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Success Factors for Integration of New Tools and Equipment

Håkon Audunson Ystenæs

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Supervisor: Bassam A Hussein, MTP
Co-supervisor: Sascha Schwartze, Baker Hughes

Norwegian University of Science and Technology
Department of Mechanical and Industrial Engineering

Thematic description

This study aims to propose a set of critical success factors for integration of new tools and equipment in oilfield service companies. To ensure the findings are of high relevance and thus applicable for real-life scenarios, the case-study method is applied. The report will present and analyze five interesting case-projects. Empirical data in the report will be accumulated mainly through interviews with key stakeholders involved in each case-project. The findings are compared with established theories from relevant literature concerning critical success factors.

Preface

This report is a diploma marking the end of a two-years master's degree in Project Management at the Norwegian University of Science and Technology (NTNU). The research was conducted in the spring semester of 2017, from January to June.

Several people have contributed to the research, enabling a real-life approach and interesting project cases. Firstly, I want to thank my supervisor Bassam Hussein for his feedback and input along the way. His experience and knowledge, especially within project success, has been of great value. I would also like to thank Baker Hughes, especially my contact person Sascha Schwartze for his cooperation and guidance throughout the research, and also for providing the cover image on behalf of Baker Hughes. The report contains five project cases, which were described by the respective project managers, or other heavily involved stakeholders in the projects. The people I would like to thank for sharing their interesting stories are Sascha Schwartze, Petter A. Strømme and Detlef Hahn from Baker Hughes, as well as Morten Eidem and Torgeir Wenn from Statoil.

Summary

The oilfield service industry is currently exposed to strong competition. In order to remain competitive, oilfield service companies are dependent on streamlined operations, which can be achieved by e.g. developing and applying new and more efficient products and technologies. Baker Hughes, a United States oilfield service company among the largest in the world, is now at the final stage of developing a new drilling system called the One-Trip System (OTS), which is to be tested operationally in the summer of 2017. The Norwegian department of the company is the first in Baker Hughes' organization to incorporate the new system. Based on experience, the implementation of new products is a challenging process within the company and the industry. Increasing the likelihood of successful integration of the new system into the organization is thus desirable.

There is a great deal of literature that examines the importance and application of critical success factors in projects. Studies show that there are some specific factors that, if followed by the project and its stakeholders, may increase the likelihood of a successful project. Some studies focus on success factors for projects in general, while others look at specific project types, such as product development, IT and implementation projects.

This study aims to determine the critical success factors for the integration of new tools and equipment in oilfield service companies, which may aid the integration of the OTS within the Norwegian department of Baker Hughes.

The critical success factors are mapped using a mixed method where findings from case-projects are compared with findings from relevant literature. All the presented case-projects have similar features as the OTS project, as they all relate to the integration and implementation of new products.

Based on the findings from the case-projects, a set of critical success factors for the integration of new tools and equipment in the oil service industry is proposed and presented. These success factors are analyzed and compared with findings from the literature study. It appears that the findings from the case-projects are supported by literature on success factors within projects, project implementation and change management, which increases the validity and generality of the research. The final list of critical success factors is presented below.

Project management	
	Capable and experienced project manager
	Dedicated and committed project manager
Upper management	
	KPIs support and reward use of new products
	Upper management support and trust
Stakeholder management and personnal characteristics	
	Early and continues involvement of end-user
	Openness
	Communication
	Training of end-user

Sammendrag

Oljeserviceindustrien er en sterkt konkurranseutsatt bransje. For å holde seg konkurransedyktige, er oljeserviceselskapene avhengige av å effektivisere operasjoner, som blant annet kan gjøres ved å utvikle og ta i bruk nye og mer effektive produkter og teknologier. Baker Hughes, et amerikansk oljeserviceselskap blant de største i verden, er nå helt i sluttfasen av utviklingen av et nytt boresystem kalt One-Trip System (OTS), som skal testes i operasjonell sammenheng sommeren 2017. Den norske avdelingen av selskapet er den første i Baker Hughes' organisasjon som skal ta i bruk det nye systemet. Basert på erfaring, er implementering av nye produkter en utfordrende prosess i selskapet, og i industrien, og det er derfor ønskelig å øke sannsynligheten for at integreringen av det nye systemet i organisasjonen blir suksessfull.

Det finnes mye litteratur som beskriver betydningen og anvendelsen av kritiske suksessfaktorer (CSF) i prosjekter. Litteratur viser at det finnes noen spesifikke faktorer som, om de følges av prosjektet og dets interessenter, øker sannsynligheten for at prosjektet blir suksessfullt. Noen undersøkelser fokuserer på suksessfaktorer for prosjekter generelt, mens andre ser på spesifikke prosjekttyper, som produktutviklings-, IT- og implementeringsprosjekter.

Denne studien har til hensikt å kartlegge de kritiske suksessfaktorene for integrering av nye verktøy ("tools") og utstyr i oljeservicebedrifter, noe som også kan brukes konkret av Baker Hughes ved implementeringen av OTS i den norske avdelingen.

De kritiske suksessfaktorene kartlegges ved hjelp av en blandet metode hvor funn fra case-prosjekter blir sammenliknet med funn fra relevant litteratur. Case-prosjektene som presenteres og analyseres, har alle likhetstrekk med OTS-prosjektet, da de alle omhandler integrering og implementering av nye produkter.

Basert på funnene fra case-prosjektene, er et sett med foreslåtte kritiske suksessfaktorer for integrering av nye verktøy og utstyr i oljeserviceindustrien presentert. Disse suksessfaktorene sammenliknes og analyseres opp mot funn fra litteraturstudiet. Det viser seg at funnene fra case-prosjektene støttes av litteratur på suksessfaktorer innen prosjekter, prosjektimplementering og endringsledelse, noe som bidrar til å øke validiteten og generaliteten av undersøkelsen. Den endelige listen av anbefalte, kritiske suksessfaktorer er presentert under.

Project management	
	Capable and experienced project manager
	Dedicated and committed project manager
Upper management	
	KPIs support and reward use of new products
	Upper management support and trust
Stakeholder management and personnal characteristics	
	Early and continues involvement of end-user
	Openness
	Communication
	Training of end-user

Table of content

Tables

Figures

Abbreviations

BETA	Baker Hughes Experimental Test Area
BHI	Baker Hughes Incorporated
CSF(s)	Critical Success Factor(s)
LWD	Logging-While-Drilling
MECE	Mutually Exclusive Collectively Exhaustive
MWD	Measurement-While-Drilling
NPT	Non-Productive Time
NTNU	Norwegian University of Science and Technology
OTS	One-Trip System
PDM	Product Development and Management Process
ROI	Return On Investment
RQ	Research Question
R&D	Research and Development
SDL	Steerable Drilling Liner
SOW	Scope Of Work
VP	Vice President

1 Introduction

Introduction of new products and services is a crucial determinant when it comes to an organizations' ability to survive and perform (Damanpour, 1991). By creating and introducing new products and services, an organization is able to meet new demands in a market by adapting to the new environment (Brown and Eisenhardt, 1995). Baker Hughes Incorporated (BHI) is one of the largest oilfield service companies in the world with a market capitalization of $25B as of January 15th 2017 (Bloomberg, 2017). The oilfield service industry is by every means a highly competitive industry, and is therefore bound to develop new technology and products in order to be able to compete on efficiency and effectiveness (Schwartze, 2017). August 22th 2013 BHI applied for patent in the European Patent Register, with the patent application title "Apparatus and Method for Drilling a Wellbore, Setting a Liner and Cementing the Wellbore during a Single Trip" (European Patent Office, 2014).

1.1 Presentation of the research objective

The purpose of this study is to examine previously conducted projects where new tools and equipment have been introduced in an oilfield service company. Based on the information and data from these case-projects, the report aims to determine a set of critical success factors for this type of projects. The research question (RQ) is formulated as follows:

RQ: *What are the critical success factors for integration of new tools and equipment in oilfield service companies?*

A qualitative research approach (through case-projects and analyses of findings with literature) will be used to answer the research question. The combination of these two research methods contributes to the understanding and the credibility of the results. To be able understand and answer the research question, the qualitative method is applied by conducting semi-structured interviews with key stakeholders from previously conducted implementation projects. These stakeholders hold influential positions in the case company and in its main customer company.

The core of the interviews covers the following themes:

- general information about the project and the project outcome
- factors which impacted the project outcome
- lessons learned and experiences gained from the project

1.2 Structure of the study

For case study research, Darke, Shanks and Broadbent (1998), have written a paper, which among other tips, include the one shown below.

"Demonstrate the trail of evidence… ensure that a case study is presented as an interesting and convincing story"

(Darke, Shanks and Broadbent, 1998, p. 286)

To answer the research question, Darke et. al.'s advice has been complied to by utilizing a linear-analytic structure, thus demonstrating the trail of evidence. The linear-analytic structure is a common, standard approach, and the structure consists of a literature review, methodology, empirical findings, conclusions and implications (Yin, 2013). In the literature review, prior research is presented, of which critical success factors and success criteria are the core subjects. The following section concerns methodology. Research design and methods utilized, as well as relevant limitations, throughout the research are presented and explained. The report deviates from the standard structure by including sections of case presentations and descriptions. The five different case projects analyzed are described below. It is in the researcher's belief that an understanding of each project is important, as it enables the reader to see how the empirical findings, presented in the following chapter, impacted each project. The empirical results are presented first in chapter 5, as well as a profound description of how different factors impacted the case-projects' outcome. These descriptions are included to give the reader an opportunity to follow the chain of evidence. In the discussion section, chapter 6, the empirical findings are compared to the established findings from previous literature and research. The final chapter includes the conclusion, where the research question is answered. Implications of the study are also shortly presented in the final chapter, as well as in the "executive summary" contained in the appendix.

Heinecke (2011) argues that "good" research on success factors should both be high rigor and high relevance. Other researchers have focused heavily on either science or practical application. Heinecke concludes that a mixed approach is best suited and will provide the most correct results. Such an approach can be applied by using theory, based on different perspectives, and research based on practical issues and concrete example cases. Table 1 describes the requirements of both high rigor and high relevance. This research is conducted with these research requirements in mind. The high rigor part of the research is covered mainly by the literature review. The findings from the literature review are used to support or disprove the findings from the case-projects. The research aims to achieve high relevance by conducting semi-structured interviews with key personnel who are, or previously have been, in charge of implementation and integration of new tools or equipment.

Table 1 Requirements of "good" success factor research (Heinecke, 2011, p. 58)

"High" rigor	"High" relevance
Application of adequate theories	Research based on practical issues
Theory development based on different perspectives	Translation function of researches
Theoretical grounded, casual relationships	Consideration of the organizational context
Methodological rigor	Representative research sample

2 Literature review

In this chapter, literature related to critical success factors (CSFs) for projects, the implementation phase of projects and change management, are presented. These three fields are of interest, as it is expected that integrating new tools and equipment in an organization entails characteristics within each of these three fields. It is thus important to obtain relevant knowledge about the CSFs within these fields. Another important purpose which this chapter serves, is that literature regarding success criteria is explained. This is relevant for the case-projects, because determination of success for the case-projects is an important part of the analyses. Table 4, 5 and 7 in this section are used to analyze the empirical findings with established literature in the discussion section of the report.

2.1 Project success

When analyzing project success, one can choose to focus on the project success criteria or the critical success factors. In some cases, a combination of the two approaches are utilized (Ika, 2009), as Westerveld (2003) has done when developing a model connecting success criteria and success factors.

2.1.1 Success criteria

"The iron triangle" consisting of cost, quality and time was first presented as success criteria about 50 years ago. Multiple writers agree that these three parameters can be considered as success criteria, but not exclusively (Atkinson, 1999).

De Wit (1988) refers to P. W. G. Morris and G. H. Hough which has created a model for measuring project success. Their model is based on three measures of project success, as presented in Table 2.

Table 2 Three measures of project success (De Wit, 1988, p. 169)

Project functionality
- Financially
- Technically
- Or otherwise
Project management
- Budget
- Schedule
- Technical specification
Contractor's commercial performances
- Short term
- Long term

Might and Fischer (1985) presents six measures of success, divided in groups of technical performance, cost performance and schedule performance, as presented in Table 3.

Table 3 Six measures of success (Might and Fischer, 1985, p. 73)

- Overall – the objective measure of the overall success as perceived by the respondent
- Cost – the measure of the cost over/underrun as a percentage of the initial estimate
- Schedule – the measurement of the schedule over/underrun as a percentage of the initial estimate
- Technical 1 – the subjective assessment of the technical success relative to the initial plan
- Technical 2 – the subjective assessment of the technical success relative to other development projects in the firm
- Technical 3 – the subjective assessment of the technical success measured in terms of the technical problem identification process (i.e., a successful project is one that requires little or no crisis management while meeting cost and schedule goals)

These success criteria originate from the work of Marquis and Straight (1965). According to their research, technical performance was considered superior to the other criteria, as 63 % of the research group chose this criterion as the most important in order to achieve project success. Meeting delivery schedule and target cost was placed second and third, respectively.

Baker, Murphy and Fischer’s (1997) research supports Marquis’ and Straight’s conclusion, but adds that project success cannot be adequately defined as complete according to schedule, keeping the budget and meeting the requirements for technical specifications. A project can best be defined as a success by analyzing the project’s ability to meet technical specifications and defined mission, but it must also be considered successful by the main stakeholders, i.e. the parent organization, the client, the users or clientele and the project team itself.

Regarding organization, the research of Marquis and Straight (1965) indicates that projects where administrative personnel report to a project manager are less likely to experience cost and/or schedule overruns, compared to project where administrative personnel report to a functional manager. At the same time, their research concludes that functional organizations have a higher degree of projects rated as a technical success than project organizations

2.1.2 Critical success factors

Critical success factors (CSFs) have been used since 1961 in relation with strategic planning, project management, implementation processes and also for individual pursuits (Howell, 2009). Initially, CSFs were developed by using a theoretic approach, and were not empirically derived (Pinto and Prescott, 1988). The lack of empirical reasoning and generalized research led to disagreements regarding CSFs (Pinto and Slevin, 1987). Baker, Murphy and Fisher were of the few who conducted an empirical study on success factors. Their research revealed seven general factors (Pinto and Prescott, 1988).

During the earliest research on CSFs, the researchers classified CSFs and analyzed CSFs from different perspectives, e.g. by project type, by industry (De Wit, 1988) and by project management success (not project success) (Might and Fischer, 1985). Van der Panne, Van Beers and Kleinknecht (2003) have reviewed 43 papers on success factors of innovative projects. Based on the literature reviewed, they were able to classify factors which impacted the degree of success for new products in four groups:

1. Firm-related factors;
2. Project-related factors;
3. Product-related factors; and
4. Market-related factors.

Their research indicates that firm and project related factors have significant impact on technology viability, while product and market related factors will greatly impact the commercial viability. Further, they conducted a quantitative assessment of the literature. In order to be able to conduct a quantitative assessment of the literature, the list of papers was reduced from 43 to 9, based on criteria related to the paper's reliability. This quantitative assessment did not result in any clear and strong correlation between the factors from the 9 papers included, but a qualitative assessment was also conducted. Based on the qualitative review, the researchers were able to determine 7 factors that the 9 papers agreed upon:

1. A firm's culture that is dedicated to innovation and explicitly recognizes the collective nature of innovation efforts;
2. A firm's prior experience with innovation projects (learning-by-doing; learning-by-failing);
3. The multidisciplinary character of the R&D team; in particular, a balance between technological and marketing skills, and the presence of a product champion;
4. A clearly articulated innovation strategy and a management style suited to that;
5. Compatibility of the project with the firm's core competencies;
6. An innovation's product quality and price relative to those of established products;
7. A good timing of market introduction.

Cooke-Davies (2002) argues that one must answer three separate questions in order to determine CSFs of project success:

1. What factors are critical to project management success?
2. What factors are critical to success on an individual project?
3. What factors lead to consistently successful projects?

This approach is also supported by De Wit (1988).

