

LAPPEENRANTA UNIVERSITY OF TECHNOLOGY
School of Business and Management
Master's Programme in Computer Science

PETER THE GREAT ST. PETERSBURG POLYTECHNIC UNIVERSITY
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Trade
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Aleksandr Lepekhin

UNDERSTANDING THE RELATION BETWEEN PROJECTS CHARACTERISTICS AND
THE CHOICE OF REQUIREMENTS ENGINEERING APPROACH

1st Supervisor/Examiner: Dr. Sc., Sami Jantunen, LUT / Assoc. Prof., Uolevi Nikula, LUT

2nd Supervisor/Examiner: Prof., Dr. Sc., Igor V. Ilin, Peter the Great St. Petersburg Polytechnic
University

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ABSTRACT

Author: Aleksandr Lepekhin

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The goal of this research is to understand how companies choose requirements engineering approaches in software projects. The analysis of six software projects, executed by five companies in St. Petersburg, was performed. The requirements engineering approaches within each particular project were described and the projects' outcomes were discussed. The analysis of difference between companies, which affects the way how requirements engineering approach is chosen, was proposed. Moreover, the aspects of requirements, which companies consider in scopes of software projects, were discussed. Finally, the framework, which summarizes the factors, affecting the choice of requirements engineering approach, was presented. The results of this research can be potentially useful for the companies to understand deeper the requirements engineering and contextual factors around it.

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Автор: Лепехин Александр Андреевич

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Экзаменаторы: Доктор наук Сами Джантунен / Профессор Уолеви Никула, Лаппеенрантский Технологический Университет

Профессор, д.э.н., Игорь В. Ильин, Санкт-Петербургский политехнический университет Петра Великого

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Целью данного исследования является понимание того, как компании выбирают подход к инжинирингу требований в проектах разработки программного обеспечения. Был проведен анализ шести проектов, выполненных пятью компаниями в Санкт-Петербурге. Были описаны подходы к инжинирингу требований в каждом конкретном проекте и обсуждались результаты проектов. Был предложен анализ разницы между компаниями, который влияет на выбор подхода к инжинирингу требований. Кроме того, обсуждались аспекты требований, которые компании рассматривают в рамках проектов. Наконец, был представлен фреймворк, обобщающий факторы, влияющие на выбор подхода к инжинирингу требований. Результаты этого исследования могут быть потенциально полезны для компаний, чтобы глубже понимать инжиниринг требований и факторы контекста.

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LIST OF SYMBOLS AND ABBREVIATIONS

RE – Requirements Engineering

RQ – Research Question

CI – Contextual Intelligence

1 INTRODUCTION

Fast-changing technology and increased competition are placing increasing pressure on the development process. Managers, developers, and other team members are pressured for time and budget, which are compressed to deliver competitive software (Nan and Harter, 2009). These kinds of pressure are an often-cited sources of quality problems, which might start from different requirements interpretations in order to simplify the development tasks (Austin, 2001).

Establishing the requirements enables to visualize the “right product” and reduce the possibilities of different interpretations of customer’s needs. In order to ensure that a product development team builds a system that satisfies customer and user needs, the requirements need to be defined and managed in a systematical way. The science and discipline, which addresses this issue is requirements engineering (RE) (Kauppinen et al., 2004). The requirements engineering process involves a clear understanding of the requirements of the intended system and aims to cope with the indicated problem (Kotonya and Sommerville, 1996).

The requirements engineering topic have been in scopes of different researches over the last few years (Schön et al., 2017). Despite the constant addressing of the RE process in different studies, the question of suitable RE approach choice is still controversial. The same aspect of RE is found to be positively related to the successful project results or performance efficiency in one study and neutral in another. The examples of the contradictory aspects can be user-involvement, RE model (Agile or Traditional) and utilization of requirements engineering tools (Table 1).

Table 1 – Requirements engineering topics addressing

RE topic	Point of view
User involvement	<ul style="list-style-type: none">• User involvement in development of requirements is positively and significantly correlated with the overall success of the project (Dvir, 2005).• Involving users in early phases of software development is more beneficial for success and highly recommended, than on other phases (Kujala, 2003).

	<ul style="list-style-type: none"> • User involvement generally had a larger correlation with system success than did user participation. These findings indicate that both user involvement and user participation are beneficial, but much depends on how involvement is defined (Hwang and Thorn, 1999). • User participation is minimally-to-moderately beneficial to ISD; its effects are comparatively stronger on attitudinal/behavioral outcomes than on productivity outcomes (He and King, 2008).
Using tools in RE	<ul style="list-style-type: none"> • An experienced software engineer familiar with tools can be substantially more productive than an inexperienced developer (Cataldo et al., 2006). • A reasonable tools support can improve efficiency of RE processes (Kelter et al., 2003). • 26% of respondents prefer using wall and paper for RE (Azizyan et al., 2011).
Choice between Agile and Waterfall RE	<ul style="list-style-type: none"> • The amount of code and features completed were roughly the same for both methods suggesting that on a three month project with three to four developers it doesn't matter the method used (Ji and Sedano, 2011). • Minimal empirical evidence exists to support the advantages of any one model over any other regarding cost, duration, or quality (Mitchell and Seaman, 2009). • Indicated effort and schedule overruns difference between projects following flexible and sequential development models (Molokken-Ostfold and Jorgensen, 2005).

These contradictory findings suggest that the relation of particular RE approach and the context is not yet sufficiently understood. The researches on software projects management argue that different methodologies can be appropriate for different projects depending on the context of the problem (Daniel J Fernandez and Fernandez, 2008). The context awareness can become a tool for project manager to act appropriately (Snowden and Boone, 2007). Despite that, the issue of contextual analysis lacks addressing in the existing researches on requirements engineering.

This study seeks to understand better the contextual awareness of the companies and their ability to organize RE dependently. It includes analysis of the different RE aspects and their consideration among the companies. It would help to reveal the overall perception of this activity among the companies, because even the understanding of the term “requirements engineering” might differ (Glinz, 2011). The research also has to reveal the way how companies distinguish the difference between projects’ context. It would help to find out how the companies determine the problem at hand and whether they consider adapting their problem-solving approach dependently. Finally, the linkage between the problem and the chosen RE approach has to be studied to investigate whether the companies are able to tackle problem with chosen approach. In order to study the indicated issues, the following research questions (RQ) need to be addressed:

1. How do the companies perceive the RE activity?
 - a. Which aspects to the companies consider in RE?
 - b. How do the companies evaluate the need in addressing different aspects in RE?
2. How do the companies choose the RE approach within specific project?
 - a. How do the companies distinguish the difference between the projects?
 - b. How do the companies combine different RE approaches within one project?
3. What were the experiences of using the specific RE approach for the particular project?
 - a. How was the requirements engineering process organized?
 - b. What were the project results?

This set of research question will also help to study the usefulness of the chosen RE approach for the particular project, which would link the project complexity and RE approach fields of studies.

2 LITERATURE REVIEW

Requirements engineering is the process of discovering, documenting and managing the requirements for a computer-based system. The goal of requirements engineering is to produce a set of system requirements which, as far as possible, is complete, consistent, relevant and reflects what the customer actually wants (Sommerville and Sawyer, 1999). The latest researches provide complex vision of requirements engineering activity, stating that requirements engineering is concerned with the elicitation, analysis, specification, validation and management of requirements (Dermeval et al., 2016).

The conceptual schema of requirements engineering, as seen traditionally, is represented in the Figure 1. The traditional schema of RE is also called Waterfall in the existing literature. It is organized in a sequence of stages in which the output of each stage becomes the input for the next (Balaji and Murugaiyan, 2012).

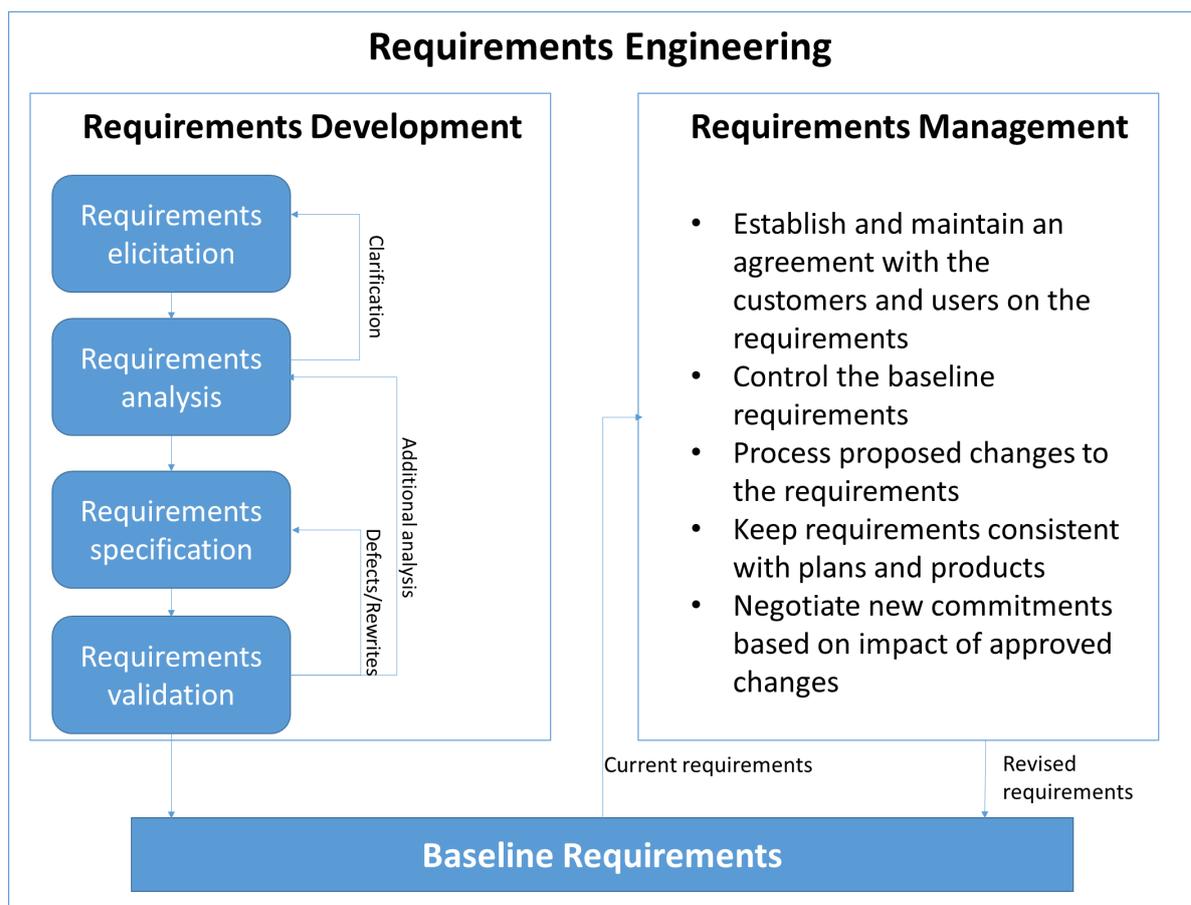


Figure 1 – Conceptual schema of traditional RE

The requirements elicitation step includes all of the activities involved in identifying the requirement's stakeholders, selecting representatives from each stakeholder class, and determining the needs of each class of stakeholders.

The requirements analysis includes representing the requirements in various forms including prototypes and models, performing trade-off analysis, establishing priorities, analyzing feasibility, and looking for gaps that identify missing requirements. The information gained in the analysis step may necessitate iteration with the elicitation step as clarification is needed, conflicts between requirements are explored, or missing requirements are identified.

The requirements are formally documented during the specification step so they can be communicated to the product stakeholders.

The last step in the requirements development process is to validate the requirements to ensure that they are well written, complete, and will satisfy the customer needs. Validation may lead one to iterate the other steps in the requirements development process because of identified defects, gaps, additional information or analysis needs, needed clarification, or other issues.

Requirements management encompasses the activities involved in requesting changes to the baseline requirements, performing impact analysis for the requested changes, approving or disapproving those changes, and implementing the approved changes.

