How to get the right people on the project?

The implications of project complexity and team member competences on project team selection

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EXECUTIVE SUMMARY

Introduction
Creating a solid project team is crucial for the success of a project. A practice to systematically select project team members is not developed within the CB&I Lummus organization. Although scientific literature describes project complexity, competences and team performance, it does not give an approach to integrate these concepts to select a project team. Therefore, this study investigated how project complexity and competences can be linked to team selection in order to increase team performance.

The research covered desk research including a literature and business review, an empirical study with a case study and competence survey, and a synthesis. This study aimed to answer the following research question:

How can project complexity and team member competences be influencing in project team member selection?

Desk research
In the literature review it was found that project complexity can have several sources. A recent study of Bosch Rekveldt (2010) combined these sources of complexity in a complexity framework. This TOE framework can be used to assess Technical, Organizational and Environmental complexity. Literature describes competences as knowledge, skills and personal characteristics required to achieve job performance as defined by appropriate standards (Boyatzis 1982; Crawford 1997; PMI 2004). The use and definition of team member competences varies among different organizations (Sinnott, Madison and Pataki 2002). Team competences can also be assessed by using a competence standard (IPMA 2007). Competences in a team can contribute in dealing with project complexity and can help bringing a project to a success (Thomas and Mengel 2008, Turner and Müller 2006). Personal and professional needs, team environment, team design, team process, team development and values are all influential on team performance (Cohen, Levesque and Smith 1997; Thamhain 2004). Team building and combining functional and relational alignment in teams increases performance (Owens, Mannix and Neale 1998; Savelsbergh, van der Heijden and Poell 2010; Markert 2011). Literature describes that team selection can be based on competences, availability, experience and interests but also on organizational responsibilities, procedures and targets (PMI 2004).

In the business review it was found that team selection is the responsibility of the CB&I Lummus project manager. Currently, there are no official procedures or guidelines for team selection. Team selection is mainly based on personal preferences and available resources. It was found that CB&I Lummus uses a performance improvement plan to appraise employees on the basis of competences. In the business review 15 available CB&I Lummus projects were selected for this research; either running or recently finished. The 16 project managers involved in these projects filled in a survey on project complexity. This survey showed that uncertainties of scope, lack of resources & skill availability, variety of stakeholder perspectives and dependencies on external stakeholders are most contributing to the complexity of typical CB&I Lummus projects.

Case study
A case study was conducted to investigate how project managers, including the director projects, organized and managed their project teams in practice. Four cases were selected out of 15 available CB&I Lummus projects. The case study showed that all cases were characterized by different elements of project complexity. Only the elements interference with the existing site and number of locations were mentioned twice. The case study showed that project managers struggled with the definition of competences. Respondents gave several examples of competences but they did not elaborate on the link between team member competences and project success. One of the reasons was there is no single definition of project success which made it difficult to determine which specific competences are required for project success.
Project managers described many considerations in team selection, including knowledge, experience, attitude, fit with the client and prior acquaintance. However, the cases indicated that in practice, team selection primarily dependents on project characteristics, personal preferences and the availability of the workforce.

**Competence survey**

Since the case study showed that project managers found it hard to identify important team member competences a competence survey was conducted. The goal of the survey was to explore the important competences of a project manager, project engineering manager and lead engineer. A model, based on CB&I Lummus competences, was developed including the following categories: task capability, managing output, encouraging attitude, social and communication skills, personal development, sharing a vision, managing team performance and managing process. This model was used to investigate which competences are needed to deal with project complexity.

The competence survey showed that different roles in a team require a different set of competences to deal with project complexity. When dealing with uncertainties in scope, the project manager, project engineering manager and lead engineer need the competence managing process. In addition, social and communication skills are important for the project manager and the project engineering manager. Task capability is required for the project engineering manager and the lead engineer. Additionally, a lead engineer needs the competence managing output. When a project is having a lack of resources and skill availability, the competence managing process is important for the project manager, project engineering manager and lead engineer. The project manager and project engineering manager additionally need an encouraging attitude. The project engineering manager also needs social and communication skills. For the lead engineer the competences task capability and managing output are also important. In a project with a variety of stakeholder perspectives, social and communication skills and managing process are competences important to the project manager, project engineering manager and lead engineer. Additionally, a project engineering manager needs the competence managing team performance. When a project has dependencies on external stakeholders, the competences social and communication skills and managing process are important to a project manager, project engineering manager and lead engineer. In addition, a project engineering manager needs an encouraging attitude. For the lead engineer the competence managing output is important.

**Synthesis**

The synthesis showed the differences between 1) the four elements of project complexity most present in typical CB&I Lummus projects and 2) the elements of project complexity found in the case study. Since there was only a minor overlap between the elements it was concluded that project complexity in CB&I Lummus projects is characterized by more than the four most important elements. It is expected that the elements found in the selected cases are part of larger set of elements contributing to the complexity of CB&I Lummus projects. Future assessments could show if other elements of complexity are part of a bigger set of elements but could also show that it is impossible to define common elements of project complexity. The TOE framework can be used in these assessments. The assessments should be conducted by more than one person to decrease the subjectivity of the assessment. Additionally, assessments should take place in various stages of the project to learn more about the dynamics of project complexity.

In the synthesis the results of the competence survey were compared to scientific literature. It was found that other studies confirm that different types of project complexity require specific team member competences. Nevertheless, one important finding was that the competences of the CB&I Lummus model lacked in covering technical and contextual competences. Therefore, the CB&I competences model was extended by adding competences from the IPMA competence baseline.
To use competences in project management processes it is recommended to further develop and integrate the CB&I Lummus competence model in the organization. It was found that the model is hardly used and poorly integrated in the existing business activities. It is recommended to adopt the following steps defined by Sinott, Madison and Pataki (2002):

1. Identify the position you are establishing competences for
2. Develop the competence model
3. Assess the individual competences and identify gaps
4. Develop strategies to address the gaps
5. Reassess competences & evaluate the return on investment (ROI)

To improve team performance it is recommended to focus more on project team development. Existing relationships are currently important in team selection but can be better developed and maintained. For instance, team building and celebrating achievements can be used to improve team relationships.

The influencing factors in team selection found in literature and practice show many similarities. In practice the project characteristics and the preferences of the project manager determine which specific selection criteria are used to select a team. The study showed the importance of relational alignment; existing relationships seemed to be very important in selecting project team members. The importance of functional alignment was less visible in the current selection. General examples were found of how team selection is dependent on the type of team role and project. However, no specific examples showed how specific functional criteria were used in team selection.

Conclusions and Recommendations
Based on these findings it is concluded that project complexity and team member competences can be influencing in project team member selection when both aspects are well understood and used in an organization. Team member competences can be linked to specific elements of project complexity and these competences can be used in the selection of project team. However, it is emphasized that using project complexity in selection requires time and experience and that competences can only be determining when these can be assessed by a well defined and accepted competence model.

It is recommended to conduct further research into the different perspectives of project team members and other stakeholders, for instance a client or a partner. A study involving the project managers and engineers could show potential misalignment in project teams. This can further help to indentify process improvements, for instance related to project team selection. In addition, it is recommended to further explore the link between team member competences and project complexity; the competences of other team roles could be explored, other competence models could be used and the link to other elements of complexity could be further explored.

It is recommended for CB&I Lummus to start assessing project complexity over a period of time to get project teams more aware of the dynamics and implications of project complexity. Furthermore, it is suggested to use the results of this research as a start of a knowledge base and to further explore the link between project complexity and team member competences. It is also suggested to further develop the existing CB&I Lummus competence model. In addition, it is recommended to use the competence model in the performance appraisals. The outcomes of the appraisals can be used to determine the competence “levels” of the individual employees. Moreover, these competences can be used as an input factor in a structured approach to team selection. To build up a structured selection procedure it is recommended to develop documented guidelines. For example, the Project Management Body of Knowledge (PMBOK) guide can be used in this process. Finally, it is suggested to look critically at some of the organizational processes. Organizational knowledge could be better used and training could take a more central role in the development of team member competences.
This research report, investigating the implications of project complexity and competences on team selection, is the result of my graduation internship at CB&I Lummus and serves as a thesis for the master Management of Technology at the Delft University of Technology.

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ABBREVIATIONS

CB&I Chicago Bridge & Iron
EPC Engineering Procurement Construction
EPFC Engineering, Procurement, Fabrication and Construction
FEED Front End Engineering Design
FPSO Floating Production Storage and Offloading
HSSE Health Safety Security Environment
ICB IPMA Competence Baseline
IPMA International Project Management Association
JV Joint Venture
LE Lead Engineer
LM Line Manager
LNG Liquefied Natural Gas
LSTK Lump Sum Turn Key
MOPEX Multiple Office Project Execution
NGO Non-Governmental Organization
PEM Project Engineering Manager
PM Project Manager
PMBOK Project Management Body Of Knowledge
PMC Project Management Consultancy
ROI Return On Investment
RQ Research Question
SQ Sub Question
TOE Technical Organizational Environmental
1 BACKGROUND

1.1 INTRODUCTION

In engineering and construction industries it is common to work in project teams. In this set-up project management is recognized as a key enabler of business change and an important contributor to business success (PMI 2004). Nevertheless, experience shows that some projects fail considerably to meet their targets (Holmes 2001; Williams 2005; Bakker 2008). Increasing project complexity is one of the possible causes of project failure (Williams 2005). In order to decrease project flaws organizations try to raise the levels of performance through the application of recognized practices and standards (Whitty and Maylor 2009).

This research report, investigating the implications of project complexity and competences on project team selection, presents the results of a graduation internship at Chicago Bridge & Iron Company (CB&I) and serves as a thesis for the master Management of Technology at the Delft University of Technology.

Section 1.2 starts with a short company description of CB&I. Section 1.3 and 1.4 explain respectively the practical and scientific problem of this study. Section 1.5 describes the objective and the research questions of the study. Finally section 1.6 presents the outline of the report.

1.2 COMPANY DESCRIPTION

1.2.1 SERVICES

CB&I is a company which delivers full-service technology and engineering, procurement, fabrication and construction for energy and natural resource industries. The company has more than 120 years of industrial experience and operates with approximately 13,000 employees worldwide. With engineering offices located around the world, CB&I holds a diverse portfolio of projects (CB&I 2011). Figure 1 shows how the different activities of CB&I cover the entire hydrocarbon value chain.

![Figure 1 CB&I Global Solution across the Hydrocarbon Value Chain](image)

The activities of CB&I are separated under the three brands: Lummus Technology, CB&I Lummus and CB&I Steel Plate Structures. Figure 2 shows how the products of CB&I range from planning, technology licensing, front-end engineering design (FEED), project management consultancy (PMC), engineering, procurement, fabrication and construction (EPFC) to commissioning and beyond.
1.2.2 CB&I Lummus

This thesis focused on the CB&I Lummus business unit, coordinated from the headquarters in The Hague. CB&I Lummus separates its upstream and downstream operations. These activities mainly cover engineering, procurement, fabrication and construction of the oil and gas facilities. Upstream operations include:

- Offshore systems including platform topsides and Floating Production Storage and Offloading (FPSO)
- Onshore gas production
- Onshore pipelines
- Gas processing
- LNG liquefaction plants and re-gasification terminals

Downstream operations include:

- Refinery process units
- Petrochemical facilities
- Gasification plants
- Hydrogen and synthesis gas plants

The CB&I Lummus organization is based upon a matrix structure. Figure 3 gives a high level overview of this organizational structure. This study included the line management and project management layers in the organization. For the line management layer a number of directors and department heads participated. For the project management layer only a select number of managing and engineering disciplines were involved.
1.3 PRACTICAL PROBLEM

As an EPC contractor CB&I Lummus executes projects for a wide range of clients in the oil and gas industry. Projects are executed in teams which can vary from 20 up to 200 persons. The composition of these project teams is as such that in a very short time span people from all over the world are brought together. These people need to achieve one common goal: executing the project in such a way that clients are satisfied and the project is profitable for CB&I Lummus.

CB&I Lummus believes that creating an effective team is crucial for the success of a project. The company believes that project teams need trust, communication and teamwork. However, currently the organization does not have a structured procedure to select their project teams. Line managers select the project managers and these managers select their team subsequently. This selection is merely guided by personal preferences and available resources.

Over the years the projects became more advanced and complex. To deal with these challenges teams need to be carefully selected to guarantee the performance and efficiency. This asks for standardization and therefore CB&I Lummus aims to improve their current team selection procedure.

1.4 SCIENTIFIC PROBLEM

Literature gives a lot of guidelines for management of large engineering projects. Nevertheless, managers still struggle in achieving scope, budget and time estimations. Williams (2005) suggested that underestimating project complexity can be the cause of project failure. Recently, research of Bosch-Rekveldt et al. (2010) has been published on project complexity. This work describes how project complexity can be assessed by the use of a framework. Related research mapped the complexity of a number of projects with the competences of the project managers (Bosch-Rekveldt, Gulden, Wolsing, Mooi, Verbreack and Sjoer 2009).
Research of Bosch-Rekveldt et al. resulted in two theoretical frameworks. The first framework categorizes project complexity into 47 technical, organizational and environmental elements. Bosch-Rekveldt claims that the use of this framework can provide a footprint of the project which can be used in forecasting complexity. The second framework uses the categories of framework one and maps these to the project manager’s competences. The framework shows that different competences are required for different types of project complexity.

The reason why complexity and competences are important is that understanding these variables brings organizations one step closer to project success. For instance the competences of a project manager can positively influence project team performance and therefore lead to project success (Bosch-Rekveldt, Gulden et al. 2009). However, it is unclear how to integrate the concepts of project complexity, competences and success into practical team selection.

More research was needed to find out if elements of complexity can be determining in team selection. Additionally, further study was required to find out which competences are important for the disciplines other than the project manager, and how these competences can be used in team selection. And finally, the concepts of team selection needed to be further explored to find out how team selection could lead to better team performance.

1.5 RESEARCH OBJECTIVE AND QUESTIONS

The main objective of this research was to find out if project complexity and competences can be used in the selection of project team members. Each project has different characteristics and has unique components which add to the complexity of a project. In order to be effective, it is likely that project teams require different competences in different projects. Therefore, the selection of team members is vital for the success of a project team. This research project intended to answer the following research question:

RQ: How can project complexity and team member competences be influencing in project team member selection?

In order to find an answer to this question the following research sub-questions were formulated:

SQ 1: How does literature describe team member competences and project complexity in relation to effective project team selection?

SQ 2: Which elements of project complexity are most present in the projects of CB&I Lummus?

SQ 3: Which team member competences are required for the success of projects?

SQ 4: Which team member selection criteria are required for building up a project team?

SQ 5: How can CB&I Lummus select a project team on the basis of project complexity and team member competences?

1.6 REPORT OUTLINE

Chapter 2 describes the research design of this study and discusses the methodology and approach. Chapter 3 presents the outcomes of a desk research covering a literature and business review. Chapter 4 presents a case study with a description of the design, the results and a cross-case analysis. Chapter 5 presents the design and outcomes of a competence survey. Chapter 6 covers a synthesis which integrates the results of the desk research, case study and competence survey. And finally, chapter 7 gives the conclusions and recommendations of this study by answering the research questions and by presenting scientific and practical recommendations.
2  RESEARCH DESIGN

2.1  INTRODUCTION

This chapter presents the research design of the study. Section 2.2 gives an introduction of how the research was performed and which methodology was adapted. Section 2.3 further elaborates on the research approach. Firstly, it is shown how the different research elements were coupled to the sub-questions of this study. Secondly, the individual research elements are described.

2.2  METHODOLOGY

For organizational studies, in general two types of methods are available: a qualitative and a quantitative method. Quantitative research seeks precise measurement and generally involves analysis of numerical data. Qualitative research focuses on the interpretation of events, words, pictures or objects and often uses participant observation or in-depth interviews (Creswell 2009).

Based on the subject and the objective of this research it was decided to adopt a qualitative research method. The strengths of qualitative research derive mainly from its inductive approach, its focus on specific situations, and its emphasis on words rather than numbers (Yin 2003). This research focused on understanding how events, actions and meanings are shaped by the unique circumstances in which they occur.

In the research we paid attention to the perspective of the employees and the events, situations, experiences, and actions they are engaged in. The interest was not only in the physical events and behavior that takes place, but also in how the employees make sense of these, and how their understanding influences their behavior. Openness and flexibility was built into the research design which allowed modifications during the research to understand new discoveries and relationships (Maxwell 2005).

This research focused on results that are understandable and experimentally credible for further use within CB&I Lummus as well as for further academic research. The evaluations in this research are intended to help improve existing practice rather than simply assess the value of existing practices in the organization. It was therefore more important to understand the process by which things happen in a particular setting than carefully comparing this setting with others (Maxwell 2005).

2.3  APPROACH

Verschuren and Doorewaard (2005) distinguish a survey, an experiment, a case study, a grounded theory research and desk research. This study combines some of these research elements. Figure 4 shows how the five research sub-questions of this study covered three phases of research, including: desk research, an empirical study and a synthesis.

Desk research was conducted to explore the scientific literature and the present business practices on the topic. The empirical study further explored the topic and combined a case study with a small competence survey. And finally, a synthesis reflected on the results of the desk research and the empirical study. To reach enough depth in the three elements of research the scope of the strategy was carefully defined. The following sections describe the individual elements in more detail.
2.3.1 DESK RESEARCH

The desk research included a literature and a business review. The literature review describes books, articles, and other sources that contain knowledge products of scientists. The business review describes documents, procedures and secondary data from CB&I Lummus.

The literature review explored the first research sub-question and identified a number of “knowledge gaps” in literature. In addition, the review investigated the scientific background related to the other four research sub-questions. This knowledge was partly used in the empirical study and later integrated in the synthesis.

The business review explored the existing organizational knowledge related to the second, third and fourth research question. Present organizational procedures were explored by informal interviews with line managers and by searching through available business documentation. The business review included secondary data from a survey to find out more about the project complexity in typical CB&I projects.

The initial desk research was kept concise; Glaser and Strauss (1968) argue that an extensive theoretical framework could negatively affect the capability of finding new and interesting information in a case study. Verschuren and Doorewaard (2005) point at the risk of a bias when a researcher starts with desk research. For that reason additional research was done during and after the empirical study to validate and extend the collected data.
2.3.2 EMPIRICAL STUDY

An empirical study was carried out to further explore the second, third and fourth research questions. Whereas desk research only explored procedures described by line managers, the empirical study investigated how well the concepts of complexity and competences apply in a practical project environment. The empirical study was separated in two phases. In the first phase a case study investigated how project teams organized and managed in practice. In the second phase a competence survey was conducted which searched for more general findings and focused on the competences of different project team members.

Case study
The empirical study started with a case study. A case study is an excellent approach in qualitative research because of its richness of the data and grounding in empirical reality (Eisenhardt 1989). Case studies are very useful in studying phenomena that are too complex for large-sample studies (Waldeck 2007) and are a well-known approach for explanatory, theory-building research (Yin 2009). Yin (2003) describes that “how” and “why” research questions, about a contemporary set of events where the researcher has little or no control, favor the use of a case study.

The case study was used to quickly gain insight in the organization and management of CB&I Lummus project teams. The study focused on the characteristics of a select number of projects and investigates how project managers organized and managed their project teams in practice. The case study explored project complexity, selection procedures, the competences of a project team and the management practices.

Yin (2003) distinguished two major types of case study designs: single-case and multiple-case. According to Yin’s conclusions, multiple samples are more powerful than those coming from a single case alone. For that reason it was decided to include multiple cases. The study deliberately included projects from a different size, a different environment and from different clients. Common conclusions from projects in different contexts immeasurably expand the validity of study. Including contrasting projects gives an additional advantage; if the subsequent findings support a hypothesized contrast, the results represent a strong start towards theoretical replication (Yin 2003).

Competence survey
The empirical study continued with a competence survey. A survey is less time-consuming to generate data and can be sent out as written questionnaire or can be used in interviews. A survey includes standardized questions and makes measurements more precise by enforcing uniform definitions upon the participant. Furthermore, a survey can collect similar data from groups which can be interpreted comparatively (Verschuren and Doorewaard 2005).

