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Communication in Building Design Management

A Comparative Study of Norway and Germany

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<p>Abstract:</p> <p>First-rate communication between design and construction site teams is imperative for the successful completion of architecture, engineering and construction projects (AEC). Still, research carried out in the Norwegian and the German industry has identified a lack of literature and qualitative research in this area. Equally, there seems to be a tendency to underestimate the correlation between communication and effectivity in most construction projects.</p> <p>This thesis aims to 1) examine how communication takes place between design and construction site teams, 2) explore the challenges of communication in the interface between design and construction and 3) extract what the Norwegian and the German construction industry can learn from each other. By addressing factors affecting communication, reasons for communication, communication networks and future needs in a comparative way, the study permits for an identification of challenges and lessons learnt. In addition to an extensive literature review and a document study, in-depth interviews were carried out according to a qualitative approach. 20 interviews in Norway (9) and Germany (11) were undertaken with key actors from different management levels in the project organisation, including representatives from design and construction site teams.</p> <p>Although limited to the cases investigated, the findings imply that there is a need for a better understanding of communication both in Norway and in Germany, and also suggest that there is a lack of effective communication both in the Norwegian industry and in other European countries. Additionally, the research revealed that there is a lack of knowledge and training in use and implementation of information and communication technology tools and team frameworks in both countries. The study contributes to increasing the awareness of a range of communication challenges, and thus has the potential of increasing AEC practitioners' and academics' understanding of communication challenges between design and construction site teams so that efficient strategies can be developed for meeting such challenges in the future.</p>

Keywords:

1. Communication
2. Design
3. Production
4. Collaboration
5. Flow

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PART 1: THE MASTER'S THESIS REPORT

PREFACE

This master's thesis was constituted during the spring of 2016 at the department for Civil and Transport Engineering (BAT) of the Norwegian University of Science and Technology (NTNU), Norway. The work was conducted within the program area of Construction Management in collaboration with the RheinMain University of Applied Sciences, Germany. The thesis corresponds to 30 credits and constitutes the final semester of the five-year master's degree program in Civil and Environmental Engineering.

The background for the work is a specialisation project in TBA4531 Project Management during my autumn of 2015 and summer internships in Backe Vestfold-Telemark (2013, 2014, 2015), where I gained interest in the topic and became aware of the importance of communication in contemporary construction. The aim of this thesis is to contribute to a better understanding of communication flow within building design teams and thereby facilitate the development of a more efficient construction process.

Differing from a traditional master's thesis at the BAT department, this document consists of 1) a master's thesis report, 2) an academic paper and 3) appendices. Combined, these three parts correspond to a traditional master's thesis. The master's thesis report aims to bridge the gap between this form of master's thesis and a traditional thesis. The report seeks to provide a meta-perspective on the work of the academic paper, which is written as a contribution to the 24th Annual Conference of the International Group for Lean Construction in Boston, USA, July 2016. The thesis is written in English because this made it possible for me to receive help from my supervisors both in Norway and in Germany. Furthermore, the same layout is used for both the academic paper and the master's thesis report. This layout is regulated by the International Group for Lean Construction (IGLC).

First and foremost, I would like to extend a big thank to my supervisors Ola Lædre, Fredrik Svalestuen and Jardar Lohne. Without your wise thoughts, ideas and support this thesis would have ended up differently. Secondly, I would like to thank Professor Stefan Plaum. I am grateful for your valuable advice and feedback. Moreover, I would like to thank the interviewees from Backe Vestfold-Telemark, Brömer & Sohn, Hochtief and Goldbeck. Without your passionate participation and inputs, this research would never have materialised in the first place. Many thanks also to Lene Nordrum for proof-reading. Finally, I must express my very profound gratitude to my family and to Marc for providing me with endless support and encouragements throughout the process of writing this thesis and in my life in general.

It always seems impossible until its done.

Nelson Mandela

Wiesbaden, June 2016

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SUMMARY

In contemporary construction, first-rate communication is arguably the one aspect that pervades all others. Without it, architecture, engineering and construction (AEC) teams cannot succeed in realising their objectives. Simultaneously, there is a growing realisation that lack of effective communication is one of the main reasons for many of the challenges currently threatening the efficiency of the AEC industry.

Theory abounds on how to communicate more effectively in organisations, and a number of different approaches and techniques have been successfully applied to other sectors. However, due to the complexity and dynamism that exists in the industry's project-based structure, a majority of these approaches are difficult to implement in AEC organisations. In spite of this, there appears to be very little evidence of theoretical and applied research focusing on communication within AEC teams. The literature further indicates that the main research challenges in this area is associated with access to data from live projects.

A pilot study by the author conducted during the autumn of 2015 showed that poor and missing communication cause many problems in the Norwegian AEC industry. Hence, a comparative method was chosen to see what (if anything) can be learned from Germany as one of the world's largest construction markets. The main objective of the current study is thus to increase knowledge about, and understanding of, communication in the design-construction interface by a comparison of different factors affecting communication, communication networks, communication channels and future needs in Norwegian and German AEC teams.