Besides the “traditional requirements engineering”, the term “agile requirements engineering” can be also found in the literature. It is used to define the “agile way” of planning, executing and reasoning about requirements engineering activities (Inayat et al., 2015). The “agile way” means that RE approach is based on Agile principles, which incorporate flexibility by cordially receiving changes to project scope and requirements definitions (Bang, 2007). The requirements are initially defined with the customer and listed in a customer wish list format; every couple of weeks they are discussed (for example, in the Scrum method), better understood, and reprioritized, to define the scope of the next iteration (Inayat et al., 2015). The conceptual schema of Agile RE adapted from Moccia (2012) is represented in the Figure 2.

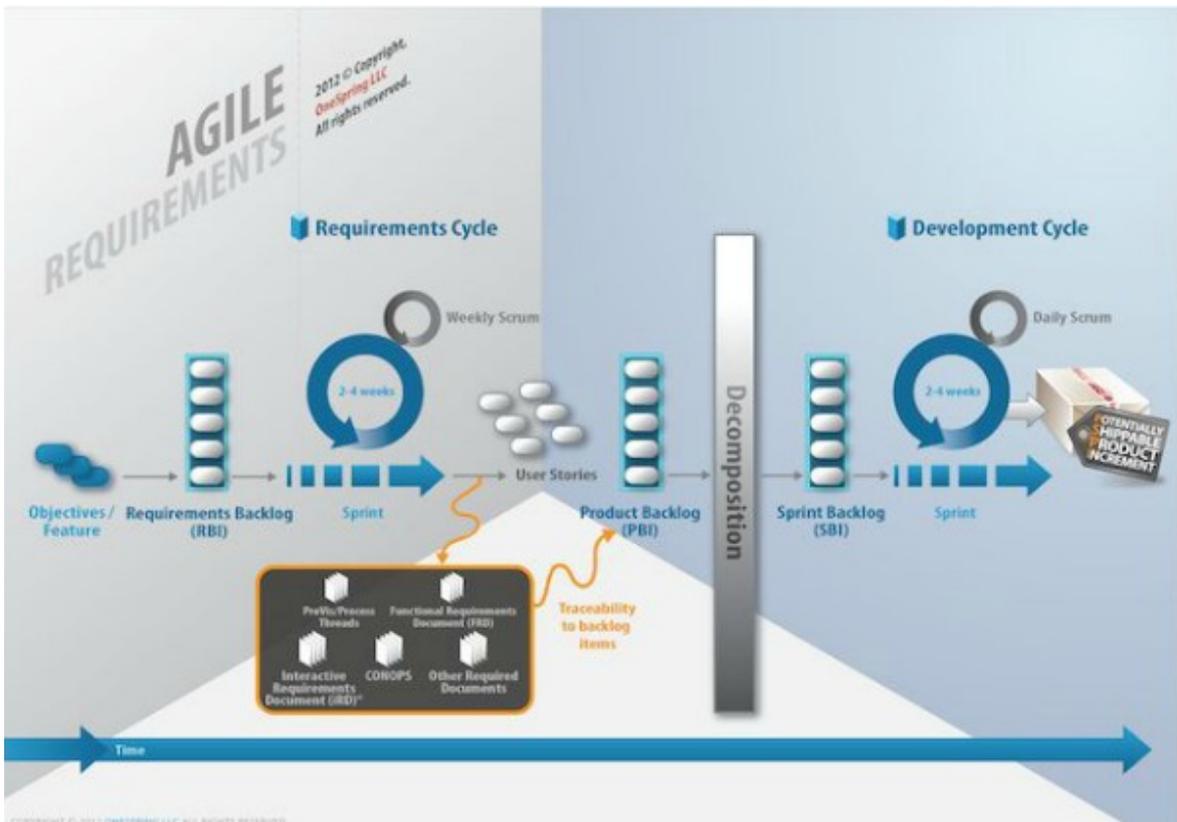


Figure 2 – Conceptual schema of Agile RE

The requirements emerge throughout the development process as a result of the constant feedback from the customer. Agile methods support shorter development cycles in order to respond to complex, fast-moving and competitive marketplaces (Cockburn, 2002).

The researches argue that this type of RE approach, unlike the traditional one, is able to cope with dynamic context of software industry: rapid changes in competitive threats, stakeholder preferences, time-to-market pressures (Ramesh et al., 2010). Some studies also indicate the efficiency of Agile approach over the Traditional in terms of lower effort and schedule overruns (Molokken-Ostvold and Jorgensen, 2005).

Despite the popularity of Agile RE, indicated in a number of researches, such as Eberlein and Leite (2002), Bjarnason and his colleagues (2011) and Adikari and his colleagues (2009), it can not be admitted as the only appropriate. Agile RE has limitations, for example, lack of attention that agile methodologies seem to pay to architectural design issues, indicated in the research of Falessi and his colleagues (2010) and Breivold and his colleagues (2010). Another important issue is the human factor. Agile RE is difficult to be organized for the larger teams and if the skills of team members differ much (Cock-

burn and Highsmith, 2001). These factors indicate the need for accurate analysis of the project and arise the question of the RE approach choice and appropriateness within specific context.

The need for addressing problem’s context when choosing the software project management approach has been constantly raised in the existing literature (Cheng and Atlee, 2007). Many of these studies have used Cynefin framework as a baseline (Snowden and Boone, 2007). Cynefin framework does not specifically focus on software projects or any other types of projects. The framework defines five different types of contexts, based on the nature of cause-effect relationships and the issues leaders are facing. Four of these – simple, complicated, complex, and chaotic – require leaders to diagnose situations and to act in contextually appropriate ways. The fifth – disorder – applies when it is unclear which of the other four contexts is predominant (Snowden and Boone, 2007). The description of the problem types, proposed on Cynefin framework, is represented in the Figure 3.

<p style="text-align: center;">Complex</p> <ul style="list-style-type: none"> - Cause and effect are only coherent in retrospect and do not repeat - Pattern management - Perspective filters - Complex adaptive systems - Probe-Sense-Respond 	<p style="text-align: center;">Knowable</p> <ul style="list-style-type: none"> - Cause and effect are separated over time and space - Analytical/Reductionist - Scenario planning - System thinking - Sense-Analyze-Respond
<p style="text-align: center;">Chaos</p> <ul style="list-style-type: none"> - No Cause-Effect relations are perceivable - Stability-focused intervention - Enactment tools - Crisis management - Act-Sense-Respond 	<p style="text-align: center;">Known</p> <ul style="list-style-type: none"> - Cause-and-effect relationships are repeatable, perceivable and predictable - Legitimate best practice - Standard operating procedures - Processes reengineering - Sense-Categorize-Respond

Figure 3 – Types of problems in Cynefin framework

The Cynefin framework provides recommendations on behavior with the problems of particular types and is widely adapted in software project management field of study. For example, Cockburn and Highsmith (2001) argued that Agile development excels in exploratory problem domains - extreme, complex, high-change projects. Daniel J. Fernandez and Fernandez (2008) proposed a comprehensive mapping of different types of problems and analyzed appropriate problem-solving strategies in software engineering field of study. The problems were divided into 4 quadrants as listed in the Figure 4 by the clear-

ness of goals and methods. There were 5 different problem-solving strategies proposed for addressing each of 4 types of the problems, which correlate with different methodologies of software project management.

GOAL	NOT CLEAR	Extreme strategy	Adaptive strategy Extreme strategy
	CLEAR	Linear strategy Incremental strategy	Iterative strategy Adaptive strategy
		CLEAR	NOT CLEAR
		SOLUTION	

Figure 4 – The framework for solution categorization (adapted from (Daniel J. Fernandez and Fernandez 2008))

- Linear strategy – traditional strategy that consists of dependent, sequential phases that are executed with no feedback loops. The project solution is not released until the final phase.
- Incremental strategy – identical to a Linear strategy except that each phase of the project releases a partial solution, the business value is delivered prior to the final stage.
- Iterative strategy – a number of repeated phases that include a feedback loop after a group of phases is completed. The last phase of a group may include a partial solution if the customer desires.
- Adaptive strategy – similar to an Iterative except for that with an Adaptive strategy each iteration's feedback adjusts the next iteration so that the next solution will be grown upon.

- Extreme strategy – similar to adaptive strategy except that instead of adjusting with each iteration to coverage upon a solution, the goal of the project must also be discovered and converged upon. An Extreme strategy differs from Adaptive mainly by unclearness of the goal.

Gomes and others (2003), though, argued that new product development (which is actually managed by Adaptive or Extreme strategy in the discussed research) is likely to be managed by combination of Agile and Traditional approach, which is called hybrid. This means that the topic needs further investigation and more detailed addressing on lower level. By “lower level” it is meant that the choice of problem-solving strategy can be investigated with focus on RE approach.

The researchers argue that RE research actually requires deeper investigation and conceptualizations by building and deepening theoretical frameworks of dealing with changing context (Jarke and Lyytinen, 2015). Jarke and Lyytinen (2015) mentioned that changing nature of the design task, growth of components and interactions, development of hardware and telecommunications technologies, globalization of organizations and other issue changed the nature of RE complexity. They proposed a framework, which addresses the issue of new complex RE (Table 2).

Table 2 – 6 V’s definition

Requirement Feature	Feature group	Definition
Volume	Simple	The size of the requirements pool influencing the scope of the work
Veracity	Simple	To what extent requirements express the needs of the stakeholders and are consistent
Volatility	Complex	The rate at which the requirements change over a given period of time
Vagueness	Complex	To what extent designers and other stakeholders understand the content and consequences of the requirement
Variance	Complex	The variation in the design scope and consequences of the requirement pool and the heterogeneity of design components involved
Velocity	Complex	The rate at which requirements are changing over time

This study explores how companies perceive the context and complexity of requirements engineering activity and choose the RE approach within the specific project. The structure of the research is following. The section 3 addresses the methodology description of the current research. The section four is dedicated to the results analysis. The section 5 provides discussion on the findings and their comparison with the existing literature. The section 6 is conclusion and results summary.

3 METHODOLOGY

In order to design the current research, the first aspect, which needs to be addressed, is the research paradigm. Different sources state that more the software industry matures, the more it is accepted that people involved in software development processes deserve special attention (Tomayko and Hazzan, 2004). For this reason, it is essential to understand the importance of subjectivity and personal interpretation of the reality and the meaning behind it. This is particularly important in this study, because it addresses the requirements engineering topic. This research area is extremely dependent on different human aspects and the way how companies organize it needs to be investigated. The interpretive paradigm was adapted in this research, because it seeks explanation within the realm of individual consciousness and subjectivity, within the frame of reference of the participant as opposed to the observer of action (Burrell and Morgan, 2011).

The previous studies define a number of common choices for gathering the research data, which can be done by means of different approaches (Silverman and Marvasti, 2008). These approaches are categorized into quantitative, qualitative or combination of both (Saunders et al., 2009). In order to study the numeric data, the quantitative approach is commonly used, while the qualitative approach is applicable when the textual data is needed for the research. The qualitative approach was selected for data gathering and analysis by means of interviews and surveys. In scopes of the current research it allows to investigate different aspects of the field, connected with professional background and past of the interviewee, as well as to study current and future ideas. For this, the open-ended interview was formed in order to study the companies.

3.1 Data Gathering

The interview questions were designed accordingly with the research questions and aimed to highlight the aspects of running software projects, connected with choosing the requirements engineering approaches and project results in order to find out the relation between the chosen tools and techniques and project outcomes.

The design of the questions for the interview was organized in a spiral manner and the questions were revised several times after receiving feedback. The feedback was provided by an external reviewer with practical background and research experience. The initial

approach towards the interview questions formation was based on the practical and research experience. The questions were formulated based on the listed aspects, and put in a chronological order, derived from the project activities sequence. Literature was studied mostly after the interviews and the results analysis in order to formulate scientifically-based research results and compare them with the existing knowledge of the topics.