A survey was used to investigate the importance of competences for different disciplines in a project organization. In this survey the competences three project team roles were reviewed, namely the project manager, the project engineering manager and the lead engineer. The survey included respondents from project management and line management. Line management is responsible for a competent workforce whereas the team members in a project require certain competences; by letting both parties review the competences in a project team similarities and differences could be identified. This enabled to explore the link between the targets of line management and the practical requirements of the project management disciplines.
2.3.3 SYNTHESIS

The synthesis is the conjunction of a particular set of research activities. The primary goal and focus of the synthesis was an attempt to integrate empirical research for the purpose of creating generalizations. The research synthesis pays attention to relevant theories, critically analyzing the research they cover, tries to resolve conflicts in the findings and attempts to identify central issues for future research (Cooper, Hedges and Valentine 2009). The synthesis triangulated the information from the various sources and methods. Triangulating reduces the risk that conclusions will reflect only the systematic biases or limitations of a specific source or methods, and allows to gain a broader and more secure understanding of issues which are investigated (Maxwell 2005). Interviews were used to obtain different perspectives and descriptions of behavior and events. Internal documents and literature are used to further understand and validate the findings of the observations and interviews. Findings from these different sources are merged in a comprehensive analysis which presents the results, limitations and implications of the research project.
3 DESK RESEARCH

3.1 INTRODUCTION

This chapter presents the outcome of the desk research. The desk research was conducted to explore the scientific and practical background of the research topic.

Section 3.2 presents the results of a literature review which focused on research SQ 1: “How does literature describe team member competences and project complexity in relation to effective project team selection?” After a short introduction different scientific concepts are described. Finally, an overview of the literature is given and the scientific gaps are discussed.

Section 3.3 describes the outcomes of a business review which explored the existing activities and procedures of CB&I Lummus. This review was guided by research SQ 2: “Which elements of project complexity are most present in the projects of CB&I Lummus?”, research SQ 3: “Which team member competences are required for the success of projects?” and research SQ 4: “Which team member selection criteria are required for building up a project team?” This section describes characteristics of CB&I Lummus projects and project teams. The section closes of with a discussion showing how the different procedures are integrated in the further steps of this research.

Section 3.4 concludes on the outcomes of the literature and business review.

3.2 LITERATURE REVIEW

3.2.1 OUTLINE

The literature review was divided into four topics. Team selection was the central topic of the review. Complexity and competences were studied as input for team selection. As output for team selection team performance was reviewed.

Figure 5 gives an overview.

![Figure 5 Focus of literature review](image)

The following sections describe the above topics individually. The last sub-section discusses the outcomes and presents a number of the scientific “gaps” found in the literature.
3.2.2 PROJECT COMPLEXITY

Project Complexity

Project complexity is studied in many research projects. Turner and Cochrane (1993) classified complex projects according to whether the goals of the project are well defined or uncertain and whether the methods to achieve these goals are well defined or uncertain. Baccarini (1996) described complexity as many interrelated parts and distinguished organizational and technological complexity. Williams (1999; 2005) expanded the concepts of Baccarini and Turner and found that project complexity negatively influences project success. Williams characterized project complexity by two dimensions; structural complexity and uncertainty. Structural complexity is influenced differently by different types of interdependency, such as pooled, sequential and mutual interdependencies. Other dimensions of structural complexity include multi-objectivity and multiplicity of stakeholders. Uncertainty is made up of uncertainty in project goals and uncertainty in the means to achieve those goals.

Xia and Lee (2004) described projects as complex when they deal not only with technological issues but also with organizational factors largely beyond the projects team’s control. Whitty and Maylor (2009) concluded that a high level definition of project complexity should include structural, dynamic and interaction elements. De Brujin, de Jong, Korsten and van Zanten (1996) described the “softer” aspects from the environment which are assumed to influence project complexity. They concluded that project complexity could be separated into technical, social and organizational complexity.

Recently, Bosch-Rekveldt (2011) integrated and expanded the existing literature by developing a framework to grasp project complexity in engineering projects in the process industry. The author made a distinction between complex projects and project complexity; the first is a class of project and the latter is based on what aspects make a project complex. Project complexity is described as a project characteristic; therefore a project could be characterized by its complexity footprint. A TOE framework with Technical, Organizational and Environmental elements of complexity was developed to determine the complexity footprint in projects. Table 1 presents the three categories with the subcategories of the TOE framework. The 47 elements are classifiable among these subcategories (Bosch-Rekveldt, Jongkind et al. 2010).

<table>
<thead>
<tr>
<th>Technical</th>
<th>Organizational</th>
<th>Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goals</td>
<td>Size</td>
<td>Stakeholders</td>
</tr>
<tr>
<td>Scope</td>
<td>Resources</td>
<td>Location</td>
</tr>
<tr>
<td>Tasks</td>
<td>Project team</td>
<td>Market conditions</td>
</tr>
<tr>
<td>Experience</td>
<td>Trust</td>
<td>Risk</td>
</tr>
<tr>
<td>Risk</td>
<td>Risk</td>
<td></td>
</tr>
</tbody>
</table>

Table 1 TOE framework (Bosch-Rekveldt 2011)

By considering the 47 elements of the framework users can create a footprint in terms of where the complexity is expected in a project. Bosch-Rekveldt assumed that knowing, understanding and characterizing these complexities by applying the TOE framework early in the project and in subsequent project phases improves the project management practices. However, understanding project complexity in order to better manage projects does not directly lead to reducing project complexity. The goal of using the framework is to better adapt the project development steps to the specific complexities by using the complexity footprint. A project in its early stage could be assessed on its expected complexity and specific actions could be taken. Since project complexity changes during the project life cycle, use of the framework in various stages of the project should also be considered in order to grasp the dynamics of project complexity. Careful selection of the persons involved in the complexity assessment is essential because of the subjective nature of the assessment (Bosch-Rekveldt 2011).
3.2.3 COMPETENCES

Competence definition
Thomas and Mengel (2008) suggested to prepare a project team to deal with complexity by specific competence development. Therefore the definition of a competence was further explored. Competences can cover the characteristics of an individual but could equally well apply to a department, team and organization (Boreham 2004). Literature gives a number of definitions for competences related to individuals. Bayatzis (1982) and Crawford (1997) described competences as follows:

*Competences include knowledge, skills and personal characteristics required to achieve job performance as defined by appropriate standards*

This definition is extended by PMI (2004) which defines the competences of an individual as follows:

- a cluster of related knowledge, attitudes, skills and other personal characteristics
- that affects a major parts of one’s job
- correlates with performance on the job
- and can be improved by means of training and development

Several organizations for project management have defined competence standards (PMI 2004; CCPM 2006; IPMA 2007). Section 3.3.3 describes a performance improvement plan which is used to assess the competences of CB&I Lummus employees.

Competence standard
To extend and discuss the performance improvement plan of CB&I Lummus we used the IPMA Competence Baseline (ICB). The ICB contains basic terms, tasks, practices, skills, functions, management processes, methods, techniques and tools that are used in good project management theory and practice, as well as specialist knowledge and experience, where appropriate, of innovative and advanced practices used in more specific situations (IPMA 2007).

The ICB describes a range of technical competences, behavioral competences and contextual competences. Four categories of people, to which the same standards apply, are specified. These categories are based on the extent a particular competence is present and applied by the person assessed.

- Project director: ability to direct an important program or multiple projects, with the corresponding resources, methodologies and tools. The person must demonstrate the successful use of the competence element in the coordination of a program and/or projects and has to be involved in the development of project managers and the use of the competence elements.
- Senior project manager: ability to successfully use the competence element in complex project situations. The candidate has also guided (sub) project managers in their application and implementation of the competences.
- Project manager: ability to successfully use of the competence element in project situations with limited complexity. The candidate might need to be guided in the further development of the competence element.
- Project management associate: only knowledge related to the competence element is assessed. Capacity and common knowledge is not sufficient to perform at a satisfactory level of competence.

The technical competence range covers competences to meet interested parties’ requirements, competences to integrate work in a temporary project or organization and competence to produce single project deliverables throughout all phases of a project, program or project portfolio. The behavioral competence range covers the project manager’s attitudes and skills. These competences relate to the project manager himself, to
his direct contacts, to contextual parties and to elements such as economy, society, culture, and history. The contextual competence range covers the project manager’s competence in managing relations with the line management organizations and the ability to function in a project focused organization (IPMA 2007). Table 2 gives an overview.

<table>
<thead>
<tr>
<th>Behavioral competences</th>
<th>Technical competences</th>
<th>Contextual competences</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Leadership</td>
<td>• Project management success</td>
<td>• Project orientation</td>
</tr>
<tr>
<td>• Engagement &amp; motivation</td>
<td>• Interested parties</td>
<td>• Program orientation</td>
</tr>
<tr>
<td>• Self-control</td>
<td>• Project requirements &amp; objectives</td>
<td>• Portfolio orientation</td>
</tr>
<tr>
<td>• Assertiveness</td>
<td>• Risk &amp; opportunity</td>
<td>• Project program &amp; portfolio implementation</td>
</tr>
<tr>
<td>• Relaxation</td>
<td>• Quality</td>
<td>• Permanent organization</td>
</tr>
<tr>
<td>• Openness</td>
<td>• Project organization</td>
<td>• Business</td>
</tr>
<tr>
<td>• Creativity</td>
<td>• Teamwork</td>
<td>• Systems, products &amp; technology</td>
</tr>
<tr>
<td>• Results orientation</td>
<td>• Problem resolution</td>
<td>• Personnel management</td>
</tr>
<tr>
<td>• Efficiency</td>
<td>• Project structures</td>
<td>• Health, security, safety &amp; environment</td>
</tr>
<tr>
<td>• Consultation</td>
<td>• Scope &amp; deliverables</td>
<td>• Finance</td>
</tr>
<tr>
<td>• Negotiation</td>
<td>• Time &amp; project phases</td>
<td>• Legal</td>
</tr>
<tr>
<td>• Conflict &amp; crisis</td>
<td>• Resources</td>
<td></td>
</tr>
<tr>
<td>• Reliability</td>
<td>• Cost &amp; finance</td>
<td></td>
</tr>
<tr>
<td>• Values appreciation</td>
<td>• Procurement &amp; contract</td>
<td></td>
</tr>
<tr>
<td>• Ethics</td>
<td>• Changes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Control &amp; reports</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Information &amp; documentation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Communication</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Start-up</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Close-out</td>
<td></td>
</tr>
</tbody>
</table>

Table 2 Competence baseline (IPMA 2007)

Collective competences
The literature described above regards competences as an attribute of individuals. Boreham (2004) described that the attribute of competence could equally well apply to a department, team and organization. The so-called collective competences are usually the result of individual competences common throughout the organization. Collective competences include skills such as process improvement, teamwork, performance measurement, values, new ways of thinking or performing and knowledge management (Sinnott, Madison et al. 2002).

Boreham (2004) emphasized the importance of recognizing both individualistic and collectivistic competences, and where appropriate, to regard them as mutually constitutive. According to Boreham collective competences help in dealing with contradictions in a project (e.g. maintaining quality combined with costs cuts, safeguarding procedures which impede work flow combined with productivity targets, etcetera). Collective competences help overcome the divergent goals and different perceptions. The author further suggested to develop a knowledge base which can be maintained on a more enduring basis than the individual knowledge bases of its members. The rationale behind a knowledge base is sharing and capturing the collective competences even while individuals leave the team.

Competences related to project complexity
To find out how competences can be used to deal with complexity Bosch-Rekveldt, Gulden and others (2009) investigated the link between competences of a project manager and the complexity of a project. Based on the findings from both a literature review and interviews, a preliminary map was developed linking three types of project complexity with five competence groups. This map, presented in Table 3, gives insight and guidelines for choosing the appropriate project manager for a project with specific complexity (Bosch-Rekveldt, Gulden et al. 2009).
Competence development

IPMA proposes a standard competence model applicable to different types of project managers. Nevertheless, in practice the definition and use of competences varies from one organization to another. Therefore Sinnott, Madison and Pataki (2002) propose a framework to develop and maintain competences in an organization, adapted to the needs of an individual company. The authors describe the following development steps:

1. Identify the position you are establishing competences for: knowing what organizational performance you are trying to achieve in order to identify the “desired state” competences. Organizational performance assessments can help evaluate the success of your development efforts.
2. Develop the competence model: identify the competences that truly have an impact on results.
3. Assess the individual competences and identify gaps: knowing the competences of employees in order to compare them with the desired state
4. Develop strategies to address the gaps: You need to have the training and development programs and resources that can address the gap in competences.
5. Reassess competences & evaluate the return on investment (ROI)
3.2.4 TEAM SELECTION

Team selection practices
Team selection is a process divided into several stages that allows the best candidates to be chosen in terms of expected performance and future prospects within the organization. In particular, the selection of a project manager as well as competent team members has critical effects on a project performance (Mikkelsen and Folmann 1983; Fabi and Pettersen 1992; PMI 2004). Project teams are traditionally formed by a manager who selects individuals based on characteristics such as functional expertise or formal title, and then assigns them to a group or team. However, years of research resulted in more guidelines for the creation of teams.

Katzenbach and Smith (1993) describe voluntary formation, or self-selection, where teams select members themselves. Wi, Oh, Mun and Jung (2009) described a team formation model based on knowledge and collaboration. In this model the project manager and team members are chosen on the basis of competences. First, the important competences for a particular function are defined, second the competences of the available workforces are evaluated and third, the person with the highest average score on competences is appointed.

The PMBOK guide (2004) describes input factors, tools and techniques, and output factors of team selection. Input factors cover aspects as required competences, availability, experience and interests but also organizational responsibilities, procedures and targets. Tools and techniques include the different aspects of team selection such as acquisition, negotiation and assignment. Output factors describe what is needed during and after the team selection to deal with changes and to ensure that the resources stay available.

3.2.5 TEAM PERFORMANCE

Team performance
To find out how team selection can lead to effective team the principles of team performance were explored. Thamhain (2002) studied the factors influencing team performance. The researcher found that team leadership and project team environment are strongly associated with team performance. In 2004 this study continued with a case study. The results showed that in today’s complex projects success is no longer the result of a few experts and skilled project managers. Project success is rather dependent on effective multidisciplinary efforts, involving teams of people and support organizations interacting closely together. By analyzing the relationship between the elements of project environment and team performance, the following conclusions emerged (Thamhain 2004):

1. Factors that satisfy personal and professional needs of team members are the strongest drivers to high team performance.
2. Managers can “control” the work environment, such that it is supportive to team members. A supportive team environment drives project performance.
3. Project team development must be an ongoing process to achieve and sustain high project performance.
4. Project management process influences team performance. Team leaders must work with senior management to ensure that organizational ambience is conducive to effective team work.

The research of Cohen, Levesque and Smith (1997) provides a wider scope on team behavior and distinguish the following general influences on performance:

- the external environment: the organization and its direct market
- the team design: team composition, team organization and task design
- the team process: the interaction between team members or external contacts
- the values of the team
Research of Owens, Mannix and Neale (1998) investigated the team selection process and the relationship with team performance. They describe the functional and relational alignment as necessary components for an effective team.

Functional alignment requires understanding of the tasks to select members such that the team has the required skills and abilities and apply those skills to performing the tasks (Hackman 1990). In case a task is non-routine or complex, teams may want to seek for heterogeneity of knowledge, skills and abilities to avoid misalignment. In case innovation and creative decision making is required a variety of perspectives in a group is beneficial (Owens, Mannix et al. 1998).

Relational alignment focuses at group values and norms of behavior and how well potential members are able to work together. The study showed that status diversity in a group may lead to decreased conflict and improved social relations in a group but may cause increased risk in engaging in groupthink if low status individuals remain without influence or participation in the group. The study also indicated that preexisting relationships in teams have multiple advantages. Although pre-existing relationships may sacrifice critical evaluations for harmonious processes and consensus it results in high levels of team performance, high individual satisfaction and high mutual knowledge about the team member skills, perspectives and interpersonal styles (Owens, Mannix et al. 1998).

The authors conclude that teams will be more successful to the extent they are formed with attention to both functional and relational alignment but note that functional and relational alignment is often restricted by strategic and organizational settings (Owens, Mannix et al. 1998).

Team building
To ensure team performance guidance and development of business teams is required; activities generally known as teambuilding. New teams, such as project teams, often use teambuilding sessions to prevent problems and conflicts in project execution (Savelsbergh, van der Heijden et al. 2010).

Savelsbergh, van der Heijden and Poell (2010) described that team goals and individual goals need to merge in a team. The interaction between team and individual goals needs to be transparent and needs to point in the same direction. Otherwise team work is substituted by competition (Saavedra, Earley and Van Dyne 1993). Teams develop their own language. They often use the same way of communicating and spread a similar message to the outside world. While being together team members discover common characteristics. Non-work related activities are therefore justified and significantly contribute to team results. Additional activities where team members discover their strong and weak points also add to the cohesion of a team.

Markert (2011) described another approach to team building and proposed that risk management should be used as a tool during team building workshops to help identify which potential problems to fix first. He advocates partnering, a type of team building which causes people in the participating team to look out for everyone’s best interest while insisting on working together. Markert believes project management’s best practices only work when they are launched in a culture where trust exists and communication flows easily. He therefore introduced a structured approach which describes the following seven key elements in team building:

1. Align everyone: alignment of the team and supporting organizations is crucial to a true results-oriented team effort. Expectations of teamwork behavior and project outcomes need to be clearly stated and frequently revisited.
2. Selflessly contribute: a person’s ego can help or hinder the efforts of the team. An ego that drives one to do what it takes to ensure success is useful and to be encouraged, an ego that requires credit for everything prevents team building.
3. Be trustworthy: trust is earned, not demanded. Being trustworthy is the prerequisite to earning trust. Sharing of ideas that can solve problems, save money, and/or improve the outcome can help trust to be earned, yet most often occurs only after trust is established. Many hidden agendas prevent and destroy trust. It is essential to become aware of these hidden motives and deal with them.

4. Communicate well and often: communication is necessary and helpful to the team and imperative to the production of quality results. Regular feedback and resulting action regarding project team performance is necessary to keep a team alive.

5. Empower people: people empowered to do the job will get more done than those who are not. Those who are empowered will help the organization make better decisions.

6. Synergize to maximize brainpower and energy: synergy available from a teamwork culture can be very beneficial. Those who are encouraged to consult with other team members will make better decisions. Having open and honest discussions is valuable in the search, discovery, and prevention of potential problems and the resolution of actual problems.

7. Celebrate often and well: recognition and reward are essential to personal motivation and often needs to be nothing more than a thank you in private and/or public. Tangible rewards, when possible, are fine when properly shared. Rewarding the team as a whole is much better than rewarding only the team member who worked as an individual.

### 3.2.6 DISCUSSION

The literature review aimed at giving background knowledge on the research topic. This resulted in a knowledge base which is presented in Table 4.

<table>
<thead>
<tr>
<th>Concept</th>
<th>Description</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project complexity</td>
<td>- negatively influences project success</td>
<td>(Williams 2005)</td>
</tr>
<tr>
<td></td>
<td>- is characterized by technical, organizational and environmental complexity and is project specific</td>
<td>(Bosch-Rekveldt, Jongkind et al. 2010)</td>
</tr>
<tr>
<td>Competences</td>
<td>- cover knowledge, skills and personal characteristics required to achieve job performance</td>
<td>(Boyatzis 1982; Crawford 1997; PMI 2004)</td>
</tr>
<tr>
<td></td>
<td>- can be separated into behavioral, technical and contextual competences</td>
<td>(IPMA 2007)</td>
</tr>
<tr>
<td></td>
<td>- not only relate to individuals but also to a team or organization</td>
<td>(Boreham 2004)</td>
</tr>
<tr>
<td></td>
<td>- are needed to deal with project complexity</td>
<td>(Bosch-Rekveldt, Gulden et al. 2009)</td>
</tr>
<tr>
<td></td>
<td>- can contribute to project success</td>
<td>(PMI 2004; Thomas and Mengel 2008)</td>
</tr>
<tr>
<td></td>
<td>- are dependent on the organization and need to be developed and maintained</td>
<td>(Sinnott, Madison et al. 2002)</td>
</tr>
<tr>
<td>Team selection</td>
<td>- can be based on input factors, tools and techniques, and output factors</td>
<td>(PMI 2004)</td>
</tr>
<tr>
<td>Team performance</td>
<td>- increases by satisfying personal and professional needs, supportive team environment, team development and managing process</td>
<td>(Thamhain 2004)</td>
</tr>
<tr>
<td></td>
<td>- is influenced by environment, team design, team process and values</td>
<td>(Cohen, Levesque et al. 1997)</td>
</tr>
<tr>
<td></td>
<td>- increases with functional and relational alignment in the team</td>
<td>(Owens, Mannix et al. 1998)</td>
</tr>
<tr>
<td></td>
<td>- increases with team building</td>
<td>(Savelsbergh, van der Heijden et al. 2010; Markert 2011)</td>
</tr>
</tbody>
</table>

Table 4 Factors related to the success of project teams
The theory described in the literature review also raised some questions. The following scientific “gaps” were identified:

- **Use of TOE framework**: Bosch-Rekveldt (2011) developed the TOE framework to identify project complexity footprint. According to the author the framework could be useful to adapt project development steps to this complexity footprint. Since the framework is recently developed little is known about the practical usefulness of the framework. Therefore, it remained unclear how the framework can be used for team selection.