Since the beginning of success factor research, different success factors have been determined. The research has been based on different type of projects and industries. The type of projects analyzed in this report, integration of new tools and equipment, involves implementation and change management. These fields have been analyzed by different researchers, and some researchers have also combined multiple studies on each field, in order to determine the most important success factors for each field. Since the integration of new tools and equipment is a combination of different fields, it is of interest to analyze which of these success factors that are considered valid and important for this particular type of project.

A project can be defined as *"…a temporary endeavor undertaken to create a unique product, service, or result. The temporary nature of projects indicates that a project has a definite beginning and end."* ("Project Management Institute", 2012, p. 3). One can thus confirm that developing and implementing new tools or equipment is a part of a project, as all of the characteristics within the definition are fulfilled. CSFs for projects in general is a widely researched topic. These factors tend to be less specific than CSF for more specific types of projects or project phases, as they should be applicable for all projects and project phases. As these factors are general, they should also be valid for projects with the aim of implementing new tools or equipment in an oil service company, and will therefore be examined in this research.

Table 4 is created based on the research by Westerveld (2003). Westerveld analyzed work by Morris and Hough (1987), Munns and Bjeirmi (1996), Belassi and Tukel (1996) and Pinto and Slevin (1988).

Table 4 Critical success factors for projects (Westerveld, 2003)

Leadership and team
Policy and strategy
Stakeholder management
Resources
Contracting
Project management
Success criteria
External factors

"Implementation" is one of six phases in a project, according to Hobbs (2009). The implementation phase evolves around "*Passing what you have created over to those who will be using it, and helping them to adjust to any changes*" (Hobbs, 2009, p. 9). Since the aim of this thesis is to determine CSFs for integration of new tools and equipment in an oilfield service company, it is natural to look at CSFs for the implementation phase of projects, as there are a lot of similar characteristics, per the definition of the implementation phase by Hobbs.

These factors will still be general for different types of projects and industries, but they are exclusive for the implementation phase of projects. One can thus affirm that this is a more specific list of CSFs than the list for "projects" as presented in Table 4. Pinto and Slevin (1987) analyzed five different published papers on success factors for project implementation. Based on their research, they were able to determine nine critical success factors as shown in Table 5.

Table 5 Critical success factors for project implementation (Pinto and Slevin, 1987)

Clearly defined goals
Competent project manager
Top management support
Competent project team members
Sufficient resource allocation
Adequate communication channels
Control mechanisms
Feedback capabilities
Responsiveness to clients

2.2 CSFs associated with change management

Change management can be defined as

> *"...managing the process of implementing major changes in information technology, business processes, organizational structures and job assignments to reduce the risks and costs of change and optimize benefits."* (Murthy, 2007, p. 22)

Integration of new tools and equipment involves change management, because it will require new job assignments as well as a change and addition of some business processes (Schwartze, 2017). Shown below is a table created by Murthy (2007) which describes different dimensions of change management.

Table 6 Dimensions of change management (Murthy, 2007, p. 23)

Impact on business		Technology	Processes	People
High	Strategic	- Enterprise architecture - Supplier partnership - Systems integrators - Outsourcing	- Ownership - Design - Enterprise wide processes - Internet enterprise processes	- Change leaders - Loose/tight controls - Executive sponsorship and support - Aligning conditions on satisfactions
Low	Operational	- Technology selection - Technology support - Installation requirements	- Change control - Implementation - Management support processes	- Recruitment - Retention - Training - Knowledge transfer
		Low	Level of Difficulty / Time to Resolve	High

Based on the definition by Murthy and the findings from recently conducted research on the OTS project-case, these types and phases of the projects include all three categories of change management: Technology, processes and people (Ystenæs, 2016). The OTS case-project also includes both strategic and operational elements. With Table 6 as a base, the elements included in the OTS case-project will range from low impact to high impact on the business, as well as the level of difficulty will range from low to high.

Because integrating new tools and equipment in an oilfield service company involves, as discussed, the same characteristics as the implementation phase of a project, one can also argue that integrating new tools and equipment must include some level of change management, per the definition by Hobbs presented previously: "*…and* ***helping them to adjust to any changes***".

Success and failure of change initiatives and projects is a widely discussed theme (Creasey and Hiatt, 2008), (Paterson, 2014), (Creasey*, et al.*, 2014), (Levasseur, 2010), (Ball, 2000). For the purpose of this thesis, the CSFs determined by Creasey*, et al.* (2014) will be used. The CSFs found by Creasy and his team at Prosci are also considered valid by other publications and researchers. These CSFs are presented in Table 7.

Table 7 Critical success factors for change management (Creasy, et al., 2014)

Active and visible executive sponsorship
Structured management approach
Dedicated change management resources and funding
Frequent and open communication about change and need for change
Employee engagement participation
Engagement and integration with project management
Engagement with and support from middle management

All projects will require some level of change management. The requirement for structured change management approaches and dedicated change managers is dependent on the level of complexity in the project. For traditional projects with few stakeholders, it is possible to make decisions fast as it is easy to achieve stakeholder agreement. For larger and more complex projects however, it may be difficult to get stakeholder approval and agreement, which in result slows down the decision-making process (Kerzner and Belack, 2010).

Change might emerge from a strategic or operational incentive (Murthy, 2007), or it can come as a result of another project (Kerzner and Belack, 2010). Even though change may be a necessity or a direct result of a project, it is not guaranteed that all stakeholders support the change. For some of the stakeholders, a change can result in loss of authority or power, lower status or also loss of employment in the most extreme cases. In other words, it is not given that all stakeholders, even key stakeholders, want the project to succeed, even though they might express so verbally. In order to prevent key stakeholders to resist the change, the project manager should conduct a thorough stakeholder analysis in order to identify the stakeholders who are most likely to resist (Kerzner and Belack, 2010). The importance of the stakeholder analysis for integration of new tools and equipment is also discussed by the researcher in a previous context (Ystenæs, 2016).

Change management also evolves around the nature and instincts of humans. Humans are naturally wary of change, and a change can impact humans in a variety of ways, resulting in reactions such as denial, anger, sadness and more. Change management is an important tool in order to reduce these reactions (Kerzner and Belack, 2010). These human reactions are also the reason why change projects can be considered as the most complex type of projects (Kerzner, 2013).

The project-cases analyzed in this report are not considered as change projects, as the change itself is not the main objective for the projects. The understanding of change management and change in general is even though important, as the new product integrations also caus changes for some of the stakeholders.

3 Methodology

This chapter aims to describe the chosen methodology which has been applied in order to answer the research question. The first section in this chapter describes the research design of the report, and the second section explains the different research methods which are applied. In the last section of this chapter, the limitations of the research design and methods are disclosed, and the actions initiated by the author to reduce the limitations and uncertainties are described.

3.1 Research design

Research design should assist the researcher in the process of answering the research question, by using an orderly approach regarding data collection and analysis. According to McGaghie*, et al.* (2001), research design has three main purposes:

> *"(1) to provide answers to research questions, and (2) to provide a road map for conducting a study using a planned and deliberate approach that (3) controls or explains quantitative variation or organizes qualitative observations."* (McGaghie, *et al*, 2001, p. 929)

According to Bryman and Bell (2015) there are six main research designs: experimental, cross-sectional, longitudinal, case study, comparative and mixed-method design. Based on the nature of success factors, research within the field should be both high rigor and high relevance (Heinecke, 2011). In order to answer the research question sufficiently and with as deep understanding as possible, multiple sources of data and evidence are used to triangulate the results, thus leading to improved validity of the research (Yin, 2013). Because of the relatively small sample size, i.e. number of informants, results that are only supported by one informant are still included in the findings. Triangulation is thus used in the sense of strengthening the significance of the most broadly supported findings.

3.1.1 Choice of research design

The case study design is a popular qualitative approach, where the researcher carefully observes a social unit. The social unit can be a person, an institution, a community, and so on (Kothari, 2004). Yin (2013) argues that a case study design is best suited for open research questions, often formulated as *how* or *why*, where the investigator has little control. In order to answer the research question raised in this report, the case study design is applied. The cases in this study are represented by 5 projects, referred to as case-projects. The research design is facilitated by interviews with employees, managers and directors in both Baker Hughes and Statoil, used to gain information about each of the case-projects. The information from the interviews is analyzed in order to propose a list of CSFs for integration of tools and equipment, and these results are later compared with findings from the literature review. The combination of methods applied in the research design, in this case the case study-method and the interview-method, allows for more convincing evidence than any method can provide alone (Bryman and Bell, 2015). The case study design was chosen based on the open characteristics of the research question as well as the purpose of this study.

Since each manager interviewed answered based on his experience from different projects, this can be characterized as a multiple case study with 5 cases providing vital information to the research. With multiple cases it is possible to apply a replication approach, where triangulation can be used to confirm the conclusion for each case (Yin, 2013).

The choice of doing 5 project cases was mainly based on practical constraints. Interviewing is a time-consuming method, compared to e.g. survey, both for the researcher and the interview objectives. The work of analyzing each interview is also demanding, and should be considered important for the research. Based on these constraints, it was decided that 5 was a sufficient number of cases. The limitations caused by these constraints are addressed in section 3.3 "Limitations of design and counter measures".

Figure 1 is a graphical illustration of the research design methods applied, in order to answer the research question. In the following sections, the choice and characteristics of the research methods are elaborated.

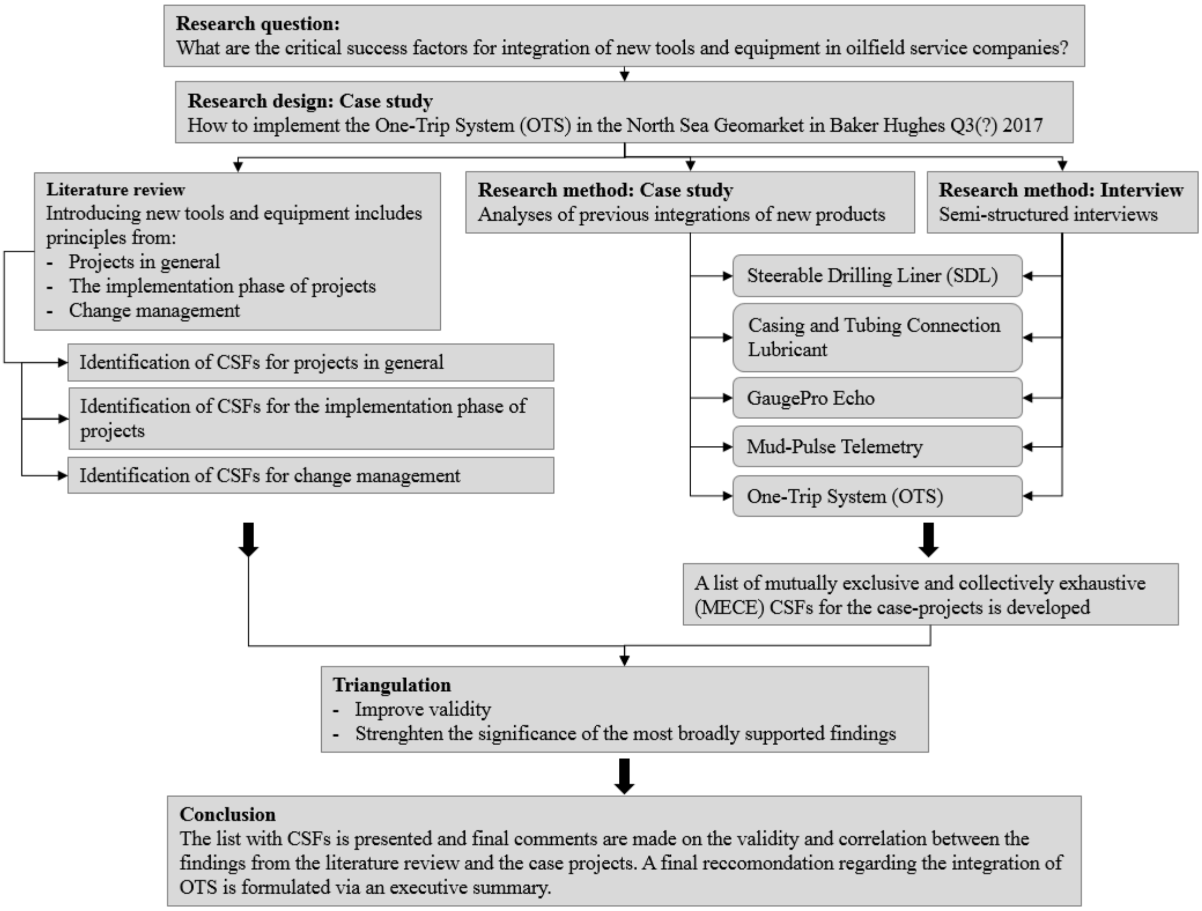


Figure 1 Illustration of research design and methods applied

3.2 Research methods

The term *research methods* includes all methods, or techniques, applied when conducting research (Kothari, 2004). According to Kothari, research methods can be placed in three different groups:

1. *"In the first group we include those methods which are concerned with the collection of data. These methods will be used where the data already available are not sufficient to arrive at the required solution;*
2. *The second group consists of those statistical techniques which are used for establishing relationships between the data and the unknowns;*
3. *The third group consists of those methods which are used to evaluate the accuracy of the results obtained."* (Kothari, 2004, p. 8)

For the first group, methods of collecting data, Kothari presents several different methods including interview method, survey and schedule method, case study method and some other less common methods for data collection. For the second and third group, different statistical methods can be applied. These methods include different versions of chi-square tests and analysis of variance.

The chosen methodology in this research is a mixed approach, which implies that multiple methods and techniques are applied during the research. The main methods applied are case study and interview. These methods are elaborated on in the following subsections.

3.2.1 Case study method

In order to answer the research question of how to integrate new tools and equipment in an oilfield service company, the case study method was applied to collect relevant data. The case study method is a qualitative analysis, where the researcher, through observations, focuses on every aspect of an individual, a group or an institution (Kothari, 2004). The main case in this research is the integration of OTS in the Norwegian department of Baker Hughes. The OTS is complex, and will impact, and be impacted by, multiple departments of Baker Hughes (Schwartze, 2017). In addition to this "main case", four additional case projects were analyzed in order to increase the generality and the validity of the research.

The process of conducting a case study can be divided in five major phases, according to Kothari (2004, p. 114):

1. *"Recognition and determination of the status of the phenomenon to be investigated or the unit of attention.*
2. *Collection of data, examination and history of the given phenomenon.*
3. *Diagnosis and identification of causal factors as a basis for remedial or developmental treatment.*
4. *Application of remedial measures i.e., treatment and therapy (this phase is often characterized as case work).*
5. *Follow-up programme to determine effectiveness of the treatment applied."*

The research conducted in this report includes the first three phases listed above. The time aspect did not allow the researcher to apply the measures found valid, nor was there sufficient time for follow-up to determine the effectiveness of these measures.

The first step, the status of the phenomenon to be investigated, was given from the very start of the research. The research was initiated because Baker Hughes saw the challenges with integration of new tools and equipment, and the company is going to introduce the completely new product OTS during the summer of 2017.

For the second phase of the case study method, the interview method was applied. This method is described in the following subsection. For step three, the information gathered through literature review and the interviews, was analyzed and compared with each other, in order to define the casual factors and the final result.

3.2.2 Interview method

Like survey is a popular method for quantitative analysis, interviews are popular for qualitative analysis. Interviews may be used to collect data in both quantitative and qualitative research approaches. Interviews for quantitative research are designed and conducted in such a manner so that the responds have a high reliability and validity regarding measurements of one or multiple key concepts. Interviews applied in qualitative research, like in this report, are designed in a more generalized matter so that the interviewee's perspective is in focus. Another characteristic of the qualitative interview is that rich, detailed and explanatory responses are desirable, as with quantitative interviews, more concise answers are desirable (Bryman and Bell, 2015).