The research process is presented in the

Figure 6 – Analysis process **Ошибка! Источник ссылки не найден.**

Figure 5 – Research process

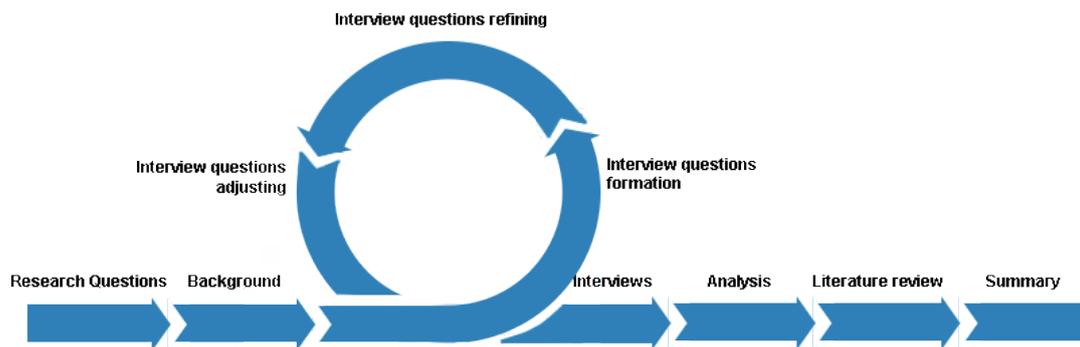


Figure 5 – Research process

All the questions were formulated as open-ended questions (Cooper and Schindler, 2014). The key motivation for this choice was the interest towards getting a vast amount of information about the companies and provoking discussion if possible. Different companies have their own definitions in scopes of analysed topics, which also came out to be a factor for choosing the open-ended questions to avoid pushing the interviewee into the frames. It will help avoid restriction on their opinions about different aspects.

The interview procedure was organized in a number of steps:

1. Contacting the company's representative and arranging a meeting.
2. Meeting with the representative and conducting the interview, using tape recorder after asking for the permission, and writing down the notes. The interview is conducted by 2 researchers (the interview data was further used for different studies). One is responsible for tracking notes and one participates in the dialog.
3. Filling the form of Data management.
4. Transcribing the interview record.

5. Analyzing results by each researcher personally and further discussion of the findings.
6. Formation of the analysis document and validating it with the interviewee through email.
7. Highlighting all the challenges and concerns for future improvement of the interview questions and survey process.

The research had the final step, which was done after the main interview part was finished and the results analysis started. When the interview results were finalized, another questionnaire was utilized in order to address the specific topic, which concerns the requirements engineering aspects.

The questionnaire was used in order to get more relevant data on the requirements engineering understanding among the companies. Some of the companies did address this topic in scopes of the main interview, but some did not. As soon as there were no direct questions about it in the main interview, the validity of this results were doubtful. Data gathering with use of extra questionnaire was organized in the following way:

- Formulating the questionnaire on RE features;
- Contacting the representatives;
- Sending the questionnaire to the representatives;
- Collecting and analyzing data.

The additional data gathering complemented the main interviews.

The convenience sampling strategy of Marshall (1996) was adopted for choosing the companies in the current research, because of the limited timeframes and the uncertainty about companies availability at the start of this research. The following criteria were chosen to form the sample of the companies:

- The companies run IT software development projects;
- The companies are located in Saint Petersburg;
- The companies are ready to share information about their operations.

The representative of each company was asked to pick one project to discuss it in scopes of the interview. The basic information about each interview is represented in the Table 3.

Table 3 – Interviews overview

Interview number	Code	Date	Duration	Number of interviewers	Representative title
1	C1P1	17.02.2017	1:33:13	2	Developer
2	C2P1	02.03.2017	1:21:39	2	Business analyst
3	C3P1	07.03.2017	0:42:00	1	Lead business analyst
4	C4P1	09.03.2017	0:52:13	1	Process Orchestration, Process Integration analyst
5	C3P2	10.03.2017	0:41:36	1	Business analyst
6	C5P1	12.03.2017	1:15:00	1	Business analyst
7	C6P1	21.03.2017	1:00:08	1	Technical product manager

3.2 Data Analysis

The study was conducted using an inductive approach. Empiric data gathered from different projects was gradually investigated from interviews to the more abstract level to propose theoretical framework. This approach let the research to be more innovative and provoke new ideas, which will contribute to theory and practice in software engineering field of study (Kothari, 2004).

The research strategy, adopted for this study, is Grounded theory-like approach (Strauss and Corbin, 1967). The analysis of the results is based on data structure concept for qualitative research, adopted from Gioia and his colleagues (2013). The analysis consists of several numbers of steps and is presented on the Figure 7:

- Defining the 1st-order concepts as close as possible to the original quotations out of the transcribed data from the 6 interviews one by one.
- Based on defined categories the 2nd-order themes are formulated. Themes are formed in order to merge extracted similarities and differences in 1st-order concepts, which concern different aspects of requirements engineering within the analyzed sample.

The process of defining the 2nd-order themes is linked to the analysis of any theoret-

ical realms, derived from the scientific literature. This step aims to investigate whether the emerging themes suggest any concepts to help in outlining any scientific findings.

- The 2nd-order themes are further aggregated into dimensions in order to generate and formulate the key finding from the gathered data, which would give the answers on the research questions.

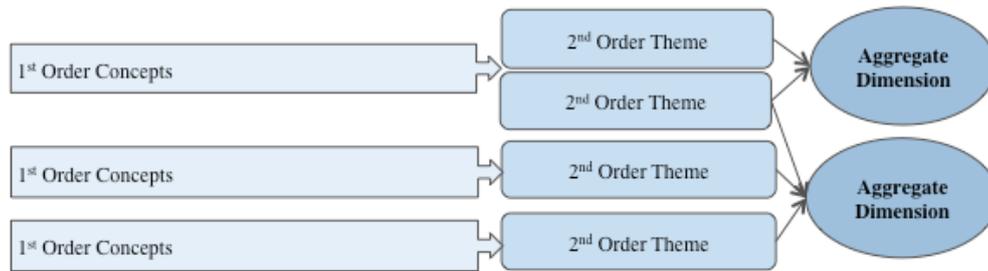


Figure 6 – Analysis process

The representation of the chosen methodology was adapted from Saunders and his colleagues (2009) and its summary can be represented by the Figure 7– Research methodology structure.

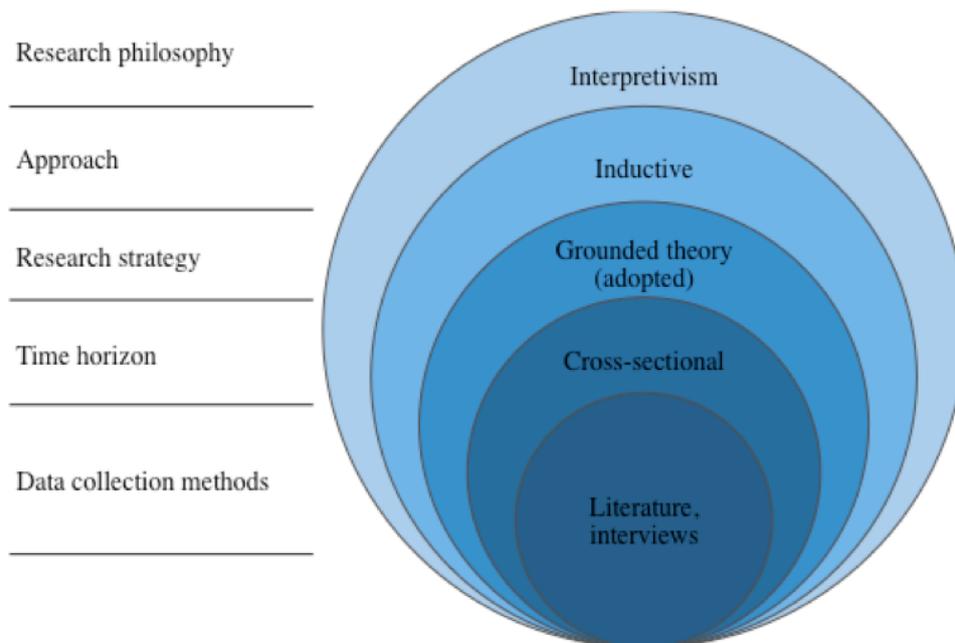


Figure 7– Research methodology structure

3.3 Addressing validity

In qualitative interpretative research, there is always room for diverse exegesis depending on the point of view of every party involved in the research, including readers. Wagner and his colleagues (2010) proposed that there are certain aspects, which need to be addressed carefully in order to ensure that the conclusions are plausible and defensible.

The following aspects need to be considered based on the previous research:

- Credibility refers to whether the results are believable from the perspective of the subjects under investigation.
- Transferability refers to whether findings from a research sample can be transferred to a broader population or to more general theoretical propositions.
- Dependability refers to whether it is possible to replicate the study, and whether this will lead to the same results.
- Confirmability refers to the degree to which the interpretations and findings of a study can be confirmed by others.
- Applicability refers to the context in which a method should be used. Thereby, the researcher's goal and the character of the research question to be examined determine the appropriate research method (Shenton, 2004).

In order to address the indicated aspects, a number of techniques, proposed by Lincoln and Guba (1985), were adopted in scopes of the current research:

- Triangulation: Two interviews were conducted by two researchers, while there were also 4 independently conducted interviews.
- Peer debriefing: The analysis of gathered data was also carried out by three researchers and then compared and discussed to ensure the exchange of ideas. Also the external researcher participated throughout all meetings and provided his feedback on the matters.
- Referential adequacy: All interviews have been recorded and transcribed.
- Member checking: The final analysis has been presented to each interviewee in order to discuss the results.

4 RESULTS

The empiric data was gathered from 6 projects, executed by 5 companies. For the purposes of categorizing the projects contexts, the Cynefin domains, described in the research of Kurtz and Snowden (2003) was used (see Chapter 2). The table below summarizes the projects.

Table 4 – Projects overview

Project ID	Problem description	RE style	Results
C1P1	<p>Software – Supplier Relationship Management system</p> <p>Customer – Large Stone production company</p> <p>Supplier – internal IT department</p> <p>Description – system development and implementation in scopes of the implementation projects portfolio dedicated to the complex change of the old software in the company.</p> <p>Cause and effect of implementation are separated in time – Knowable context</p>	<ul style="list-style-type: none"> • Baseline solution was implemented at once on production based on the high level requirements of top-management • Further development was done based on the users’ requests on a daily basis • Deployment as soon as the task is ready • Prioritization of tasks was decided in the team and tasks were tracked in the simplest tools. 	<p>The system was implemented successfully in scopes of the project and continues to be developed by the team to add more value to the users. The users attitude is overall positive and current development is dedicated to increasing of their efficiency of work.</p>
C2P1	<p>Software – Enterprise Resource Planning</p> <p>Customer – Large Oil and Gas production company</p> <p>Supplier – internal IT department</p> <p>Description – system development and implementation in scopes of the implementation projects portfolio dedicated to the complex change of the old software in the company.</p> <p>The effect from the system implementation has</p>	<ul style="list-style-type: none"> • Implementation is strictly regulated • Implementation consists of a number of steps, executed one by one with a set of closing documentation at the end of each stage. • Gathering all the business requirements at once in the beginning. • The changes were strictly regulated 	<p>The project is currently in progress and it exceeds the timeframes, established at the beginning, because of long negotiation procedures and low time restrictions for them. It also exceeds the budget, which is officially not the constraint for this project in the company.</p>