- **Competences of project team members**: the literature review resulted in a clear definition of competences and showed how competences can be assessed. Several large companies developed competence models for different team roles. Yet, in the scientific literature specific requirements on competences were only found for the project manager. As a result, it remained unknown which competences are required for other team members.

- **Competences in relation to project success**: The literature review described competences of successful project managers (Thomas and Mengel 2008; Bosch-Rekveldt, Gulden et al. 2009). However, competences alone do not guarantee project success (PMI 2004). Therefore, it remained unsure how much competences can contribute to project success.

- **Team selection**: The literature review showed that competences can be determining in the project team selection (PMI 2004; Wi, Oh et al. 2009). Nevertheless, it remained unclear if other influences of team performance, such as relationships, values and the environment, can also be determining in a team selection.

Based on the findings of the literature review, it was decided to further investigate project complexity, competences, team selection and team performance. Not only the literature of the individual topics showed “gaps” but also relation between the different topics asked for more research. The next section describes a business review which explored the existing CB&I Lummus business activities and documents related to the research topic. The following chapters describe how the topic was further explored in an empirical setting by conducting a case study and a competence survey.

### 3.3 BUSINESS REVIEW

#### 3.3.1 OUTLINE

To find out more about team selection, competences and project complexity within CB&I Lummus the existing business activities and documents were reviewed. Several informal meetings with line managers gave an impression of the existing procedures in the organization. Additionally, a survey explored project complexity in typical CB&I Lummus projects.

The next sections present the findings of the business review. First, the current team selection procedure will be discussed. Second, the employee appraisal plan will be described. Third, the CB&I project portfolio will be introduced. And fourth, the project complexity in CB&I Lummus projects will be presented. Finally, the results will be briefly discussed.

#### 3.3.2 TEAM SELECTION

During explorative interviews with line managers it became clear that the current responsibilities in team selection are straightforward; the director projects is responsible for the selection of the project manager and the project managers are responsible for the team selection. It was found that procedures, guidelines or rules related to team selection were not developed in the organization. The managers described that the current
selection is mainly guided by personal preferences and available resources. More specifically, the selection seemed to be based on the following questions: “who do I know?”, “who do I like to work with?”, and “who is available?”.

### 3.3.3 EMPLOYEE APPRAISAL

To assess and improve the performance of the employees CB&I Lummus developed a performance improvement plan. Once a year all employees are assessed on their performance; employees meeting or exceeding the performance indicators become candidates for promotion. The performance improvement plan uses competences of the employee as performance indicators. Table 5 gives a high level overview of these performance indicators. The full appraisal plan can be found in appendix IV.

<table>
<thead>
<tr>
<th>Performance improvement plan</th>
<th>Exceed</th>
<th>Fully met</th>
<th>Partly met</th>
<th>Development needed</th>
<th>Not Applicable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task/performance</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Operational</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Behavior/Social Skills</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Personal Development</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Communication/ Shared Vision</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
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<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Operational Execution</td>
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<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>

*Table 5 Performance improvement plan*

### 3.3.4 PROJECT PORTFOLIO

To find out more about the project portfolio of CB&I Lummus a number of project reports were reviewed. These archived reports were used to quickly gather information about past and present CB&I Lummus projects. The reports cover key figures as project scope, project size, type of client and type of contract. A summary of these project reports can be found in appendix I. In total 15 projects were available for investigation, either running or recently finished. A necessary condition was that the project manager on the project was still working for CB&I Lummus and that the project information was openly available for investigation.

### 3.3.5 PROJECT COMPLEXITY

To assess the complexity of CB&I Lummus projects a survey was send to 16 project managers (of the 15 available projects). This survey used the TOE framework of Bosch-Rekveldt (2010) to investigate project complexity in typical CB&I Lummus projects. Table 6 presents the 47 elements of the TOE framework which grasp technical, organizational and environmental complexity. In total 14 project managers responded which reviewed the “T”, “O” and “E” elements and valued their potential contribution to complexity in typical CB&I Lummus projects.
Technical | Organizational | Environment
--- | --- | ---
Number of project goals | High project schedule drive | Number of external stakeholders
Non-alignment of project goals | Lack of Resource & Skills availability | Variety of stakeholders’ perspectives
Uncertainty of project goals | Lack of Experience with parties involved | Dependencies on external stakeholders
Uncertainty in scope | Lack of HSSE awareness | Political influence
Strict quality requirements | Interfaces between different disciplines | Lack of company internal support
Project duration | Number of financial sources | Required local content (forced cooperation with local parties)
Size in CAPEX | Number of contracts | Interference with existing site
Number of location | Number of different nationalities | Weather conditions
Newness of technology (world-wide) | Number of different languages | Remoteness of location
Lack of experience with technology | Presence of JV partner | Lack of experience in the country
Number of tasks | Involvement of different time zones | Company internal strategic pressure
Variety of tasks | Size of project team | Instability of project environment (exchange rate, oil price, raw material price, etc.)
Dependencies between tasks | Incompatibility between different project management methods / tools | Level of competition
Uncertainty in methods | Lack of trust in project team | Risks from environment
Involvement of different technical disciplines | Lack of trust in contractor | 
Conflicting norms and standards | Organizational risks | 
Technical risks

Table 6 TOE framework (Bosch-Rekveldt, Jongkind et al. 2010)

In the first step of the survey 14 respondents reviewed the potential contribution of the elements of complexity. The scaling varied from 1 to 5 representing “not”, “little”, “some”, “substantial” and “very much” respectively. Since the respondents were not familiar with the TOE framework the answers were based on intuition. To verify these scores 13 respondents1 evaluated their own answers in a second step. The respondents were asked to select three “most” contributing elements and three “least” contributing elements. This resulted in an overview of “most” and “least” contributing elements of complexity. A full overview can be found in appendix V.

Figure 6 shows the highest relative scoring elements of complexity. The survey indicates that 62% of the respondents believe that *uncertainties of scope, lack of resources & skill availability and variety of stakeholder perspectives* are most contributing to the complexity whereas 46% of the respondents believe that *dependencies on external stakeholders* are most contributing to complexity of typical CB&I projects.

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1 One of the fourteen respondents did not fill in the second step of the survey
The four elements have the following definition:

- **Uncertainties in scope:** *unclear boundaries of project, activities are not clearly defined or are uncertain for the company and/or client*
- **Lack of resources & skill availability:** *resources as materials and personnel or skills are insufficient or unavailable during the execution of the project*
- **Variety of stakeholder perspectives:** *different perspectives of stakeholders who have direct control on the scope of the project*
- **Dependencies on external stakeholders:** *dependency on external stakeholders who have no direct control on the scope of project (e.g. governments, NGO’s, financers)*

### 3.3.6 DISCUSSION

The business review showed some project characteristics and existing business procedures. The results resulted in the following discussion:

- **Team selection:** the business review gave the impression that team selection within CB&I Lummus is not based on a structured procedure but mainly based upon informal arrangements. However, the fact that the selection procedure is informal and not documented does not automatically point towards insufficient selection methods. A lot of team selection practices could be based on the experience and tacit knowledge of the workforce.
- **Employee appraisal:** it was found that the current appraisal procedure is based on a structured and documented guideline. The performance indicators of the CB&I Lummus performance improvement plan seemed well defined and overlap with competences baseline of the IPMA (2007).
- **Available projects:** the business review resulted in a list of 15 projects available for further research. It was assumed that this list of projects is representative for the typical projects of CB&I Lummus.
- **Project complexity:** the project complexity survey indicated that *uncertainties in scope, lack of resources & skill availability, variety of stakeholder perspectives and dependencies on external stakeholders* are elements most contributing to the complexity of typical CB&I Lummus projects.

The results of the business review were used in the next steps of this study. The unclear procedures related to team selection were further explored in the case study. The cases were selected from the 15 available projects. Since the CB&I Lummus performance improvement plan was available and assumed to be well developed and integrated in the organization, it was used the design of the competence survey. In addition, the elements most contributing to the complexity of typical projects were integrated in the competence survey.
This chapter described a literature and business review to find out more about the scientific and practical background of the research topic.

The literature review focused on SQ 1: “How does literature describe team member competences and project complexity in relation to effective project team selection?” The literature review covered literature related to project complexity, competences, team performance and team selection.

The literature review showed how the concept of project complexity evolved. Most recently, Bosch-Rekveldt (2010) distinguished Technical, Organizational and Environmental complexity and developed the TOE framework to assess project complexity. The author assumed that knowing, understanding and characterizing these project complexities can improve the project management practices. A project in its early stage could be assessed on its expected complexity and specific actions could be taken.

In the literature competences are described as knowledge, skills and personal characteristics required to achieve job performance as defined by appropriate standards (Boyatzis 1982; Crawford 1997; PMI 2004). The IPMA (2007) competence baseline (ICB) can be used as standard and describes a range of technical, behavioral and contextual competences. The research of Boreham (2004) showed that competences are not only a contribute of individuals but that competence could equally well apply to a department, team and organization. Furthermore, competences covering project engineering, contracting and procurement, HSSE management, personal and leadership are useful to deal with project complexity (Bosch-Rekveldt, Gulden et al. 2009). Turner and Müller (2010) found that project managers of successful engineering projects show strong competences in critical thinking, developing, as well as influence, motivation, and conscientiousness.

Several approaches to team selection were found; Katzenbach and Smith (1993) describe voluntary and self-section and Wi, Oh, Mun and Jung (2009) described a team formation model based on competences. The PMBOK guide (2004) describes input factors, tools and techniques, and output factors of team selection. Input factors cover requirements on competences, availability experience, procedures and targets. Tools an techniques describe the different aspects of team selection and output factors describe what is needed during and after the team selection.

The influences of team performance are described by many authors. Thamhain (2004) showed that team performance increases by satisfying personal and professional needs, supportive team environment, team development and managing process. Cohen, Levesque and Smith (1997) described environment, team design, team process and values as influences of team performance. Owens, Mannix and Neale (1998) emphasized that both functional and relational alignment need to be considered in the selection of a team. Finally, Savelsbergh, van der Heijden and Poell (2010) and Markert (2011) described the contributions of team building.

The business review focused on RQ 2, RQ 3 and RQ 4. A complexity survey was conducted to answer RQ 2: “Which elements of complexity are most present in the projects of CB&I Lummus?” The survey indicated that uncertainties in scope, lack of resources and skill availability, variety of stakeholder perspectives and dependency on external stakeholders are most contributing to project complexity in typical CB&I Lummus projects.

No answer was found to RQ 3: “Which team member competences are required for the success of projects?” The CB&I Lummus performance improvement plan gave an indication of how employees develop their competences. However, further empirical research was needed to find out which competences are needed to bring a project to a success.
In addition, further research was needed to find an answer to RQ 4: “Which team member selection criteria are required for building up a project team?” The business review indicated that currently team selection is unstructured and undocumented. More empirical research is needed to see what selection criteria are used in practice.

To conclude, more research was needed to find out how project complexity can be used in team selection. Additional research was needed to explore which specific competences are needed for the members of a team; scientific literature only describes the competences of a project manager in detail. Furthermore, the factors influencing project success needed to be investigated; selecting the right competences can contribute, but do not guarantee project success. Finally, the link between team performance and team selection remained ambiguous; several factors of team performance were identified but more research was needed to find out how these factors could be integrated in team selection.
4 CASE STUDY

4.1 INTRODUCTION

The previous chapter indicated some gaps in the literature and practice, such as the link between project complexity and team selection and the relation between team member competences and project success. This chapter presents the results of a case study which explored these gaps in CB&I Lummus projects. The case study focused on research SQ 2: “Which elements of project complexity are most present in the projects of CB&I Lummus?”, research SQ 3: “Which team member competences are required for the success of projects?” and research SQ 4: “Which team member selection criteria are required for building up a project team?”

Section 4.2 presents the case definition, case screening and the case selection procedure which shows how the relevant variables of interest are defined and how the relevant data was collected. Section 4.3 describes the four cases individually and briefly reflects the outcomes. Section 4.4 presents and discusses the outcomes of a cross-case analysis which focused on the differences and similarities of the selected cases. Finally, section 4.5 concludes on the results of the case study.

4.2 DESIGN

4.2.1 CASE DEFINITION

Reliance on theoretical concepts to guide the design and data collection for a case study is an important aspect in completing a successful case study. In case studies it is important to define an appropriate unit of analysis, to identify the criteria for selecting, to screen the cases to be studied, and to suggest the relevant variables of interest and therefore the data to be collected as part of the case study (Yin 2003).

The case study started with the definition of the unit of analysis which sets the focus of the case study and determines what groups, subjects or elements are relevant in the research. In this case study the unit of analysis was set on a limited number of CB&I Lummus projects. The main point of interest was the “soft side” of the project organization, specifically the management issues related to team member selection, the competences in a project team and the challenges related to project complexity. The “hard side” of the project, with the technical and commercial aspects of projects, was not included in the scope of the study.

The next step in the case study was identifying the criteria for selecting the cases. Yin (2003) described that in a case study each case must be carefully selected in the sample so that it either predicts similar results (literal replication) or predicts contrasting results but for predictable reasons (theoretical replication). Every case should serve a specific purpose within the overall scope of the inquiry and should fit in the replication logic of the sample. Random sampling is unreliable in this research where a limited amount of cases are used. A small sample of random cases gives no guarantee for providing answers to the research questions since a sample might be unrepresentative (Verschuren and Doorewaard 2005).

It was decided to include four projects in the case study. Including four projects resulted in a variety of perspectives and including more projects would have resulted in an information overload. The projects were purposefully selected in order to maximize representativeness and to increase the chance of replication (Yin 2003). Hence it was decided to select projects with different characteristics but with fundamental overlapping elements in scope.
The four cases were selected from the list of 15 projects created in the business review. The selection was based on information derived from project reports and an interview with the director projects. The interview transcript can be found in appendix VII.

In the case selection two key criteria were determining. The first selection criterion was the success of the projects. The selection aimed for three “problem” projects and one “success” project. By adding a “successful” case and three “flawed” cases the link with other aspects such as complexity, competences and team selection could be explored. The success of the projects was defined by the director projects. We acknowledged that the definition of success is subjective and should be viewed from different perspectives (Morris and Hough 1987). Therefore, the case study also reflected on the different definitions and criteria of success given by the director projects and the project managers.

The second project selection criterion was the scope of project. All the selected cases embrace engineering, procurement and construction management (EPCM) activities. This factor is important since the scope of services has a large influence on the characteristics of a project team. The scope of services does not only influence the size of a project team but also determines the workforce requirements. Delivering a front-end engineering design (FEED) requires a completely different project team than the execution of a project management consultancy (PMC) project. The selected cases are presented in Table 7.

The first case is the biggest project in the case study. Although the scope of services is comparable with the other cases, the project is in operational and organizational terms most advanced. The project was a success with a profit for CB&I Lummus and a satisfied client. Case two is the smallest project in the case study. The project was executed for the same client but partly failed. Problems during construction phase decreased the client satisfaction. Case three is the second biggest project in the case study. This project is exceptional for the cultural issues and the complicated relationship with the client. Currently this project is running and the finishing date is estimated in 2014. The project has not been a success thus far due to financial setbacks caused by many scope changes and unplanned activities. Case four is the mid-size project in the case study. The project is running and planned to be finished at the end of 2011. The project partly failed due to scope and budget overruns.
### Table 7 Selected cases

<table>
<thead>
<tr>
<th>Case</th>
<th>Client</th>
<th>Location</th>
<th>Size (man hours)</th>
<th>Scope</th>
<th>Contract</th>
<th>Finished</th>
<th>Success</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A</td>
<td>South-Asia</td>
<td>Home office: 2.7 million Construction: &gt;51 million</td>
<td>Build-up new plant</td>
<td>EPCM</td>
<td>Reimbursable + Incentives</td>
<td>Yes</td>
</tr>
<tr>
<td>2</td>
<td>A</td>
<td>West-Europe</td>
<td>Home office: 51,000 Construction management: 17,000 Construction: 210,000</td>
<td>Revamp of existing plant</td>
<td>Basic Design &amp; Engineering, Cost Estimation, Engineering, Procurement, Construction</td>
<td>Lump Sum Turn Key</td>
<td>Yes</td>
</tr>
<tr>
<td>3</td>
<td>B</td>
<td>East-Europe</td>
<td>1.3 million</td>
<td>Update existing plant</td>
<td>Basic Engineering, Project Management, Detailed Engineering, Procurement, Author supervision</td>
<td>Engineering: Lump Sum Procurement: Percentage Fee Author Supervision: Reimbursable</td>
<td>No</td>
</tr>
<tr>
<td>4</td>
<td>C</td>
<td>West-Europe</td>
<td>Home office: 120,000 Construction Management: 68,000</td>
<td>Build-up new plant</td>
<td>Phase I: Basic Engineering, Technical Evaluation, Cost Estimation. Phase II: EPCM, PMC</td>
<td>Reimbursable + Incentives</td>
<td>No</td>
</tr>
</tbody>
</table>

### 4.2.3 DATA COLLECTION

Among the different data collection methods, interviewing is the most widely applied technique for conducting systematic social enquiry in qualitative research. Interviews are a very useful way to quickly gather a large amount of data. During interviews the researcher can ask immediate follow-up and clarification questions, which is a very efficient way of exploring a topic (Marshall and Rossman 2010).

In this case study the director projects and the project managers from the selected cases were interviewed. The interviews took place in a natural setting where the participants were questioned in their own business environment (Creswell 2009). The use of semi-structured interviews allowed participants to discuss their experiences truthfully, which in turn enabled discovering the meanings of participants’ opinions and thoughts (Stokes and Bergin 2006; Marshall and Rossman 2010). A downside of this interview approach is the disturbing effect of the interviewer; an interviewer can direct a respondent into a certain direction. This disadvantage is diminished by the use of an interview framework and by being aware of this negative side-effect (Opdenakker 2006; Marshall and Rossman 2010).

Figure 7 shows the relationship between the director and the project managers. The director projects was interviewed about the outcomes of the projects and the selection of the project managers. The interview with the director projects was short and informal. The project managers were interviewed about the selection of their project team, the required competences in the specific project, the effectiveness of team management and the possible improvements for the selection of project teams. The interviews with the project managers were structured and were supported by an interview framework. This framework was based on the five research sub-questions of this study and consisted of fourteen explorative questions. The results of the interviews with the director projects and the project managers are clustered and integrated in the case study.
results, presented in the next section. The interview framework can be found in appendix VI. The interview transcripts can be found in appendix VII.

![Diagram showing the research focus of the case study]

### 4.3 CASE STUDY RESULTS

#### 4.3.1 CASE ONE

Case one was investigated through interviews with the director projects and the last project manager on the job. The following paragraphs present the outcomes of the interviews.

**Introduction**

Case one is one of the biggest project CB&I Lummus has ever executed. The project covered the build-up of a new plant in Asia. The plant is built on an island 5 km off the shore. The project started with a Front End Engineering Design (FEED), continued with basic engineering activities, and was followed by a full Engineering, Procurement and Construction Management (EPCM). The project contract form was based on reimbursable + incentives and the project was carried out in a Joint Venture (JV) with an Asian partner.