Furthermore, interviews as a research method can be conducted in different manners: structured, semi-structured and in-depth interviews (Bryman and Bell, 2015). For this research, the semi-structured approach was used. Semi-structured interviews consist of a list of topics that shall be addressed during the interview, and these topics are usually written as questions, commonly referred to as an interview guide. The interviewer will often improvise responses and follow-up questions, depending on the response from the interviewee. Questions that are not in the interview guide may be asked if the interviewer discovers topics of interest which are relevant to pursue, and some questions from the interview guide may be left out. This freedom facilitates natural and freely formulated answers (Bryman and Bell, 2015). These characteristics were the main reason for the choice of the semi-structured interview method. It was desirable to let the interviewees answer freely as each interview covered different project-cases. At the same time the cases had to be comparable and they should thus have a similar structure.

An interview guide was created before the interviews, in order to help the researcher cover all relevant topics in an appropriate order. This guide was also sent to the interviewees some time before the interview so that they got the time to think over the topics to be discussed. The same interview guide was used for all of the interviews in order to increase the comparability of the cases (Bryman and Bell, 2015).

For qualitative interviews, a detailed analysis of the interview is required. To capture all important information during the interviews, voice recording was used[1]. One may argue that a recorder will make the interview more formal, and thus limit the interviewee ability to answer freely. But according to Bryman and Bell (2015), voice-recording is almost a must for qualitative interviews. In addition to capturing all information, the interviewer is able to listen more carefully, keep eye contact and think out relevant and important follow-up questions, instead of being occupied taking notes. The application of voice recording will have a positive chain reaction, as illustrated in Figure 2.

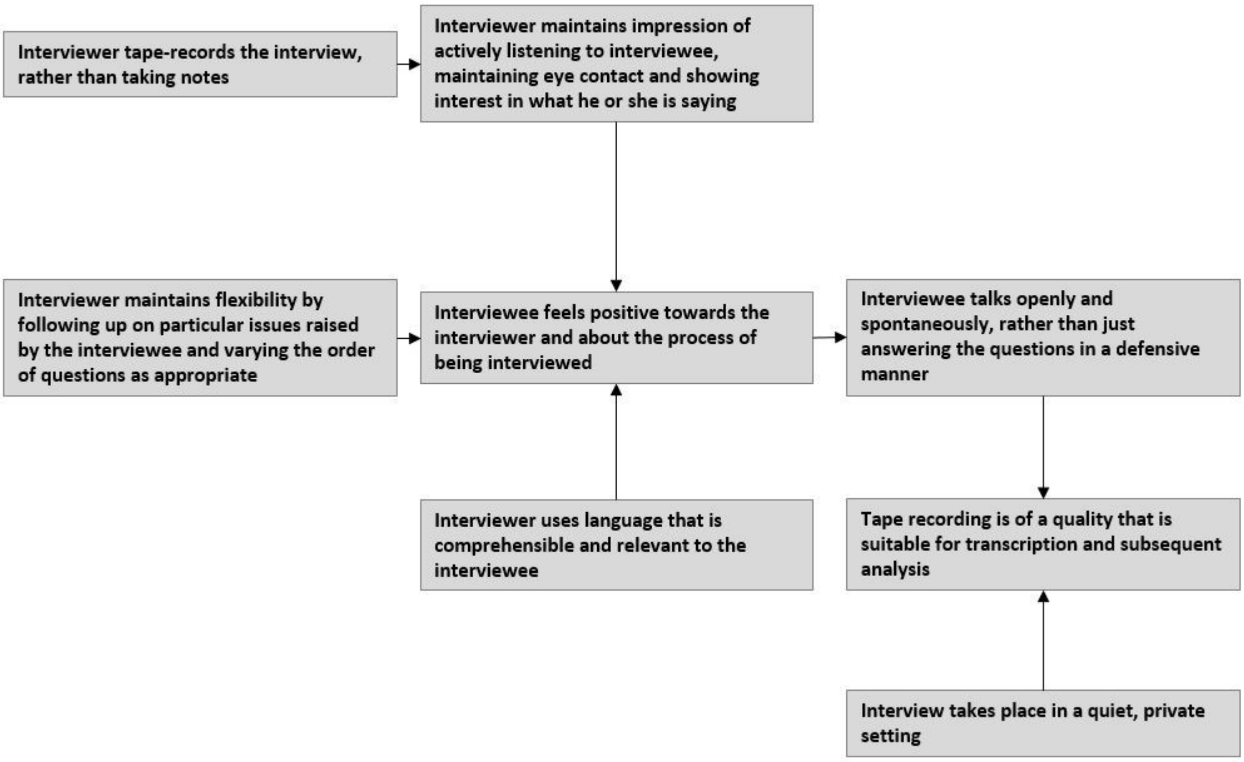


Figure 2 Consequences of recording interviews (Bryman and Bell, 2015, p. 416)

Five interviews were conducted in total. Each interview represents a case-project, and is presented in chapter 4.1. There was one informant per project. The results from the interviews are presented in chapter 5. The interviews lasted approximately one hour each. A list of the informants/interviewees is presented in Table 8, together with their title and experience.

[1] Voice recordings were used in four out of the five interviews. One of the interviewees preferred not to be recorded, which the researcher naturally respected. In the one interview where voice recording was not applied, the interviewer took notes throughout the interview.

Table 8 Interviewee information and background

Informant	Informant 1	Informant 2	Informant 3	Informant 4	Informant 5
Company	Statoil Forskningssenter	Statoil Forskningssenter	Baker Hughes Norge AS	Baker Hughes Inteq GmbH	Baker Hughes Norge AS
Company location	Rotvoll, Trondheim, Norway	Rotvoll, Trondheim, Norway	Tananger, Sola, Norway	Celle, Lower Saxony, Germany	Tananger, Sola, Norway
Project-case	SureTrak Steerable Drilling Liner (SDL)	Casing and tubing lubricant	GaugePro Echo Underreamer	Mud-Pulse Telemetry	One-Trip System (OTS)
Title of interviewee	Principle Researcher	Researcher	Manager – Hole Enlargement (Casing/Liner Drilling Systems)	Director, Product Development (Drilling Systems)	Technical Advisor (Drilling systems)
Experience of interviewee	12 years of experience from Statoil 3 years' experience as field engineer abroad in another company	25 years of experience from Statoil 10 years' experience in operations, remaining years spent in research and development	12 years of experience from Baker Hughes Worked in Celle prior to joining the Norwegian office	25 years of experience in Baker Hughes	6 years of experience in Baker Hughes Worked in Celle prior to joining the Norwegian office
Interview date	27.03.2017	27.03.2017	31.03.2017	24.04.2017	31.03.2017
Location of interview	At the company's office	At the company's office	At the company's office	Video call from Baker Hughes Norge AS' office	At the company's office

3.3 Limitations of design and counter measures

In this section the limitations of the research design and the applied techniques are discussed. In subsection 3.3.3 the measures taken to reduce the limitations, are summarized. The actions taken in order to reduce the limitations are presented according to the three tests Yin (2013) presents: construct validity, external and internal validity and reliability. These tests are all frequently and commonly used to judge and measure the quality of a research design.

3.3.1 Limitations related to the research design

When only a few project-cases are analyzed in a case study, one will limit the capability to draw generalized conclusions which are valid for a larger number of different project cases. Another natural risk when working with a small amount of cases, is that some input is misunderstood and information which is easily available is presented as more important than it in fact may be (Voss, Tsikriktsis and Frohlich, 2002). A concrete counter action which was initiated was to interview people in different positions, different departments and in different locations in the case-company (Baker Hughes). Additionally, people from case-company's main customer and partner in the OTS-project were interviewed (Statoil). A further counter-measure would be to interview even more people, preferably also from several different companies, to increase the size of the sample population and create a more holistic picture. Practical constrains prevented the researcher from initiating this counter-measure, as discussed in the next sub-section.

According to Yin (2013), the quality of research is mainly determined by its transparency and, most importantly, its replicability. A case study protocol describes the general strategy applied to collect information, as well as a standardized procedure for data collection (Yin, 2013). A case study protocol, which can be found in Appendix A, was developed to increase the convenience of replicating this study. Another measure taken by the researcher, is that chain of evidence is applied. The principle of chain of evidence is that the information throughout the report is presented in such a way that it enables and helps the reader to follow the evidences, leading from the research question and all the way to the final conclusions (Yin, 2013). Especially focus was paid to chain of evidence in the empirical findings chapter of the report, where the reasoning behind each CSF is elaborated on, in addition to direct quotes from the interviewees.

Another factor impacting the quality of the research thesis, is whether a set of operational measures are defined. If such measures are not determined, it is likely that data are collected based on subjective judgements (Yin, 2013). The researcher's counter measure is to compare collected data and findings with literature within the same field. The chain of evidence-principle allows the reader to decide whether they agree with the conclusions or not. Because multiple project cases are analyzed, there will also be some findings that are more heavily supported than other. All relevant findings are though included, based on the qualitative approach and the small amount of data.

3.3.2 Limitations related to practicalities

Limitations related to practicalities in this research are mostly concerning resources, in the sense of available time and personnel from the case company. At the same time as the research is conducted, the case company is going through an organizational restructuring, caused by an upcoming merger with another major company. The researcher's contact person in the case company was available throughout the research process, but it turned out to be challenging to find informants to be interviewed, who had desirable project experience relevant for the study. Since the engineering department, and thus project managers, in the case company are based in Germany, it was difficult to get in touch with these people. It would benefit the study to have input from more of these people, but the resources were not sufficient to achieve this. However, one person from this location was interviewed and provided important information.

The researcher's contact person in the case company attempted to get a confidentiality agreement from the company, but because of heavy workload and the restructuring of the company, the confidentiality agreement was never provided. In four out of five interviews, a recorder was used to ensure no relevant information is missed out and to eliminate note taking, which is time consuming and may be disruptive. However, one of the interviewees preferred that the researcher took notes and did not record the interview, which was a result of the lack of confidentiality agreement. When a recorder is not used, the risk of misinterpretations and loss of information increases, because the notes taken during the interview are not satisfactory. This risk was though reduced significantly, as the text included in the report was sent to the informant for review.

All the informants who have contributed to the research, are educated engineers, and are thus interested in the technological aspects of each project. During the interviews, some time was spent to shift the focus away from technical solutions, and over to organizational factors, strategies, project processes and so on.

3.3.3 Actions taken to reduce the limitations

Counter-measures were taken to reduce the limitations, as described throughout the previous sections. Table 9 describes how the measures taken throughout the research process have impacted the quality of the research, as previously defined after Yin's three tests: construct validity, external and internal validity and reliability.

Table 9 Counter measures' effect on the quality of the research

Reliability	Construct validity	Internal/external validity
Development and application of case study protocol, including the interview guide	Application of the chain of evidence-theory	Comparison of case findings with established theory within the field
	Informants from different companies, different departments and with different experience	

4 Case presentations

This chapter contains descriptions of the five case-projects analyzed in this report. The purpose of this chapter is to inform the reader about the background for each of the projects, as well as to create an understanding for the purpose of each project, who the key stakeholders were and how the project turned out. It is in the researcher's belief that an understanding of the general characteristics for the case-projects increases the takeaway from the results and the conclusions of this report. The case presentations contain some industry-specific terms and glossary, which are attempted explained throughout the presentations. If the reader seeks more in-depth descriptions in order to fully understand the case-projects, this can be found in Appendix B.

4.1 Introduction to the cases

In this section of the report, five project cases are presented. One informant is interviewed about each project, and these interviews are thus the main source of information used to describe the projects. All five projects are conducted by either Baker Hughes or Statoil, or both as a joint project. Three of the projects are described from Baker Hughes' perspective, and the remaining two project-cases are described from Statoil's perspective. One of the projects described from Baker Hughes' perspective, is the OTS project. This project is not yet finished. The findings from this report should further support the implementation of the OTS itself.

It was chosen to interview people from Statoil because of their tight collaboration on the OTS-project with Baker Hughes. Another, and more general, argument to get input from both perspectives is that the majority of projects conducted by Baker Hughes, and also other oilfield service companies, are in done collaboration with their customers. The complexity, budgets and timelines of the project-cases presented vary a lot. Common for these projects, is that they all evolve around a new product that was developed and implemented in the organization (except the OTS which will be implemented at the end of 2017). All products developed in these projects are in use today.

The interviewees, or informants, are people who were project managers or had other heavily involved positions in the projects they described. Because the informants were heavily involved in the projects, they all provided thoughtful descriptions and information regarding the projects.

The case projects are presented, to provide important and relevant information about each project. The success factors, detected by the interviewer and the interviewee, are presented in chapter 5, in addition to the reasoning and justification of each CSF.

4.1.1 Case 1: Steerable drilling liner

In conventional drilling, a set of processes needs to happen in a defined sequence. These processes include, among others, drilling and inserting casing and tubing (which is steel pipes that supports the wellbore walls). The traditional approach is to drill the hole, pull out the equipment, and then insert the tubing and casing. A common risk in these types of operations, is that the hole collapses before the tubing and casing is inserted, which naturally leads to delays in the operation because the hole needs to be drilled again.

During operations in 2004, the operational department in Statoil saw the need and the possibilities of combining multiple processes, reducing the risk of hole collapse and increasing efficiency at the same time. The concept evolved around combining traditional drilling processes using new technology. More precisely, the goal was to develop a product that could drill and insert tubing and casing in one single run. The new product was named “Steerable drilling liner” (SDL) by Statoil, and later “SureTrak” by Baker Hughes.

When Statoil needs a new product, they usually develop a set of technical requirements which they use in a tendering process with possible partners. These technical requirements were defined in 2005, and the tendering process was initiated when all the requirements were defined. In the beginning of 2006, Statoil chose Baker Hughes as the provider, and developer, of the new product. The contracting was then conducted, and the project was officially initiated. The project had a duration of about three years, and the new product was finished in 2009. The following period was a first-use phase for Statoil. The first-use phase is a phase which all new products go through when they are first launched. This phase was finished by the end of 2010 and the product was now officially commercial. The project had a budget of approximately 40 MNOK.

The involved parties of this project were mainly Baker Hughes and Statoil. Internally in the companies, different departments and managers were involved at different stages during the project. It was the Research and Development department, located at Rotvoll, which was in charge from Statoil’s side. From Baker Hughes’ side, multiple departments were involved. Statoil also engaged their operational departments a lot. The operational departments are in this case also the end-consumer, so it was considered crucial that they were informed and provided their opinions. The project was led by the informant, which has approximately 15 years of experience from the oil and gas industry. He worked for Schlumberger as field engineer, placed in Azerbaijan, for three years. He then joined Statoil as a researcher, and currently holds the position as principle researcher.

The SDL project had both commercial and technical success criteria. Before the tendering process began, a document with scope-of-work (SOW) was created. This document contained all technical requirements for the new product, so that the bidders could calculate how much the development would cost them. The technical requirements are thus not negotiated on; it is simply up to the bidders to deliver on these requirements set from Statoil. When the bidders make offers to Statoil, they are evaluated on their capability to deliver on the technical requirements, as well as the estimated cost. Sometimes the bidders also add in important factors and criteria which Statoil has not thought of themselves. Statoil also operates with commercial success criteria, where cost is the most important criterion. If the equipment is too expensive to use, it does not matter how good the technology is. Delivery time was also set as a requirement. For more expensive technology, it is not granted that Baker Hughes, in this case, has the equipment in their hands at all time. Therefore, Statoil had a criterion describing how long time it should take from Statoil orders a job, and until Baker Hughes is ready to go with all equipment in place.

According to the informant, there were not too many issues during the project. During testing, some minor adjustments and fixes were done, but the informant will not characterize this as issues. The informant says that the way it was communicated, both internally and with Baker Hughes, made sure that major issues and challenges were avoided.

The project turned out to be a success, all criteria considered; schedule, cost, delivery and technical. It was also a broad acceptance and approval for the project outcome, every major stakeholder agreed that the project was a success. Even though it took a while for the product to pass the firs-phase use, the informant would not describe this as a technological issue. The solution to these issues was to adjust settings for pressure and other things, which is totally normal and should be expected for these types of projects. The project did not experience any soft problems either. The informant mentions that back in 2005, the funding and budgeting did not have the same focus as today. But because of well-established communication channels, he does not think that the project would struggle with soft, or organizational, issues if it were to be carried out today with a tighter budget.

