60812 conform FMEA approach.

Raspotnig et. al [13] also combine safety and security methods for combined safety and security assessments of air traffic management systems. The approach of their publication relies on modeling misuse cases and misuse sequence diagrams within a UML behavior diagram, which implies a lot of additional modeling expenses for the early development phase.

The SAHARA concept [11] quantifies the security impact on dependable safety-related system development on system level. This concept classifies the probability and impact of security threats using the STRIDE approach [12].

Usually no or only limited evidences support the industrial applicability and usefulness of these research approaches in productive context. However, an approach has to be chosen to continue development of the BMS system in a more structured way. In this case, we based on the SAHARA concept, which is described in more detail in the next section and which appears to be the best practically suitable systematic approaches towards concurrent safety and security development.

4 SAHARA Approach

The SAHARA method combines the automotive HARA [8] with the security domain STRIDE approach [12] to trace impacts of security issues on safety concepts on system level.

STRIDE is an acronym for spoofing, tampering, repudiation, information disclosure, denial of service, and elevation of privileges. Key concept of this threat modeling approach is the analysis of each system component for susceptibility of threats and mitigation of all threats to each component in order to argue that a system is secure.

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[1] http://soqrates.eurospi.net/
[2] http://sesamo-project.eu/
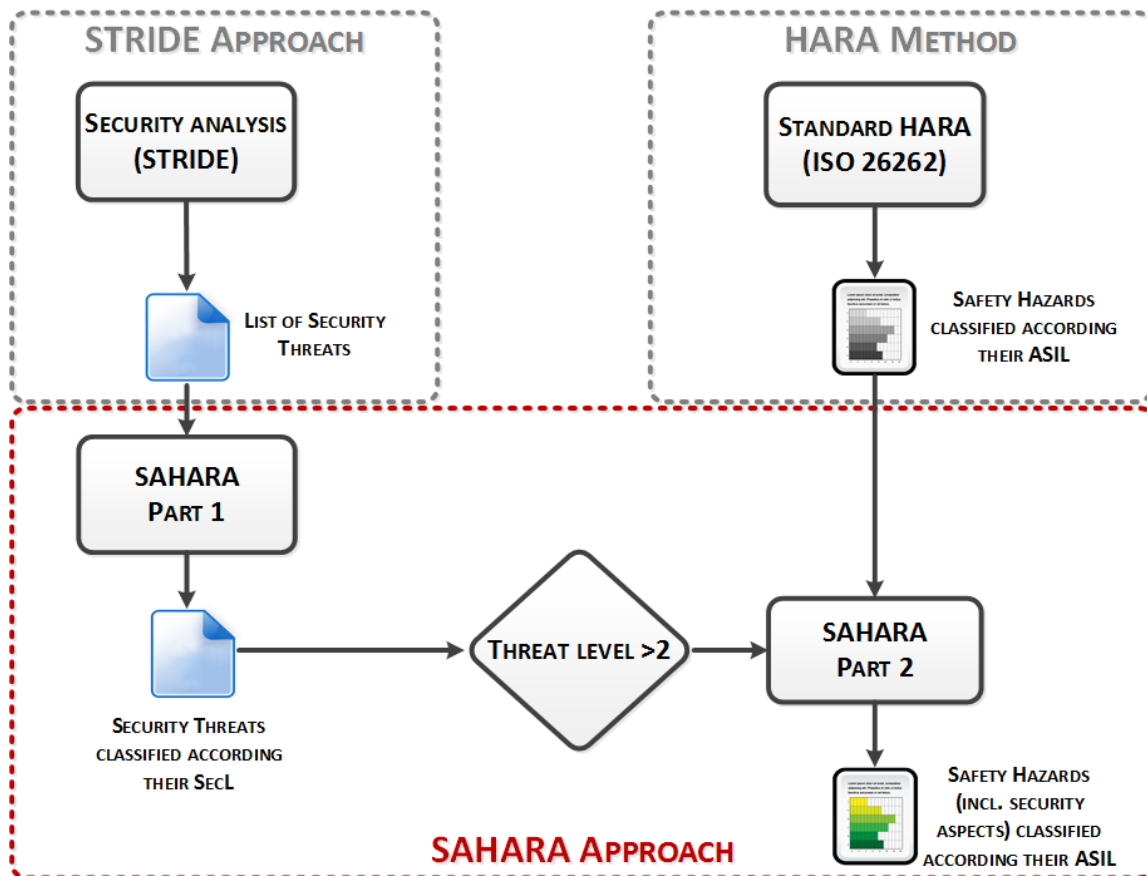
Figure 2: Conceptual Overview of the SAHARA Method

Figure 2 shows the conceptual overview of the SAHARA method. For the initial stage an ISO 26262 conform HARA analysis (right part of the overview figure) can be performed in a conventional manner. Also a security focused analysis of possible attack vectors of the system can be done using the STRIDE approach independently by specialists of the security domain (left part of the figure). In the next step the SAHARA method then combines the outcome of this security analysis with the outcomes of the safety analysis. Therefore, a key concept of the HARA approach, the definition of automotive safety integrity level (ASILs) is applied to the STRIDE analysis outcomes. Threats are quantified aligned with ASIL analysis, according to the resources (R), know-how (K) required to exert the threat, and the threats criticality (T).

The second stage is the hand-over of information of security threats that may lead to a violation of safety goals for further safety analysis. This improves completeness of safety analysis in terms of hazardous events initiated due to security attacks, related to the ISO 26262 requirement of analysis of 'foreseeable misuse'. Moreover, a combined review of the safety analysis by security and safety experts also helps to improve the completeness of security analysis.