The project team had three different project managers. The first project manager executed the FEED of the project. Initially, it was planned to replace the first project manager by someone with more experience for the subsequent EPCM phase. Nonetheless, the client successfully requested to keep the same project manager. Only six months later the client demanded replacement of this project manager. According to the client the first project manager did not show enough leadership, especially in construction management. The second project manager was a senior construction manager already working in Asia. Shortly after his assignment the client replaced its project manager as well. Due to conflicts and a poor relationship between the two new project managers CB&I Lummus decided to replace its project manager again. The last project manager originally worked in line management as director projects and construction and took an additional role as project sponsor. In the final phase he dropped these two roles and took over the role as project manager.

In the interviews the last project manager and director projects both agree that the project was successfully executed. The first aspect of success was a satisfied client. The second success was achieved in safety and delivering a quality project within the schedule. Finally, the project was financially successful due to achievement of incentives and budget targets.

**Complexity**

With the use of the TOE framework the project manager identified three major elements contributing to the complexity of the project. According to the project manager these elements made the project execution challenging for project team. Table 8 presents the three elements and gives a short clarification.
Table 8 Complexity in project one

**Element of complexity:** Clarification

**Number of locations**
MOPEX\(^2\) with JV partner and many subcontractors added to the complexity. Team building was difficult with teams at different locations. Therefore team building with key persons in the team was essential. These people had to manage and motivate their people subsequently.

**Number of contracts**
Due to project size the work was divided in several work packages. With around 100 sub-contracts many interdependencies added to complexity, in both construction and commercial management.

**Size of project team**
The size of the team and MOPEX required management on a higher scale with less involvement; the project manager had to delegate tasks to others and had to make sure these people controlled their own team.

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**Competences in a project team**
The project manager emphasized that requirements on competences depend on the specific role of the person. Expertise is very important in project management. However, the project manager believes that in daily work leadership and the ability to motivate are at least as important. He noticed that persons are often chosen on the basis of expertise while a large project requires additional management skills.

**Selection and team building**
Table 9 gives a summary of the utilized selection procedures in the project one. The director projects explained how the project manager got selected. The project manager described how he selected the team.

**Selection of:** Clarification

**Project manager:**
The project manager was one of the two ‘right’ persons available who was willing to take over the project. His experience in other international projects made him qualified. His excellent relationship with the client was determining. Furthermore, his analytical skills, leadership style and authority were important considerations in the selection.

**Team:**
The project team already existed when the project manager took over the project. However, selection and reassignment was necessary during the project and was led by concise procedures. The project manager preferred well-known people from previous projects. He looked at what a person had been doing in the past, in what environment, and depending on the position if the person is able to lead a large team. The project manager believes leadership is of key importance for building up a team. Willingness to work abroad was often required. Depending on the vacancy the project manager was willing to do concessions in selection. Some key slots require very specific and skill-full people where other vacancies could be filled by people with less experience. The project manager highlighted that personal coaching was an important aspect of team building. He pointed out that selection procedure was a difficult and subjective process.

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**Table 9 Selection procedure in project one**

The project manager described that after the selection the team consisted of known persons and new persons. A team building event was organized to discuss the targets, objectives and strategy in the project. The project manager explained that weekly meetings were further used to discuss problems, direction and strategy. He described that intervention was needed when deliverables were not met, personal issues were giving problems, chemistry between people was missing or when complaints came from colleagues or the client.

\(^2\) MOPEX: multiple office project execution
Challenges
The project manager explained that it was challenging to get commercial successful again and to get a drive and efficiency to gain back the trust of the client. The reassignment of two project managers and the lack of strategy and discipline of JV had a major impact on the trust of the client. However, he also believes the client started with a weak project organization. According to the project manager this was the reason the client decided to replace its project manager as well.

Lesson learned
The project manager believes that the future process of selection and assignment must be more decisive. Important decisions in team selection have to be made more carefully and independently from the client. The project manager thinks that a strong client is an advantage. He explained that strong and decisive project managers on both sides (CB&I Lummus and client) often solve organizational problems themselves instead of pushing these problems to the project team members.

According to the project manager this project started with a soft and accommodating project manager on the client side. He thinks that as a result the first CB&I Lummus project manager could keep his position after the FEED phase, even though a more experienced and decisive person was needed. According to the project manager this project was lacking strong leadership. As a result, the project managers were misaligned and were not spreading one clear message.

According to the project manager management of a JV can be better organized in the future. He pointed out that CB&I Lummus failed as JV leader to create clear guidelines and a strategy at the start of the project. The project manager illustrated that it is very important to have complementary teams: partner teams need to support, control and strength each other. He believes the JV partner did not assign their best people as a result of the lack of incentives in the reimbursable contract. The project manager underscored that challenging and tracking your partner is crucial for project success in a JV.

Future team selection
The project manager explained that team selection is a unique process for each project. He explained that some competences are role specific. In view of the project manager the type of contract is important; some people perform better in a lump sum turn-key project and others are better in reimbursable projects. Another aspect is culture; some persons are unable to work in a certain culture (e.g. women in Arabian countries). An additional aspect relates to complementary competences. He explained that everyone has strengths and weaknesses; some persons are excellent commercial managers but are not interested in details while others have technical skills but are unsuccessful in keeping overview. According to the project manager these people can complement each other in a team.

The project manager explained that start-up team selection still allows “experiments” with new and inexperienced people; it gives the opportunity for testing, adjusting, reassigning and coaching of team members. The project manager emphasized that this is very different from reassignment during the project, where it is crucial to select the right persons at once. In ideal team selection the résumé of a person is important. The following aspects are determining in team selection: known person from previous projects, experience with the client, past success in teamwork, past success with client, client requirements.

Reflection
In the interviews it became clear that that case one was a large scale and complicated project. The project manager seemed to be an experienced, knowledgeable and charismatic leader. The project manager was confident and proud about his project achievements; he gave the impression the he was the right man at the right place.
Although the interview gave a lot of insights many examples did not relate to the case. It is for instance unlikely that the examples of team selection relate to the specific case; at the time the project manager was assigned the team was already mature which makes his involved in team selection doubtful. Other examples, such as the differences between start-up selection and reassignment, are also likely to be based on general experience rather than case specific knowledge.

### 4.3.2 CASE TWO

Case two was investigated via three interviews with the director projects, the project manager and the assistant project manager. In the following paragraphs the outcomes of the three interviews are described.

**Introduction**

Case two is a project which covered an upgrade of existing plant in west-Europe. The first phase of the project included a FEED study which was done by a competitor. CB&I Lummus got awarded an EPCM contract. Engineering and procurement is carried out in a joint venture between two subsidiaries under the CB&I brand. An external partner was responsible for the construction management activities. The project was arranged as a Lump Sum Turn Key (LSTK).

Both the project manager and the assistant project manager were involved in the entire life span of the project. They explained that the team has been coping with a number of problems. First, a major problem was caused by the presence of ceramic fibers. These fibers were unexpected and delayed the demolishing of the first installation. This problem was sent back and handled by the client itself. For the second installation a new project plan was set up. This second phase of demolishing and rebuilding was executed on time. According to both managers a quality product was delivered with a small budget overrun.

The project manager and assistant project manager agree that the project was a success. The number of change orders saved the project financially. It is assumed that the client is satisfied since rumors tell that the plant already paid itself back in 1.5 years. According to the director projects the project was not a full success. The problem with the ceramic fibers decreased the client satisfaction and subsequently the success of the project. Additionally, there was a fire accident during the project which also caused discussions with the client.

**Complexity**

With the use of the TOE framework the project manager identified three major elements of complexity in the project. Table 10 presents the three elements and gives a short clarification.

<table>
<thead>
<tr>
<th>Element of complexity:</th>
<th>Clarification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uncertainties in scope</td>
<td>Generally a revamp project is difficult due to the uncertainties in scope. The project manager explained that he insisted that everyone in the project team continuously listed the uncertainties in scope. He believes that this approach saved the project. This resulted in a large amount of change orders.</td>
</tr>
<tr>
<td>High project schedule drive</td>
<td>The client wanted to keep the plant fully operational which required minimal shut down periods of the two installations. CB&amp;I Lummus made a very tight schedule for all the activities and got awarded the contract. Each team member needed to be aware of the project schedule drive since delay had drastic consequences for the client. Communication and teamwork was crucial in this project.</td>
</tr>
<tr>
<td>Interference with existing site</td>
<td>All the building activities needed to be done next to fully operational installations. Safety was most importance on site. Components needed to be transported over running facilities; a complex operation which caused a lot of tension in the teams. The project manager explained that individual coaching was important in managing these tensions.</td>
</tr>
</tbody>
</table>

Table 10 Complexity in project two according to the project manager
The assistant project manager also identified three elements of complexity. A short explanation is given in Table 11.

<table>
<thead>
<tr>
<th>Element of complexity</th>
<th>Clarification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Newness of technology</td>
<td>Both the client and CB&amp;I Lummus had very limited experience in building this type of plant</td>
</tr>
<tr>
<td>Project duration</td>
<td>The project got delayed as a result of the presence of ceramic fibers³.</td>
</tr>
<tr>
<td>Interference with existing site</td>
<td>The two revamp installations had to be kept operational as much as possible. Therefore certain tasks had to be done sequential in order to keep the production process running. According to the project manager operators on site were mainly concerned about their own production targets and reluctant to cooperate in construction activities. Therefore, it was crucial to get the construction activities on the priority list of the clients’ project. Alignment of the project teams was crucial, especially with a lump sum project where every delay costs money. Therefore training meetings were organized to get the involvement and acceptance of the operators on site. Handling complexity is according to the project manager a continuous process of steering and motivating the team members.</td>
</tr>
</tbody>
</table>

Table 11 Complexity in project two according to the assistant project manager

Competences in a project team
The project manager explained that he used competences of the team members to determine who could execute certain activities. However, he also mentioned that a lot of competences became visible during the project when certain activities were picked up by people. The project manager strongly believes in on the job training. He explained that the best way to develop competences is to train people by experienced senior employees; education is a start but competences come from learning by doing.

The assistant project manager emphasized that people in the office and the people on site need other competences. Process engineers need theoretical competences whereas people on site need practical competences. Language skills are important, especially when working on site where speaking the native language is a big advantage.

Selection and team building
Table 12 gives a summary of the selection procedures in project two. The director projects explained how the project manager got selected. The project manager described how he selected the team.

<table>
<thead>
<tr>
<th>Selection of:</th>
<th>Clarification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project manager:</td>
<td>According to the director projects the project manager was selected on the basis of experience with the JV partner, experience in construction projects, focus on details, team building skills, availability and willingness to work on the project.</td>
</tr>
<tr>
<td>Team:</td>
<td>The project manager described he selected on the basis of experience and commitment. He explained he likes open-minded people who are willing to reflect and change their behavior when necessary. He prefers neutral team players without prejudices about the work and the team. He believes in a team with 'team players' instead of a team of 'talents' with only self-esteem.</td>
</tr>
</tbody>
</table>

Table 12 Selection procedure of project manager in project two

³ The respondent misinterpreted the meaning of the question since the project duration was not an element of complexity as such. The increase of project duration was a result of other complexities in the project.
The project manager thinks it is crucial to keep steering the people in a project team. Issues between people need to be solved immediately. Talking and reflecting about behavior is an important task of the project manager. The project manager believes that the overall outcome of the project is the most important indicator of performance and effectiveness. He described that a team full of trust, commitment and mutual loyalty increases performance and effectiveness significantly. The project manager believes this can only be achieved by team guidance and close management of team member clashes.

The assistant project manager also described his selection procedure. Table 13 gives a summary.

<table>
<thead>
<tr>
<th>Selection of:</th>
<th>Clarification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Team:</td>
<td>Most of the team selection work was done by the project manager. However, at the time the assistant project manager was working for project engineering he selected a group of 12 engineers. The assistant project manager looked if people were intro- or extrovert to get a balanced team with both type of people. He explained that such a selection procedure is not always possible when a team of the client is also involved.</td>
</tr>
</tbody>
</table>

Table 13 Selection procedure of assistant project manager in project two

The assistant project manager often saw that problematic situations are a reason to shift work packages to other people. In that way team members can assist and complement each other.

**Challenges**
The biggest challenge for the project manager was steering all people in the same direction. Three different partners bring three different cultures into the project. Problems with the design of the plant caused numerous problems during construction. The challenge was to manage the different cultures of the cooperating businesses and to let them work in one team to deal with these problems.

The assistant project manager explained that steering the people in the same direction and creating a sense of urgency to work together towards deadlines was challenging. A lot of tensions rose when disciplines with different tasks were simultaneously working on site.

**Lesson learned**
In the EPCM phase of the project the assistant project manager executed project engineering and project control tasks. According to the assistant project manager a wrong decision because there was no time to focus on one of the two disciplines. When cost problems appeared the assistant project manager took a full time role as project controller and dropped the role as project engineer. He believes that in the future both roles have to be filled by different persons at the start of the project.

In addition, the assistant project manager believes the project team was too inexperienced at the start of the project. A shortage of people resulted that most of the managers and lead engineers had no experience with working on a construction site. In a team of ten people only two people had experience with similar projects. The assistant project manager advocates a more experienced project team: at least fifty percent of people should have experience in similar projects. Having more experienced people in a project decreases the risk in managing complexity. The assistant project manager admitted that this problem is difficult to solve in the future since the continuous fluctuations in the amount of projects also require a flexible workforce.

**Future team selection**
The project manager believes it is crucial to know the people in the project team, to know what drives them and to know where tensions arise. He believes project managers need to focus more on the human aspects of managing a project. The project manager explained that technical skills are important. Nevertheless, he would set communication skills as a number one criterion in team member assignment model. The project manager thinks that self-awareness of team members is very important to manage complexity. The project manager
believes a project team does not only need very talented people; a team needs people who are committed, full of team-spirit and open to change.

The assistant project manager believes it is important to know the people in the team and to use their individual competences. Nevertheless, he also believes that in some cases you can assign new people with less experience to let them grow and gain experience. The assistant project manager believes a certain amount of human resource planning is needed to have the right people at right time. He thinks that the more EPC projects are being executed the more people get trained and become available for similar projects in the future. Additionally, he advocates HR planning on a world scale to deal with the fluctuations in workforce.

Reflection
The interviews with the project manager and the assistant project manager showed a clear difference between their project tasks; the project manager focussed at the overall management (e.g. scope, schedule) of the project whereas the assistant project manager focussed more at operational issues (e.g. technology). This different focus is also shown in the outcomes of the assessment of project complexity. This work division was beneficial for the project since both persons not only focussed at their own activities but also ensured that they both dealt with their own problems.

The interviews gave the impression that the project manager and assistant project manager worked together excellently. It was also shown that they had a similar approach and thoughts about the project. It became clear that both managers focussed on the “soft side” of project management. They focussed on complementary teams where personalities and attitude as most important contributes. We point out that this could be a risk in a project with a lump sum contract where “hard skills” are needed to finish in time and within budget. In the case this risk was mitigated by adding other people to project focussing on the “core” targets of the project.

4.3.3 CASE THREE

Case three was investigated through interviews with the director projects and the most recent project manager. In the following paragraphs the outcomes of the interviews are described.

Introduction
Case three is a project which is currently carried out and covers a major update of existing plant in east-Europe. At this moment CB&I Lummus executes the project under four contracts: two for engineering, one for procurement and one for construction. The project manager explained that this is not a typical project since execution already takes more than 10 years.

The project manager first worked two years as project engineer on the project. In the following five years he was a project engineering manager with responsibility for three subcontractors and external engineering activities. When the former project manager retired at the end of 2009 he took over the role as project manager.

Overall the project three is not successful. The project manager explained that the several claims in the project harmed the relationship with the client and that the project delivered marginal profits for CB&I Lummus. He only thinks that the project is been successful in a way that a lot of experience is gained in executing a project in east-Europe. The director projects also explained that the project is not financial success; author supervision and engineering activities are not profitable since a lot activities are out of scope, but reluctantly been executed to maintain the relationship with the client. Only the procurement activities are a reasonable success.

Complexity
With the use of the TOE framework the project manager identified three major elements of complexity in the project. Table 14 presents the three elements and gives a short clarification.
Element of complexity: Clarification

Unclarity of project goals
The client agreed on using a western design and engineering approach. The problem was that the client expected a design similar to east-European designs. These designs are far more detailed than general western designs.

Unclarity of methods
Initially western standards were used to attract western subcontractors. However, the work packages went to east-European subcontractors due to their lower prices. The lack of experience with western work packages gave a lot of problems; the contractors could do the job technically but had very different thoughts about layout and documenting. The project manager believes CB&I Lummus underestimated these issues.

Number of different languages
Communication with the client has been very difficult due to a language barrier. Everything needed to be translated to the local language since knowledge of English is very limited. The project manager indicated that this makes it very hard to build up a relationship with the client.

Table 14 Complexity in project three

Competences in a project team
The project manager believes every person can positively add to a team when competences are complementary. For instance limited international experience of a lead engineer can be solved by adding a local to the team. The project manager explained that for this project several experienced senior lead engineers were selected. Experience with engineering subcontractors and project management consultancy (PMC) has been essential in this project. The project manager also experienced that it is beneficial to have locals in the team; in meetings foreign persons can be too direct and local people can be far more effective in getting to an agreement. However, he illustrated that locals often make agreements without documenting these, which is subsequently causing problems.

Selection and team building
Table 15 gives a summary of the selection procedures in project three. The director projects explained how the project manager got selected and the project manager illustrated how he selected the team.

<table>
<thead>
<tr>
<th>Selection of:</th>
<th>Clarification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project manager:</td>
<td>The director projects explained the project manager was primarily selected on the basis of his experience with the project and his excellent relationship with the client. An addition reason for his selection was that he was available and willing travel and work abroad.</td>
</tr>
<tr>
<td>Team:</td>
<td>The project manager explained that at the time he got assigned he did not select a lot of people since the team already existed. However, as project engineering manager he did select team members. He used the criteria knowledge, work spirit and personal connection. The project manager explained that he is open for other methods and approaches as well; he explained that a team with different people and different opinions is even better for making the right decisions.</td>
</tr>
</tbody>
</table>

Table 15 Selection procedure in project three

The project manager believes teambuilding is very important. The client is not interested in team building and therefore these sessions are separately organized. The project manager prefers non-work related activities over the traditional brainstorming meetings but pointed out that not all team members are interested. As a result these team members often become outsiders.

Challenges
Project three has been challenging in many aspects. The lack of information has made the project difficult; often specifications from the client side came very late to incorporate in the design. To prevent clashes CB&I Lummus incorporated many of these specifications while these late adjustments are normally a reason for
change orders. The punctuality of the Russians has also been challenging. A design is not accepted until it is 100 percent flawless and payment only takes place after the product has met the full expectations of the client. The project manager explained that keeping the overview has been the biggest challenge in the project. He thinks that most failures take place between the interfaces; the areas where specific work packages need to connect.

**Lesson learned**
An important lesson from this project is the importance of documentation. Initial protocols related to the use of western standards and western subcontractors have been reported insufficiently. This caused many problems when the client decided to use local subcontractors instead.

The project manager acknowledges that communicating with the client is still difficult. Part of the problem is that the client does not have people inside the CB&I Lummus project team. He believes that more involvement of the client would have made communication and consultation less problematic.

The project manager believes the complexity in this project is underestimated, although managed adequately. This project brought a lot of experience about doing business in east-Europe but also about doing PMC projects; this experience can be used in other projects as well. The project manager believes that during the start-up there was a lack of experience in the team. He thinks this caused unrecovered damage to the relationship with the client.

**Future team selection**
The project manager has certain preferences and likes to work with the same people. At a project start-up he usually starts listing the preferred lead engineers and then asks the departments if they are available. The project manager illustrated that the following selection criteria are determining in a team member assignment model:

- Knowledge and experience: does a lead engineer have enough senior experience?
- Quality of persons: does the team have enough skills and experience? (although not only very skilled and experienced people are needed)
- Knowledge on language: English language skills are very important (especially with translations to Russian)
- Impression of the person: is the person more or less talented than the résumé is suggesting?
- Flexibility: is the person flexible in doing different tasks? (flexibility is very important for a manager)

**Reflection**
Case three is exceptional in terms of duration, location and client. Since the project duration of more than 10 years was unplanned, it was not a surprise that this project is not profitable anymore. However, we found it remarkable that there is still no deadline or milestone for finishing the project. One would expect that after all these years the project needs to be finished as soon as possible.