4.1.2 Case 2: Casing and tubing connection lubricant

Tubing and casing are major parts of drilling operations, as briefly described in the previous project-case. The tubing and casing pipes are usually 12 meters long, and are connected with a threaded connection. For deep wells, a great number of these pipes must come together, preferably as efficient as possible. To ease the job of connecting the pipes, a chemical product called “dope”, similar to thread grease, is applied to the threaded area of the pipes to reduce the friction between the pipes while connecting them.

The interviewee for this project case started his career in Statoil as a researcher, before he went into the operational department where he worked with drilling. While he was out on the platforms, he noticed that the operators had to re-apply dope to the pipes, because the friction was too high when they first tried to assemble the pipes. The informant thought that it had to be another chemical solution that would be more reliable than the one currently in use. He talked with the discipline leader, who supported the proposal. With the discipline leader’s support, a project with the aim of developing a new and more reliable dope was initiated in 2010. The informant himself was in charge of the project, and started working as a researcher again.

The project, officially named “Casing and tubing connection lubricant”, had a relatively low budget of 2 million NOK. The dope was developed by Statoil in cooperation with a supplier, which had been supplying Statoil with the dope they had been using for years. According to the interviewee, the supplier most likely spent more than Statoil on the project, as the supplier probably wanted to continue the cooperation with Statoil, and saw the long-term return on investment (ROI).

There were few people involved in the project from Statoil’s side, hence the affordable budget. The informant functioned as main researcher and project manager, and the discipline leader was also actively involved. Throughout the project’s 6 years’ duration, three restructures of the organization in Statoil took place. As a consequence, different people oversaw the project from the upper management, and different people were involved from the HSE department. The supplier was also heavily involved, and there was constant communication between Statoil and the supplier.

As the dope is a chemical, there are strict environmental requirements for this kind of product. The project requirements related to environmental aspects were the dominant requirements; if the new chemical did not get approved by Statoil’s HSE department, the product could not be used. Another major requirement was that the new dope should result in fewer incidents where the operators must re-apply dope to the threads, as this is time consuming. The dope Statoil was using did not work very well in cold and harsh conditions, so it was also set as a requirement that the new dope should work efficiently in all temperatures.

The dope was to be applied onshore. Since the pipes usually lie on the platform for multiple days before they are used, they are exposed to saltwater, which may wash off the dope, which in return is resulting in additional work for the operators as they need to re-apply dope. Therefore, another requirement for the new dope, was that it had to withstand the strain of being exposed to harsh conditions and saltwater. The supplier conducted tests of the new dope at their facilities, and reported the results to Statoil. Some of the tests, one regarding the dope's impact on minor organisms living in the sea, had to be tried several times before the HSE department at Statoil approved the new product.

One of the main challenges with this project occurred when the development process was finished. As mentioned, the new dope needed approval from the internal HSE department in Statoil before the product could be commercialized. The communication between the project team and the HSE department had not been sufficient, and the HSE department did not share the project team's view on the new dope. If the project team and the HSE department had not come to an agreement and common understanding, the whole project could have been stopped right before implementation. The project team also had some challenges with achieving the environmental requirements, but they found a solution to this challenge before it impacted the project in any significant degree.

After launch the new dope proved to be better than the previous one, and it is now the standard on every rig Statoil operates. The statistics indicates that the number of pipes which needs to be greased several times to be connected to each other, is lower with the new product. Every involved party of the project agreed on the project success, including the operators in Statoil and the supplier.

4.1.3 Case 3: GaugePro Echo - Underreamer

In some drilling operations, especially offshore operations, it is desirable to increase the diameter of the wellbore in some sections. To be able to do so, a tool called "underreamer" is used. Common purposes of enlarging the wellbore in some sections are, among other things, to place the casing correctly, to use a larger casing size than the originally drilled hole or to allow the operator to use a larger drilling liner. For many years, the underreamer remained the same. The reamer blades, which expand out from the tool when the underreamer is activated, are traditionally activated with a so-called “ball-drop method”. This is a mechanical activation of the reamer blades, and there is thus a risk of mechanic failure involved in this process.

In 2006, Baker Hughes started the development of a new underreamer, with the commercial name GaugePro Echo. The project was initiated after a need from Statoil while they operated a rig at the Grane-field. When the project started in 2006, the new underreamer was developed and engineered only for a single hole size. Between 2006 and 2012 there were only four tools, all for the same hole size, available. The new underreamer turned out to be a success, and in 2012 the development for additional hole sizes was initiated. The hole sizes 8”, 12” and 14” were developed specifically for Statoil, and two additional sized tools, 16” and 18”, were solely developed by Baker Hughes.

This project was a normal project for Baker Hughes, in the sense that the need came from an operator. The usual process for product development projects in Baker Hughes is that an operator initiates a tendering process, and the interested companies who believe they have the capability to deliver the product, make an offer to the operator. After the developer is chosen, the project is initiated. The most important criterion of success for Baker Hughes in these types of projects is thus delivering a product which meets the set of technical requirements agreed upon in the contract developed after the tendering process. Besides this technical-based requirement, return on investment (ROI) is the single most important criterion for Baker Hughes. The management in Baker Hughes will have their expectations to these types of projects, and operates with goals for both revenue and margins for new products. Non-productive time (NPT) and percentage of successful jobs were also two important success criteria in this project.

When asked if there were any issues or challenges with GaugePro Echo project, the informant says that there are always issues and challenges with these types of projects. One of the challenges was to price the new product. It is the local office’s responsibility to set a price for the new product. One of the cost drivers of these types of products is service and maintenance, which is done between the jobs. Before the tool has been running for a while, it is difficult to predict how much time the maintenance and service work will require. Another side of the same issue, is that it is difficult to predict which parts that will wear out the fastest, and thus be replaced. Production, and storage, of spare parts are also a cost driver. On the organizational side, the biggest local issue in this project was related to training of the local stakeholders. Employees in departments such as logistics are not involved in these types of projects, so they need to be trained and educated regarding the new product. On the global side, it is also a brand new team that has responsibility for the product. The phase where the product goes from development and into commercial use is usually a challenging phase. In the GaugePro Echo-project, training of local stakeholders was done by the informant. The issues regarding spare parts organizing were also handled by the informant, together with a person who was brought in from Baker Hughes' Houston office to assist the informant.

When the product first was commercial, it took time to get it running as it should. After two years of adjustments and minor changes, they achieved a smooth and established process. Even though the product still needs “babysitting”, as the informant describes it, it is one of the best performing single-tools on the drilling side, both regarding revenue and reliability, e.g. a low NPT. As mentioned, the success with the tool developed specifically for Statoil led Baker Hughes to develop other sizes of the tool. The operators, i.e. Statoil, do not give Baker Hughes data on how their products are performing compared to Baker Hughes’ competitors, but the GaugePro Echo is often chosen, so it is clear that the operators are happy with the product.

4.1.4 Case 4: Mud-pulse telemetry

Real-time information and data is an important factor for drilling operation success. The capability of gathering this sort of data in real-time is found in applications such as measurement-while-drilling (MWD) and logging-while-drilling (LWD). Over the years, the technology and complexity of drilling operations have developed a lot, which in return has increased the requirement for real-time transmission bandwidth. Some examples of data which are desirable to have access to while drilling are temperature, annular pressure and drilling dynamics. In order to transfer data from the sensors, the MWD and LWD tools, pressure pulses in the mud system are used. The pressure pulses are sent in Morse-codes and transcribed by computers, so numbers and graphs are presented for the operator.

Baker Hughes was one of the first companies that developed mud-pulse telemetry, which was a competitive advantage for the company. After a while, one of the largest competitors surpassed Baker Hughes data transmission rate. At the time, Baker Hughes’s mud-pulse system delivered around 1 bit per second, while the competitor was able to transfer 3 bits per second. As the technology evolved, more input was desirable, thus the demand for higher data transmission rates increased.

Unlike the vast majority of projects in Baker Hughes, the project of developing a new mud-pulse system was not initiated after a tender process. This project was solely initiated by the technology department. They wanted to push the boundary for data transmission rates, which would be a great competitive advantage if they succeeded. The vice president (VP) of

technology in Baker Hughes was the person who officially initiated the project. The project had a budget of several million dollars.
The project started out with two people who conducted a feasibility study. Later on in the project, several more people were involved, mostly from engineering. When the technology was commercialized, employees from all relevant departments were involved, also support functions such as document control and logistics. The project followed a standardized process for product development projects in the organization of Baker Hughes, named "product development and management process" (PDM). This process was implemented not long before the mud-pulse telemetry project was conducted. This established and standardized process is used to ensure the quality of each project is as high as possible, as well as ensuring the best possible return and impact for the resources available. The process utilizes gates, where gatekeepers have the power to decide if a project should continue into the next phase, if it should be shut down or potentially if any other actions should take place before the project continues.

The VP of technology had one single technical requirement for the new product; it should be able to transfer 10 bits per second for 10 000 meters. If the project team were to deliver a product which met these technical requirements, Baker Hughes would have a product which was market-leading. The project should also stay within the budget, as well as the timeline.

During the project, the project team ran into some challenges. As the interview objective puts it; there are always challenges when developing and implementing new technology. Since this project was initiated from the technology and engineering side, and not directly for a customer willing to pay straight away, this project represented a somewhat higher risk for the organization than other projects conducted after a tendering process, thus was the project not one of the ones with the highest priority internally. As a result, the project was strictly limited on resources; time, money and people. The project team had to convince upper management that the project had a potential in order to get allocated resources. By creating small-scale prototypes of the new product, instead of simply handing over a report with estimates, the project team was able to persuade the upper management, and gatekeepers, that the project was worth the resources.

The interviewee believes that one of the important tasks of a project manager is to compromise between time, money and people, since you will rarely be allocated a sufficient amount of all three. Since this project was not among the ones with highest priority, it was difficult to get more money and people. Thus, they had to compromise and use more time than originally planned. The project team had to wait in order to get spare parts, and also wait until people were done with other tasks and projects before they could be involved.

As mentioned above, the project ended up taking longer time than first estimated. One of the reasons why, was because of the priority of this project. There was also an issue with receiving the allocated resources. The project received about 60 % of the initially planned budget, and thus they had to compromise by using longer time. Once the project got all their resources, it turned out that they also would need more money. The project ended up exceeding the budget with about 50 %. Even though the timeline and the budget was exceeded, the project team ended up delivering a product which achieved the technical requirement for the project, 10 bits per second for 10 000 meters. As this was the main requirement, the project was still considered a success.

4.1.5 Case 5: One-Trip System (OTS)

The one trip system (OTS) is a further development of SDL (project-case 1), and it is based on the same principle: combining operations to increase efficiency and be able to drill challenging wells. In addition to drill and set the tubing like the SDL does, the OTS will have the capability to drill, set tubing and cement in one single run, thereof the name “one-trip system”. A successful one-trip operation will drastically reduce the time spent on drilling. It will also enable the operators to drill difficult and challenging wells, as the risk of a hole collapse is reduced. The need for this new technology came from Statoil. Since Statoil and Baker Hughes already had developed the SDL together, it was natural that Baker Hughes continued the development of OTS.

The feasibility study of OTS was initiated right after the first commercial operation with SDL, and the official start of the project was in 2013. The technology has been under development since, and the final tests are planned to be conducted during the summer of 2017. The final tests will take place at Baker Hughes Experimental Test Area (BETA). The project has a budget of 300-400 million NOK (depending on different factors, e.g. exchange rates), and it is the largest single-project of the drilling department of Baker Hughes ever.

In the early phases of the project, a lot of time was spent on developing a timeline. The timeline was developed together with Statoil. Statoil wanted the new system to be ready earlier than Baker Hughes felt comfortable to promise, but Baker Hughes managed to cut down some of the time by conducting some of the activities in parallel. The time aspect of the project was one of the requirements and success criteria which came early from Statoil. Another major component that was emphasized in the early phase, was development of technical requirements. These requirements are formulated in a specific document named “scope of requirements”. This is one of the most important documents in the project, as it is vital input for the engineers designing the product. Late changes in these requirements will have a drastic impact, and may set the project almost back to start.

On the commercial side of requirements and success criteria, the product line manager, who is located at Baker Hughes' headquarters in Houston, has made a set of financial goals for the project and the new product. The interviewee indicates that it is difficult to predict how well a new product, especially as complex as the OTS, will perform in the first period. The financial goals set by the product line manager is thus something that the project team in Norway and Celle does not relate to too much, as there is not much they can do to influence the financial impact of the new product. Goals, or requirements, for NPT and efficiency are not set at the time the interview is conducted. To summarize: The “scope of requirements”-document is thus the most important criteria for success for this project. The technical requirements are absolutely crucial for project success, and it may overshadow other criteria, which all are dependent on whether or not the product meets the technical requirements.

Throughout the project, there have been challenges related to technical solutions, as expected for this type of complex product development. The project team has taken actions to reduce some of the technical risks, including engaging an external company to do mechanical testing of some of the components. Mechanical testing is usually conducted by Baker Hughes themselves, but since the technology and technical requirements for the OTS are so complex, a more complex testing facility was also desired. The project was also allocated testing time at BETA, which, according to the interviewee, is critical for ensuring project and implementation success.

The project is well funded, and the project team has not been particularly limited by its resources during development. The issue is that the project is under the global organization during development, but when the development is completed, the project and product is under the responsibility of the local office. The local office has not set aside resources, nor been assigned resources from the global organization, to train and educate employees in their own organization. Most of the employees in the local organization in Norway do not have any particular knowledge about the new product, which they need to have when the product becomes commercial. Offshore personnel, employees in support functions such as logistics and accounting, as well as project managers need training.

As this project is yet to be finished, it is impossible to decide whether or not the project will be a success. However, the project has been conducted according to the timeline and within the budget this far. The final testing at BETA will show if the technical issues have been taken care of, or if it will need further development and mechanical changes. As of now, the most serious challenge with the whole project, according to the interviewee, is funding of training employees in the local organization. The project team in the local office will use the findings of this report to do further planning of the work needed in regards of the implementation.

5 Empirical findings

5.1 Final list of CSFs

The final list of Critical Success Factors (CSFs) detected from the five project-cases is presented in Table 10. A total of 8 factors, distributed over three groups, are included in this list.

Table 10 Final list of detected critical success factors for integration of tools and equipment in the oilfield service industry

Project management	
	Knowledgeable and experienced project manager
	Dedicated and committed project manager
Upper management	
	KPIs support and reward use of new products
	Upper management support and trust
Stakeholder management and personnal characteristics	
	Early and continuous involvement of end-user
	Openness
	Communication
	Training of end-user

The process of determining this final list of factors is described in the following section. In chapter 6, the result is compared with findings from the literature review. The implication of the result is presented in the executive summary in Appendix C.

5.2 Chronological reasoning of results

The first step in the process of developing a generic list of CSFs, was to determine success factors from each of the project-cases investigated. The result from each of the projects are presented in the Table 11 to Table 15. Reasoning, justification and explanation of each success factor are presented in 5.3.