	<p>been perceived over long period of time – Complex context</p>		
C3P1	<p>Software – Accounting system Customer – Large Paper production company Supplier – external team from IT company Description – implementation of the standard solution with basic functionality for certain purposes of accounting processes, the customer previously worked with the paper and Office applications without any software. Cause and effect of implementation perceivable and predictable – Known context</p>	<ul style="list-style-type: none"> • Rapid implementation of baseline solution • Customization based on the constant users’ feedback • Continuously working with end users on a daily basis without any pending tasks 	<p>The project became the absolute success and was admitted as one of the most successful in the IT company. It was on time, budget and scopes. In addition, the users provided highly positive comments on the software implemented and the way how team worked.</p>
C3P2	<p>Software – Enterprise Resource Planning Customer – Medium Machinery production company Supplier – external team from IT company Description – customization of the existing software, which was already launched into production, but did not cover the needs of the customer. The current problem is not clearly linked to the</p>	<ul style="list-style-type: none"> • Requirements were provided by the key stakeholder • The requirements did not change significantly • The cooperation with end users was very difficult, because they were poorly allowed to provide their own requirements • The software customization was organized by steps with periodic 	<p>The project is admitted by the invited business analyst as almost failure one from the beginning, because the objectives did not compile with the principles of ERP. The project did not exceed the frames, but the customer did not get the desirable results and business value.</p>

	software system, no perception of cause and effect – Chaos context	demonstration of result	
C4P1	<p>Software – Integration platform</p> <p>Customer – Large retail company</p> <p>Supplier – external team from IT company</p> <p>Description – development and implementation of the software in order to integrate different systems and increase their efficiency.</p> <p>Cause and effect of implementation are separated in time – Knowable context</p>	<ul style="list-style-type: none"> • It was decided to use Kanban in order to speed up • Use of physical Kanban board • Everything was done on production environment • High and intensive development. • The end product was documented afterwards. 	<p>The project was admitted as highly successful, despite the fact, that there were more resources invested in this project, than it was initially planned. It was on time and on budget (because the extra resources were internal), the product came out to be very useful.</p>
C6P1:	<p>Software – Website platform</p> <p>Customer – Large retail company</p> <p>Supplier – internal IT department</p> <p>Description – development of the software from scratch in order to use it further for expanding business. The software was aiming to be able to produce websites for the distributors in a short period of time.</p> <p>Cause and effect of implementation are separated in time – Knowable context</p>	<ul style="list-style-type: none"> • Combination of Waterfall and Agile approaches. • The waterfall was utilized in order to get the minimum viable product based on the baseline requirements to the product. • More concrete requirements are formulated by the users after MVP delivery and executed in sprints. • RE continues after the launch into production to evolve the product. 	<p>The project was admitted to be total success, as the product has been delivered on time, scopes and budget. The users provided positive reaction on the product as it fit their expectations. The product itself was also aligned with the high-level business needs and helped to reach the initial objectives of the company.</p>

4.1 Interviews analysis

The Table 4 – Projects overview addresses the overview of RE approaches within specific project context and describes the projects' outcomes, proposing the answer to the Research question 3 (What were the experiences of using the specific RE approach for the particular project?). Further analysis is dedicated to deeper understanding of companies' behavior in scopes of these projects. The first step of investigation was organized through analyzing the transcribed interviews for each company. The text of each interview was walked through in order to pick up different quotations about the ways how companies acted in scopes of each project and aggregate them into different theoretical realms. The first step of analysis was not specifically linked to requirements engineering investigation, but was aiming to study deeper different aspects of the company in the specific project context.

C2P1

The company, which executed the C2P1 project, has a big set of regulations and rules, which were continuously addressed by the interviewee. The company's representative highlighted the standards or regulations for: defining the project success, responsibilities of each team member, project lifecycle, documentation templates. In addition, the interviewee emphasized that the documented approach does not change from project to project. This issue can be potentially aggregated into "Prescribed tools and techniques for each project".

In addition to the previous aspects, the interviewee pointed out the need for getting approvals throughout the project from different departments, which care about security in the company ("It is monitored that without specific meetings you can not move the project to the next stage"). Specifically, the key point here is that the project "can not be moved" further without these approvals. The proposed concept here can be "No step without approvals".

The prescribed aspects, described in the first paragraph, are set under control of a number of management levels. The representative emphasized that the project execution is controlled by project manager ("The lower level of the team is PM"), the project board on the

next level (“Project management team includes project board, which consist of the key customer from all project directions”) and also the project office on the highest level (“There is the project office which controls how the projects are going”). It might potentially mean that company values high control over the project execution, for the 2nd order concepts it can be aggregated into “Management control on each level”.

Further analysis revealed a number of peculiarities in running the project. They are all linked to high priority of control over employees and have a number of conflicts with key Agile principles (Fowler and Highsmith, 2001):

- “They tried to make it Agile, but did not work, because any Agile is not possible in our company, because it is impossible to control the performer”.
- “If there is meeting with the customer, the protocol is written”.
- “Email for interaction with customer is more preferable in order to fix the information”.
- “The product of the project is also a vast amount of support documentation”.
- “The criterion for project success is signing up the final box of documents”.
- “It is admitted that the project is successfully closed if the customer has signed the final box of documents”.

All these aspects can be summarized into “Control instead of agility” concept, which is formulated mainly based on the first quotation, while the rest are supportive.

In addition to the highlighted quotation about control over agility, the representative pointed out the ways how requirements are managed. Specifically, the requirements changes aspect was addressed in different parts of the interview. It was found through the quotations analysis that the changes in requirements are welcome mainly on the early stages of the project (“On the survey stage, the requirements are constantly changing”). Later on, the requirements can hardly be changed, because the specification is already done (“When it comes to the requirements specification stage and the requirement is not connected with preciously mentioned, it can be rejected”; “You can always take the specification and ask: where were you a week ago?”). These “Set in stone requirements” can be potentially another concepts, which represent the way how company acts.

All the 2nd order concepts and their supportive quotations are summarized in the Figure 8.

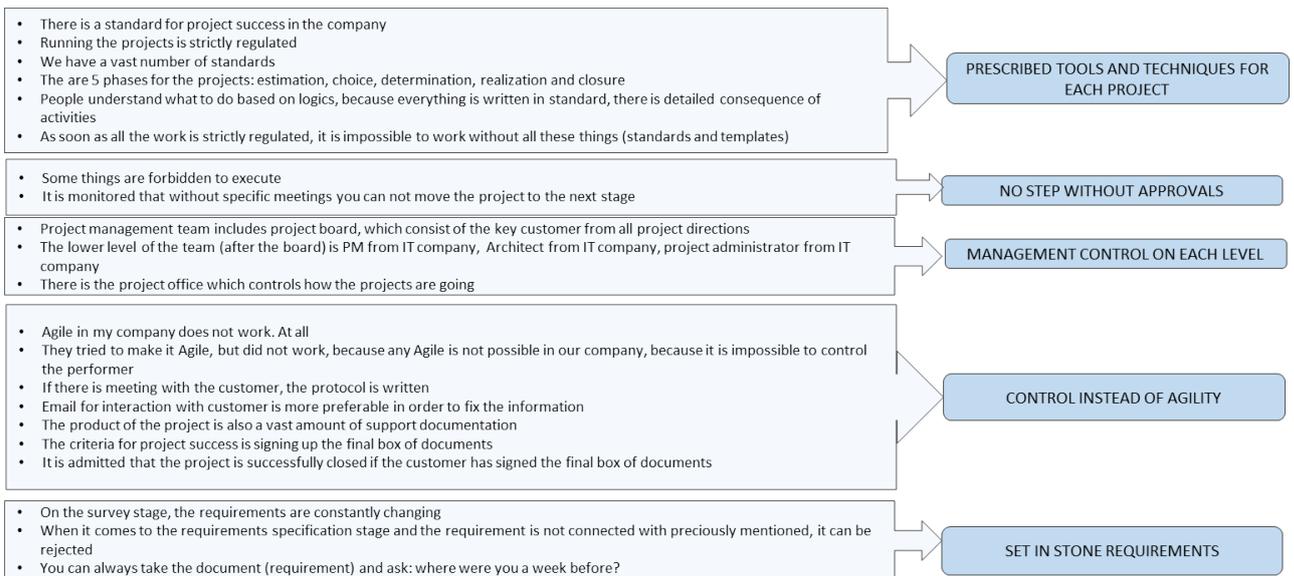


Figure 8 – Project C2P1 analysis

C3P2

The company of C3P2 project seemed to be not very efficient in project investments and its overall guidance. The interviewee indicated the following statements:

- “They wanted to save money and tried to implement by themselves with the use of some external specialists”.
- “They did not want to give us the project, they wanted to manage it by themselves”.
- “They do not want to spend money and as a result spend much more”.

As data shows, the company constantly tried to save money, but not very successfully, facing different mistakes further and, as a result, spending even more. This can be potentially called “Illusion of casts saving”, because the company seemed not to manage costs properly but tried not to invest.

In addition to the previously said, the project guidance was constantly transferred from one company to another, which is indicated by the statements:

- “They used to have several contractors who tried to implement, but did not”.
- “The modelling was previously done by another company”.

These aspects give an impression of seeking for cost-saving again, but another concept can come out of this data. This can be potentially “Constant transfer of the project between parties”, which is linked to the previously said, but reveal another important issue.

The interviewee also mentioned different indicators about the way how the company perceived the whole project and the attitude of the employees to it:

- “They had the understanding that if everything fits what was on the old version, then it is good”.
- “I was constantly asking to know how they work. Nobody wants anything, other solicitudes”.
- “I was trying to figure out how their company works and put it into ERP”.

The last two quotations can be interpreted as a clear “Reluctance to share information with the project team”. While the first one seems to mean that company could potentially be “Stuck with the existing way of thinking”. Both aspects can be related to each other on the higher level of analysis, but here they are considered as separate concepts.

In addition to these two aspects, it was also found out, there is also some kind of “Top-management pressure” in place, which is supported by the following statements:

- “Everybody is trembling in front of the main accountant and everything goes down because of it”.
- “The chief accountant and the head of IT were constantly asking how the things are going”.

All the 2nd order concepts and their supportive quotations are summarized in the Figure 9.

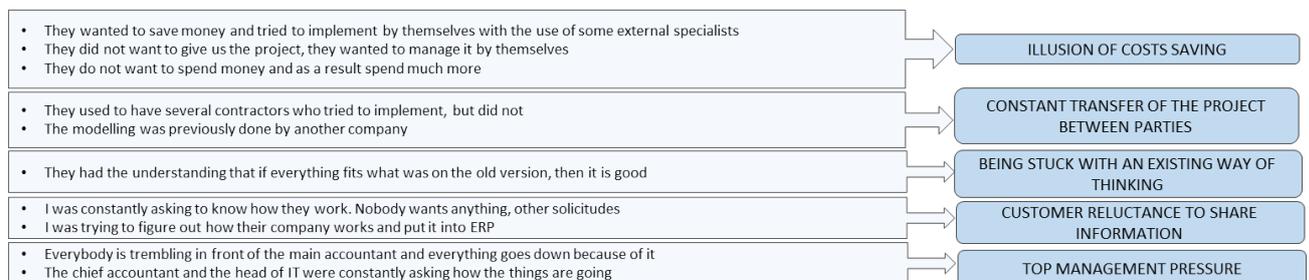


Figure 9 – Project C3P2 analysis

C4P1

The project C4P1 revealed many opposite aspects to the failed project C3P2. Instead of “Illusion of cost saving” and “Constant transfer of the project between parties”, revealed in the previous project, the C4P1 representative provided the following quotations:

- “Architect, 2 PMs (both sides), 2 our integrators and 2 customer’s integrators and unlimited developers”.
- “We were working 16 hours a day without weekends”.
- “The delivery of results was in a tick. As soon as something ready, it is put on production”.
- “The test report was not always written, no time for bureaucracy”.

There is clear “Readiness to invest resources” (the first quotation) in the project and “High intensity of work” (the rest quotations) within the project team.

In addition, there is potentially useful information about the size of the company, which could be the explanation of the way how it performs and would be valuable for the further analysis:

- “The company is young and small”.
- “The directors act as PMs on the projects”.
- “I am focused on integration tasks, but have to deal with the others, because there is lack of people”.

The small size company seems to prefer active value-adding work, which was already indicated above. The “Small company as a big team” is a 2nd order concept, which can aggregate the quotations.