One other aspect we found noteworthy is the pressure on the team. This project is not only executed abroad but also at remote location and in a different culture. Adding the long life span of the project makes it hard to gather and motivate people who are willing to work on the project. We found it for instance exceptional that the project manager is still enthusiastic and full of encouragement after all these years of working on the same project.

Case three showed a number of project facets which were greatly underestimated. For instance the differences in working methods and engineering approaches caused many problems. But also the implications of a language barrier and the differences in culture were underestimated. We found it remarkable that CB&I Lummus did not anticipate more on these facets by using integrated teams and by involving more local knowledge to improve information flows.
4.3.4 CASE FOUR

Case four was investigated through interviews with the director projects and the most recent project manager. In the following paragraphs the outcomes of the interviews are described.

Introduction
Case four is a project covering the construction of a new power plant in west-Europe. Currently one part of the project is being executed by CB&I Lummus. Another part is executed by an external contractor and managed by CB&I Lummus as project management consultant (PMC). CB&I Lummus has a reimbursable contract with the client.

The first project manager on the project was responsible for the tendering and start-up of the project. After his promotion another project manager took over his role. After one year this person left CB&I Lummus and the recent project manager was assigned.

According to the recent project manager the project is a success thus far. However, he noted that definite success is only achieved when the project is delivered on time and when the client is satisfied and open to new collaborations. He believes other aspects of success are delivering a quality product, delivering within budget and deliverance of profit for CB&I Lummus. According to the director projects the project is not a full success. The project flaws come from schedule and budget overruns. These overruns are partly caused by scope changes but are mostly caused by inefficient project execution. Although CB&I Lummus earns extra money out of the reimbursable contract the client satisfaction decreases.

Complexity
With the use of the TOE framework the project manager identified three major elements of complexity in the project. Table 16 presents the three elements and gives a short clarification.

<table>
<thead>
<tr>
<th>Element of complexity</th>
<th>Clarification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of locations</td>
<td>The external contractor operates from the south-Europe. Components and equipment used by the contractor come from America. Therefore, design and engineering activities take place at different locations. As PMC CB&amp;I Lummus has to make sure that all interfaces are aligned. Communication between the client and contractors is of key importance.</td>
</tr>
<tr>
<td>Interface between different disciplines</td>
<td>Since different disciplines are working in different locations it adds complexity to the alignment of the project activities. The project manager emphasized that alignment requires careful documentations of agreements and procedures.</td>
</tr>
<tr>
<td>Interference with existing site</td>
<td>The new power island has to be coupled with an existing power plant located directly next to the building site. Therefore, some of the building activities take place while the existing plant is fully operational.</td>
</tr>
</tbody>
</table>

Table 16 Complexity in project four

Competences in a project team
The project manager believes that people in the team have to be open and listen to each other. He explained that getting the right people is a process of answering the following questions: Who do I need? Who did I work with? Is the person the one I need? Is this person available?

Selection and team building
Table 17 gives a summary of the utilized selection procedures in project four. The director projects explained how the project manager got selected. The project manager described how he selected the team.
Selection of:

<table>
<thead>
<tr>
<th>Clarification</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Project manager:</strong> According to the director projects a number of aspects were determining in the selection of the project manager. First of all his attitude, patience and communication skills were important for this project; especially for managing the client. Secondly, his technical skills and integrity were determining. And finally, his availability and willingness to work on the project were important in his assignment.</td>
</tr>
<tr>
<td><strong>Team:</strong> At the time the project manager was assigned the team already existed. The project was in construction phase therefore selection was adjusted to construction activities. The project manager explained that he preferable selects known people from previous projects. He normally starts with listing the people he successfully worked with and who are appropriate for the new position. The second step is investigating who is available and who can be taken from another project.</td>
</tr>
</tbody>
</table>

Table 17 Selection procedure in project four

The project manager thinks team building is very important for success of a project. He organized an internal team building to increase team efficiency and to identify improvements for the project. He additionally organized a team building session with the client. In this session only the lead engineers from CB&I Lummus and the client came together. The project manager believes the best team building is a healthy balance between hard work and leisure.

The project manager measures performance and effectiveness primarily on the basis of targets in a schedule. At the start of each week meetings are organized to measure progress. Common questions are as follows. What are the targets for this week? Are we reaching these? If not, what do we need to do to reach them?

**Challenges**

The project manager described that a contract gives guidelines with commercial and technical specifications. He described that engineers sometimes deviate from these guidelines because they believe they have a better alternative. It has been challenging to make sure everyone works according the rules and the scope of the contract. Key is to minimize changes from the contract internally and to minimize changes from external sources as well.

Another challenge was on one hand managing the interfaces with the contractors, and on the other hand managing the interfaces with the client and the existing power plant. The respondent illustrated that the external contractor of the power island was very closed in the beginning. Since the power island is being paid under lump sum they were very cautious and protective. The biggest challenge for the project manager was to get everyone open, transparent and communicating. He believes this was to the benefit of all parties.

**Lesson learned**

According to the project manager this project showed that lead engineers need to have communicative skills since a lot work has been done in collaboration with the other contractors. He thinks that a lead engineer with only technical skills needs someone next to him to communicate outside the organization. The communication between the interfaces is very important. The respondent thinks it is important to have a transparent organization where a project team is easy accessible and where also the client and contractors are easy to contact and openly share information.

The respondent believes in managing the interfaces in the environment and in the organization. Language barriers give not only operational difficulties but also make it hard to guarantee safety. Yet, all workers need to be aligned because this project is executed under local rules and standards.
Future team selection
The project manager believes that the type of the project determines what people are needed in team. Key questions are: what level of experience is required? What is the prior acquaintance and was this successful? The project manager also looks at the type of client. What kind of person would fit to the client? What is the scope of the project? Is this person capable of doing the job? According to the respondent department leaders often determine if a person has sufficient capacity and experience for a position.

Reflection
In contrast to the director projects the project manager was very positive about case four. This could have been caused by ignorance of the problems related to budget and schedule or more likely, by a very positive attitude to keep up atmosphere in the project team. We admire the attitude of the project manager; he was clearly confident and proud about his work in the project.

What makes this case complicated is that the project team has been responsible for two project components; on one hand the EPCM of a part of the power plant and on the other hand the PMC role involving the other contractor. This gave the CB&I Lummus team a “double” role; the team had to supervise and cooperating with the other contractor which gave internal and external pressure on the team.

In the interview the project manager showed to be a very effective communicator. He also indicated communication skills as most important competence for its team members. We expect that communication skills positively contributed to deal with the “double” role in the project. However, we also think that an excess of communication flows and meetings could have played role in the budget and schedule overruns. A more hierarchical approach might have been more effective in the project management process.

4.4 CROSS-CASE ANALYSIS

4.4.1 RESULTS

This section introduces a cross-case analysis which treats each case as a separate study and probes whether different cases share some similarity and deserve to be considered as instances of the same type of general case (Yin 2003). In this analysis the evidence from the cases is examined, categorized and clustered to address the initial propositions of the study. Table 18 presents the outcomes of the analysis. The first columns separate the results of the individual cases and the final column presents a number of general conclusions. In the next section the unique characteristics and cross-case patterns of the outcomes are discussed.
### Topic of Interest:

<table>
<thead>
<tr>
<th>Project success</th>
<th>Definition of project success according to the project managers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Success: +</td>
<td>• satisfied client: yes safety: yes schedule: yes, although delay due change orders quality: yes, some quality issues are being solved financial success: yes</td>
</tr>
<tr>
<td>View of PM:</td>
<td>Success: +</td>
</tr>
<tr>
<td>Success thus far: +/−</td>
<td>• satisfied client: no, many issues and claims financially: no, marginal profit experience: yes, a lot of lessons learned</td>
</tr>
</tbody>
</table>

### Conclusions

Final success is achieved when:
- plant is running on time
- client is open for new collaborations

• success can be defined in various ways

### Elements of complexity:

**Most contributing elements of complexity according to the project managers**

- number of locations: MOPEX with JV and many subcontractors
- number of contracts: many interdependencies
- size of project team: less personal, more delegating

#### View of PM:
- uncertainties in scope: large amount of change orders
- high project schedule drive: tight schedule, minimum shut-down
- interference with existing site: operational facility

#### View of assistant PM:
- newness of technology: limited experience with Hydrowax
- project duration: misinterpreted
- interference with existing site: operational facility

- unclarity of project goals: different standards and expectations
- uncertainty in methods: western standards, Russian subcontractors
- number of different languages: language barrier

- number of locations: contractors at different locations
- interface between the different disciplines: difficult with number of locations
- interferences with existing site: connection with operational site

• complexity is project specific
• interference with existing site and number of locations are common elements of complexity

### Competences:

**Experience and view of the project managers on the competences in a project team**

- requirements on depend on role
- a manager needs expertise, although leadership and ability to motivate are at least as important in a large project

#### View of PM:
- used in allocating work
- some competences become visible during the project
- education is a start but competence develop with on the job experience

#### View of assistant PM:
- requirements on depend on role: people in office need theoretical competences whereas people on site need practical competences
- competences in a team have to be in balance
- including locals in the team is beneficial

- team members have to open for new ideas and have to listen to each other
- respondents have a different interpretation of competences
- competences are role specific

---

Table 18 Cross-case analysis
<table>
<thead>
<tr>
<th>Selection: Determining aspects in the selection of the project manager according to the director projects</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Preference for:</strong></td>
</tr>
<tr>
<td>Key considerations:</td>
</tr>
<tr>
<td>type of project</td>
</tr>
<tr>
<td>Remaining comment:</td>
</tr>
</tbody>
</table>

| View of PM: Preferences for: | expertise | communication skills | self-awareness, willingness to reflect, openness to change | commitment, team spirit, no prejudgments | technical skills |
| Remaining comment: | managers should focus more on human aspects of a team |

| View of assistant PM: Preferences for: | knowledge and experience with similar projects | known persons | advanced language skills |
| Key considerations: | willingness to work on site/abroad | personal characteristics | balance in team: combining intro- and extrovert people |
| Remaining comments: | experience is not always required: people can grow and gain experience | more similar projects increases the experience of the workforce | world scale HR planning resolves problems with fluctuations in resources |

| Preferences for: | known persons |
| Key considerations: | fit with client | level of experience needed | scope of the project | phase of the project | prior acquaintance and successes with person | capabilities of the person | when partners involved lead engineers needs communication skills or assistant with these skills | availability |
| Remaining comment: | department heads often determine if person is capable for a job |

Table 18 (continued) Cross-case analysis
<table>
<thead>
<tr>
<th>Table 18 (continued) Cross-case analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Topic of interest:</strong></td>
</tr>
<tr>
<td><strong>Team management</strong></td>
</tr>
<tr>
<td>Experiences and approaches of the project managers in managing the team</td>
</tr>
<tr>
<td>- team building is used to discuss targets, objectives and strategy</td>
</tr>
<tr>
<td>- weekly meetings for problems, direction and strategy</td>
</tr>
<tr>
<td>- personal coaching is important: intervention with personal/team problems, with complains or with failures in deliverables</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Challenges for the project managers in managing the project</td>
</tr>
<tr>
<td>- getting back the drive and efficiency in the project team</td>
</tr>
<tr>
<td>- getting back the trust of client after efficiency and management problems</td>
</tr>
<tr>
<td>- team building is difficult with a large international team: key people are included and have to motivate their people subsequently</td>
</tr>
<tr>
<td>Challenges</td>
</tr>
<tr>
<td>- challenges are project specific</td>
</tr>
<tr>
<td>Case 1</td>
</tr>
<tr>
<td>--------</td>
</tr>
<tr>
<td><strong>General:</strong></td>
</tr>
<tr>
<td><strong>Project management process:</strong></td>
</tr>
<tr>
<td><strong>View of PM:</strong></td>
</tr>
<tr>
<td><strong>View of assistant PM:</strong></td>
</tr>
</tbody>
</table>

Table 18 (continued) Cross-case analysis
This case study intended to include four projects with similar (EPCM) project activities. Although this was achieved in the case selection we found huge differences between the characteristics of the projects. The variations in size, complexity and geographic characteristics made the projects difficult to compare. Nevertheless, the cross-case analysis resulted in a number of general conclusions. The following paragraphs present the outcomes of the analysis and discuss the cross-case patterns of the findings.

Success
In the case selection project success was defined as a combination of a satisfied client and profitability for CB&I Lummus. Based on this definition case one was successful, case two and four partly failed, and case three failed completely. During the execution of the case study it was found that this definition can be contradicting; maintaining the client relationship may require sacrificing the financial success of the project, for example by executing out of scope activities. Additionally, the case study showed that project managers often mentioned more criteria of success; often criteria in which they achieved success.

To further study the success of the projects the definition was taken to a wider perspective. The following criteria are adopted from literature (Chan and Chan 2004; Turner, Müller et al. 2006; Bakker, Arkesteijn et al. 2010):

- commercial success
- meeting client requirements
- meeting budget
- happy client
- achieving purposes
- meeting timescales
- happy sponsor
- meeting quality
- happy team
- no accidents
- start up

The outcomes of case one were surprising. Although the project was selected for its success we believe the process of acquiring the project team flawed. The replacement of three project managers considerably decreased the happiness of the client, sponsors and team. It is especially worrying that in case one interviews indicated that the problems with the project managers were partly anticipated; line management already had serious doubts about the capabilities of the project managers before they got assigned. This points to a more fundamental problem; the project was either underestimated or a capable project manager was not available.

Case two was most in line with the expected success. The project team seemed successful and a quality project was almost fully delivered within the constraints of time and budget. The project failed in achieving a happy client; CB&I Lummus did not take the responsibility for the problems in the construction phase which decreased the client satisfaction. The project also coped with a fire accident which made this project not a success.

Case three has been a failure in many ways. An exceptional long duration, many out-of-scope activities with corresponding budget and schedule overruns made this project a commercial disaster. Both the team and the client are unhappy about the outcomes of the project and the client believes CB&I Lummus did not meet all the requirements.

The outcomes of case four were contrasting. Whereas the project was selected for its flaws the project manager was very optimistic about the outcomes of the project. He did not mention anything related to project flaws. However, based on the findings of formal and informal interviews we believe this project failed. The client satisfaction decreases since costs and schedule overruns are still increasing.
Concluding, to determining the success of project it is necessary to agree on the criteria of success. This case study showed that these criteria often differ among the project managers. Another difference was found between running and finished cases was found; in the finished cases the project managers appeared to be more open to reflect on the success and failures of their projects. This could be explained by the fact that looking back on a finished project cannot harm the project outcomes anymore. This makes it easier to reflect on the achievements and flaws of a project. A final remark is that the continuity of leadership is crucial for the effectiveness and performance of the project team (Parker and Skitmore 2005). In the case study it was found that all project managers emphasized the importance of the relationship with the client. Building up a relationship requires the continuity of a project manager. Case one, three and four flawed in the continuity of leadership since the project manager was replaced two time or more.

**Project complexity**

In the case study the respondents used the TOE framework to identify three elements most contributing to project complexity. The cross-case analysis shows that the elements of complexity differ among the cases. Only two elements of complexity were listed several times; **interference with the existing site** was mentioned in case two and case four and **number of locations** was mentioned in case one and case four. Case two and case four are both brownfield\(^4\) projects, which is an explanation for the **interference with the existing site**. Case one and case four are both projects with multiple subcontractors located at a **number of locations**, which made these projects complex to manage.

The outcomes of the complexity assessment showed seven technical elements of complexity, five organizational elements of complexity and one element related to environmental complexity. This indicates that the project managers in the case study perceive technical and organizational elements as most contributing to project complexity.

To wrap-up, the case study gave an indication of project complexity in the four selected cases. Since all four cases were either in late phase of construction or already finished the project managers looked back at the lifecycles of the projects and indicated the elements most contributing to the complexity of the project. In practice project complexity changes over the life-cycle of the project (Bosch-Rekveldt, Jongkind et al. 2010). Unfortunately, the case study lacked in showing how useful and reliable the TOE framework can be to identify project complexity throughout the different project phases.

**Competences**

To find out more about competences the project managers were asked about the use and importance of competences in a project team. During the interviews it became clear that the respondents struggled with the definition and meaning of competences. As a result the interview questions were differently interpreted. The cross-case analysis shows that project managers generally see competences as a concept. Unfortunately clear examples of competences were seldom given. One general outcome of the cross-case analysis was that different disciplines, such lead engineers and project managers, require different competences.

In the interviews the project managers gave different descriptions of important competences. In case one the respondent explained that a project manager needs leadership skills, experience and success in previous projects. Additionally, a project manager needs expertise and the ability to motivate. The project manager in case two described that the work was allocated according to the competences of people and that team members were selected on the basis of experience, commitment and attitude. In case three the project

\(^4\) Brownfield sites are abandoned or used industrial and commercial facilities available for redevelopment or expansion (Environmental Law Institute 2009)
manager described that competences need to be balanced in a team. People with different capabilities can contribute and complement each other; experienced and less experienced persons can complement each other. In case four the project manager explained that persons with an open attitude are preferred; people need to be open to new ideas and need to listen to each other.

A comparison with IPMA Competence Baseline (2007) showed that the project managers mainly described behavioral and technical competences. Examples of behavioral competences are leadership skills, openness and motivation. Only project management success was mentioned as technical competence. Experience cannot be seen as a competence but rather contributed to the development of competence (PMI 2004). Scientific literature describes competences as knowledge, skills and personal characteristics required to achieve job performance as defined by appropriate standards (Boyatzis 1982; Crawford 1997). Surprisingly, the CB&I Lummus performance improvement plan was not mentioned by the project managers. Apparently, the competence “standard” of CB&I Lummus is not as well integrated as presumed in the business review.

To conclude, the case study results were too vague and too general to identify important competences. It seemed that respondents need a better guideline to identify competences. Not only categories of competences are necessary but also a focus on specific disciplines is needed to come to an overview of important competences.

Selection
The case study investigated how the project managers selected their team in the past and how they would develop a future team selection model. It appeared that project managers would not really change their current practices of team selection. For that reason the cross-case analysis combined the examples of the present and future of team selection practices.

The case study showed that current team selection procedure is simple, informal and unstructured. Also the selection of the project managers does not seem to be guided by a standard procedure. In the interviews the respondents described that many considerations were determining in the selection of the teams. The cross-case analysis shows that project managers were primarily selected on the basis of availability and willingness to work on the project. Additionally, experience and relational aspects such as client and team relationship were indicated as important considerations in team selection. The cross-case analysis further indicates that project managers all have their own approach to team selection. They select on the basis of knowledge, experience and attitude. Again, the relational aspect turned out to be an important factor; the project managers aim for a fit with the client and the team and preferably select known people from previous projects.

The individual cases gave also insight in the experiences and preferences of the individual project managers. In case one the project manager explained that start-up team selection allows experiments with new and inexperienced people but that reassignment requires the right persons at once. The project manager also explained that some teams work better under lump sum whereas other teams are more efficient under reimbursable contracts. In case two the project manager emphasized that team selection should be focused more on the human aspects. The project manager believes that communication skills, commitment and team spirit are at least as important as experience and technical skills. The assistant project manager adds that personal characteristics and team balance with intro- and extrovert people are important considerations in the selection. In case three the project manager explained the importance of flexibility, work spirit and language skills. The project manager also mentioned that contrasting personalities are not only negative but can also improve the decision making process. In case four the project manager described the influence of the characteristics of the project. The scope of the project, the phase of project and the partner involvement determine the requirements in the selection. It was also mentioned that department heads often determine if a person is capable for a specific function.
When looking critically at the outcomes of the cross-case analysis it can be concluded that a structured approach to team selection is not shown in the individual cases. Furthermore, it is questionable if the considerations in team selection were case specific. In case one, three and four the project managers were assigned during the project which implicates that they did not select the team but rather reassigned some people on the project.

The business review described that team selection is the responsibility of the project manager. In practice the project manager is still responsible, but it turns out that the project manager only selects the “key” people and that these people subsequently select their team. The criteria in the selection do not only depend on personal preferences but also depend on the specific role of the person. To find out which selection criteria apply to specific roles in a team more research is needed.

**Team performance**

The case study also investigated what happened after the team selection and how project managers managed their team. The cross-case analysis points out that the project managers have different approaches to team management. Some of the respondents described that they managed their team with a focus on project output whereas others focused on creating trust, commitment and relationships. As a result team building practices were also organized differently; some managers used team building to discuss targets, objectives and the strategy of the project whereas others used team building to improve internal relationships by organizing activities not related to the project.