The combination of the different mindsets and engineering approaches of safety engineers and security engineers, which are able to work independently from another and mutually benefit from others findings, are more likely to gain higher maturity of their analysis.

First step of the SAHARA approach to combine security and safety analysis is to quantify the STRIDE security threats of the system under development in an analog manner as done for safety hazards in the HARA approach. Table 1 classifies the **required resources - 'R'** to threaten the system's security and gives some examples of tools required to successfully exert the security threat. Level 0 covers threats not requiring any tools at all or an everyday commodity, available even in unprepared situations.

Level 1 tools can be found in any average household, while availability of level 2 tools is more limited (such as special workshops). Tools assigned to level 3 are advanced tools whose accessibility is very limited and are not wide-spread.

Level	Required Resource	Example
0	no additional tool or everyday commodity	randomly using the user interface, strip fuse, key, coin, mobile phone
1	standard tool	screwdriver, multi-meter, multi-tool
2	simple tool	corrugated-head screwdriver, CAN sniffer, oscilloscope
3	advanced tool	debugger, flashing tools, bus communication simulators

Table 1: Required Resource 'R' Classification - determination of 'R' value for required resources to exert threat

The classification of the **required know-how - 'K'** is shown in Table 2. In this case level 0 requires no prior knowledge at all (the equivalent of black-box approach). Level 1 covers persons with technical skills and basic understanding of internals, representing the equivalent of gray-box approaches. White-box approaches are tantamount to level 2 and represents persons with focused interests and domain knowledge.

Level	Required Know-How	Example
0	no prior knowledge (black-box approach)	average driver, unknown internals
1	technical knowledge (gray-box approach)	technician, basic understanding of internals
2	domain knowledge (white-box approach)	person with technical training and focused interests, internals disclosed

Table 2: Required Know-How 'K' Classification - determination of 'K' value for required know-how to exert threat

An overview of the **criticality of a security threat - 'T'** is given in Table 3. Level 0 indicates in this case a security irrelevant impact, such as raw data which can be visualized but whose meaning cannot be determined. The threat impact of level 1 threats is limited to annoying, maybe reduced, availability of services. Threats implying damage of goods or manipulation of data or services belong to level 2. While level 3 threats imply privacy intrusion or impacts on human life (quality of life) as well as possible impacts on safety features.

These three factors determine the resulting security level (SecL). The SecL determination is based on the ASIL determination approach and is calculated according to (1). A depiction of this SecL determination in matrix form is shown in Table 4.

$$SecL = \begin{cases} 4 \; if \; 5 - K - R + T \geq 7 \\ 3 \; if \; 5 - K - R + T = 6 \\ 2 \; if \; 5 - K - R + T = 5 \\ 1 \; if \; 5 - K - R + T = 4 \\ 1 \; if \; T = 3, K = 2, R = 3 \\ 0 \; else \end{cases} \quad (1)$$

Level	Required Know-How	Example
0	no security impact	no security relevant impact
1	moderate security relevance	annoying manipulation, partial reduced availability of service
2	high security relevance	damage of goods, invoice manipulation, non availability of service, possible privacy intrusion
3	high security and possible safety relevance	maximum security impact and life-threatening abuse possible

Table 3: Threat Criticality 'T' Classification - determination of 'T' value of threat criticality

Required Resources 'R'	Required Know-How 'K'	Threat Level 'T' 0	1	2	3
0	0	0	3	4	4
	1	0	2	3	4
	2	0	1	2	3
1	0	0	2	3	4
	1	0	1	2	3
	2	0	0	1	2
2	0	0	1	2	3
	1	0	0	1	2
	2	0	0	0	1
3	0	0	0	1	2
	1	0	0	0	1
	2	0	0	0	1

Table 4: SecL Determination Matrix - Determination of the security level from R, K, and T values [11]

The SAHARA quantification scheme is less complex and requires less analysis efforts and details of the analyzed system than other proposed approaches. Furthermore, the quantification of required know-how and tools instead of any likelihood estimation (e.g. of the attacks success or fail) is beneficial due to the fact that the classification of these factors is more likely to remain the same over the whole life-time of the developed system. Besides this, the quantification of these two factors can be seen as equivalent to a likelihood estimation of an attack to be carried out. This quantification enables the possibility to determine limits of resources spent to prevent the system from a specific threat (risk management for security threats) and the quantification of the threats impact on safety goals (threat level 3) or not (all others). An information which is, as mentioned earlier, handed over to the safety analysis method in the second stage of the SAHARA approach. In the case of safety-related security threats, the threat are analyzed and resulting hazards evaluated according their controllability, exposure, and severity.

5 Conclusion

In conclusion, safety and security are two challenging research domains for automotive systems. Although these two features have been treated separately it is becoming increasingly relevant to exploit commonalities and tackle safety and security development with concurrent methods. This paper provided a brief overview of available system dependability analysis methods and standards (focusing on security attributes) and their practical applicability for safety- and security-related system development at early development phase. Furthermore, the description of an approach, called SAHARA method, and its accomplishment to an early development phase safety-hazards and security-threat analysis has been shown. The approach conjointly combines concurrent safety and security co-development and supports the considerable overlap of in-place safety and security methods. The aim of this paper was to provide a position statement for the discussion of available analysis methods and their practical applicability for safety- and security-related system development at early development phase.

Acknowledgment

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