Some preferences on the methodology choice were also discussed by the company’s representative, emphasizing the preference of highly intensive approaches like Kanban (“We used methodology (Kanban) when we realized that project is complicated and we can not keep moving by intuition, we picked methodology and finished on time”). Studying this quotation, it was found out that this was not just the preference, but mainly understanding of the need to use. More quotation about this choice were found in the interview:

- “The choice of Kanban was done by PM from customer, because we were not on time, he has written down the tasks on the sheets during the night. We were just faced with the fact”.
- “Normally everything is done on time and budget without any specific methodology”.
- “The planning was bad”.

The analysis showed that Kanban choice here seems to be a kind of “lifebuoy” to finish the project in scopes and increase intensity of the work. The 2nd order concept was called “Kanban lifebuoy”.

In addition, the interviewee mentioned the style of work with the customer as a part of this kind of intensive work. The company clearly was focused on the needs of customer:

- “It was always understandable what the client wants”.
- “To get the same level of understanding, there was face to face communication”.

The phrase “always understandable” is very strong here, because the issue of misunderstanding the business needs is constantly addressed in different researches (Fricker et al., 2010). The quotations were aggregated into “High level of customer understanding”.

In addition to the previously said, the company’s representative pointed out other aspects of working with the customer:

- “The customer's representatives were together with supplier in a one big team”.
- “When the first problems appeared, all the team was moved to the customer's office with full permission on any activities”.
- “The customer trusted us totally”.

The aspects differ from concept “High level of customer understanding”, but represent other important aspects like collaborative working on the project or issue of trust between the customer and supplier. The aggregate dimension here is “Mutual trust and collaboration”.

All the 2nd order concepts and their supportive quotations are summarized in the Figure 10.

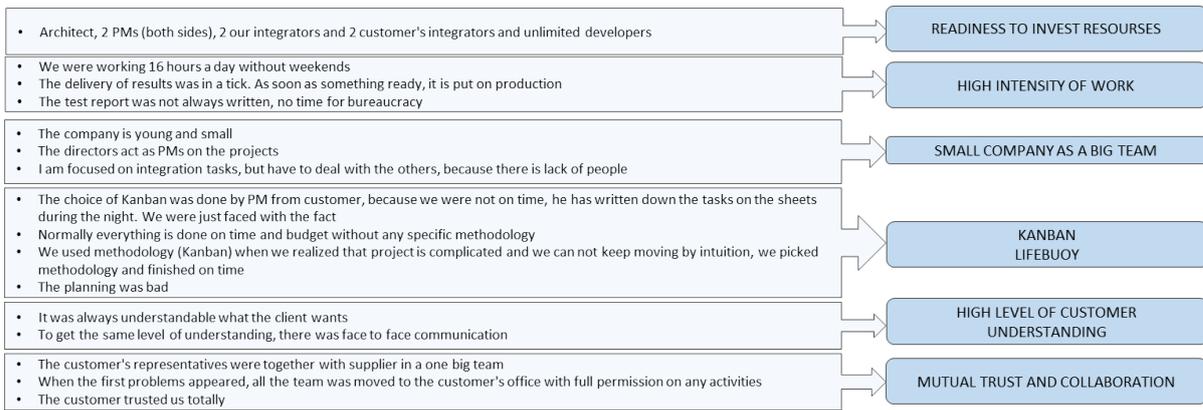


Figure 10 – Project C4P1 analysis

C6P1

Studying the interview transcription of the project C6P1, the first thing, which came out of data, was the fact that company actually tends to use different methodologies and know exactly where they could be applied. In addition, the room for improvement and its variants were discussed for the existing methods:

- “We decided that we need to adopt Scrum with some elements of Kanban to understand what is going on around”.
- “We actually work with Agile methodologies, but the first iteration is Waterfall (but still in sprints)”.
- “When something new appears on the Waterfall stage, it can wait until the support. On the support stage, the changes can be implemented in scopes of one sprint”.
- “There is Project Manager from contracting company and in fact, it is book-based scrum, with product owner and scrum master”.
- “There is daily communication in a way: "which tasks you do today, tomorrow”.
- “Once in 2 weeks there is big planning meeting for starting/closing the sprint”.

The quotations clearly lead to the indicator that company actually combines the methods very mindfully and knows exactly which method is better for a particular project part. The dimension can be “Agile and waterfall combination”.

In addition to the methods combination, the company’s representative highlighted the way how the artifacts are used:

- “Even though we call it waterfall, we did not have much documentation”.

- “We did not document the product itself much, because there were many other things to do, not wasting time on documentation”.
- “Even on the waterfall phase, the tasks are put into backlog. There are sprints which would close the tasks”.

The company seems quite intelligent in the project management context and has strong theoretical base, being able to choose exactly which artifacts are valuable for them and the customer. The 2nd order concept can be “Adapting the set of artifacts”.

The company’s representative provided the following quotations on the way how requirements elicitation was organized:

- “When the stakeholders ask for something, the team asks "why do you need it"”.
- “The stakeholders put the priorities for the requirements”.
- “There were 15 high level business requirements”.

The analysis revealed that the project team is very much focused on the business value of the requirements. The business requirements are not required to be specific, but the project teams provides the analysis by themselves. The 2nd order concept here can be “Business dictates requirements” in order to emphasize that the software development is based on value-adding for the business users.

The way in which the team worked with the stakeholder was characterized with the interviewee by the following quotations:

- “We invite the stakeholder to the meeting and record everything (after the solution search)”.
- “There might be conflicting requirements which elaborate more with the stakeholder”.
- “There were cases when the stakeholder was understood incorrectly, but we always could explain it (why it was done in another way)”.

In addition to the “Business dictates requirements” concepts, the analysis of the indicated quotation revealed that the team tends to communicate a lot with the stakeholders in order to deliver the requirements properly and avoid any conflicts. This can be aggregated into “Continuous communication with stakeholders”.

All the 2nd order concepts and their supportive quotations are summarized in the Figure 11.

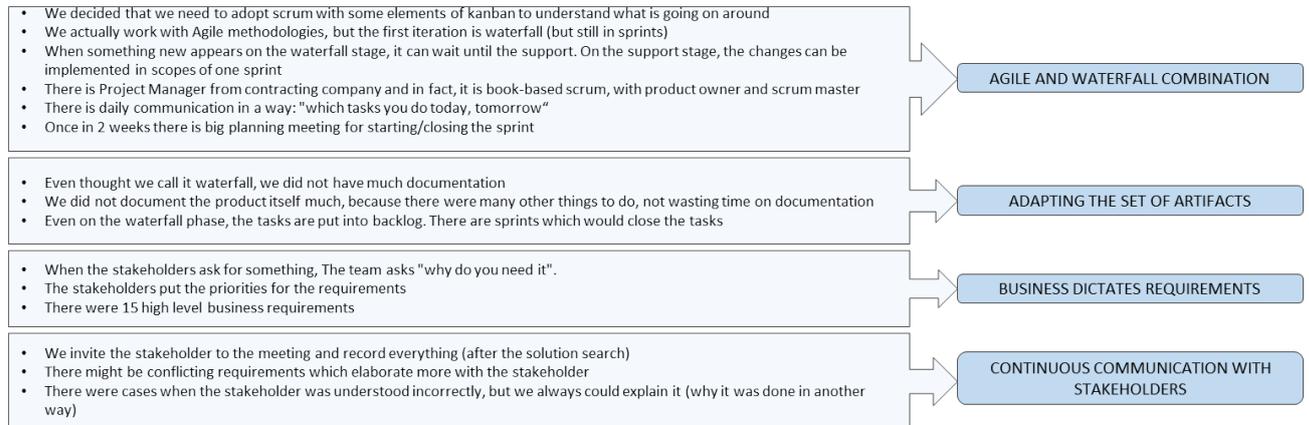


Figure 11 – Project C6P1 analysis

C3P1

The C3P1 project was rather extreme one for the company's representative due to different factors: remote customer, inability to work remotely, tight schedule, absence of any software at the customer before the implementation project. In scopes of the interview the company's representative emphasized a lot the way how the team performed:

- "We evaluated the requirements inside the team, by expert judgement, deciding what can be neglected and made the users to be aware".
- "Based on the experience of project management, what we to do, what can be neglected, and so on".
- "It was perfect, because we were sent there by three analysts and the project manager. We had fairly cohesive team".
- "We had a cool architect, with experience of implementation, could delegate responsibilities, spoke self-confidentially".
- "From the previous experience I might pick team, close-knit team and clear distribution of responsibilities".

As it can be seen from the data, the personal skills and experience of the team played great role in scopes of that project. The concept "Personal skills and experience are topmost" can be derived from the quotations. The decisions on requirements were taken inside the team again based on the experience – "RE decisions within the team".

The representative introduced different aspects of the way how team performed:

- “There was no such thing as a pool of pending tasks. We tried to put everything in progress immediately”.
- “It was express implementation, our favorite word. We planned for a week ahead”.

These quotations show high intensity and motivation to work of the team. They can be summarized into “Motivation to deliver the product faster”.

Concerning the interaction with the customer, the company’s representative highlighted the following:

- “We had our own office at the factory, we had our own phone, everyone knew it and called us, after that everything was solved”.
- “There was no remote work, only direct communication”.
- “There was face to face communication with the client”.
- “We were testing together with users”.
- “We had manuals for the users, schemas”.

It can be clearly derived from the data that the team had “collaborative face to face communications” with the users and the user-involvement was indicated in different activities.

In addition to this style of interaction with the customer, the representative discussed a lot the aspects of working specifically with the users:

- “We were working directly with end users”.
- “We were testing together with users”.
- “We had manuals for the users, schemas”.

It can be seen from these quotation that the team was not only working with users on requirements elicitation, but tried to organize high level of user-involvement in many different activities. This could be represented by the 2nd order concept “Continuous user-involvement”.

All the 2nd order concepts and their supportive quotations are summarized in the Figure 12.

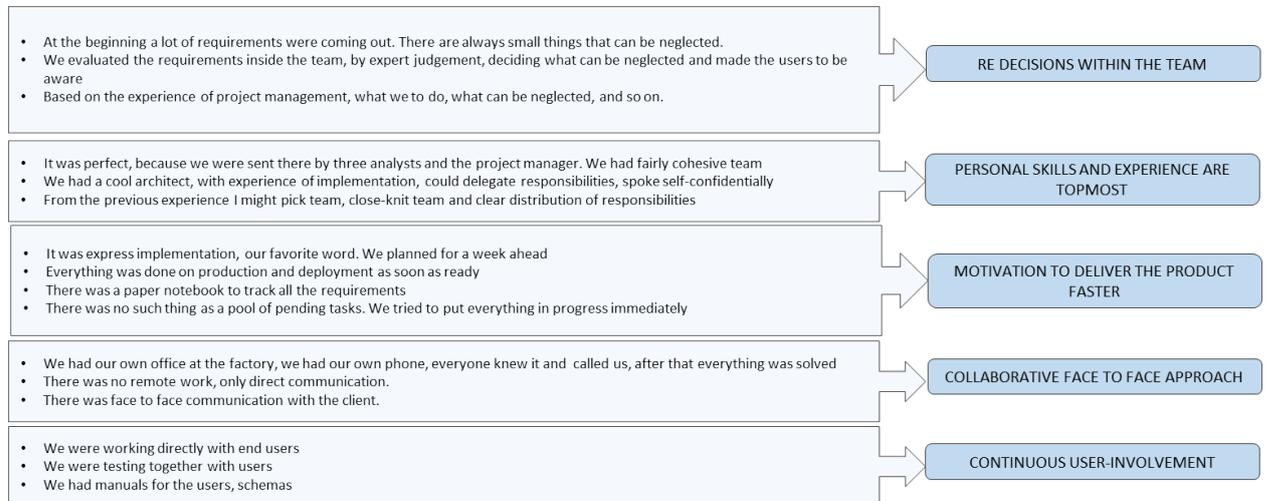


Figure 12 – Project C3P1 analysis

C1P1

The project C1P1 revealed the similar concepts as the C3P1, which concern the project team. The representative highlighted the leadership aspects within the team, which affected the project performance (“Lead developer participates in meetings with the board of directors on the large tasks”, “If the requirement is big and baseline, than I consult with the lead developer”). The quotations can be aggregated into “Experienced and skilled leader” dimension, which shows the aspects of team organization and performance.