It was also found that team performance can be influenced by the type of contract. Case one showed that the activities of a specific team can get a low priority as a result of lack of incentives in a reimbursable contract. A lack of incentive can subsequently lead to budget and schedule overruns (Howard, Bell and McCormick 1997). Case four indicated that a lump sum contract can cause closed and protective behavior which can harm collaboration between partnering teams.

Unfortunately, the case study did not show to what extent team building practices and the type of contract contributed to project success and failures. This was because the criteria of success differed among the cases and the background knowledge about the teams and the contracts of the cases was limited.

**Challenges and lessons learned**

Finally, the challenges and lessons learned were analyzed. The cross-case analysis shows that the challenges in the projects were mostly related to the unique characteristics of the project. The only common challenges in the projects were team and interface management. All project managers found it hard to get the team in the same direction and to align the interfaces in the project to prevent mistakes and ensure the quality in the projects.

The lessons learned were also case specific. In case one the problems with the project managers were a lesson that the processes related to team selection and the team interaction are important. In case two and three the importance of scope control were shown; in case two this contributed to success and in case three this went wrong. Case four indicated that information distribution and interface management are essential when several teams need to work together.
The case study investigated four cases in detail by conducting interviews with the director projects and five project managers. The case study focused on project success, project complexity, competences, team selection, team performance and the challenges and lessons learned.

In the case study project complexity was assessed to answer research SQ 2: “Which elements of project complexity are most present in the projects of CB&I Lummus?” The case study showed that the cases have a different “footprint” of project complexity. A cross-case analysis showed that the interference with the existing site and number of locations were the only elements mentioned in two cases. Overall, the project managers perceived technical and organizational elements as most contributing to project complexity.

In addition, the case study explored research SQ 3: “Which team member competences are required for the success of complex projects?” The case study showed that project managers struggled with the definition of competences. Respondents gave several examples of competences, such as leadership skills, openness, motivation and project management success. However, in none of the cases it became clear if certain competences contributed to success and if a lack of competences resulted in project flaws. Therefore the link between competences and project success remained unclear. Respondents needed a better guideline to identify competences; categories of competences and specific disciplines needed to be defined to come to an overview of important team member competences. Furthermore, a clear definition of project success was required; the case study showed that the current definition of project success of CB&I Lummus is incomplete and differs among the project managers.

At last, the case study investigated research SQ 4: “Which team member selection criteria are required for building up a project team?” Respondents described many considerations in team selection, including: knowledge, experience, attitude, fit with the client and prior acquaintance. Nevertheless, the case showed that in practice, team selection is based on personal preferences and the availability of the workforce. In addition, selection criteria are dependent on the type of role in the team.
5 COMPETENCE SURVEY

5.1 INTRODUCTION

As described in the previous chapter, the case study showed that project managers found it hard to identify important competences in their teams. Nevertheless, the interviews indicated that competences are useful in the selection of a team. For that reason it was relevant to further explore the requirements on competences. This chapter presents a competence survey which investigated the importance of competences within a project team. This survey focused on SQ3: "Which team member competences are required for the success of projects?"

Section 5.2 defines the scope of the survey and describes how the relevant data has been collected. Section 5.3 describes the results of the survey. Section 5.4 concludes on the outcomes of the project.

5.2 SURVEY DESIGN

5.2.1 DEFINITION

The design of the survey started with the research focus. One of the outcomes of the case study was that requirements on competences are role specific. Therefore it was decided to use the survey to investigate the competences of specific disciplines, namely the competences of the project manager, the project engineering manager and the lead engineer.

The survey was distributed in a second round of interviews. This approach saved time; all 18 respondents scheduled in a one hour interview and filled in the survey immediately which at the end resulted in 100 percent response. It was decided to approach both project team members and line managers. Project team members know from experience which competences are important in a team. Line managers have to make sure that team members with the right competences are available. Including both perspectives gave the opportunity to identify similarities or differences between both groups.

In the survey the project managers from the case study were involved again. This made it easy to quickly schedule new appointments. Additionally, other disciplines below the project managers were included in the survey, namely; the project engineering managers and the lead engineers. These contacts were provided by the project managers as well. For line management the director projects, the director procurement, the director engineering and the department heads of process, civil and piping were involved. Figure 8 gives an overview of the survey respondents.
The inquiry in the project organization was done downstream; respondents reflected on their own competences and on the competences of the people below them. Additionally, line management reflected on the competences of all three layers in the project organization. The reason for not including upstream evaluations in the project organization came from the possible biased results; upstream appraisal in the project organization might have caused resistance since respondents then suddenly need to review their superior. Table 19 gives an overview of which respondents reflected on which competences.
The survey described in the business review investigated project complexity in CB&I Lummus projects. The results, presented in chapter 3 showed that the following four elements most contribute to complexity in typical CB&I Lummus projects:

- Uncertainties in scope
- Lack of resources & skill availability
- Variety of stakeholder perspectives
- Dependencies on external stakeholders

The survey was used to investigate which competences are important to a specific discipline when dealing with the above elements of project complexity. The survey focused on three disciplines, namely; the project manager, project engineering manager and lead engineer. Figure 9 gives an overview of the internal structure of the survey and shows how the respondents (self) reflected on the importance of competences in complex projects.

### Table 19 Respondent chart

<table>
<thead>
<tr>
<th>Respondent:</th>
<th>Competence appraisal of:</th>
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<tbody>
<tr>
<td></td>
<td>Project Manager</td>
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<td>Project Manager 1</td>
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<td>Project Manager 2</td>
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<td>Project Manager 3</td>
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<tr>
<td>Project Manager 4</td>
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<tr>
<td>Project Engineering Manager 1</td>
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<td>Project Engineering Manager 2</td>
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<td>Project Engineering Manager 3</td>
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<td>Project Engineering Manager 4</td>
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<td>Lead Engineer 1</td>
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<td>Lead Engineer 3</td>
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<tr>
<td>Lead Engineer 4</td>
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<td><strong>LINE MANAGEMENT</strong></td>
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<td>X</td>
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<td>Director Engineering</td>
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<tr>
<td>Department Head Civil</td>
<td>X</td>
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<tr>
<td>Department Head Process</td>
<td>X</td>
</tr>
<tr>
<td>Department Head Piping</td>
<td>X</td>
</tr>
<tr>
<td>Director Procurement</td>
<td>X</td>
</tr>
</tbody>
</table>

**5.2.2 INTERNAL DESIGN**

The survey described in the business review investigated project complexity in CB&I Lummus projects. The results, presented in chapter 3 showed that the following four elements most contribute to complexity in typical CB&I Lummus projects:

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Competence models are often developed to specific needs of a company (Sinnott, Madison et al. 2002). Since CB&I Lummus developed a performance improvement plan based on competences, it was decided to adopt this plan and to use this in the competences survey. Since this improvement plan is currently used in employee evaluations, it could not be directly used in this study. It would give biased results since respondents could confuse or relate it to their own performance review. In addition, the problem was that several elements in the performance improvement plan were poorly defined and overlapping. For this reason it was decided to reform the appraisal model in an attempt to make it simple and more focused. The competence overview of Sinnott, Madison and Pataki (2002), presented in appendix II, was used to review these categories and to sharpen up the definitions of the model. This reformation resulted in a competences model with eight categories.

Figure 10 gives a presentation of the competence model. In the survey the respondents have been asked to fill in the competence model for each element of complexity. The competence scale ranged from “not really” important to “very much” important.
Task capability includes the skills directly related to the discipline. The competence covers technology skills which are necessary to understand and support the engineering activities but also includes innovativeness and effective problem solving.

Managing output has an external focus and primarily looks at reaching the targets of the project. These targets consist of delivering a quality product, delivering the quantity within the schedule and awareness of HSE during the execution of the project.

Encouraging attitude sums up stimulating behavior in the project. A person with this competence is cooperative and proactive, dedicated to the job, has a positive attitude, is integer and has sound judgments. The person takes measures to solve problems and does not allow mistakes, failure, and other personal crises to undermine results.

Social and communication skills relate to writing, oral and behavioral skills. This competence covers the ability to communicate, listen and interact effectively. It furthermore shows to the willingness to share ideas and perspectives and encourages others to do the same.

Personal development relates to involvement of the persons own development and to involvement of team member development. This includes identifying the needs for improvement in own work and in the work of other. Development is defined as coaching and investing in training of the individuals.

Sharing vision is providing a structured, challenging direction in the project. Vision describes long- and short-term goals and should be communicate with a clear, vivid and relevant description of where the project organization should be in weeks, month or years out. A shared vision should be built in the team and should be translated in actions. A shared vision is implemented by striving for team results, by openly sharing information and by holding regular group meetings.
Managing team performance focuses on the health and balance in the team. Team needs to work together and therefore certain activities need to be delegated. A team needs feedback and poor performance should be addressed. Team building is also an important element since it increases the cohesion of the team and can increase performance.

Managing process has an internal focus and looks at the variables in the project. An employee with this competence is aware of the contract while being cost and schedule conscious. Additionally, management of risks and changes is important.
5.3 COMPETENCES IN A PROJECT TEAM

5.3.1 OUTLINE

The following sub-sections describe the outcomes of the competence survey. Four sub-sections present which competences are important to deal with project complexity caused by uncertainties of scope, lack of resources & skill availability, variety of stakeholder perspectives and dependencies on external stakeholders.

Four respondent groups were included in the survey, namely line managers, project managers, project engineering managers and lead engineers. The average scores of the competences are presented by respondent group. In case the scores of the groups differed more than “1” point, the competence score was identified as divergent. A competence with an average score between “3” and “4” was identified as important.

5.3.2 UNCERTAINTIES IN SCOPE

Figure 11 shows that when a project has an uncertain scope the project manager needs the competences social and communication skills and management process. Obviously uncertainties in scope can only be managed by communication and negotiation with the relevant stakeholders. Managing process is essential to manage the uncertainties in scope which can influence the contract, costs and schedule of the project. A divergent score is seen in sharing a vision. Line management thinks that sharing a vision is an important competence whereas project managers believe this is less important with uncertainties in scope. This might be caused by the fundamental differences between the two disciplines; line management has a long term focus where a vision is important whereas project managers are short term oriented and need to manage on output.

Figure 11 indicates that project engineering managers needs the competences task capability, social and communication skills and management process when dealing with uncertainties in scope. The figure also shows that task capability is more important for project engineering managers than for project managers; likely due to their influence on engineering activities. Again, the different perspectives of sharing a vision are seen; line management thinks sharing vision is important while project engineering managers themselves consider this competence as less important. Other differences are seen in the competences managing output and encouraging attitude; only project managers think that project engineering managers need the competence managing output. Project managers and project engineering managers believe that encouraging attitude is an important competence for a project engineering managers whereas the line managers disagree.

Figure 11 points out that a project with uncertainties in scope requires lead engineers with the competences task capability, managing process and managing output competences. Apparently, from all disciplines lead engineers need to be most concerned about the outputs of the project. They need to chase their team of engineers to reach the targets of the project, even when these can change due to the uncertainties in scope. The graph of the lead engineer shows that among the three highest scoring competences the lead engineers and line management have the most divergent scores. This also indicates that respondents not fully agree about the importance of the competences task capability and managing output.
Figure 11 Required competences for uncertainties in scope
5.3.3 LACK OF RESOURCES & SKILL AVAILABILITY

Figure 12 shows that when a project team is having a lack of resources and skills available a project manager needs to have the competences encouraging attitude and managing team performance. A project manager needs to deal with these limitations and has to make sure the team operates at maximum performance. Therefore a manager needs to be the front leader in teamwork, provide feedback and encourage all team members to be cooperative and proactive. A minor divergence between the respondent groups is shown in the competences social and communication skills and encouraging attitude. According to project manager social and communication skills are not really important whereas encouraging attitude is very important. Line managers disagree and think that the project manager needs more social and communication skills and to a lesser extent a good encouraging attitude.

When a project engineering manager is facing a lack of resources and skills available this requires a project engineering manager with the competences managing team performance and an encouraging attitude. For project engineering managers the respondents also agree that social and communication skills are important. Figure 12 shows that respondents have a different views on the competence sharing a vision; project engineering managers themselves think this is less important than the project managers. The survey also shows that engineering managers themselves think that the competences managing process and managing team performance are more important than project managers.

When a project is coping with a lack of resources and skills available this requires a lead engineer with the competences task capability, managing output and managing team performance. A lead engineer needs task capability to support and understand its engineering team. The lead engineer is responsible for the targets of its engineers and therefore needs the competence managing output. And due to a lack of resources and skills available a lead engineer needs the competence managing team performance to optimize the outputs of its engineers. Figure 12 also shows some differences between the respondent groups. Project managers and project engineering managers think that a lead engineer needs the competences social and communication skills and personal development when its team is having a lack of resources and skills available. In contrast, line management disagrees and thinks that personal development and social and communications skills are less important. The lead engineer believes the competence managing process is important whereas the other respondent groups indicate that this competence is less important for a lead engineer.
Figure 12 Required competences for lack of resources & skill availability
5.3.4 VARIETY OF STAKEHOLDER PERSPECTIVES

Figure 13 shows that with a variety of stakeholder perspectives a project manager needs to have the competences social and communication skills and managing process. If a number of stakeholders have direct influence on the scope of the project it is likely that a project manager needs to safeguard the targets in the contract. Therefore the project manager also needs to have social and communication skills to deal with the various stakeholder perspectives and to get these in the same direction. In addition, Figure 13 shows a number of divergent scores. Project managers think that with a variety of stakeholder perspectives it is important to manage team performance whereas line managers think it is more important that project manager share a vision.

Figure 13 shows that in a project with a variety of stakeholder perspectives the competences communication skills, managing process and managing team performance are important for a project engineering manager. Compared to the project manager the project engineering manager has more contact with the team of engineers and therefore managing team performance might be more important. However, line management disagrees for management of team performance and believes this is less important. Respondents also disagree about the importance of personal development; especially line management thinks this is not really important.

The survey shows dispersed scores for the competences of a lead engineer to deal with a variety of stakeholder perspectives. The majority of the respondents scored management of process as important while project managers disagree. It is possible that project managers think managing process is more their own task. Respondents agreed on the importance of social and communication skills and also agreed that personal development is not really important for a lead engineer. Project engineering managers and line managers believe tasks capability is important for a lead engineer while project managers and lead engineers disagree. Only project managers think a lead engineer needs an encouraging attitude while only line management thinks that managing team performance is unimportant for a lead engineer when having a variety of stakeholder perspectives.
Figure 13 Required competences for variety of stakeholder perspectives
5.3.5 DEPENDENCIES ON EXTERNAL STAKEHOLDERS

Figure 14 underlines that respondents believe it is important to have project managers with competences managing process and social and communication skills when the project is dependent on external stakeholders. Safeguarding the contract and targets of the project is important when the project deals with external influences. In addition, respondents agree that social and communication skills are important to manage those external stakeholders. In contrast to line management the project managers believe that managing team performance is more important in their position.

For project engineering managers the competences managing process, social and communication skills and encouraging attitude are important when a project is dependent on external stakeholders. The encouraging attitude is presumably needed to make the team positive, cooperative, proactive and integer to effectively manage the dependencies on external stakeholders. Figure 14 also shows dispersed scores. Project engineering managers see social and communication skills as very important while line managers believe this is less important. The project engineering managers think that managing team performance is important whereas line management and project managers disagree. And line management views managing output as important and managing process as less important while project engineering managers have an opposite view. Other differences between respondents are seen in sharing a vision and task capability.

Figure 14 indicates that most respondents agree that a lead engineer needs the competences managing process, managing output and social and communication skills to handle dependencies on external stakeholders. Only project managers believe that managing process and managing output is not as important for a lead engineer. Furthermore, project managers scored task capability as undecidedly important for lead engineers while lead engineers themselves think it is important. Project managers also believe that sharing a vision is somewhat important for a lead engineer whereas project engineering managers rate this as not really important.
Figure 14 Required competences for dependencies on external stakeholders
### 5.3.6 DISCUSSION

#### Overview
Table 20 presents an overview of the competence survey results. The table shows the required competences of the project manager (PM), project engineering manager (PEM) and the lead engineer (LE) related to the four elements of complexity.

The survey shows that for a number of competences all respondents agree on their importance. These competences have an average score between “somewhat important” and “very important” with not more than “1” point deviation between the answers of the respondent groups. The table marks these competences with a “+” which shows that on average the respondents indicate the individual competences as important for the particular element of complexity.

A number of scores of the respondent groups deviate with more than “1” point, indicating that one or more respondent groups disagree about the importance of these competences. These are the deviations, or disagreements, described in the previous sections and are indicated as “?” in Table 20. A number of competences are important on average, but one or more respondent groups disagree with more than “1” point. These are indicated by “? / +”.

<table>
<thead>
<tr>
<th>Competences</th>
<th>Task Capability</th>
<th>Managing output</th>
<th>Encouraging attitude</th>
<th>Social &amp; communication skills</th>
<th>Personal development</th>
<th>Sharing vision</th>
<th>Managing team performance</th>
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<td>Lack of res. &amp; skill availab.</td>
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<td><strong>LE</strong></td>
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Table 20 Competences overview (+ = high score, ? = dispersed scores)
Table 20 shows that the elements of complexity require two “sets” of competences of the project manager. For uncertainties in scope, variety of stakeholder perspectives and dependencies on external stakeholders the competences social and communication skills and managing process are important to the project manager. In case a project manager is facing a lack of resources and skill availability the competences encouraging attitude and managing team performance are important.

A project engineering manager requires other competences than a project manager. To manage uncertainties of scope, the competences task capability, social and communication skills and managing process are important. With a lack of resources and skills available, the competences encouraging attitude, managing team performance and social and communications skills are important. When having a variety of stakeholder perspectives, the competences social and communication skills, managing team performance and managing process are important for a project engineering manager. And when a dependency on external stakeholders exists, project engineering managers needs the competences encouraging attitude, social and communication skills and managing process.

For a lead engineer the important competences change again. To deal with uncertainties in scope, the competences task capability, managing output and managing process are important. With a lack of resources and skills available, task capability, managing output and managing team performance are important competences. With a variety of stakeholder perspectives, social and communication skills and managing process is important. And with dependency on external stakeholders the lead engineer needs the competences managing output, social and communication skills and managing process.

Competences important to the discipline
As described above, the important competences differ for the project manager, project engineering manager and lead engineer. When the influences of project complexity are ignored, the survey results also show some general nuances in the scores of the competences. It appeared that the importance of the competences task capability and managing output increases in the lower levels of the organization. In contrast, the competence encouraging attitude is important for the project manager and the project engineering manager but unimportant for the lead engineer. And at last, the competences social and communication skills, managing team performance and managing process are important to all three the disciplines. Table 21 presents how the importance of competences shifts for the different disciplines; “+” indicates important for one element of complexity and “++” indicates that the competences are important for two or more elements of complexity.

<table>
<thead>
<tr>
<th>Competences</th>
<th>Task Capability</th>
<th>Managing output</th>
<th>Encouraging attitude</th>
<th>Social &amp; communication skills</th>
<th>Personal development</th>
<th>Sharing vision</th>
<th>Managing team performance</th>
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<td>PEM</td>
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</table>

Table 21 Competences important for the PM, PEM and LE
Competences important to complexity
So far, the competences of the project manager, project engineering manager and lead engineer were distinguished. However, the survey also shows that some of the competences are important to all three the disciplines. Uncertainties of scope generally require the competence managing process. For a lack of resources and skill availability the competence managing team performance is important. And finally, for a variety of stakeholder perspectives and dependencies on stakeholders the competences social and communication skills and managing process are important. Table 22 shows which competences are always important to deal with the different elements of project complexity. ("++")

| Competences | Task | Capability | Manager | Managing | Encouraging | Social & | Personal | Sharing | Managing | Managing |
|-------------|------|------------|---------|----------|------------| communication | development | vision | team performance | process |
| Uncertainties | | | | | | | | | | ++ |
| in scope | | | | | | | | | | |
| Lack of res. | | | | | ++ | | | | ++ |
| & skill availab. | | | | | | | | | | |
| Variety of | | | | | | | | | ++ |
| stakeh. persp. | | | | | | | | | | |
| Depend. on | | | | | | | | | ++ |
| ext. stakeh. | | | | | | | | | | |

Table 22 Competences important in relation to project complexity.