Table 11: Critical success factors detected from case 1: Steerable Drilling Liner (SDL)

Upper management support
Involvement of end-user during all project phases
Communication
Create a general positive mindset regarding new products
Broad experience of project manager
Project manager stays with the project until the first-use phase is completed
Training of the end-users
Openness
Persuade capabilities of project manager
Dedicated project manager
KPIs must support the use of new technology

Table 12: Critical success factors detected from case 2: Casing and Tubing Connection Lubricant

Communication between stakeholders
Requirements and agreements in written form
Support from upper management in the implementation phase
Openness between the contracting parties
Early involvement of stakeholders
Knowledgeable project manager
Dedicated project manager

Table 13: Critical success factors detected from case 3: GaugePro Echo - Digital Underreamer

Knowledgeable project manager
Upper management must value learning and knowledge
Test new technology where it is easy and affordable
Official event where everybody in the organization is informed when new products are implemented
Commitment and personal characteristics of project manager
Trust from upper management

Table 14: Critical success factors detected from case 4: Mud-Pulse Telemetry

Knowledgeable project manager
Upper management must value learning and knowledge
Test new technology where it is easy and affordable
A checklist/training document should be created by a team of people with first-hand experience with the new product
Commitment and personal characteristics of project manager
Trust from upper management

Table 15: Critical success factors detected from case 5: One-Trip System (OTS)

"Scope of requirements"-document is precise and complete
Satisfactory amount of test time
First commercial runs should be easy jobs
Willingness to invest in training
Local offices should have the opportunity to rent the product from the global organization, without acquiring the product as an asset
KPIs should reward operational managers who use new technology
Openness between the license owner and the developer (Baker Hughes and Statoil)
Dedicated and committed project manager

With all success factors for each individual case determined, a single list containing all the success factors was created. This list consists of 24 CSFs as presented in Table 16. Success factors of great similarity were merged into single factors, to keep the final list consisting of collectively exhaustive and mutually exclusive success factors.

Table 16 Complete list of critical success factors detected from the project-cases

Project management	
	Knowledgeable and experienced project manager
	Dedicated and committed project manager
	Persuade capabilities of project manager
	Project manager stays with the project until the first-use phase is completed
	Create a general positive mindset regarding new products
	Expect challenges during the first runs – be prepared
Upper management	
	KPIs support and reward use of new products
	Upper management must value learning and knowledge
	Upper management support
Contracting and documentation	
	Requirements and agreements in written form
	Scope of requirements-document is precise and complete
	Contracts are developed on a local level
	A checklist/training document created by a team of people with first-hand experience with the new product
Stakeholder management and personnal characteristics	
	Early and continuous involvement of end-user
	Personal relationships
	Openness
	Communication
	Training of end-user
	Users should have a positive first interaction with the product
Organization	
	First commercial runs should be easy jobs
	Geomarkets should have the opportunity to rent the product from the global organization, without acquiring the product as an asset
	Official event where everybody in the organization is informed when new products are implemented
Testing	
	Test new technology where it is easy and affordable
	Satisfactory amount of test time

All of the CSFs presented in Table 16 should be considered important for introducing new tools or equipment in oil-service companies. But to increase the ability to draw more generalized conclusions, CSFs which were detected in only one of the project-cases, were removed. Table 17 presents the number of case projects which supports each of the factors.

Table 17: The case-projects support of each detected critical success factor

Critical success factors	*Supported by case number*				
Project management	**1**	**2**	**3**	**4**	**5**
Knowledgeable and experienced project manager	✓	✓		✓	
Dedicated and committed project manager	✓	✓	✓	✓	✓
Persuade capabilities of project manager	✓				
Project manager stays with the project until the first-use phase is completed	✓				
Create a general positive mindset regarding new products	✓				
Expect challenges during the first runs – be prepared			✓		
Upper management					
KPIs support and reward use of new products	✓				✓
Upper management must value learning and knowledge				✓	
Upper management support and trust	✓	✓	✓	✓	
Contracting and documentation					
Requirements and agreements in written form		✓			
Scope of requirements-document is precise and complete					✓
Contracts are developed on a local level			✓		
A checklist/training document created by a team of people with first-hand experience with the new product				✓	
Stakeholder management and personnal characteristics					
Early and continuous involvement of end-user	✓	✓	✓		
Personal relationships			✓		
Openness	✓	✓			
Communication	✓	✓			
Training of end-user	✓				✓
Users should have a positive first interaction with the product			✓		
Organization					
First commercial runs should be easy jobs					✓
Local offices should have the opportunity to rent the product from the global organization, without acquiring the product as an asset					✓
Official event where everybody in the organization is informed when new products are implemented			✓		
Testing					
Test new technology where it is easy and affordable				✓	
Satisfactory amount of test time					✓

Excluding the factors which are supported by only one of the case projects, leaves a final list of eight CSFs, as presented in Table 18. These 8 factors are further analyzed and compared to findings from literature in the discussion section of the report, and the conclusion is also based on these eight factors.

Table 18: Final list of critical success factors

Critical success factors	*Supported by case number*				
Project management	**1**	**2**	**3**	**4**	**5**
Knowledgeable and experienced project manager	✓	✓		✓	
Dedicated and committed project manager	✓	✓	✓	✓	✓
Upper management					
KPIs support and reward use of new products	✓				✓
Upper management support and trust	✓	✓	✓	✓	
Stakeholder management and personnal characteristics					
Early and continuous involvement of end-user	✓	✓	✓		
Openness	✓	✓			
Communication	✓	✓			
Training of end-user	✓				✓

5.3 Justification of the presented CSFs

In this section, each critical success factor from each of the projects is explained and justified. Each factor is explained with a short paragraph written by the researcher, with the interview transcripts as the source. In addition to these paragraphs, each of the factors is backed with a direct quote from the interviewee. This does not apply for case-project number 4, as this interview was not recorded, following the interviewee wish. The critical success factors are presented in the same order in this section, as they are presented in Table 11 to 15.

5.3.1 Case 1: Steerable drilling liner

- CSF: Upper management support

According to the informant, upper management was of importance regarding project success. One of the reasons why this was important, was that the upper management contributed to signal to others that it was desirable to spend time and money in order to implement the new product in an effective manner. If the upper management knows about the challenges, the strengths, and the potential gains with the new technology, it is more likely that they support the increased spending in the short term, in order to collect the long-term win.

"If upper management does not support the project implementation, the implementation process will come to a stop."

"Upper management must allow field personnel to spend more time and money on the first operations with new products."

- CSF: Involvement of end-user during all project phases

The informant emphasizes the importance of involving the end-users, and mentions reasons why he believes it is important: When the end-users are involved from the very beginning of the project, time and money are saved during the implementation phase of the project, because the end-users already have an understanding of the new technology. The risk of design errors being made will also be reduced, as the operational units will provide the requirements from their perspective.

"The end-user as well as the other stakeholders were involved throughout the project – they participated in all meetings and everything we did was communicated to all stakeholders. The end-users were also invited to testing in both Germany and USA. This ensured that everyone was updated, and when the technology was ready, everyone knew what it would require to start using the product."

- CSF: Communication

The interviewee explains how the communication in this project contributed to project success, and the main reason why the communication was effective: the interviewee, who was project manager for this project, had operational experience before he joined the research department. This enabled him to communicate effectively both to the researchers and the developers, as well as the operational personnel. The efficient communication enabled the end-users to be involved early, and keeping them involved throughout the project.

"The communication in the project was very effective, between the researchers, developers and end-users. They were involved and talked the same language through me."

- CSF: Create a general positive mindset

Bad reputation, or rumors, travels fast. The informant says that this is the case also when people are talking negatively about development projects. Negative loaded rumors about a new product or technology will affect the implementation in a negative way, as people tend to adopt a negative attitude toward the new product or technology.

"It is important that key stakeholders speak positively about the projects. There should be a consensus in the organization, and no one should feel overruled or overlooked. I think that is crucial."

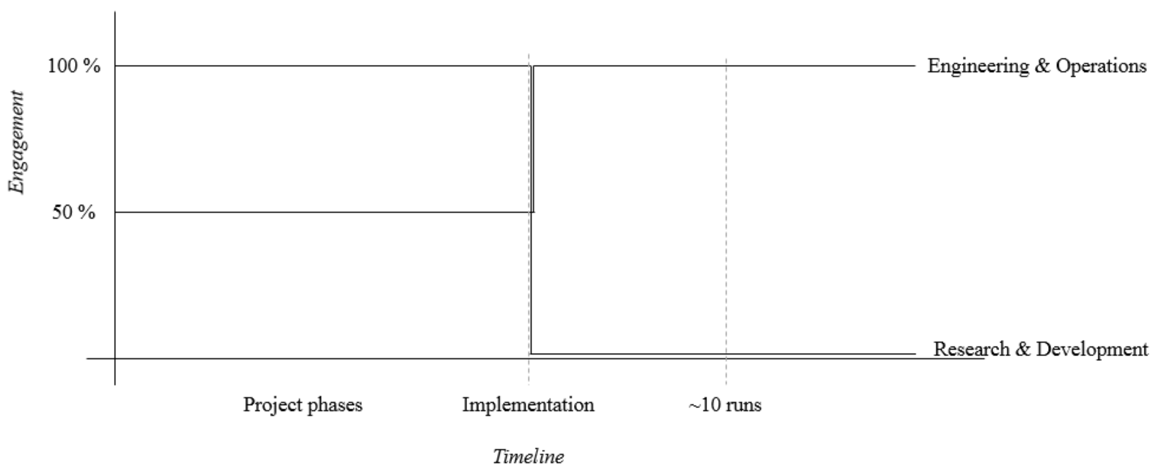
- CSF: Broad experience of project manager

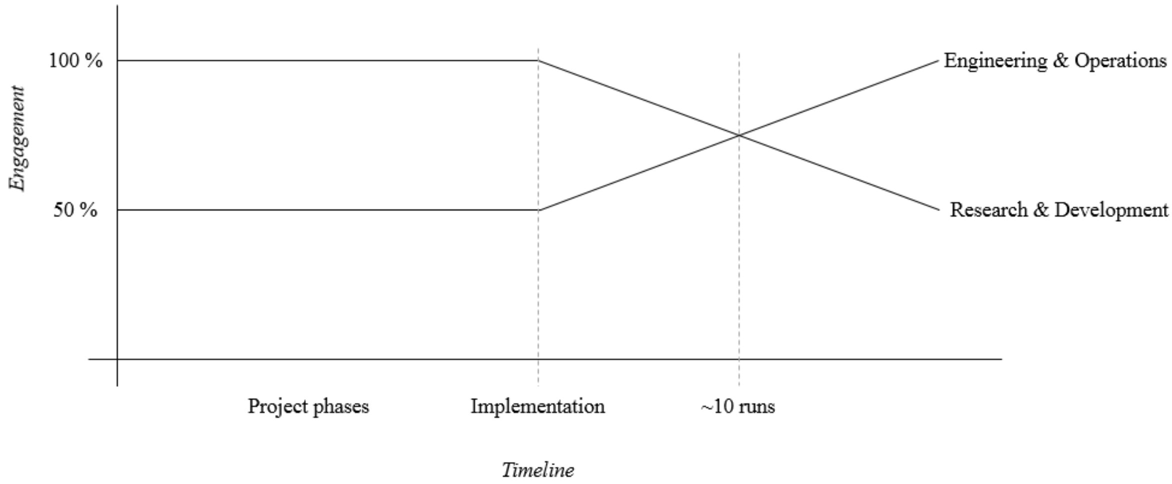
The interviewee considers the project management of the SDL project a success. According to him, the single most important factor for achieving project management success, was the broad experience of the project manager (who also was the interviewee). Because of his operational background, he was able to communicate very effectively with the end-users, which were the operational units in Statoil. The vocabulary among the operational units differs a lot from the vocabulary used in the research and development department. The broad experience from both departments was thus a huge advantage.

"I actually believe the management of this project was crucial. This project was the first time the project manager came from the operational department into research and development, which made it easier to communicate with the end-user. So I believe that the project management was, if not essential, very important."

- CSF: Project manager stays with the project until the first-use phase is completed

At the time the SDL project was carried out, the regular procedure was that the project managers' engagement and responsibility were eliminated at the very time the newly developed product had passed the first operational test. Another person in another department in Statoil took over the responsibility for the operations with the new product. This means that the people who had spent several years developing a new product, were not involved and on-site when the first operations were conducted. According to the informant, this did not work very well. Because of the project manager's dedication and interest in the SDL project, he stayed with the SDL throughout the first runs, and he is still heavily involved with the SDL today. The approach of involving project managers throughout the first use-phase is a lasting change, and it is the regular approach in Statoil today. The figures below are a representation of this change.





"At that time, I was supposed to engage in the first operational test, and then the whole project and product was supposed to be handed over to another department in Statoil. But this approach did not work too well. I stayed with the project throughout all the first runs, and this was a lasting change that was implemented in projects in Statoil, as a result of this project. Other people saw the benefits of this approach."

- CSF: Training of the end-users

When the product was developed, the drilling engineer and operations' engagement increased, which is natural, as the product went commercial. It is the drilling engineers and operational people who are the end-users of the product, and it is thus important that they know how to use the product. According to the informant, it is also important they are trained and informed properly, in order to increase their willingness to work with the new product.

"I believe the operational people are excited about new products, as long as they feel that we take care of the details. Then they are able to enjoy the new and exciting products. It is not exciting for them, on the other hand, if they get a lot of new responsibilities and tasks without possessing the knowledge required to conduct the tasks. It is thus very important that they get the training they need."

- CSF: Openness

Openness can be said to be a wide term for a personal characteristic. The interviewee talks about how openness between the key stakeholders enables efficient communication, in addition to the importance of leadership with an "open" attitude.

"Openness is important. Also the management must be open, and they should trust that the project team has the required knowledge and experience."

- CSF: Persuade capabilities of project manager

Throughout the interview, the interviewee mentions that there are some differences between the operational units and the researchers. This gap was greater at the time the SDL project was carried out than it is today. With this in mind, it was important that the project manager, who was based in the research department, was able to convince the operational units about certain aspects of the projects, and not least to gain support from the operational units.

"One comes from the sideline and tells people who are working hands-on with the equipment every day how they should do their job. It is critical to possess experience enough to convince, and to appear robust. One needs to be confident, and be able to answer all questions. This is critical. The second you can not answer, you will get "eaten"."

- CSF: Dedicated project manager

According to the interviewee, the single most important factor for project success, was the engagement and commitment from the project management. One person that cares a lot and has a lot of drive will be able to influence the key stakeholders and other involved people. This will create a chain reaction, and it will make it easier to get things done efficiently.

"You need one person who is very passionate for the project, I think that is the keyword. One person that is willing to sacrifice time and effort. One person that makes sure things get done. This one person will sell the technology to other employees, and shares knowledge. You need one person who really wants project success, and is willing to put down the work."

- CSF: KPIs must support the use of new technology

Statoil measures operational success with a set of Key Performance Indicators (KPIs), where one of the most important is non-productive time (NPT). It is fair to assume that brand new products and technology will have some more issues in the first runs, than old and well-known products. It is thus important that there are some KPIs that support the use of new technology.

"No matter how much I want to implement and start using a new product, it is the end-user that is measured according to their KPIs, and it is their call to decide whether or not they want to try a brand new product. If they are measured on risk and cost, and only those factors, it is a natural decision to turn down new technology… Upper management must create KPIs which encourage operational managers to use new technology."

5.3.2 Case 2: Casing and tubing lubricant

- CSF: Communication between stakeholders

When the product was developed, the HMS department in Statoil had to approve the product for commercial use, because the product was a chemical. The project team had not paid too much attention to this process, as they all saw the benefit of this new product. The problem was that the HMS department did not have the same information and knowledge as the project team. The project team struggled with getting the product approved, which resulted in some delays. According to the interviewee, this "misunderstanding" was a result of lack of communication between the project and the HMS department. The interviewee also states that the end-user was involved throughout the project, and that this was important for the project success.

"The HMS department did not see the whole picture, that we saw. We had not communicated clearly and enough with them. We did not expect that they would prevent us the way they did, so that was a challenge that arose from lack of communication."

- CSF: Requirements and agreements in written form

This project ended up taking longer time than expected. In the early phases of the project, the project manager tried to align the project with the organization, and talked to people that would assist the project further down the line. But since the project ended up taking longer time than expected, some of the organization was also reorganized, and people had changed locations and positions. It ended up being difficult to take advantage of the work that had been put down earlier in the project, and the project manager had to make new agreements with different parts of the organization, because none of the earlier agreements had been written down.