In addition, as well as in the project C3P1, the interviewee pointed out different aspects of working with the customer:

- “More trainings for the users should be provided”.
- “There were manuals, video lessons and copy of the system stored on web 3 months before switching the software”.
- “Many directors participate on the project in tasks setting”.
- “There is collective responsibility of the team and users in fitting the requirements”.
- “Sometimes users can participate in testing (data checking after updating)”.

There could be two aspects derived from these quotations. The first is “Trying to involve users”, which is aggregated from the first two quotations. It represents willingness of the team to involve users and integrate them more into the project, feeling need in that. But it can be seen that except for involving users into the project activities, the team also seeks for collaboration with them and top management. It can be aggregated into another concept, which is “Corporate collaboration on the project”.

The speed of product delivery aspects were again emphasized in the analyzed project (have already been indicated in C3P1 and C4P1):

- “This approach was chosen to speed up the implementation. What's the purpose to wait?”
- “Everything was implemented at once and users came one day to work and had to work with the new software”.

These aspects were aggregated into the concept “Idea of being fast”.

In addition, despite the speed of implementation, the team paid a lot of attention to the development process itself:

- “The connections and dependencies in the code are always checked carefully”.
- “If he requirement do not bother the logic of the system or other processes, it does not bring serious changes, I do it by myself”.
- “5% of requirements might happen when the requirement’s execution breaks something”.

It can be seen that implementation of the requirements is organized in a mindful way, the representative checks the software integrity. This reveals the concept, which was called “attention towards software consistency”.

The interviewee also discussed the changes of requirements:

- “15-20% of requirements can change after implementation on production”.
- “Developers deliver basic version before doing further development”.

These quotations show that requirements changes are welcome by the team, because almost 1 out of 5 requirements might change after being put into production. It can be seen that the team works based on principles of agility, seeking for the feedback from the cus-

tomers on early stages of development. These can be aggregated into one of the Agile principles – “Changes are welcome”.

All the 2nd order concepts and their supportive quotations are summarized in the Figure 13.

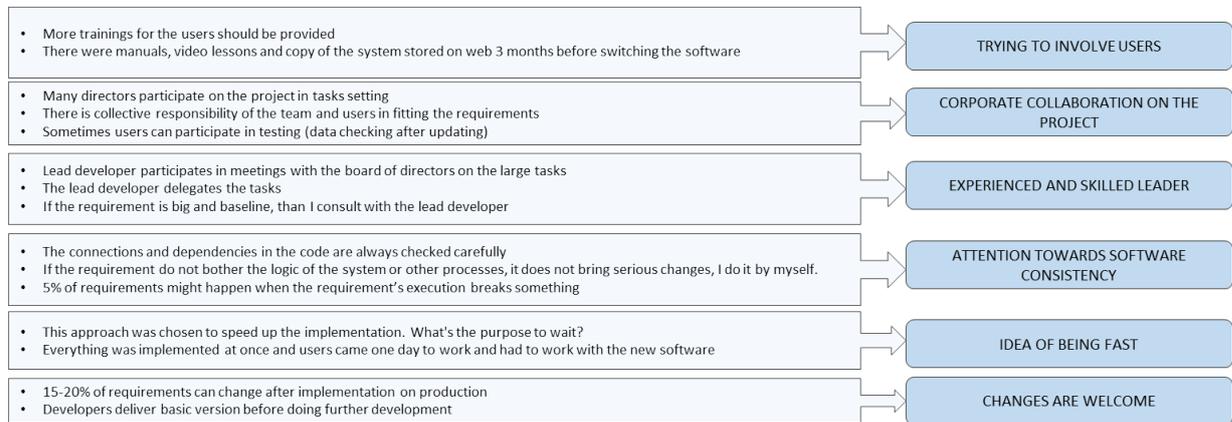


Figure 13 – Project C1P1 analysis

4.2 The concepts analysis and Aggregate dimensions development

The analysis of 1st order themes and 2nd order concepts gave a comprehensive overview of the companies and the ways how they run the specific projects. The analysis revealed several themes with the same meaning, which emerged in different projects. For example, “Trying to involve users” means almost the same as “Continuous user-involvement”, “Motivation to deliver the product faster” means the same as “Idea of being fast”. It means that there are clear similarities in companies’ characteristics. Leaving only one of those concepts would help to reach more abstract level of analysis and merge the sets of concepts into the aggregate dimensions.

The analysis of the 2nd order concepts started with looking for the similarities in the ways how companies run the projects and behave within specific project context. For example, the “Mutual trust and collaboration”, “Continuous user-involvement” and “Changes are welcome” are all identifying equal behavior of the team in interaction with the customer, which is characterized by adapting to the customer’s needs. Adding to the same group “RE decisions within the team”, “Personal skills and experience are topmost” draws a picture of the company, which also values the personalities of team members. While the

teams are likely to be characterized by the following concepts: “Idea of being fast” and “Attention towards software consistency”.

These characteristics were put in the aggregate dimension, named **adaptive mindset** of the company.

On the contrary, there are obviously 2nd order concepts, which can potentially be formed in another group. For example, instead of “Changes are welcome” there is a concept “Control instead of agility” or “Set in stone requirements”. The issues, linked to corporate control, also emerged through other concepts: “Prescribed tools and techniques for each project” and “Top management pressure”. All these aspects make different aggregate dimension to emerge, which is more about the companies, valuing control and strict regulations. The 2nd order concept “Being stuck with an existing way of thinking” seems also supportive for this grouping. It can be proposed that the companies of emerging type might have communication issues within the software project and “Customer reluctance to share information” can be also integrated into this group.

These characteristics were put in the aggregate dimension, named **bureaucratic mindset** of the company.

After these two dimensions were formed, the following 2nd order themes were left for the analysis:

- Agile and Waterfall combination;
- Adapting the set of artifacts;
- Stable project practices;
- After-project product evolution;
- Proactive Waterfall;
- Business dictates requirements;
- Continuous communication with stakeholders.

Some of these characteristics seem similar to those, which were aggregated into “Adaptive mindset” dimension (for example “Continuous communication with stakeholders” and “Continuous user-involvement” in Adaptive mindset). But deeper analysis showed that in the remained group the points seem to have stronger meaning. For example,

“Changes are welcome” in Adaptive mindset have become “Business dictates requirements”, meaning much higher attention to the business needs of the customer.

There are “Agile and Waterfall combination” and “Adapting the set of artifacts”, which reflects the ability to adjust to the project context, seeking for the better way to run it with use of different tools and techniques. In addition, it can be seen that there is high focus on customer satisfaction, because the “product continues to be evolved after the project”.

The aggregate dimension for this type was called **holistic mindset**.

The summary on the aggregate dimensions, which represent companies’ mindsets, are demonstrated in the Figure 14, together with the 2nd order concepts, which have formed them.

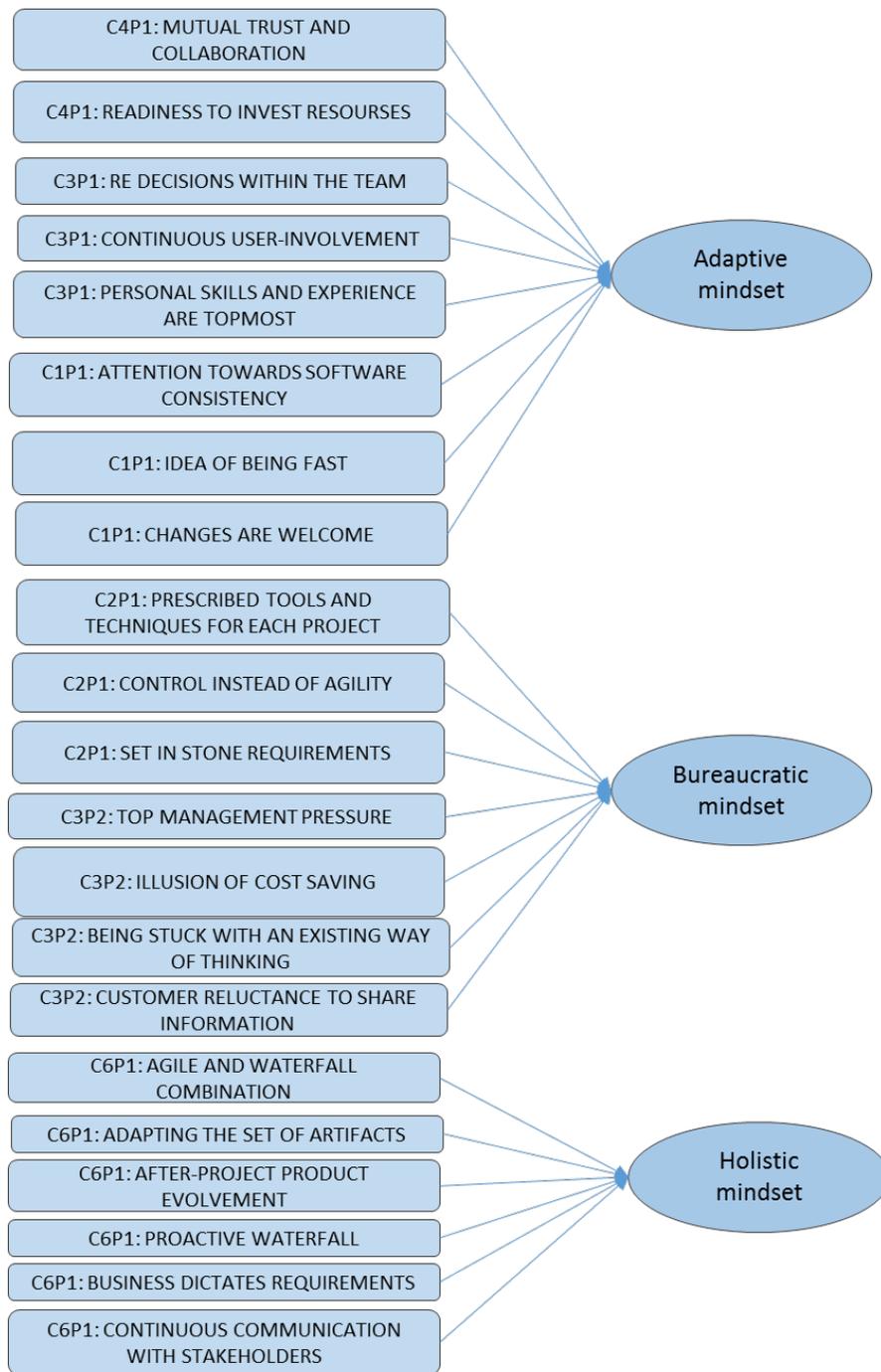


Figure 14 – Aggregate dimensions formation

Each aggregate dimension represents how the company performs the project and can be characterized differently.

Adaptive mindset (C4P1, C1P1, C3P1):

- The company has established requirements engineering approaches, admitted to be the same for all the projects.

- The teams of this type of companies are motivated to step aside from the corporate standards in order to find the most suitable approach within the project context.
- The company management at the same time either relies on the teams' decisions, or do not control the way in which the team had decided to act.

Bureaucratic mindset (C3P2, C2P1):

- The established project practices from one project to another.
- Appreciating the high level of control when running the project by means of excessive documentation.
- The project teams in scopes of this level do not adjust to the context of specific project due to different factors, which could be either lack of ability because of number of regulations, or either lack of motivation.

Holistic mindset (C6P1):

- Continuous seeking for processes improvement by the company on its corporate level.
- Having strong practical and theoretical background, being able to diagnose whether the “book-based” knowledge is applicable in the specific context.
- Feel need in combining different methods and approaches from situation to situation, as they are able to distinguish the strong points of different methodologies and indicate their applicability for particular project.
- The companies of this type are likely to focus not only on the specific project context, but they have more broad view on the context of their business.
- The teams, executing the specific project, get the corporate support and governance, feeling low need in adjusting by themselves, as this is decided on the corporate management level and enhanced on the team level.