Final remarks
Besides the important competences the survey showed a number of disagreements/dispersed scores ("?") between the respondent groups. Table 20 shows that the more respondents groups reflect on the importance of a competence, the more disagreements emerge (shown for the PEM and LE). In other words, increasing the number of people involved in the evaluation of competences increases, to certain extent, the number of disagreements as well. For that reason the findings of the survey are of limited use; the “agreements” shown in Table 20, Table 21 and Table 22 give an indication of what competences to deal with project complexity. Further research is needed to explore the causes of the disagreements between the different disciplines.

Another finding was that the respondents experience that project managers and project engineering managers commonly have overlapping tasks in the project. However, the results of the survey shows that the competences task capability and managing team performance are more important to project engineering manager. This indicates that both disciplines do have a slightly different focus in a project team.

Finally, respondents believe the competence model needs further development. Some competences are missing whereas others can be merged or reformulated. In addition, the competences model should differentiate the types of project complexity; several respondents struggled with the definition of a variety of stakeholder perspectives and the dependencies on external stakeholders. A general remark was that managing the perspectives and the dependencies of the stakeholders is essentially a problem for a project manager. Respondents found it difficult to picture the impact of these complexities in the work of a project engineering manager and lead engineer.
The competence survey investigated the importance of competences for a project manager, project engineering manager and lead engineer. The competence survey focused on research SQ 3: “Which team member competences are required for the success of projects?”

The competence survey used a competence model including: task capability, managing output, encouraging attitude, social and communication skills, personal development, sharing a vision, managing team performance and managing process. This model was used to investigate which competences are needed to deal with project complexity caused by uncertainties in scope, lack of resources and skill availability, variety of stakeholder perspectives and dependencies on external stakeholders.

When dealing with uncertainties in scope, the three disciplines need the competence managing process. Social and communication skills are important for the project manager and the project engineering manager. Task capability is required for the project engineering manager and the lead engineer. Additionally, a lead engineer needs the competence managing output.

When a project is having a lack of resources and skill availability, the competence managing process is generally important to the three disciplines. The project manager and project engineering manager additionally need an encouraging attitude. The project engineering manager also needs social and communication skills. For the lead engineer the competences task capability and managing output are also important.

In a project with a variety of stakeholder perspectives, social and communication skills and managing process are competences important to the three disciplines. In addition, a project engineering manager needs the competence managing team performance.

When a project has dependencies on external stakeholders, the competences social and communication skills and managing process are important to the three disciplines. In addition, a project engineering manager needs an encouraging attitude. For the lead engineer the competence managing output is important.

Besides the importance of specific competences it was found that the respondents often disagree about the importance of competences. For that reason the findings of the survey are of limited use: the survey only indicates the importance of competences where respondents mostly “agreed” on. In addition, the competence model used in this survey needs to be developed. It is required to investigate if competences can be added or merged and if the competence model can differentiate between the different types of project complexity. To conclude, the survey only looked at the importance of competences to deal with project complexity. Therefore, the link between competences and project success remained unclear.
6  SYNTHESIS

6.1  INTRODUCTION

This chapter integrates and reflects on the outcomes of this study. The findings from the desk research, case study and competence survey are combined in order to find an answer to research SQ 5: “How can CB&I Lummus select a project team on the basis of project complexity and team member competences?”

Section 6.2 starts with the findings related to project complexity. In section 6.3 the findings on competences are discussed. In section 6.4 the results related to team performance are described. Section 6.5 discusses the findings on team selection. In section 6.6 the limitations of the study are presented. And finally, section 6.7 discusses the validity of the study.

6.2  PROJECT COMPLEXITY

Complexity in CB&I Lummus projects
As described in the business review, presented in section 3.3, project managers perceive uncertainties in scope, lack of resources & skill availability, variety of stakeholder perspectives and dependencies on external stakeholders as most contributing to the complexity of typical CB&I Lummus projects. In the case study, presented in chapter four, the project managers assessed the complexity of their own projects. It showed that the selected cases have a different complexity footprint than the typical projects. Most elements mentioned in the case study overlap with middle scoring elements of the complexity survey. Uncertainties in scope is the only high scoring element of project complexity in the survey which was also mentioned in the second case. Number of different languages is a low scoring element in the survey but has a high score in the third case; this is explained by the unique circumstances of a client team which hardly speaks English. Interfaces between different disciplines is another low scoring element in the survey which has a high score in case four; a possible explanation is that the project manager from case four found it hard to deal with many different disciplines at many different locations.

The difference between the findings of the business review and the case study indicates that the present complexity in the projects of CB&I Lummus is characterized by more than four elements. We predict that the elements of project complexity found in the cases are part of a larger set of elements contributing to the complexity of CB&I Lummus projects. An assessment of other projects could extent the overview of elements of complexity currently present in CB&I Lummus projects.

We emphasize that in future assessments of project complexity the subjectivity of the assessor should be taken into account (Bosch-Rekveldt 2011). In our case study the subjectivity is particularly visible in case two where both the project manager and the assistant project manager assessed project complexity. The project manager identified complexity related to organization issues (scope and schedule) whereas the assistant project manager perceived more operational (technological) issues as most contributing to complexity. Based on these findings we assume that each discipline has a different perception of project complexity. Therefore it is important involve more than one person in the assessment to create a reliable footprint of project complexity.

Additionally, future assessments should take the dynamic character of project complexity into account. Bosch-Rekveldt (2011) proposed to use the TOE framework in various stages of the project in order to grasp the dynamics of project complexity. In this study project complexity was assessed at one point in time. As a result it was not possible to explore how complexity changed during the project lifecycle. More importantly, it did not show how well project complexity can be forecasted at the start of a project.
Using project complexity for team selection

Bosch-Rekveldt (2011) described that by knowing the areas of project complexity, attention could be paid to the management of these. The following paragraphs explore whether project complexity can be used in team selection.

We expect that project complexity can be a useful factor in team selection. However, we emphasize that business integration requires time. In order to use project complexity in team selection it is necessary to make a reliable prediction of what elements of complexity can be expected during the project. The case study showed that the elements of complexity in typical CB&I Lummus projects are not sufficient to make this prediction. Projects need to be assessed on an individual basis to create a reliable footprint of project complexity.

We expect that assessment of project complexity upfront is difficult without making use of a guideline or a tool. The case study results confirm this by showing that project complexity was often underestimated; in the first case this resulted in two project manager replacements and in case three this resulted in a lot of scope changes and problems with the client. Therefore, we propose to assess project complexity by using a tool, such as the TOE framework. Project managers should start with monitoring project complexity at the different phases of a project. In this way project managers can get familiar with “concept” of complexity and they can learn how project complexity “changes” during the project. When a certain amount of knowledge and experience is gathered project complexity can be used as a factor in team selection.

Concluding, to assess and use project complexity in team selection requires experience and cannot be implemented in a short period of time. A knowledge base is required to get a full understanding of the dynamics and subjective nature of project complexity. We point out that the four most contributing elements of complexity in typical CB&I Lummus projects can be used in this knowledge base. Moreover, knowledge about the dynamics of project complexity in the different phases of the project can also be added in the future. Subsequently, management can use this by preparing project teams to manage this project complexity.

6.3 COMPETENCES

Competences in typical CB&I Lummus projects

The case study showed that project managers find it difficult to identify important competences to deal with project complexity. The use of competences was explored in the case study but only resulted in a few examples of behavioral and technical competences. Furthermore, it was found that requirements on competences are dependent on the type of discipline; for example a project manager needs other competences than an engineer. To find out more about the importance of competences a competence survey was conducted. This survey explored which competences are important to a project manager (PM), project engineering manager (PEM) and lead engineer (LE) when dealing with project complexity caused by uncertainties in scope, lack of resources & skill availability, variety of stakeholder perspectives and dependencies on external stakeholders. The survey included respondents from both project management and line management.

The survey results were combined in a preliminary map between project complexity and the important competences for the three different team roles. Table 23 gives an overview. In some cases the respondent groups strongly disagreed about the importance of a competence: these disagreements are indicated by “?”.
Table 23 Important competences to deal with project complexity for different disciplines

Table 23 shows that the disciplines (PM, PEM, LE) need different competences to deal with project complexity. It indicates that project managers (PM) need social and communication skills and managing process whereas the disciplines on a lower level in the team (PEM and LE) additionally need the competences task capability and managing output. Literature confirms these findings; project managers typically have an external focus to meet project contract, cost and schedule requirements whereas managers involved in engineering should have a more internal focus on technical and operational issues (Demeulemeester and Herroelen 2002).

Bosch-Rekveldt (2009) also explored the link between competences of a project manager and project complexity. Table 24 gives an overview of the findings of this study.

Table 24 Project complexity mapped to project manager competences (Bosch-Rekveldt, Gulden et al. 2009)

A number of differences can be put forward when contrasting our outcomes with the outcomes of Bosch-Rekveldt. For technical complexity (e.g. uncertainties of scope) Bosch-Rekveldt indicates that project engineering and leadership are very important, whereas the competence survey shows that social and communication skills and managing process (with contract management) are important. For organizational complexity (e.g. lack of resources and skill availability) the study of Bosch-Rekveldt shows that contracting and procurement, personal and leadership competences are very important. The results of the competence survey partly overlap with managing team performance and encouraging attitude but do not show the importance of contracting procurement. And finally, for environmental complexity (e.g. variety of stakeholder perspectives and dependencies on external stakeholders) HSSE management is important and personal and leadership competences are very important whereas the competence survey shows again that social and communication skills and managing process (with contract management) are important.
We originate the differences between the two studies to different designs of both studies. The survey investigated competences to deal with single elements of complexity whereas Bosch-Rekveldt looked at the areas of project complexity. It is questionable if competences important to one element of complexity can be compared with the competences important for an area of project complexity. Furthermore, both studies use different competence categories which limit the validity of the comparison. Especially the different competence categories in our model raised questions during the survey. Therefore the next paragraphs further discuss the design of the competence model.

**CB&I Lummus’ competence model**

Our competence survey not only showed which competences are important to deal with project complexity; the results also indicated which competences are not important to deal with the four elements of project complexity, such as personal development and sharing a vision. In addition, it was found that respondents perceived the categories of the competence model as overlapping and confusing. Furthermore, the survey showed that respondents groups can disagree about the importance of competences, indicated as “?” in Table 23. These findings were a reason to further investigate the strengths and weaknesses of the competence model.

The design of the competence model was based on the CB&I appraisal plan. It was intended to create a model with eight competences covering a larger list of CB&I competences. Table 25 shows how the CB&I Lummus competences are covered by these categories.

<table>
<thead>
<tr>
<th>Category</th>
<th>CB&amp;I Lummus competences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task capability:</td>
<td>Technology skills, innovativeness, effective problem solving</td>
</tr>
<tr>
<td>Managing output:</td>
<td>Delivering quality, delivering quantity, meeting schedule, awareness HSSE</td>
</tr>
<tr>
<td>Encouraging attitude:</td>
<td>Cooperative, dedicated, positive, integer, proactive</td>
</tr>
<tr>
<td>Social and communication skills:</td>
<td>Communicates, listens and interacts effectively</td>
</tr>
<tr>
<td>Personal development:</td>
<td>Involvement in own/other development</td>
</tr>
<tr>
<td>Sharing a vision:</td>
<td>Strive for team results, openly sharing information, holding regular group meetings</td>
</tr>
<tr>
<td>Managing team performance:</td>
<td>Delegating, giving feedback, team building, addressing poor performance</td>
</tr>
<tr>
<td>Managing process:</td>
<td>Contract awareness, cost conscious, schedule conscious, risk management, change management</td>
</tr>
</tbody>
</table>

Table 25 CB&I Lummus competence covered by the competence model

To explore the strengths and weaknesses of the competence model the IPMA (2007) competences baseline (ICB) was used to critically reflect on the CB&I Lummus competences. Table 26 gives an overview of the competences in the ICB.
<table>
<thead>
<tr>
<th>Behavioral competences</th>
<th>Technical competences</th>
<th>Contextual competences</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Leadership</td>
<td>• Project management success</td>
<td>• Project orientation</td>
</tr>
<tr>
<td>• Engagement &amp; motivation</td>
<td>• Interested parties</td>
<td>• Program orientation</td>
</tr>
<tr>
<td>• Self-control</td>
<td>• Project requirements &amp; objectives</td>
<td>• Portfolio orientation</td>
</tr>
<tr>
<td>• Assertiveness</td>
<td>• Risk &amp; opportunity</td>
<td>• Project program &amp; portfolio implementation</td>
</tr>
<tr>
<td>• Relaxation</td>
<td>• Quality</td>
<td>• Permanent organization</td>
</tr>
<tr>
<td>• Openness</td>
<td>• Project organization</td>
<td>• Business</td>
</tr>
<tr>
<td>• Creativity</td>
<td>• Teamwork</td>
<td>• Systems, products &amp; technology</td>
</tr>
<tr>
<td>• Results orientation</td>
<td>• Problem resolution</td>
<td>• Personnel management</td>
</tr>
<tr>
<td>• Efficiency</td>
<td>• Project structures</td>
<td>• Health, security, safety &amp; environment</td>
</tr>
<tr>
<td>• Consultation</td>
<td>• Scope &amp; deliverables</td>
<td>• Finance</td>
</tr>
<tr>
<td>• Negotiation</td>
<td>• Time &amp; project phases</td>
<td>• Legal</td>
</tr>
<tr>
<td>• Conflict &amp; crisis</td>
<td>• Resources</td>
<td></td>
</tr>
<tr>
<td>• Reliability</td>
<td>• Cost &amp; finance</td>
<td></td>
</tr>
<tr>
<td>• Values appreciation</td>
<td>• Procurement &amp; contract</td>
<td></td>
</tr>
<tr>
<td>• Ethics</td>
<td>• Changes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Control &amp; reports</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Information &amp; documentation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Communication</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Start-up</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Close-out</td>
<td></td>
</tr>
</tbody>
</table>

Table 26 IPMA competence baseline (ICB)

A comparison between the competences defined by CB&I Lummus and the ICB gave two new insights. First, the ICB describes much more technical and contextual competences than defined by CB&I Lummus. Second, the eight categories of the competences model are too specific and out of balance; the categories personal development and sharing a vision have a large share in the CB&I Lummus competence model whereas the ICB pays less attention to these competences. In addition, the ICB gives a wide range of technical competences whereas the competence model only covers these competences in managing output and managing process.

Based on the above described findings, we investigated which competences are potentially missing in the list of CB&I Lummus. Thereafter, we extended the CB&I Lummus competence model by merging and adding a number of categories. The categories sharing a vision and personal development were merged with the category managing team performance. Furthermore, the categories encouraging attitude and social and communication skills were combined into the category personal competences. In addition, the categories managing process and managing output were combined. And finally, the categories managing organization and context were added. Table 27 gives shows how the competences of CB&I Lummus and ICB are merged into a preliminary CB&I Lummus competence model.
As shown in Table 27, the behavioral competences of the ICB were covered thoroughly by the CB&I Lummus competences. Only the competences self-control, relaxation, and leadership were added to the category personal. In addition, the competence conflict and crisis was added to managing team performance.

Compared to the ICB, the CB&I Lummus competences lacked a number of technical competences. The competences related to the management of the internal organization, stakeholders, documentation and project start-up and project close-out were missing in the list of CB&I Lummus. Therefore, the category managing organization was added. In addition, the competences resources cost & finance and procurement & contract were added to the category managing process and output.

At last, we found that the most contextual competences were missing in the competence model. Therefore, a category was added including the primary contextual competences such as systems, products & technology, HSSE awareness, finance and legal.

**Table 27 Preliminary CB&I Lummus competence model**

<table>
<thead>
<tr>
<th>Behavioral competences</th>
<th>Technical competences</th>
<th>Contextual competences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal competences</td>
<td>Task capability</td>
<td>Managing organization</td>
</tr>
<tr>
<td>Communicates and</td>
<td>Technology skills (CB&amp;I)</td>
<td>Project management success (ICB)</td>
</tr>
<tr>
<td>listens effectively (CB&amp;I)</td>
<td>Innovativeness (CB&amp;I)</td>
<td>Interested parties (ICB)</td>
</tr>
<tr>
<td>Self-control (ICB)</td>
<td>Effective problem solving (CB&amp;I)</td>
<td>Project requirements &amp; objectives (ICB)</td>
</tr>
<tr>
<td>Relaxation (ICB)</td>
<td>Leadership (ICB)</td>
<td>Project organization (ICB)</td>
</tr>
<tr>
<td>Leadership (ICB)</td>
<td>Cooperative (CB&amp;I)</td>
<td>Control &amp; reports (ICB)</td>
</tr>
<tr>
<td>Positive attitude (CB&amp;I)</td>
<td>Dedicated and proactive (CB&amp;I)</td>
<td>Information &amp; documentation (ICB)</td>
</tr>
<tr>
<td>Integer (CB&amp;I)</td>
<td>Managing team performance</td>
<td>Start-up (ICB)</td>
</tr>
<tr>
<td>Openly sharing</td>
<td>Conflict and crisis (ICB)</td>
<td>Close-out (ICB)</td>
</tr>
<tr>
<td>information (CB&amp;I)</td>
<td>Delegating (CB&amp;I)</td>
<td>Managing process and output:</td>
</tr>
<tr>
<td>Holding regular group</td>
<td>Giving feedback (CB&amp;I)</td>
<td>Scope &amp; deliverables (CB&amp;I)</td>
</tr>
<tr>
<td>meetings (CB&amp;I)</td>
<td>Team building (CB&amp;I)</td>
<td>Time &amp; project phases (CB&amp;I)</td>
</tr>
<tr>
<td>Addressing poor</td>
<td>Sharing a vision (CB&amp;I)</td>
<td>Resources (ICB)</td>
</tr>
<tr>
<td>performance (CB&amp;I)</td>
<td></td>
<td>Cost &amp; finance (ICB)</td>
</tr>
</tbody>
</table>

Using the competence model

Based on the findings of our case study and competence survey we expect that effective use of competences requires that all disciplines in an organization integrate, accept and use a competence model.

In the case study it was found that CB&I Lummus currently makes limited use of a competence model. Respondents were interviewed about the importance of competences but the results were marginal. Surprisingly, none of the project managers mentioned the competences covered by the CB&I appraisal plan. This indicated that the model is poorly integrated in the organization. A number of informal interviews confirmed that the model is hardly used in the appraisal of employees. Therefore, we suggest that CB&I Lummus needs to further integrate and develop the preliminary CB&I competence model in order to use competences in the future.
Furthermore, the competence survey showed that a number of respondents disagree about the importance of competences; this indicates a mismatch between the perceptions of the respondent groups (project specific vs. line management). To effectively use a competence model we point out that an organization needs to resolve this mismatch; all the disciplines in an organization need to agree on the importance of competences for the different disciplines.

To further develop and integrate the competence model within CB&I Lummus we propose to adopt the competence development steps of Sinnot, Madison and Pataki (2002):

1. Identify the position you are establishing competences for
2. Develop the competence model
3. Assess the individual competences and identify gaps
4. Develop strategies to address the gaps
5. Reassess competences & evaluate the return on investment (ROI)

This study started with the first two steps of competence development. We recommend further exploration of these steps. In the first step we limited our study to the project manager, project engineering manager and lead engineer but we point out that the competence model is applicable to other engineering disciplines as well. For the second step, we recommend to use the preliminary CB&I competence model, as shown in Table 27, in practice. The model needs to be tested to see how well the new competences apply to different disciplines. Furthermore, it needs to be further investigated which competences are required for different disciplines. Finally, when the first and the second step are finished, the next steps can be used to develop competences in the organization.

6.4 TEAM PERFORMANCE

In the case study it was found that project managers described various management approaches to create a high performing project team. Some emphasized on the importance of project targets and strategy whereas others focused on relationships and trust and commitment in the team. Two cases indicated poor team performance. In case one the crisis of two project manager replacements harmed team performance. In addition, the team performance of the JV partner flawed. In case three, team performance was harmed due to different cultures and a complicated client relationship.