"We should be better at documenting, and writing things down. Something was agreed upon, but when you come back 5 years later to initiate the planned action, they have likely forgotten the agreement, and you may have forgotten some things yourself."

- CSF: Support from upper management

Even though this project was relatively small, considering the amount of involved people and the budget, the interviewee states that support form upper manager was important.

"It is important that upper management is informed, has an understanding of the project and supports it. This will give the project manager and the project team a healthy work environment. That is important."

- CSF: Openness between contracting parties

The project was carried out as a partnership between Statoil and a supplier. The supplier developed the chemical, product, after instructions and specifications from Statoil. As for most other project, there was a project timeline and a budget. The timeline got overrun, and the interviewee believes that the supplier spent more resources on developing the product than they had planned initially. The interviewee says that the supplier was open with the team from Statoil throughout the project, and the team from Statoil was open with the supplier. This increased the effectiveness of the cooperation.

"When you are open with one another, it is easier to solve potential challenges or issues… The supplier was very open, which made things easier. When the relationship between the contracting parties is open and friendly, it is easier to get acceptance for delays and similar."

- CSF: Early involvement of stakeholders

As previously discussed, the late, or lack of, communication, caused the project not to finish according to the schedule. The interviewee says that early involvement of the key stakeholders, e.g. the HMS department, would further increase the success of the project. Early involvement of stakeholders is the most important lesson learned for the interviewee, which was project manager.

"The importance of early and clear communication is maybe the most important lesson learned for me from this project. Looking back at it, it is obvious that the key stakeholders should be involved earlier, and also that other people could have been involved."

- CSF: Knowledgeable project manager

The interviewee for this project had 10 years of experience from operations, before he joined research and development. This operational experience helped him as a project manager in research and development, mainly because he was able to communicate effectively with end-users and other customers.

"It is important that the project manager has experience and knowledge. You need to understand what you are doing. In my case, my operational experience helped me. I was able to communicate directly with the end-users and other customers."

- CSF: Dedicated project manager

When asked about the single most important factor for project success, the interviewee says a dedicated project manager.

“The single most important factor for ensuring success, is that the project manager is engaged on a personal level. In every project like this, one will experience issues and challenges, and in those times it is helpful to have a dedicated project manager who really wants to see success.”

5.3.3 Case 3: Gauge-Pro Echo – Digital Underreamer

- CSF: Project mentor in upper management

An important factor impacting how efficient and effectively one can implement a project like this, is the communication between the project team and the upper management. The informant says that it would be beneficial for this project if the project team had a mentor in upper management, who the project manager could contact directly, and who already was updated on the status of the project.

“If I were to get an approval for something, I would have to go three levels up in the organization, which usually takes extra time. A more efficient way to do it, would be that each project, or product, had a mentor in the upper management, who could directly communicate with other members of the upper management, to get these types of approvals.”

- CSF: Contracts are developed on a local level

Since the project was officially assigned to the global organization in Baker Hughes, the global organization also drafted and formulated the contract for the project. According to the informant, it is important for the implementation that the contract is specific and precise from the very beginning of the project. It turned out that the pricing and some other parts of the contract were not optimal and specific enough for the project. The contract was thus reworked by the local organization in Baker Hughes, in much tighter communication with Statoil than the initial contract.

“The project itself was officially done at a global level both in Baker Hughes and Statoil, but it turned out that the contracting team at global level did not come up with the best agreement for none of the parts. In the end, we fixed the contracts on a local level.”

- CSF: Personal relationships

Key personnel in the project teams from Baker Hughes and Statoil knew each other on a personnel level even before this project was initiated. The informant says that these personal bonds lead to efficient communication flow, and information is not held back.

"During all my years, here in Norway, I have worked on projects with the same guys from Statoil. The team is like an old couple; we know what we expect from each other and communicate very directly…. I think it is very important with personal relationships. You need to trust your partner. None of the parties should hide information from each other. The meetings are very efficient… It takes time to build trust, so when the same team of people works together on multiple projects, it saves time."

- CSF: Early and continuous involvement of end-user

The informant says that it is important to have the customer involved from the beginning and throughout the project, to ease the work related to implementation. The implementation will unfold with fewer issues if both parties have the same knowledge and the same expectations.

"Statoil attended all the meetings and were fully informed at all times. We off curse have some internal things to discuss, and the same goes for Statoil, but everything regarding development was a team effort. Otherwise it doesn't work."

- CSF: Expect challenges during the first runs, be prepared

Testing is a large part of product development and commercialization. The informant says that testing is important, but no matter how much test time one has had, one should be prepared for challenges in the first commercial runs. Especially electronics and the programming part of the tool might experience issues, and it is important to have a plan to tackle these challenges as effectively as possible.

"Since I have worked in this environment for years, I have learned to expect the worst, and be happy if things turn out better than expected. With some experience, I try to anticipate what may happen, and reduce the chances of it happening. When we add new tools to a BHA, we usually experience some issues with the electronics and on the programming side. These issues are very difficult to locate before drilling, since it is a different environment. We try to test everything we can, but it is impossible to match the reality."

- CSF: Make an effort to increase the likelihood of a positive first-touch of the system for the end-user

The interviewee suggests that the first commercial run(s) should be conducted in wells that are not too difficult. This will decrease the likelihood of issues during the operation. Another positive effect of successful first runs, is that operators and other personnel who handle the new product first hand, have a positive first experience with the product. This will ease the process of using the product in the future, as more people in the organization have a positive attitude regarding the product.

"Whether or not people are positive to changes related to new tools is different based on personality. It also depends on the first contact with the tool. If there is an issue the first time someone new is handling some aspect of the new product, they will probably not like the tool in the future. If the product works as it should and everybody is happy, then it is easier to enjoy working with the new tool."

- CSF: Official event where everybody in the organizations is informed when new products are implemented

The informant says that in previous implementations and introduction of new products in the organization, he has missed an event where the new product is introduced for everyone in the organization. This event does not necessarily need to require a lot of resources. The most important outcome should be that everyone in the organization is aware that there is a new product coming in, what it is called, how it will help in operations and so on.

"We are lacking some type of event when we are implementing new tools, like the GaugePro Echo. Especially in operations. It is difficult to deal with new technology because you already have a lot of work to do. Taking care of the operations and making sure the customer is happy."

- CSF: Committed project manager

The importance of a committed project manager is also mentioned by the informant as one of the important factors for implementation success. The informant for this project was not the project manager for the project, as the project management team was placed in the engineering department in Celle, but he was heavily involved in the project the whole time.

"We can't have a very quiet person as a project leader for a project like this. It is important to have someone in the driving seat, who is passionate."

5.3.4 Case 4: Mud-Pulse Telemetry

CSF: Knowledgeable project manager

The project manager should have the knowledge and experience that is required to successfully manage the project and the team. From the informant's experience, the most important task of the project manager is to compromise between time, money and quality. As the informant explains, it *is highly challenging to balance the three aspects time/budget/quality in the right way to deliver and introduce an innovative/competitive product to the market at the right time by fulfilling all relevant customer needs.* For this specific project, the project manager prioritized quality, and it was difficult to get sufficient money. As a result, the project dragged out over the schedule, because the project manager had to compromise. The ability to make the right compromises is a major factor in regards of success, according to the informant.

- CSF: Upper management must value learning and knowledge

The upper management has a major influence on implementation success. In this specific project, one of the reasons why the upper management chose to continue with the project after the initial studies, was because they saw that the engineers and developers learned a whole lot from researching on the subject. At one of the gatekeeping-meetings, the project team did not present numbers and analyses in a PowerPoint presentation, which is the usual approach. Instead, the project team presented a small-scale prototype of the product they wanted to produce. The decision makers were first of all positive because the prototype showed promising results, but mainly because they valued how much knowledge the project team had gained. Whether the product was to be produced or not, knowledge is a lot worth in an oil service company like Baker Hughes.

- CSF: Test new technology where it is easy and affordable

The interviewee mentions that it is beneficial to test new technology and products in low-budget areas. Some geographical areas require less resources to operate in than others, which reduces the involved risk with testing.

- CSF: A checklist/training document should be created by a team of people with first-hand experience with the new product

The informant for the mud-pulse telemetry project emphasizes the importance of knowledge among all employees that are in touch with new products; field engineers, R&D department, operational units and management. In this project, a few people from each of these departments

– people in different positions – contributed in making a document with the most important information regarding the new product. The informant suggests that a type of checklist and document for training should be produced by people from the different departments, who all have knowledge about the new product.

- CSF: Commitment and personal characteristics of project manager

The informant says that the personal characteristics of the project manager are crucial for project, and implementation, success. The project manager functions as a type of role model for the rest of the project team, and the project manager's attitude and confidence will influence the attitude and confidence of the project team as well. A project manager with a positive attitude has the power to impact the project in a positive matter.

- CSF: Trust from upper management

The upper management should also possess the capability of trusting the project team. It is important that upper management is able to delegate work to the project team, and trust that they will deliver. In some situations, projects may need more time or money than initially planned, as in this project where they needed more of both. *The upper management must serve as stakeholder for the project to decide on the continuation, recycling or killing the project when the project justification is changing (e.g. market changes, business case changes, technology changes, etc.).* For the project team, it is also important that the upper management trusts them, and what they are working on. It is natural that some projects are shut down before they are finished, but the reasons need to be clearly explained to the team members to avoid demotivating the people and encourage them for a new project.

5.3.5 Case 5: One-Trip System

- CSF: "Scope of requirements"-document is precise and complete

For each single component and for the complete system being developed, Baker Hughes has documents named "scope of requirements". This "scope of requirements" documents follow the project all the way from the beginning to the implementation. In order to have a successful implementation, it is crucial that all relevant requirements are included in this document, as changes in the requirements could require a large amount of additional resources. It is also crucial that the operational units are active during the phase when the requirements are set, so that they have all the functionality they need and want.

"This is maybe the most important document. When we have finished the work of formulating this document, the document is locked for changes. The engineering department uses these documents as a base when developing the tools. It is important that time and effort is put down in the document, so that the document is precise, and all important information is included. If one needs to make changes in the specifications a year or two into development, the development work put down in that time is almost useless."

- CSF: Satisfactory amount of test time

Test time is one of the most important factors for project implementation success, according to the interviewee. Now that the OTS project has been awarded test time at the BETA facilities, this part of the OTS project seems to be in good shape.

"It is crucial that we reach the goals regarding reliability, and enough testing is one of the major elements in doing so."

- CSF: First commercial runs should be easy jobs

A failed run, or a run with major delays or challenges, no matter what reason, is damaging for a new technology. If one the first runs fails, even though the product still is in the first-phase, managers of other wells will hesitate to try the technology themselves. The informant indicates that one typically does not look into the reason why something failed, as the fail in itself scares away potential users and customers. With this in mind, it is important to find the right wells to do the initial runs, and gradually increase the difficulty of the operations.

"I do not think it is beneficial to accept the most challenging jobs in the beginning – the system should rather be "tested" in the commercial environment by performing relatively simple jobs. One bad run would denigrate the system, and possibly spoil future opportunities. Even though one failed on a really difficult run, it would be marked and remembered as a failure. The details will not be remembered. It is beneficial to build a reputation for the tool first, then one can better handle a failed run in the future."

- CSF: Willingness to invest in training

The interviewee talks about his experience from the SDL project, where he helped out with training of personnel during the implementation. The number of jobs with the SDL was relatively low, and as a result, it was not invested a lot of resources in training a lot of people.

As a result, the SDL was sent to Germany for service, because the workshop in Norway was not trained in this new product. The interviewee is clear when he says that this has to change with the OTS, as they are aiming for a lot higher volume for this product. Thus is it required to drastically increase the resources for training around the time of implementation.

"With SDL, it was mainly one person who was in charge of training, and as of for now, it is mainly one person for the OTS as well. I think that it is challenging to only have one person in charge of training, even though it might do the job initially, more people will be needed closer to implementation and during this phase. It is necessary to take a risk and invest in training in order to get the new product up and running successfully. If one awaits the investment related to training, it will negatively impact the chances of really succeeding on a large scale."

- CSF: Local offices should have the opportunity to

Internally in Baker Hughes, a local office can either rent tools and equipment from the global organization of Baker Hughes, or the local office may acquire tools and equipment, and it is thus in the local office as an asset. Whether the local office chooses to rent or acquire the tools and equipment is dependent on a lot of factors. For the OTS, the only way it can be used by the local office in Norway, is if this local organization acquires the product. This is a large investment, also for the local office in Norway which is one of the local offices with the largest revenue from drilling. For small geomarkets with less revenue, it will be difficult to purchase the tools and equipment. It is also a risk that if a local office chooses to invest and purchase the product from the global organization, that the jobs are absent. Based on this information, the informant believes it would be beneficial for the global implementation of OTS if the local offices were given the opportunity of renting the product instead of purchasing it upfront.

"I wished we had a transitional phase where Baker Hughes globally owned the equipment. It is a major investment that needs be made in order to purchase the equipment needed for a job, as we also need an extra set of everything, as reserve. This investment is a lot of money even for a large geomarket as Norway, which also has a large drilling department with high earnings. For smaller geomarkets, it is truly challenging to make a million dollar investment in assets and inventory."

- CSF: KPIs should reward operational managers who use new technology

Upper management and operational managers are measured on revenue and margins from quarter to quarter, and often from month to month. With these KPIs in focus, it is difficult to defend the investment and risk of using brand new and expensive products in simple operations. In order to get as many runs as desirable with the new product, and in wells that are not too challenging, managers should be encouraged and rewarded for using new products like OTS.

"Everything is measured after the same parameters. It is cost, margins, earnings and so on. It is difficult to defend an investment in a project which will impact these KPIs, even if it is only in the short term. The leadership is measured from quarter to quarter, so it is natural that they want to make decisions which show results, rather than investing 2-3 million USD in assets and inventory that might not even get used that much."

- CSF: Openness between the license owner and the developer

As mentioned in the project description, a lot of the people involved in the OTS project are the same people that were involved in the SDL project some years earlier. A lot of these people know each other on a personal level, which the informant says is beneficial, mostly in regards of efficient communication and openness. The informant points out that it is not necessary to keep things hidden from each other, or try to present things different from what one feels.

"We have a very good dialogue with Statoil. We spend a lot of time with the people we are working with from Statoil, and one can say that we develop a type of friendship. This creates a very low threshold for raising questions, and both parties can be honest with each other. We do not need to think too much about how we present an issue neither, both parties can talk directly."

- CSF: Dedicated and committed project manager

Throughout the interview, it gets clear that the interview objective is passionate about the OTS project. The interview objective describes a lot of different tasks he conducts, and responsibilities he undertakes. When asked about how much of the work he does and will be doing with the OTS is listed in his job description, the informant says that very little of what he does is defined as a work task he has responsibility for. It is clear that he puts down the time and effort because he is genuinely interested in the project, and definitely dedicated to see the project succeed.

"A very small amount of what I do is defined as my responsibility in my job description. You learn to see where help is needed. One of the reasons why I spend time helping people in other departments, is that I have noticed that a lot of people have the impression that SDL is difficult to work with. I want to contribute to removing those impressions. It is also interesting and

rewarding for me personally, as I get to see all the sides of the projects. I get a good and very holistic understanding of how the new system works. There are quite few people that get that opportunity."

- CSF: Training of end-users

Two of the most involved persons in the OTS project from the Norwegian office of Baker Hughes have previously traveled to several locations around the world, including Alaska, Saudi Arabia and Germany, to train operational units in using SDL, which they were also involved with. The interview objective states that training of employees is one the most important factors when implementing new and complex technology. For simpler new products, like a simple tool to be added to the drilling liner, the need for training is less than for a complex system like OTS.

"It turns out that new technology and products represent a challenge for multiple departments in the organization. Both for the logistics and finance departments there are new information they need to know, and implement in their systems. I have helped out these departments previously with the SDL. I would not call it courses, but it is a kind of on-the-job training."