4.3 Ability to perceive the context among the companies

Further analysis is dedicated to deeper investigation of the way in which the companies of these proposed mindsets (bureaucratic, adaptive and holistic) choose the RE approach in a specific project context. This issue can be addressed through comparison of problem

and problem-solving strategy in each particular case. IT would reveal the ability or inability of the companies to choose the RE approach, which fits into the specific context.

In order to demonstrate how the companies of different mindsets chose the RE style within the specific project context, the graphical mapping was provided in the Figure 15. Each project was placed on the board in one of four quadrants: known, knowable, complex, chaos, based on its context. For the purposes of categorizing the RE style from the projects description Table 4 – Projects overview, the strategy types, proposed by Daniel J. Fernandez and Fernandez (2008), were used (see Chapter 2). The adapted RE style was placed in the domain, where it originally refers.

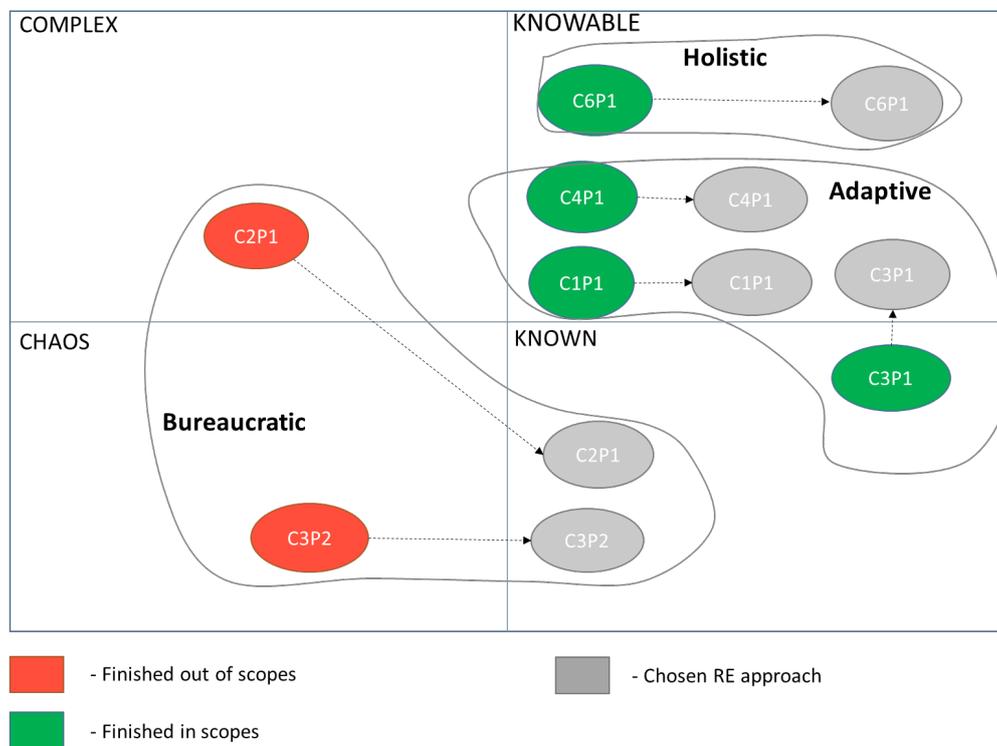


Figure 15 – Projects mapping

The results analysis propose that the software development projects are more likely to fail if the problem-solving approach the team has chosen to use is originally intended for problems with lower levels complexity. The indicated mismatching is likely to be a characteristic of the “bureaucratic mindset” companies.

The situation differs for the companies of “adaptive” and “holistic mindsets”. These types of companies tend to choose problem-solving approaches, which are likely to provide

successful results. It was found that the approach can potentially be successful as long it is designed to deal with higher levels of complexity than the design problem at hand.

4.4 Problem nature perception among the companies

The problem nature perception is addressed in the current section. The baseline for the analysis is the following hypothesis, derived from the previous section: the companies of bureaucratic mindset prefer organize requirements engineering in a more simple way and pay less attention to its complexity, than adaptive or holistic companies.

In order to support or disapprove this hypothesis, the perception of the RE complexity by each company had to be studied based on the additional specific survey. To define the difference between the visions of RE activity by each company, a number of aspects and their importance for the companies had been studied. The aspects of requirements engineering have been taken from Jarke and Lyytinen (2015), because they proposed a provocative study on modern complexity of RE (see Chapter 2). The aspects were divided into simple and complex groups, as was proposed in the chosen model. This division would also help to analyze whether the companies are aware of complexity of RE discipline or prefer perceive it in a simple way.

Each project was addressed one by one through a survey. It was aiming to reveal how the companies perceived each RE aspect within the particular project. All the aspects got the following rating based on the survey:

- There was need for consideration indicated, the need is marked as High – 2.
- There was need for consideration indicated, the need is marked as Low – 1.
- There was no need for consideration indicated or the team did not take the aspect into account – 0.

The results of RE survey are provided in the Table 5.

Table 5 – RE survey results

	C1P1	C2P1	C3P1	C3P2	C4P1	C6P1
Volume	“There are the high level tasks and a number of smaller tasks which constantly refreshes, there more than 80 tasks in the backlog. It has to be planned to have a big picture of the project and plan it.” (2)	“There were about 120 high level requirements from one business direction and 60-70 from another. This is highly important aspect to consider.” (2)	“Initially there was a vast amount of requirements, they were all tracked. This refreshing backlog gave us the understanding of the project scope.” (2)	“The number of requirements was derived from the accounting documentation lines. The aspect is considered as important, because it helps to get the system structure and internal interaction.” (2)	“There were about 400-500 tasks on the board. This was the highly important aspect.” (2)	“There were about 15 high level requirements, we track the amount of them” (2)
Veracity	“Reaching the same level of understanding and correct formulation of the requirements by continuous communication. You have to pay attention to it in order to avoid doing extra job.” (2)	“The business requirements are continuously negotiated to reach the same level understanding and represent the needs of stakeholders” (2)	“All the meeting protocols were written down in order to keep all the desired requirements. We had only face to face communication with the users	“Highly urgent aspect, because it is important understand the real need in the requirement and be able to propose solution.” (2)	“The requirements were rarely understood incorrectly, because it was more technical project, but we did pay much attention to it.”	“The requirements are often perceived in a wrong way, but explained afterwards why they have been executed in this way” (2)

			to get deeper understanding.” (2)		(2)	
Volatility	“15-20% of requirements change after getting to production, because the user understands better what he wants. The key point here is to deliver the basic version as soon as possible.” (1)	“Paying a lot of attention, the changes are strictly regulated, so it is highly important to manage them by different approaches.” (2)	“The tasks were constantly refreshing. We totally engaged users in the implementation right from the beginning, so we had to work with it.” (2)	“Difficult to consider, small chances to forecast what would be going on.” (1)	“The process model changes, everything changes, many underwater stones, we had to react fast, because there were many ongoing projects in parallel. The aspect though is less important, because the project was more technical.” (1)	“All the changes are welcome on the iterative developer after delivering the MVP. The changes can be done within sprint” (2)

Vagueness	“The connections are always checked carefully to ensure integration when the requirement is implemented. It might happen in 5-7% of implemented requirements. Very urgent aspect, because there were no analyst who check the comprehensiveness of the requirement” (2)	“The work is organized based on specification, everything is clear.” (1)	“Did not pay much attention to this aspect”	“Very important in one row with Veracity, here it is also important to have the person in the team with the knowledge of context (of customer’s business)” (2)	“It often happens when the requirement implementation affects somehow other requirements and we control it. One of the most urgent aspects.” (2)	“We write user-stories to get comprehensive understanding of requirement place and influence” (2)
Variance	“We did not pay much attention to this aspect.”	“The aspect is not clearly perceived, but all the processes, which concern the variation of the design scope, are regulated.”	“Did not pay much attention to this aspect”	“Not much important, can be achieved through constant communication” (1)	“Very important aspect to take into consideration to get the comprehensive product.” (2)	“We do not take it much into consideration”
Velocity	“The company is contin-	“For the changes	“The project was	“Everything changes and	“We prepared a	The product stays c

	uously growing and the needs are growing over time.” (1)	after a period of time there are prescribed procedures to manage changes, the aspect addressed” (1)	fast, express-implementation, so most concentration was on volatility.” (1)	we had to work with it. You need to organize the contracting in a correct way and work.” (1)	process for changes when the product was ready. You just had to follow it.” (2)	our support and 25-30% of its functionality can change, because the needs are changing” (2)
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The way how requirements aspects are addressed do not appear to depend on the company's mindset. For example, the project C3P2 is characterized by considering all the RE features, while the company there has bureaucratic mindset. The project C4P1 is also characterized by considering all the RE features, and the company has adaptive mindset. The proposed hypothesis is admitted as wrong. The problem nature seems to be understood equally among the companies of different mindsets. Though, taking into account the mismatching of actual problem context and problem-solving strategy in different companies, it can be proposed that the companies of different mindsets could potentially differ by ability of acting across the contexts. This means that despite comprehensive vision of RE activity and managing variety of its aspects, some companies might be able to act effectively only in a limited number of problem domains.

4.5 Towards the framework

The companies of adaptive or holistic mindset seem to have higher ability to adapt, because they tend to choose more appropriate RE approach for the particular project. The summary on the companies' mindsets is represented in the Figure 16.

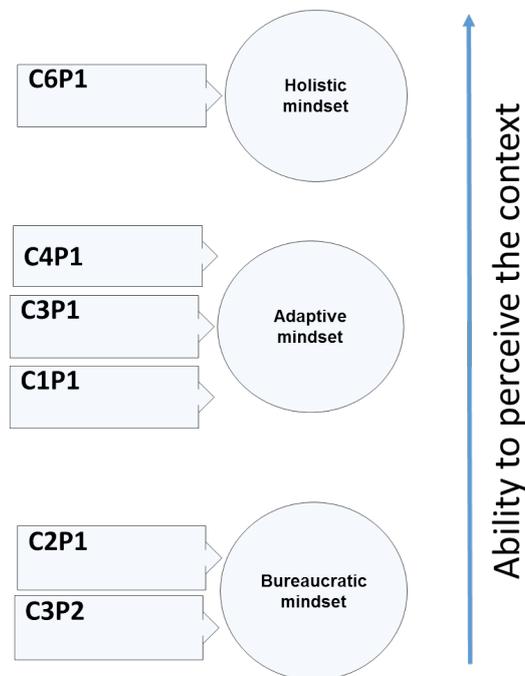


Figure 16 – Companies' mindsets

Each mindset of the company was characterized by the way how the project was executed. These “Execution styles” can be potentially divided in the following categories based on the gathered data:

- Controlled style of project execution is indicated in the companies of bureaucratic mindset, where the established rules can be the barriers adjustment to the situation. The typical concepts, which characterize this execution style, are: “prescribed tools and techniques for each project” or “control instead of agility control instead of agility”. At the same time, the controlled style can be useful in simple projects domain;
- Approved style is a characteristic of the companies with adaptive mindset. Despite the existence of well-established approaches within these companies, the teams are able to act depending on the context. The typical concepts, which characterize this execution style are: “personal skills and experience are topmost”, “re decisions within the team” or “mutual trust and collaboration”.
- Enhanced style is a characteristic the companies with holistic mindset. The performance of the team is aligned with mindful choice of the approach by corporate management and supported by them with suitable project guidance. The typical concepts, which characterize this execution style, are: “adapting the set of artifacts” or “agile and waterfall combination”.

The final framework, summarizing the interrelation between company’s context perception levels, project execution style and the choice of RE approach, is represented in the Figure 17. The figure is divided into 2 zones. They represent, whether the companies, which fall in each of these categories, are likely to choose the compatible problem-solving approach or tend to seek for more simple approach.