Thamhain (2004) described that a large number of performance factors derive from the “human side” of a team. Organizational components that satisfy personal and professional needs have a strong effect on cooperation, commitment, risk management, and ultimately drive team performance. Our study gave the impression that within CB&I Lummus the human side is sometimes put on a second place. Existing relationships seem important in team selection but it remained unclear how the organization actively builds on these team relationships. It is therefore recommended to focus more on project team development. For instance, by focusing on the values of a team, the interaction between team member and the contact to external contacts which are important influences of team performance (Cohen, Levesque et al. 1997).

In the case study the project managers pointed at the importance of team building. Project managers have different approaches to team building; some focus on the objectives of the project by involving only the management layers whereas others focus on the relational aspects of the whole team by organizing non-work related activities. Based on the literature we believe that team building should always focus on the relational aspect, for instance by bringing the full team together to discover common characteristics. Non-work related activities contribute to team results; activities where team members discover strong and weak points add to the cohesion of a team (Savelsbergh, van der Heijden et al. 2010).
Our study also gave the impression that CB&I Lummus hardly celebrates its achievements. We propose to put some effort in appreciation of the workforce; recognition and reward are essential to personal motivation and often needs to be nothing more than a thank you in private and/or public. Rewarding the team as a whole is better than rewarding only the team member who worked as an individual (Markert 2011).

Owens, Mannix and Neale (1998) investigated the link between selection and team performance and advocate functional and relational alignment in team selection. Our study shows that CB&I Lummus project managers select their team on functional requirements, such as skills and experience. They focus on relational aspects by selecting on “prior acquaintance”, “experience with the client” and “client relationship”. Based on the above findings we recommend to pay more attention to both functional and relational alignment. How this can be achieved in team selection is put forward in the next section.

6.5 TEAM SELECTION

This study indicated that in CB&I Lummus project complexity and team member competences are at this moment not determining factors in team selection. Currently team selection is an unstructured procedure; project managers have their own preferences in selection and rely on existing relationships, technical knowledge, experience in previous projects, and experience and relationship with the client. Besides these preferences other factors such as the available workforce, the type of vacancy, the type of project and personal connections are determining in project team selection.

Based on the findings of our research we emphasize that the current approach to team selection is effective in most cases. In fact, literature confirms many of these factors of team selection. We point out that the project managers of CB&I Lummus acknowledge the importance of relational alignment; CB&I Lummus can be proud on the way the existing relationships are used in team selection. However, functional alignment is less visible in the current selection. General examples of how team selection is dependent on the type of discipline and project did not show that specific functional criteria are used.

To integrate a structured approach to team selection we recommend to use the PMBOK (PMI 2004). As shown in Figure 15, the PMBOK describes that in the process of acquiring a team three aspects are important: input, tools and techniques, and output.

The input factors, such as availability, interest and experiences, are currently used in the selection. We point out that CB&I Lummus can determine abilities by using the competences model presented in the previous section. Team member selection can be guided by the three steps of Wi,Oh, Mun and Jung (2009): define the required competences, assess the competences of the available workforce and finally select the team member with right competences.

Many of the tools and techniques were mentioned in the case study. To structure the team selection, we recommend to develop documentation with guidelines for the use of these tools and techniques.

At last, the output factors should be considered. Again, we recommend integration of these output factors in documented guidelines for team selection.
The input of team selection covers the following factors:

1. Enterprise Environmental Factors
   - Availability: who is available?
   - Ability: what competences do people need to possess?
   - Experience: have the people done similar or related work? Have they done it well?
   - Interests: are the people interested in working on this project?
   - Cost: how much will each team member be paid? (Especially when contracted from outside)

2. Organizational Process Assets
   - Are there policies, guideline, or procedures governing the selection. (HR departments can assist)

3. Roles and responsibilities
   - Roles and responsibilities define the positions, skills, and competences that the project demands

4. Project Organization Charts
   - Project organization charts provide an overview regarding the number of people needed for the project

5. Staffing Management Plan
   - The staffing management plan with the project schedule identifies the time periods each project team member will be needed and other information important to acquiring the project team

The tools and techniques for team selection consist of:

1. Pre-assignment
   - If project team members are known in advance they can be pre-assigned (e.g. in a proposal)

2. Negotiation
   - Negotiations with functional managers or other project management teams to appropriately assign scarce or specialized resources

3. Acquisition
   - When organization lacks in the in-house staff needed, the required staff can be acquired outside.

4. Virtual teams
   - Using electronic communication for instance to form teams over widespread areas, to add expertise to the team, to reduce travel expenses or to incorporate other offices

The output of team selection procedure covers the following aspects:

1. Project Staff Assignments
   - The project is staffed when appropriate people have been assigned to work on it (project directory filled up, names in the organizational charts and schedules)

2. Resource Availability
   - Resource availability documents are created with the time periods each project team member can work on the project (creation of reliable schedule)

3. Staffing Management Plan
   - After the selection may be needed due to changing functions, promotions, retirements, illnesses, performance issues, and changing workloads.

---

**Figure 15 PMBOK guide to team selection (PMI 2004)**

### 6.6 LIMITATIONS

The case study included projects with different characters. Although we found a number of cross-case patterns, the cases had many different characteristics. This limited the number of general conclusions.

In the case study the project managers were asked for important competences in a project team. A limitation of study is that we did not make a clear distinction between the competences of a project manager and other disciplines.

A limitation of the case study is that only the perspectives of the director projects and project managers were included. It could be that these disciplines experienced the projects very different than for instance the engineering disciplines in the project teams.

In the case study a number of project managers were interviewed who were not directly involved in team selection. Their experience on team selection in the specific cases was therefore limited. Nevertheless, their general experience gave valuable insights in the factors influencing a team selection process.
In the competence survey the CB&I Lummus competence model was used. In the synthesis it was found this model lacked various technical and contextual competences. This has caused a bias in the outcomes of the survey since only the respondents had more behavioral competences than technical and contextual competences to choose from.

A limitation of the competence survey is that the number of respondents changed because of the “downstream” character of the evaluation. The competences of the project managers were reviewed by two respondent groups, the competences of the project engineering managers were reviewed by three respondent groups, and the competences of the lead engineers were reviewed by four respondent groups. This caused that a disagreement (“?”) about the importance of a competence, included wider variety of answers for the lead engineer in comparison to the project manager.

6.7 VALIDITY

A research design is supposed to represent a logical set of statements. Therefore validity and reliability are of key importance in design of the research. This research considered the following concepts of Yin (2003) related to validity and reliability:

- Construct validity: establishing a correct operational measure for the studied concepts
- Internal validity: establishing relationships between the different sources of evidence
- External validity: establishing domain to which a study’s findings can be generalized
- Reliability: demonstrating that the operations of a study can be repeated with the same results

Construct validity was achieved by multiple sources of evidence. Desk research was used to explore the scientific and practical background and identified a number of “gaps” related to research topic. A case study and a competence survey explored these “gaps” by gathering empirical evidence. The synthesis reflected on the outcomes of the study by combining the results of the desk research, case study and competence survey. This led to the conclusions which subsequently gave its scientific and practical recommendations.

The internal validity relates to the data collection approach. To increase the internal validity of the case study the interviews were conducted with only basic knowledge about the scientific literature. This minimized bias and influences of the interviewer which increased the objectivity of the interview results. In the competence survey the internal validity was increased by the “downstream” design: since evaluating superiors could lead to bias respondents only evaluated their own competences and the ones of their inferiors. This made respondents very open and objective in their answers.

We expect that our findings apply to all projects of CB&I Lummus. The case study started with thorough selection and covered four projects to extend the validity of the generalizations. In addition, the competence survey included respondents from project management and line management to incorporate the different perspectives in the organization. Furthermore, external validity was expanded by a critical view and by including sector specific literature such as the TOE framework and the IPMA. Although the study focused on the projects of CB&I Lummus we expect that some of the findings, such as the specific requirements on competences to deal with project complexity, also apply to other companies in the process industry. Further research is needed to expand this external validity.

The reliability of this study was guaranteed by documenting the numerous design decisions in the study. The interviews in the case study were recorded and conducted according to an interview protocol to ensure the reliability of the interview transcripts. Overall, this report presents the different phases in the study in such a way that other researchers are able to repeat the procedures and arrive at the same results.
7 CONCLUSIONS AND RECOMMENDATIONS

7.1 INTRODUCTION

This study investigated the selection of team members on the basis of team member competences and project complexity. Besides this, the influences of the project team performance were explored. This study started with desk research, followed by a case study and competence survey to investigate these concepts in an empirical setting.

Literature describes competences as important to deal with project complexity. However, an important knowledge gap in the link between complexity, competences and team selection was identified. This research aimed to fill this gap.

Empirical data was gathered in CB&I Lummus. The company executes projects in the oil and gas industry as an Engineering, Procurement and Construction (EPC) contractor. Their ultimate goal is to satisfy customers and execute profitable projects. Therefore they aim to create effective teams. Currently, their team selection is merely guided by personal preferences and available resources. This study assessed how project complexity and team member competences can be influencing in future team selection.

This chapter presents the conclusions and recommendations of this study. Section 7.2 gives the answers to the research sub-questions and the main research question in subsequent subsections. Section 7.3 presents the recommendations for further research. Finally, section 7.4 provides a number of recommendations for CB&I Lummus.

7.2 CONCLUSIONS

7.2.1 INSIGHTS FROM LITERATURE ON COMPETENCES AND PROJECT COMPLEXITY

SQ 1: How does literature describe team member competences and project complexity in relation to effective project team selection?

The relationship between team member competences and team selection is described in various scientific articles. It was found that selecting the right competences in a project team is crucial for achieving project success. Besides team member competences effective team selection can also be based on availability, experience, interest, responsibilities, business procedures and targets.

The direct relationship between project complexity and project team selection was not found in literature. However, some articles stipulate the importance of the link between appropriate competences of a project manager to deal with project complexity. Having the right competences such as project engineering, personal and leadership skills can help in dealing with project complexity. Unfortunately, scientific literature does not prescribe which competences are required for other team roles.

Scientific literature describes that effective project team selection leads to better team performance. In team selection relational and functional alignment are necessary components for an effective team. Other factors such as the team environment, the team process and the values of the team turn out to be also important influences of team performance.
Based on the findings of the literature review it can be concluded that specific aspects as team member competences, project complexity and their interrelationship to effective project team selection turned out to be an important knowledge gap. Hence, little is known about influence their influence on team performance. The next research questions further explored these above topics by gathering empirical evidence.

7.2.2 PROJECT COMPLEXITY IN CB&I LUMMUS

SQ 2: Which elements of project complexity are most present in the projects of CB&I Lummus?

In this study project complexity was assessed in typical projects and in four selected projects. It was found that the following elements of complexity are most present in typical CB&I Lummus projects.

- Uncertainties in scope
- Lack of resources & skill availability
- Variety of stakeholder perspectives
- Dependencies on external stakeholders

In the case study the project complexity of the four selected projects was assessed. Surprisingly, the elements of complexity mentioned in the case study only overlapped to a limited extent with the elements of typical projects. In each project different elements contributed to project complexity; elements often related to the unique characteristics of the projects.

Based on the differences between typical projects and the selected projects in the case study it can be concluded that it is impossible to identify a small set of elements of project complexity most present in CB&I Lummus projects. Apparently project complexity is not uniform in the projects of CB&I Lummus; the set of elements most contributing to the project complexity differs among the projects. It could be that the elements found in this study are part of a larger set of elements but it could also be that it is impossible to define common elements of complexity in the project of CB&I Lummus.

Future assessments in other projects could extent the overview of elements of complexity most present in CB&I Lummus projects. Such an assessment should take place in different phases of the project to explore the dynamics project complexity. To incorporate the subjective character of the assessment more people should assess project complexity instead of relying solely on the view of the project manager.

7.2.3 COMPETENCES REQUIRED FOR PROJECT SUCCESS

SQ 3: Which team member competences are required for the success of projects?

The results of the case study were insufficient to identify team member competences required for project success. One of the reasons is that project managers were unable to identify project team member competences contributing to project success. Another reason are the different definitions of project success which made it difficult to determine which specific competences are required.

Nevertheless, a number of important competences were found for the project manager, such as leadership skills, openness and motivation. This study also showed that certain project characteristics require certain team member competences. For instance project scope, type of client and the type of contract require a specific set of competences.
In a competence survey the link between project complexity and team member competences was explored. It can be concluded that the project manager, project engineering manager and lead engineer need different competences to deal with project complexity. The requirements on the competences of the project manager and project engineering manager show similarities, most likely because the project engineering manager is often a close assistant of the project manager. Both disciplines need to manage on output and require social and communication skills, probably due to their external connections and responsibilities. Lead engineers need specific competences, such as task capability and managing output, to deal with technical and organizational complexity. These competences are required to manage the internal issues in the project team.

7.2.4 TEAM SELECTION CRITERIA

SQ 4: Which team member selection criteria are required for building up a project team?

It was found that CB&I Lummus uses no explicit criteria for team member selection. In practice the team member selection involves various considerations, such as availability, prior acquaintance with the project manager, working attitude, experience with in similar projects, required competences, fit with the client, fit with the team and fit with the type of project. Often the personal preferences of the project manager and the availability of the workforce are determining in team selection.

Scientific literature describes various selection criteria such as functional expertise, competences, availability, experience and interests. Other contextual factors from organizational responsibilities, procedures and targets can also be influential in team member selection. It was found that besides functional criteria relational aspects are also important in building up an effective project team.

Various selection criteria are both mentioned in practice and literature, such as competences, availability and experience. It can be concluded that these selection criteria are required to build up a project team. However, in practice the project characteristics and the preferences of the project manager determine which specific selection criteria are used to build up a team. Therefore, it was not possible to formulate generic guidelines for the use of team member selection criteria.

7.2.5 TEAM SELECTION IN CB&I LUMMUS

SQ 5: How can CB&I Lummus select a project team on the basis of project complexity and team member competences?

Currently, project complexity is not used in the selection of project CB&I Lummus project teams. Team member competences are being considered but are not determining in the team member selection. To select project teams on the basis of project complexity and team member competences, CB&I Lummus should give the current team selection procedure more structure.

To use project complexity in team selection CB&I Lummus should start assessing project complexity throughout the lifecycles of the project. The TOE framework including Technical, Organizational and Environmental elements of project complexity can be used in this process. This creates an understanding about the implications and dynamics of projects for those involved in the project. Gathering knowledge and experience about project complexity also increases the reliability of ex-ante assessment of project complexity.
To deal with project complexity certain team member competences are required which can be used in team member selection. This study showed four elements most contributing to the project complexity of typical CB&I Lummus projects. These elements were linked to the requirements on team member competences. In order to make more of these links CB&I should assess the complexity of future projects to learn about the presence of other elements of complexity. In addition CB&I Lummus should expand its competence model with a wider set of competences since especially technical and contextual competences are currently missing.

7.3 PROJECT COMPLEXITY AND COMPETENCES IN TEAM SELECTION

RQ: How can project complexity and team member competences be influencing in project team member selection?

Project complexity and team member competences can be influencing in project team member selection when both aspects are well understood and used in an organization.

Project complexity needs to be assessed on an individual basis since every project is unique and likely to show different elements of project complexity. To assess project complexity the TOE framework can be used. The framework gives a footprint in terms of where complexity can be expected in a project. To improve expectations project complexity should be measured in the different projects and various project phases. This creates experience and helps developing generic guidelines to assess project complexity. A project complexity footprint can be used to take specific actions. One action should be selecting project team members with appropriate competences to deal with project complexity.

Dealing with complexity requires different competences in specific team roles. An organization should explore which elements of complexity are present in their projects to define requirements on team member competences. To use competences in team member selection, an organization needs to develop and integrate a well defined and accepted competence model. The use of team member competences in project team member selection requires three steps. First, the important competences for a team role need to be defined. Second, the competences of the available workforce need to be assessed. And third, the person with appropriate competences needs to be selected.

7.4 RECOMMENDATIONS FOR FURTHER RESEARCH

Based on the findings of this research a number of recommendations for future research will be presented in this section.

In this study empirical evidence was gathered by means of a case study. The perspectives of the project managers and the director projects were incorporated by using exploratory interviews. The use of a semi-structured approach turned out to be very effective since it gave the interviewees the freedom to bring in their own perspectives and to give case specific details. The interviewees explained a lot about the success, failures, and complexity of the projects. In addition, they thoroughly described the process of building up and managing a project team. Since the case study only focused at the top management level it might be interesting to conduct further research into the differences between the project team member perspectives. A study involving both the project managers and engineers could show potential misalignment in project teams. This can further help to identify process improvements, for instance related to project team selection. Additionally, other stakeholders, such as clients and partner teams could be involved in future studies. This could contribute in determining the success and failures of particular projects.
In the competence survey the link between team member competences and project complexity was explored. It was found that different roles in a team require different competences to deal with certain types of project complexity. Future research could expand the results of this study in three ways. First, the competences of other team roles could be explored. This study focussed at engineering disciplines and investigated the requirements on the competences of a project manager, project engineering manager and lead engineer. In future research it might be interesting to look at other team roles, for instance the team members involved in planning and procurement activities. Second, future research could expand the link between project complexity and team member competences. The competence survey focussed on a set of competences defined by CB&I Lummus. The synthesis showed that the CB&I Lummus competence model lacks in describing various technical and contextual competences. In future research it is therefore recommended to use a different competence model, such as the IPMA competence baseline, to explore how a wider set of team member competences can be linked to certain types of project complexity. Third, it is recommended to further study how other project complexity elements of the TOE framework can be mapped to specific team member competences. The competence survey focussed on four specific elements of project complexity. Since this study showed that many other elements are contributing to the complexity of projects, it is recommended to further explore how other elements of project complexity can be linked to team member competences.

7.5 RECOMMENDATIONS FOR CB&I LUMMUS

Based on the findings of this research a number of recommendations for CB&I Lummus will be presented in this section.

First, it is recommend to start with assessing project complexity throughout the lifecycle of the projects to explore the implications of project complexity. By using for instance the TOE framework to assess project complexity, project teams can get more familiar with the aspects of project complexity. In addition, measuring complexity throughout the projects gives more knowledge about the subjectivity of the assessors and the dynamics of project complexity. In the future this knowledge can help in making reliable predictions of project complexity. When the organization is able to make a reliable prediction of project complexity the link to requirements of the project team, such as specific competences, can be further explored.

It was shown that typical CB&I Lummus projects have typical elements of project complexity which require specific competences from the workforce. The results of this research provide a good start of a knowledge base to further explore the link between project complexity and team member competences. Both project management and line management can use this knowledge to prepare future project teams for project complexity and can developing strategies manage certain types of complexity.

Second, it is suggested to further development and integration of the new CB&I Lummus competence model. This study expanded the CB&I Lummus competence model by giving more attention to the technical and contextual competences of individuals. However, exploration of how well these competences apply to the different disciplines and to add a rank to the competences in the model could provide additional insights. In this way the model can be used to determine the “level” of competences for a specific discipline. In addition, it is recommended to discuss the importance of the competence of specific disciplines; discussion is the only way to resolve the mismatches between for instance lead engineers and project managers.

In the development of the competence model the guidelines from the IPMA competence baseline would be a valuable. Furthermore, it is suggested to conduct the individual performance appraisals more frequently and consistently by using the competence model. It would be wise to store the outcomes of the appraisals centrally in such a way that during team selection the competences of individuals can be derived from the appraisal plans.
Third, it is recommended to use the PMBOK guide to develop a structured procedure for team selection and to give competences a more prominent role in the selection but not to diminish all the informal arrangements. Furthermore, functional and relational alignment needs to be combined in team selection; competences can be used in functional alignment and informal arrangements are still required for relational alignment in teams. Although this recommendation seems radical, many of the steps described by the PMBOK guide are already used in team selection. CB&I Lummus should only develop a guideline for using these selection steps more consistently in every project.

Finally, it is suggested to look critical at the organizational processes within the organization. During this study a lot of people explained how much they learned from their projects. They described that a lot of this experience and knowledge can be used in future projects. However, no one seems to know how this knowledge should be captured and used in other projects. This provides an opportunity for CB&I, they could do better in gathering organizational knowledge and learning from their projects. Another finding is that many employees pointed at the importance of experience. Experience can be gained by executing projects but also by personal training. During this study it became apparent that within CB&I Lummus training takes only a small role in the development of the workforce. A more central role of training could help in developing the competences of the workforce to deal with the complexity of future projects.
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