6 Discussion

When analyzing the findings with the previously detected CSFs from literature, it is an evident connection between the results and the literature. CSFs for "project implementation", presented in Table 5 in chapter 2.1.2, supports four out of the eight CSFs found from the case projects. CSF for "projects", presented in Table 4 in chapter 2.1.2, supports six out of the eight CSFs found from the case projects, and CSF for "change management", presented in Table 7 in chapter 2.2, supports six out of the eight CSFs.

In the following paragraphs, the similarities between the findings and the literature are further discussed. The paragraphs follow a chronological order, where each paragraph covers one group of CSFs (respectively project management, upper management and stakeholder management and personal characteristics). It is worth mentioning that the comparison of the project-case findings and the literature findings is a challenging process, and is open to individual interpretation. The main reason why it is a challenge, is the level of specificity. E.g. one of the CSFs for "projects" from literature is defined as "project management" (Westerveld, 2003). In the findings from the case-projects we have "knowledgeable and experienced project manager" as well as "dedicated and committed project manager". The two CSFs from the project-case findings can be placed under "project management", but it is not given that the CSF "project management" from literature includes specific focus on e.g. the commitment of the project manager. This opens to interpretations. It is in the researcher's best belief that the analysis presented below follows the logical chain of evidence.

Table 19: Literature support of the case-project findings

Critical success factors	*Supported by CSF for…*		
	Projects	*Project implementation*	*Change management*
Project management			
Knowledgeable and experienced project manager	✓	✓	
Dedicated and committed project manager	✓		
Upper management			
KPIs support and reward use of new products			✓
Upper management support and trust	✓	✓	✓
Stakeholder management and personnal characteristics			
Early and continuous involvement of end-user	✓	✓	✓
Openness	✓		✓
Communication	✓	✓	✓
Training of end-user			✓

Project management

The research has detected two CSFs which are within the field of project management. More specifically they both concern the project manager.

- CSF: Knowledgeable and experienced project manager

Westerveld (2003) has defined "project management" as a CSF for "projects". This factor is considered supportive of the finding, as the project manager will need knowledge and experience in order to deliver effective project management.

"Competent project manager" is one of the CSFs for "project implementation", presented by Pinto and Slevin (1987). This factor clearly supports the CSF from the project-cases.

CSFs for "change management" (Creasey*, et al.*, 2014) include some factors which have similarities to this finding, i.e. "structured management approach". This factor is though not considered supportive, as the similarities are vague.

- CSF: Dedicated and committed project manager

One of the tasks of a project manager is to acquire personnel, and keep them motivated (Meredith and Mantel, 2012). Based on the responses from the interviewees, a dedicated and committed project manager is also motivating for other people around them. Westerweld's (2003) list of CSFs for projects include "project management". The project manager will naturally play an important role for the management of the project, and the CSF for "projects" is thus considered supportive.

None of the CSFs for project implementation, presented by Pinto and Slevin (1987), are considered supportive of this finding. The same goes for the CSFs for change management, presented by Creasey*, et al.* (2014).

Upper management

The two CSFs placed in the group "upper management" are both concerning challenges and factors that are impacted by, or are impacting, the upper management.

- CSF: KPIs support and reward the use of new technology

This CSF may be the most specific formulated CSF from the project-case findings. The researcher argues that the core of this factor, is that the management supports the use of new technology and products, and that the resources for the use of new products are available. From the project-cases, specifically project-case five, it is clear that the project managers are measured on operational KPIs, which has a negative impact on the willingness to use new technology, because of the risk involved. One of the CSFs on the list of CSFs for change management is "dedicated change management resources and funding" (Creasey*, et al.*, 2014). This CSF is considered supportive, as the project-case finding is depending on resources (as explained in 5.3.5), and the integration of new tools and equipment is considered a change, according to Murthy's (2007) definition.

Within the field of "projects" and "project implementation", none of the CSFs are considered supportive.

- CSF: Upper management support and trust

This CSF was detected in four of the five project-cases, which alone indicates that the significance of this factor is considerable. Established theories also support this factor, as explained below.

A CSF for "projects" is "leadership and team" (Westerveld, 2003). Even though this factor is vague and open for interpretation, it is the researcher's belief that the core of this CSF is similar to the finding from the project-cases.
For "project implementation", a CSF is "top management support" (Pinto and Slevin, 1987). The description of the *level* of management differs from the project-case findings, but the similarities are either way considerable, and the CSF is considered supportive of the project-case findings.

Creasey*, et al.* (2014) have detected "engagement with and support from middle management" as a CSF for change management. The *level* of management is described different, but the similarities are convincing, and this CSF is thus considered supportive.

Stakeholder management and personal characteristics
Two out of the four project-case findings placed in this group, are supported by CSFs from all the fields investigated in the literature review; "projects", "project implementation" and "change management".

- CSF: Early and continuous involvement of end-user

This factor is somewhat specific, and is also dependable on the ability to meet the other CSF in this group: openness and communication.
As previously discussed, are the CSFs for "projects" more general than the findings. However, the CSF "stakeholder management" for "projects" (Westerveld, 2003) is considered supportive, as an important part of stakeholder management is to focus on the relationship with interest groups, which in the later years also has been emphasized in the daily work (Huber, 2006).

For "project implementation", the CSFs "feedback capabilities" and "responsiveness to clients" (Pinto and Slevin, 1987) are determined supportive. The end-users can be considered as the customers for these projects, as it is the end-user that will use the product, although they do not pay for the product themselves.

"Employee engagement participation" is a CSF for "change management" (Creasey*, et al.*, 2014). This CSF is considered supportive of the finding, as the end-user in these projects also can be considered employees.

- CSF: Openness

This is one of the CSFs from the project-cases which is quite general and vague. "Openness" in this context is of significance for the relationships between the developer and the license-owner of the development projects, as well as internal in the companies. As elaborated in 5.3, the term "openness" is applicable and relevant for multiple situations, which enables it to be supported by multiple of the CSFs from literature:

Stakeholder management and project management, which are two CSFs determined for projects (Westerveld, 2003), both include "openness". Without some level of openness, it is difficult to achieve good relationships with the stakeholders (Huber, 2006). "Openness" can also be considered beneficial in order to conduct project management. Literature findings on CSFs for "projects" are thus considered supportive.

"Frequent and open communication channels" is a CSF within the field of change management (Creasey*, et al.*, 2014). The vocabulary used, "…open communication" emphasizes that "openness" is desirable, and this factor is thus considered supportive.

- CSF: Communication

This CSF from the project-case findings is considered supported by all CSFs within all three fields of interest.

CSFs for projects include “leadership and team” and “project management” (Westerveld, 2003). Neither of these include “communication” directly, but “communication” can be considered as a part of both “leadership and team” and “project management”. CSFs for “projects” are thus considered supportive.

Pinto and Slevin (1987) state that “adequate communication channels” and “feedback capabilities” are CSFs for “project implementation”. In this case, communication is mentioned directly, as well as “feedback capabilities” are dependent on communication.

For “change management”, Creasey*, et al.* (2014) classify “frequent and open communication about change and the need for change” as a CSF. This factor is considered supportive of the project-case finding.

- CSF: Training of end-user

This factor is more specific than the previously discussed factors. As experienced earlier, this may lead to less supportiveness from literature, as this specific case is not analyzed in depth previously.

However, from the list of CSFs for “change management”, the factor “employee engagement participation” is presented (Creasey*, et al.*, 2014). The CSF “training of end-user” is considered to have several similarities with employee engagement. Engaging, supporting and encouraging the end-users, which also are the employees going through a change, is considered important as elaborated in 5.3. Based on these arguments, the CSF from literature is considered supportive of the project-case finding.

7 Conclusions

RQ: *What are the critical success factors when introducing new tools and equipment in an oil service company?*

A list of 24 Critical Success Factors (CSFs) has been identified from five case-projects, as presented in Table 16. Because of the relatively small sample size, i.e. number of informants, results that are only supported by one informant are still defined as a part of the result. However, the part of the result that is emphasized the most, is the list of eight CSFs presented in Table 10. It was chosen to focus on these eight, as they all were supported by two or more of the project-cases. Triangulation, in the form of comparing these eight CSFs with established theories, is used to strengthen the significance of the most broadly supported findings.

On a general note, there seems to be a coherence between the CSFs for integration of new tools and equipment in oilfield service companies and the already established CSFs from literature. CSFs for projects, project implementation and change management were compared with the CSFs from the project case findings. All of the three fields seem to be highly relevant regarding integration of new tools and equipment, as multiple of the CSFs overlap in each case. It is worth noticing that the vocabulary used to describe the CSF in literature is less specific than for the findings in this report. It is natural to assume that this originates from the research question. The research question concerns a specific phase of a project, in a specific type of project in a specific type of industry. It is thus natural that the CSFs found will be more specific than factors for “projects” or “change management” themselves.

The CSF “dedicated and committed project manager” was detected in each and every one of the case projects. The results imply that dedication and commitment are more important characteristics for the project manager, than actual knowledge or other capabilities, which was mentioned by three of the informants. However, the numerical basis is not considered significant enough to include this as a final conclusion. All eight of the CSFs which was detected in two or more of the case-projects, are thus considered equally significant.

The relatively low number of case-projects analyzed has an impact on the validity of the results. Optimally, one should have 15 to 25 respondents in order to ensure the validity of the research

(Gripsrud, Olsson and Silkoset, 2010). Because of resource constraints, from both the researcher and the case company, 15-25 cases were out of reach. Other tactics were though applied to strengthen the validity and the reliability, as discussed in chapter 3.

"Active and visible executive sponsorship", which is a CSF found in change management literature, was not recognized in the findings from the case projects. One can argue that the vocabulary used in this CSF is different, and more theoretical, than the colloquially, and that could be part of the reason why this CSF is not found in any of the case projects. It is though worth mentioning that the interview objectives themselves have taken this responsibility, to be change management sponsors, even though it was not delegated to them by anyone. In the long run, it might be beneficial to officially assign one or more people as responsible for the change associated with integrating new tools and equipment. This could make the process more reliable and stable.

7.1 How the results should be applied for the integration of the OTS

Because this research was conducted in cooperation with a specific company, a short presentation has been created in order to convey the findings in a clear way to the key stakeholders in the company. The presentation covers how the findings from the research should be applied in the upcoming integration of the OTS. Some of the information from this summary is presented below, the rest is found in Appendix C.

For the two CSFs placed in the project management-group, the results imply the following:

- Based on the analysis, there seems to be somewhat unsystematic who is in charge of training and the other processes associated with integration of new products. Because the individuals who are the most involved in the projects are ***dedicated and committed***, they take care of tasks which are actually outside of their area of responsibility. One should acknowledge and accept that integration of new products does in fact require an organizational change, and one should thus facilitate this process.
- In order to keep ***knowledgeable and experienced project managers***, or other key stakeholders, motivated to work with integration of new products in the long run, their role should be clearly defined and appreciated. This is supported by research on change management specifically:
    - Dedicated change management resources and funding
    - Structured management approach

- Active and visible executive sponsorship

For CSFs related to upper management, the following is implied.

- It is a higher chance that delays will occur when using new tools and equipment for the first time, compared to well-tested products. As this will impact the KPIs of the department, it is fair to assume that managers will be reluctant to try out new products, when they have another option which is “safe”. At the same time, it is desirable that new products get running-time as well. A possible solution discovered throughout the interviews, is to implement a set of ***KPIs which support and reward the use of new products***. This would encourage project managers to adopt new technology in a faster rate.
- In four out of five of the project-cases, ***trust and support from upper management*** is mentioned as important for success of the new product implementation. This should thus be emphasized and focused on throughout the implementation. As trust is subjective and individual, it is challenging to determine a general approach to this factor.

And finally, for CSFs related to stakeholder management and personal characteristics, the following is implied.

- It is concluded that ***early and continuous involvement of the end-user, communication, training of end-users*** and ***communication*** all are important for implementation success. These CSFs are within the field of stakeholder management, and they are all connected and dependent on each other.
- The amount of **training of end-users**, however, is strongly dependent on the resources allocated for this purpose, so the road to taking advantage of this factor is more clear than for the other CSFs within the field of stakeholder management.
- **Communication**, **openness** and **involvement of the end-user** should be possible to conduct regardless of resources.

7.2 Suggestions for future research

The results in this report are based on the data derived from a total of five different project-cases, from two different companies. For future research, it is recommended that one extends the research described in this report, by investigating more projects. The additional projects should preferably also originate from different companies. With a wider basis of data, it is possible to further generalize the results, and the validity of the findings would also increase as the basis of data increases.

It is also recommended that some sort of quantitative research is conducted, in addition to the qualitative, or case-method, approach. This would further test the generalization and applicability of the identified CSFs. A quantitative approach could be achieved by e.g. conducting a survey.

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Appendix A: Case study protocol

This section aims to support the researcher throughout the investigations. The section includes a list and short description of the interviewees and the case projects, as well as the most general strategies and characteristics of data collection. The interview guide used during all five interviews is presented at the end of this section.

1 Data collection procedures

Interviewees and case projects

The table below briefly describes the background and experience of the informants for each project case, as well as where and when the interviews were taking place.

Informant	Informant 1	Informant 2	Informant 3	Informant 4	Informant 5
Company	Statoil Forskningssenter	Statoil Forskningssenter	Baker Hughes Norge AS	Baker Hughes Inteq GmbH	Baker Hughes Norge AS
Company location	Rotvoll, Trondheim, Norway	Rotvoll, Trondheim, Norway	Tananger, Sola, Norway	Celle, Lower Saxony, Germany	Tananger, Sola, Norway
Project-case	SureTrak Steerable Drilling Liner (SDL)	Casing and tubing lubricant	GaugePro Echo Underreamer	Mud-Pulse Telemetry	One-Trip System (OTS)
Title of interviewee	Principle Researcher	Researcher	Manager – Hole Enlargement (Casing/Liner Drilling Systems)	Director, Product Development (Drilling Systems)	Technical Advisor (Drilling systems)
Experience of interviewee	12 years of experience from Statoil 3 years' experience as field engineer abroad in another company	25 years of experience from Statoil 10 years' experience in operations, remaining years spent in research and development	12 years of experience from Baker Hughes Worked in Celle prior to joining the Norwegian office	25 years of experience in Baker Hughes	6 years of experience in Baker Hughes Worked in Celle prior to joining the Norwegian office
Interview date	27.03.2017	27.03.2017	31.03.2017	24.04.2017	31.03.2017
Location of interview	At the company's office	At the company's office	At the company's office	Video call from Baker Hughes Norge AS' office	At the company's office

Interview preparations and objective

The researcher, and interviewer, shall prepare for the interviews in such a matter so that:

1. The interviews are scheduled some time ahead, thus the interviewees have time to do eventual preparations
2. The interview guide is ready and sent to the interviewees a couple of days ahead of the interview
3. Obtain sufficient theoretical information in order to ask important follow-up questions

The following information should be obtained through the interviews:

1. Background information about the informant
2. An accurate and detailed description of the case project
3. The interviewees' thoughts on which factors that impacted the project outcome
4. Other relevant information

2 Interview guide

I. Structure of the interview

1. Introduction
2. Interviewee information
3. Description of a project similar to the implementation of OTS
4. Factors which impacted the project success

1. Introduction of the study

This interview is designed with the purpose of determining critical success factors for implementation of new tools and equipment in oil service companies. The interviewer is a student at the Norwegian University of Science and Technology, and is writing a master's thesis with the same purpose. The implementation of Baker Hughes' new OTS drilling liner is in focus in regards of the thesis, and is used as a practical case.

2. Interviewee information

1. Name
2. E-mail
3. Position
4. Years of employment in Baker Hughes/Statoil
5. Other relevant information

3. Description of a project similar to the implementation of OTS

Describe a project which you have been involved in, or one that you have sufficient knowledge about. The questions listed below should create the base of the project description, but other relevant information should also be mentioned.