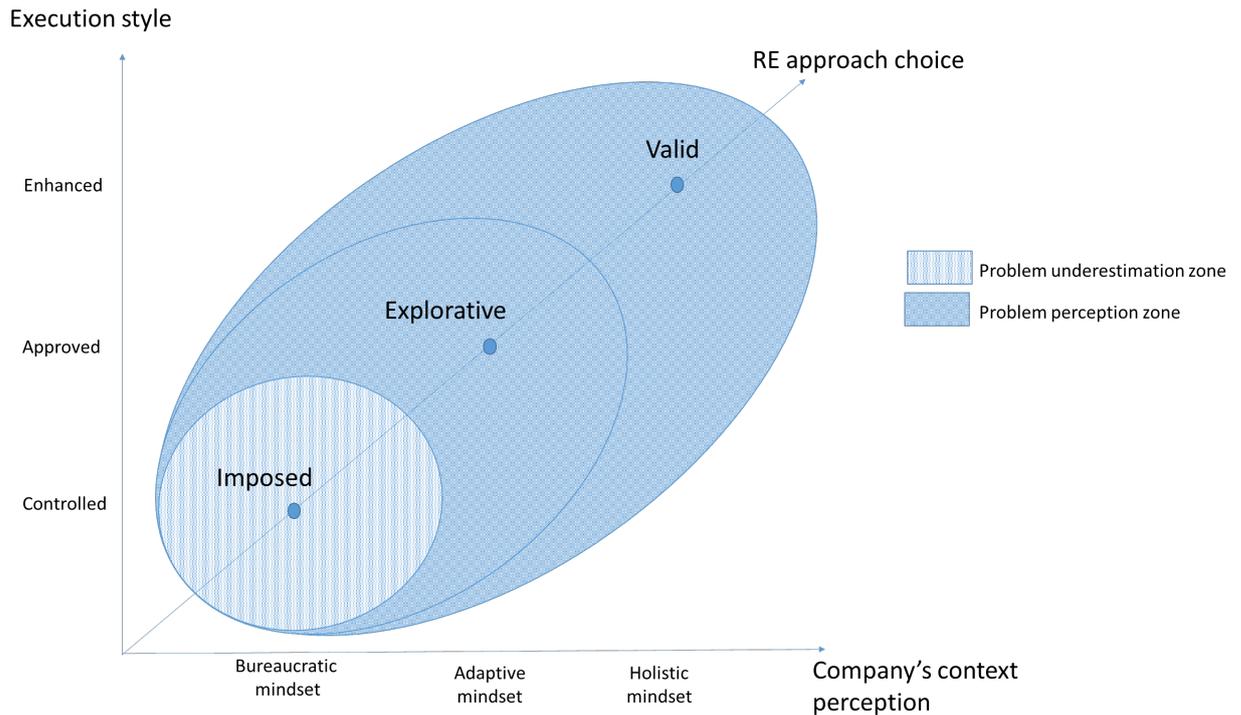


Figure 17 – RE choice framework

The research results revealed that companies have an overall comprehensive vision of requirements engineering activity (RQ1). The companies tend to evaluate addressing different RE aspects as considerably valuable issue in managing software projects. The perception of the RE complexity, though, is different among the studied companies. The difference is characterized by the ability of the companies to act across the contexts and adapt towards different problem levels. It was proposed that the companies could be potentially different in their mindsets, which characterize how the RE approaches are chosen (RQ2).

The bureaucratic mindsets are likely to target simple strategies of requirements engineering, which seem to be poorly able to solve more complex problems. In bureaucratic companies the freedom of software developers in terms of tools and techniques choice is limited, this potentially makes them become less aware about the context. While moving to adaptive or holistic level of context perception, there are more chances that approaches would be chosen mindfully within the specific project context. The combination of different RE approaches is also possible among these types of companies, which helps those addressing contexts of different complexity.

The final framework summarizes the main research findings and aims deepening theoretical frameworks, which would help to generate strategies of dealing with this complexity in RE field of study.

5 DISCUSSION

5.1 Framework analysis

The final framework, derived from the empiric data, addresses the issue of context perception as an important factor for acting successfully in scopes of software development projects. The investigation of projects' results revealed that the issue of problem underestimation could be critical for the company in terms of finishing project in agreed scopes. Wingo and Tanik (2015) emphasized the ability of the company to choose the approach compatible with the problem level as an important factor of efficient acting. This phenomenon has been constantly addressed in the literature. The Ashby's Law of Requisite Variety postulates that to obtain a desired outcome, the system must match the number of states in the input with at least an equivalent number of states in the regulatory process (Ashby, 1991). For the software engineering field of study it has been adapted to state that a solution cannot control an environment of greater complexity (Sheard and Mostashari, 2009).

This study identified three different mindsets among the 6 explored projects: Bureaucratic, Adaptive and Holistic. The characteristics of companies' mindsets have become the basis for the difference between their context perceptions. For example, bureaucratic context was characterized in the literature as "the way we do things around here", which affects the emerging culture (Berger, 2007). Adaptive mindset is constantly addressed issue through different researches on Agile project management, indicating the need to act depending on the context (Murphy, 2004). Despite the natural adaptiveness of the Agile methodologies, some researches still emphasize that there is strong need tailoring it to a specific project context (Cao et al., 2009). The high-level contextual aspects, linked to the project surroundings, are taken into consideration by companies with holistic mindset based on the proposed framework. In the existing literature it was stated that different contextual variables have significant correlations either with the quality of planning or with goal changes and plan changes in the company (Dvir and Lechler, 2004).

The framework proposes that the execution styles differ among the companies of the indicated mindsets. De Dreu and Weingart (2003) argued that the corporate control influence exists in the organizations and it affects the employee's behavior.

Overall, the ability to perceive the context, which is represented through these different mindsets, is addressed in the literature with the term “contextual intelligence”. Contextual Intelligence (CI) is a construct that involves the ability to recognize and diagnose the plethora of contextual factors inherent in an event or circumstance, then intentionally and intuitively adjust behavior in order to exert influence in that context (Kutz and Kutz, 2008). This term was adapted in scopes of the current research in order to study the CI of the companies in software projects. Kutz and Bamford-Wade (2013) also proposed a model for CI on the corporate level - The Contextual Intelligence Model for Organizational Leadership (Figure 18).

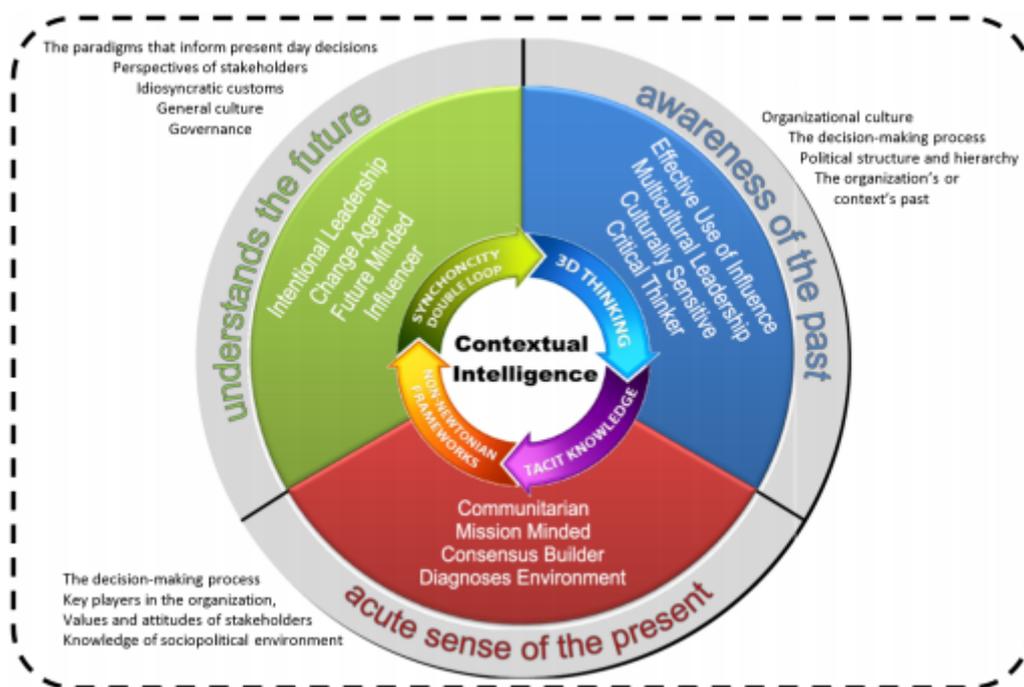


Figure 18 – The Contextual Intelligence Model for Organizational Leadership

The ability to perceive the context and act dependably on the corporate level is addressed in this model by integrating the principles of tacit knowledge, synchronicity and time orientation. The Contextual Intelligence Model for Organizational Leadership correlates with the proposed framework in terms of similarities between the addressed concepts. The decision making process, for example, can be argued as a baseline characteristic for the proposed framework of RE choice. The companies of holistic mindset have the most mindful decision-making process in RE, which takes into consideration contextual factors of project and organizational level. On the other hand, the bureaucratic mindset companies, which are argued to be less sensitive in context perception, seem to have regulated and less flexible decision-making process.

5.2 Limitations and scope of the further research

The current research revealed different theories in requirements engineering field of study and, specifically, its linkage with complexity theory and contextual intelligence term. The research has different limitations, which have to be overcome in future researches. First of all, the size of the research sample is considerably small for the RE field of study and the indicated results and projects outcomes could be generated accidentally. Moving on to the abstract level from the empiric data results in loss of information from one step to another and the size of the research sample is quite important here.

Next limitation is the geographical location of the companies. All the companies are situated in one city and, possibly, some external contextual factors could have been influential on the way how companies act. In addition, the number of representatives from one company could be also increased in order to get clearer picture of the way how company performs from more comprehensive point of view.

The framework, proposed in the current research, needs further testing on the larger empiric sample in order to evolve. The future researches could be potentially dedicated to the testing the framework and studying whether the proposed factors, affecting the way how companies do RE, are comprehensive enough or there are more complex interrelations.

6 CONCLUSION

In scopes of the current research the requirements engineering topic was addressed. The investigation was focused on the way how companies perceive the complexity of RE activity and their ability to adjust it within a specific project context.

The 6 projects, executed by 5 companies, were deeply studied in scopes of the current research in order to discover the peculiarities of each specific RE approach and build the final framework around it, which targets more abstract level and can be possibly tested on larger research sample.

The analysis of research sample showed that generally speaking, the RE complexity perception and comprehensive view of this activity does not have direct influence on the way how companies adjust to the project circumstances. The consideration rate of complex requirements engineering features came out to be lower than that for the simple RE features in general among the companies. All the teams took into consideration simple RE features, while complex RE features were recognized as less important and influential within the studied sample. Despite that, it was demonstrated by empiric data that some companies are still able to adjust RE approaches to the specific project context, while the rest choose more simple approach than the project requires. This issue was studied on a more abstract level of analysis by means of contextual intelligence phenomena.

The three different types of context perception among the companies were derived from the interview transcriptions: bureaucratic mindset, adaptive mindset, holistic mindset, which are different by their ability to analyze and act depending on the context. Different types of execution style within these type of companies were superposed with these mindsets: controlled, approved, enhanced, which are different by level and types of corporate control, affecting the team performance. It was proposed that in combination these two dimension define the way how RE approach is chosen in scopes of the specific project context: whether this choice is imposed, explorative or valid. Different characteristics and peculiarities of the approaches, which are likely to be chosen, are summarized.

Overall, the study revealed the underlining reasons for the difference between the ways how companies choose the RE approaches. The importance of this research can be highlighted either from the software engineering field of study as well as from the practitioners point of view. Concerning, the scientific contribution, the research will investigate the

complexity aspects in the field of requirements engineering, which is still poorly disclosed topic. As for practical value of the research, it will link different project parameters with requirements engineering approach and investigate whether it was suitable in this particular situation and to what extent.

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