1. What was the purpose of the project?
2. Why was the project initiated?
3. When was the project initiated? What was the duration of the project?
4. What was the approximate budget of the project?
5. What were the success criteria of the project?
    a. How were these criteria developed?
    b. How and when were these criteria enacted?
6. Who were important stakeholders in regards of the project?
    a. How did they impact the project?
    b. What were the interests of the different stakeholders?
    c. To what degree did the different stakeholders support the project?
7. Which risks did the initial risk assessment detect?
    a. How were these risks handled during the project?
8. Did the project experience any significant issues or problems?
    a. Mostly hard (e.g. equipment, technology) or soft (e.g. communication, commitment) issues?
    b. Which phase of the project?
    c. How was it handled and resolved?
    d. What was the final impact of the issue or problem?
9. What was the result of the project?
    a. Was the project considered a success?
    b. Did all major stakeholders agree on whether the project was a success?
    c. How would you summarize the project outcome?
        i. What was the actual impact compared to the planned/estimated impact?
10. Other relevant information about the project?
    a. Are there any other people I should talk to regarding the project?

4. Factors which impacted the project success

The following questions will cover the factors and barriers that contributed to, or prevented, project success.

Project and implementation

1. How was upper management involved in the project?
    a. How did the involvement, or lack of such, of upper management impact the project outcome?
2. How was the communication between the stakeholders? Did the communication impact the project outcome?
3. Were the allocated resources (time, people and funds) sufficient for the project execution?
    a. Would the project have a different outcome if the amount of resources was increased?
4. Were there any disagreements between the contracting parties of the project?
    a. How did it impact the project and its result?
    b. How were these issues solved?
    c. Did the contracting parties (and other major stakeholders) agree on the result of the project? I.e. was there any discussion about whether the criteria for success were met?
5. How did the management of this project influence the outcome?
    a. Why?
    b. Did the project manager (and/or other team members) receive feedback during the project? How did the feedback impact the project further?
    c. Regarding project management in this project, what would you consider the most important lesson learned?
6. Did all stakeholders agree on the objective and the goal of the project?
    a. If not, how did it influence the project?
    b. Did this change during any of the project phases?
7. How was the client engaged in the project?
    a. Was the project changed after wishes from the client?
    b. How did the client engagement influence the project?
8. Did you experience any technological challenges during the project?
    a. How were they solved and what was the final impact of these challenges?

Change management and training

9. Given that the project included a change (e.g. a new business process or new tools), who oversaw this change? How did this person manage the change?
10. Who other were involved in this change?
    a. To what degree did the employees participate in, and influenced, the change?
11. What caused the need for change?
    a. Who initiated the change process?
    b. How were the employees informed about the change?
    c. How did the employees respond to the change initiative?
12. How were the employees trained and educated in case the change implied new duties and responsibilities in their daily work?
13. Were the employees rewarded for taking part in the change? I.e. utilizing new tools (equipment or IT-solutions), actively training/educating themselves etc.?
14. How was the feedback from the employees regarding the change?
    a. Did they feel they had the skills and knowledge required to handle the new tasks?
15. Which personal factors would you consider important in a change process? I.e. honesty, openness, trust etc.
    a. How would you rank the importance of these personal characteristics compared to technical and/or commercial factors?

General

16. If you were to pick one factor that in your opinion was critical for project success, what would that be? Now consider the opposite: Which factor could solely prevent project success?
17. What has this project thought you about leadership?
18. Why do you think this project succeeded/failed?
19. What would you consider as the most important lesson learned from this project?

Håkon A. Ystenæs
The Norwegian University of Science and Technology
E: haakonay@gmail.com
P: +47 48 470 470

Appendix B: Technical terms

This appendix consists of definitions of technical terms and oilfield-specific vocabulary used throughout the report. This is included to enable the reader without knowledge from the industry to understand each of the case-projects. All of the definitions presented is gathered from the "Schlumberger Oilfield Glossary" online (Ramsey, *et al.*).

Bottom hole assembly

The lower portion of the drillstring, consisting of (from the bottom up in a vertical well) the bit, bit sub, a mud motor (in certain cases), stabilizers, drill collar, heavy-weight drillpipe, jarring devices ("jars") and crossovers for various threadforms. The bottomhole assembly must provide force for the bit to break the rock (weight on bit), survive a hostile mechanical environment and provide the driller with directional control of the well. Oftentimes the assembly includes a mud motor, directional drilling and measuring equipment, measurements-while-drilling tools, logging-while-drilling tools and other specialized devices. A simple BHA consisting of a bit, various crossovers, and drill collars may be relatively inexpensive (less than $100,000 US in 1999), while a complex one may cost ten or more times that amount.

Casing

Large-diameter pipe lowered into an openhole and cemented in place. The well designer must design casing to withstand a variety of forces, such as collapse, burst, and tensile failure, as well as chemically aggressive brines. Most casing joints are fabricated with male threads on each end, and short-length casing couplings with female threads are used to join the individual joints of casing together, or joints of casing may be fabricated with male threads on one end and female threads on the other. Casing is run to protect fresh water formations, isolate a zone of lost returns or isolate formations with significantly different pressure gradients. The operation during which the casing is put into the wellbore is commonly called "running pipe." Casing is usually manufactured from plain carbon steel that is heat-treated to varying strengths, but may be specially fabricated of stainless steel, aluminum, titanium, fiberglass and other materials.

Cementing

To prepare and pump cement into place in a wellbore. Cementing operations may be undertaken to seal the annulus after a casing string has been run, to seal a lost circulation zone, to set a plug in an existing well from which to push off with directional tools or to plug a well so that it may be abandoned. Before cementing operations commence, engineers determine the volume of cement (commonly with the help of a caliper log) to be placed in the wellbore and the physical properties of both the slurry and the set cement needed, including density and viscosity. A cementing crew uses special mixers and pumps to displace drilling fluids and place cement in the wellbore.

Dope

Pipe dope, a specially formulated blend of lubricating grease and fine metallic particles that prevents thread galling (a particular form of metal-to-metal damage) and seals the roots or void spaces of threads. The American Petroleum Institute (API) specifies properties of pipe dope, including its coefficient of friction. The rig crew applies copious amounts of pipe dope to the drillpipe tool joints every time a connection is made.

(Drilling) Liner

A casing string that does not extend to the top of the wellbore, but instead is anchored or suspended from inside the bottom of the previous casing string. There is no difference between the casing joints themselves. The advantage to the well designer of a liner is a substantial savings in steel, and therefore capital costs. To save casing, however, additional tools and risk are involved. The well designer must trade off the additional tools, complexities and risks against the potential capital savings when deciding whether to design for a liner or a casing string that goes all the way to the top of the well (a "long string"). The liner can be fitted with special components so that it can be connected to the surface at a later time if need be.

Logging while drilling

The measurement of formation properties during the excavation of the hole, or shortly thereafter, through the use of tools integrated into the bottomhole assembly. LWD, while sometimes risky and expensive, has the advantage of measuring properties of a formation before drilling fluids invade deeply. Further, many wellbores prove to be difficult or even impossible to measure with conventional wireline tools, especially highly deviated wells. In these situations, the LWD measurement ensures that some measurement of the subsurface is captured in the event that wireline operations are not possible. Timely LWD data can also be used to guide well placement so that the wellbore remains within the zone of interest or in the most productive portion of a reservoir, such as in highly variable shale reservoirs.

Measurement while drilling

The evaluation of physical properties, usually including pressure, temperature and wellbore trajectory in three-dimensional space, while extending a wellbore. MWD is now standard practice in offshore directional wells, where the tool cost is offset by rig time and wellbore stability considerations if other tools are used. The measurements are made downhole, stored in solid-state memory for some time and later transmitted to the surface. Data transmission methods vary from company to company, but usually involve digitally encoding data and transmitting to the surface as pressure pulses in the mud system. These pressures may be positive, negative or continuous sine waves. Some MWD tools have the ability to store the measurements for later retrieval with wireline or when the tool is tripped out of the hole if the data transmission link fails. MWD tools that measure formation parameters (resistivity, porosity, sonic velocity, gamma ray) are referred to as logging-while-drilling (LWD) tools. LWD tools use similar data storage and transmission systems, with some having more solid-state memory to provide higher resolution logs after the tool is tripped out than is possible with the relatively low bandwidth, mud-pulse data transmission system.

Mud-Pulse Telemetry

A method of transmitting LWD and MWD data acquired downhole to the surface, using pressure pulses in the mud system. The measurements are usually converted into an amplitude- or frequency-modulated pattern of mud pulses. The same telemetry system is used to transmit commands from the surface.

Packer

A device that can be run into a wellbore with a smaller initial outside diameter that then expands externally to seal the wellbore. Packers employ flexible, elastomeric elements that expand. The two most common forms are the production or test packer and the inflatable packer. The expansion of the former may be accomplished by squeezing the elastomeric elements (somewhat doughnut shaped) between two plates, forcing the sides to bulge outward. The expansion of the latter is accomplished by pumping a fluid into a bladder, in much the same fashion as a balloon, but having more robust construction. Production or test packers may be set in cased holes and inflatable packers are used in open or cased holes. They may be run on wireline, pipe or coiled tubing. Some packers are designed to be removable, while others are permanent. Permanent packers are constructed of materials that are easy to drill or mill out.

Tubing

A wellbore tubular used to produce reservoir fluids. Production tubing is assembled with other completion components to make up the production string. The production tubing selected for any completion should be compatible with the wellbore geometry, reservoir production characteristics and the reservoir fluids.

Underream

To enlarge a wellbore past its original drilled size. Underreaming is sometimes done for safety or efficiency reasons. Some well planners believe it is safer to drill unknown shallow formations with a small-diameter bit, and if no gas is encountered, to then enlarge the pilot hole. An underreaming operation may also be done if a small additional amount of annular space is desired, as might be the case in running a liner if surge pressures were problematic.

Appendix C: Executive summary presentation

Content

- Project background
- The challenge
- Intimations from established research
- Findings from the project-cases
- Conclusion
- Implication of results

1. Project background

- **The author**
  - …of the report studies for a master's degree in Project Management at Norwegian University of Technology (NTNU).
- **The study**
  - …and the associated report is a diploma written as part of a master's program at the NTNU.
  - …aims to propose a set of critical success factors (CSFs) for integration of new tools and equipment in oilfield service companies. To make sure the findings are of high relevance and feasible for real-life applications, relevant project-cases are analyzed.
  - …was initiated after the author reached out to Baker Hughes. The field of study was decided after wishes from the contact person in Baker Hughes as well as the university supervisor.

2. Intimations from established research

- Established research indicates that there are some specific *factors* that, if followed by the project and its stakeholders, may increase the likelihood of a successful project.
- Some studies examine CSFs for projects in general, while others look at specific project types, such as product development, IT and implementation projects.
- In this study, the established research for CSFs regarding (1) projects in general, (2) the implementation phase of projects, and (3) change management, are examined
- These fields are detected as the most relevant in relation to the research question. Results from a conducted literature review are presented in the tables on the following slide.

2. Intimations from established research (continued)

(1) Critical success factors for projects in general

Leadership and team
Policy and strategy
Stakeholder management
Resources
Contracting
Project management
Success criteria
External factors

(2) Critical success factors for the implementation phase of projects

Leadership and team
Policy and strategy
Stakeholder management
Resources
Contracting
Project management
Success criteria
External factors

(3) Critical success factors for change management

Active and visible executive sponsorship
Structured management approach
Dedicated change management resources and funding
Frequent and open communication about change and need for change
Employee engagement participation
Engagement and integration with project management
Engagement with and support from middle management

3. Findings from the project-cases

Five project-cases were analyzed throughout the research period. All of these case-projects have similar features as the OTS project, as they all relate to the integration and implementation of new products. The final list of CSFs is presented in the table below.

Project management	
	Knowledgeable and experienced project manager
	Dedicated and committed project manager
Upper management	
	KPIs support and reward use of new products
	Upper management support and trust
Stakeholder management and personnal characteristics	
	Early and continuous involvement of end-user
	Openness
	Communication
	Training of end-user

In total, 24 CSFs were detected. Factors detected in only one of the case-projects are excluded from the list presented above, in order to increase the validity and generality of the final result. All of the factors are presented on the following slide.

The table to the right illustrates which, and how many, of the case-projects that support each of the CSFs detected. The case-projects are numbered 1 to 5 in the diploma, which is what "case numbers" in the table refers to.

Critical success factors	*Supported by case number* 1	2	3	4	5
Project management					
Knowledgeable and experienced project manager	✓	✓		✓	
Dedicated and committed project manager	✓	✓	✓	✓	✓
Persuade capabilities of project manager	✓				
Project manager stays with the project until the first-use phase is completed	✓				
Create a general positive mindset regarding new products	✓				
Expect challenges during the first runs – be prepared			✓		
Upper management					
KPIs support and reward use of new products	✓				✓
Upper management must value learning and knowledge				✓	
Upper management support and trust	✓	✓	✓	✓	
Contracting and documentation					
Requirements and agreements in written form		✓			
Scope of requirements-document is precise and complete					✓
Contracts are developed on a local level			✓		
A checklist/training document created by a team of people with first-hand experience with the new product				✓	
Stakeholder management and personnal characteristics					
Early and continuous involvement of end-user	✓	✓	✓		
Personal relationships			✓		
Openness	✓	✓			
Communication	✓	✓			
Training of end-user	✓				✓
Users should have a positive first interaction with the product			✓		
Organization					
First commercial runs should be easy jobs					✓
Local offices should have the opportunity to rent the product from the global organization, without acquiring the product as an asset					✓
Official event where everybody in the organization is informed when new products are implemented			✓		
Testing					
Test new technology where it is easy and affordable				✓	
Satisfactory amount of test time					✓

4. Conclusions

- On a general note, there seems to be a correspondence between the CSFs for integration of new tools and equipment in oilfield service companies and the already established CSFs from literature.
- CSFs for projects, project implementation and change management all seem to be highly relevant regarding integration of new tools and equipment.
- Because of the relatively low sample size, i.e. number of project-cases analyzed, the report does not conclude on the importance of the CSFs relatively to each other; all of the eight CSFs presented in the final table are considered equally important.
- One should also be aware of the CSFs which were mentioned in only one of the project-cases (again, the sample size is not significant enough to ignore any of the findings)

5. Implication of the results: *How the results should be used in regards of the integration of OTS*

(1) Project management

- Based on the analysis of the project-cases, there seems to be somewhat unsystematic who is in charge of training and the other processes associated with integration of new products. Because the individuals who are the most involved in the projects are ***dedicated and committed***, they take care of tasks which are actually outside of their area of responsibility. One should acknowledge and accept that integration of new products does in fact require an organizational change, and one should thus facilitate this process.
- In order to keep ***knowledgeable and experienced project managers***, or other key stakeholders, motivated to work with integration of new products in the long run, their role should be clearly defined and appreciated. This is supported by research on change management specifically:
  - Dedicated change management resources and funding
  - Structured management approach
  - Active and visible executive sponsorship

5. Implication of the results

(2) Upper management

- It is a higher chance that delays will occur when using new tools and equipment for the first time, compared to well-tested products. As this will impact the KPIs of the department, it is fair to assume that managers will be reluctant to try out new products, when they have another option which is "safe". At the same time, it is desirable that new products get running-time as well. A possible solution discovered throughout the interviews, is to implement a set of ***KPIs which support and reward the use of new products***. This would encourage project managers to adopt new technology in a faster rate.
- In four out of five of the project-cases, ***trust and support from upper management*** is mentioned as important for success of the new product implementation. This should thus be emphasized and focused on throughout the implementation. As trust is subjective and individual, it is challenging to determine a general approach to this factor.

5. Implication of the results

(3) Stakeholder management and personal characteristics

- It is concluded that ***early and continuous involvement of the end-user, communication, training of end-users*** and ***communication*** all are important for implementation success. These CSFs are within the field of stakeholder management, and they are all connected together and dependent on each other.
- The amount of **training of end-users**, however, is strongly dependent on the resources allocated for this purpose, so the road to taking advantage of this factor is more clear than for the other CSFs within the field of stakeholder management.
- **Communication**, **openness** and **involvement of the end-user** should be possible to conduct regardless of resources.