The method is qualitative and based on mixed empirical material that was gathered through an extensive literature review, a study of internal documents and semi-structured, in-depth interviews. The literature review provided the foundation for the identification of general communication success factors and issues. Moreover, it allowed the identification of knowledge gaps. 20 interviews in Norway (9) and Germany (11) were undertaken. By interviewing key actors from different management levels in the project organisation, different perspectives were accounted for. A document study was conducted to obtain a deeper understanding of the six cases.

Although limited to the cases investigated, the findings imply that there is a need for a better understanding of communication both in Norway and in Germany, and also suggest that there is a lack of effective communication both in the Norwegian industry and in other European countries. Additionally, the research revealed that there is a lack of knowledge and training in use and implementation of information and communication technology tools and team frameworks in both countries. The study contributes to increasing the awareness of a range of communication challenges, and thus has the potential of increasing AEC practitioners' and academics' understanding of communication challenges between design and construction site teams so that efficient strategies can be developed for meeting such challenges in the future.

This master's thesis consists of 1) a master's thesis report that seeks to provide a meta-perspective of the academic paper, 2) the academic paper and 3) appendices. The research

work carried out is published as a conference paper from the 24th Annual Conference of the International Group for Lean Construction.

SAMMENDRAG

Effektiv kommunikasjon mellom individer, grupper og organisasjoner er en avgjørende faktor i dagens byggeindustri. Manglende eller dårlig kommunikasjon gjør det vanskelig for prosjektteam å oppnå felles mål og å levere et vellykket produkt. Blant både akademikere og praktikere er det en økende erkjennelse av at mangel på effektiv kommunikasjon truer effektiviteten av bygg- og anleggsarbeider. Likevel er fokuset på kommunikasjon ofte fraværende eller sterkt nedtonet i prosjektorganisasjoner.

I organisasjonsteorien florerer det av ulike metoder og teknikker som skal sikre effektiv kommunikasjon innad i en organisasjon. Flere har blitt implementert på en vellykket måte i andre sektorer. Dessverre anses mange av prinsippene som lite overførbare til byggeprosjekter. Årsaken til dette sies ofte å være kompleksiteten og dynamikken som eksisterer i bransjens prosjektbaserte struktur. Det finnes lite bevis for teoretisk og anvendt forskning på kommunikasjon i byggeprosjekter. Litteraturen indikerer samtidig at de største utfordringene for forskning på dette området er knyttet til tilgangen på førstehånds data fra aktuelle prosjekter.

En pilotstudie fra høsten 2015 som fungerte som opptakt for foreliggende studie, viste at manglende eller dårlig kommunikasjon er årsaken til mange av problemene i norsk byggeindustri. Et tydelig mål for masterprosjektet er å øke kunnskap om, og forståelsen for, kommunikasjon og kommunikasjonsproblemer i grensesnittet mellom prosjektering og produksjon. En komparativ tilnærming ble derfor valgt for masterprosjektet, for å undersøke hva som kan læres av Tyskland som er dominerende både på det Europeiske og det internasjonale bygg- og anleggsmarkedet. Gjennom en komparativ behandling av ulike faktorer som påvirker kommunikasjon, årsaker til kommunikasjon, kommunikasjonskanaler, kommunikasjonsnettverk og fremtidige behov, søker forskningsarbeidet å øke kunnskap om og forståelsen for kommunikasjon i grensesnittet mellom prosjektering og produksjon.

Det empiriske materialet er hentet fra et omfattende litteraturstudie, en studie av interne dokumenter og halvstrukturerte dybdeintervju. Tilnærmingen til forskningsspørsmålene er basert på kvalitative metoder. Litteraturstudiet ga grunnlag for en identifisering av kunnskapshull. Videre ble studiet brukt til å kartlegge suksessfaktorer og problemområder knyttet til kommunikasjon i grensesnittet mellom prosjektering og produksjon. Det ble gjennomført totalt 20 intervjuer i Norge (9) og Tyskland (11). Ved å intervju sentrale aktører fra forskjellige nivåer i organisasjonen ble ulike perspektiver gjort rede for. Et dokumentstudie ble gjennomført for å sikre en dypere forståelse for de utvalgte casene.

Studiets begrensede utvalg reduserer generaliserbarheten av arbeidets resultater. Likevel gis det klare indikasjoner på at det er et behov for en bedre forståelse av kommunikasjon både i Tyskland og i Norge. Forskningen gir således bevis på at kommunikasjon ikke bare skaper problemer i norsk industri men også i andre europeiske land. Samtidig avdekket arbeidet mangel på kunnskap om, og opplæring i, bruk av teknologiske verktøy og grunnleggende prinsipper om teamarbeid. Ved å øke bevisstheten rundt problemene som eksisterer i dagens byggeindustri, kan denne studien bidra til økt effektivitet i grensesnittet mellom prosjektering og produksjon.

Forskningsarbeidet danner grunnlaget for en vitenskapelig artikkel til konferansen 24th Annual Conference of the International Group for Lean Construction. Masteroppgaven består av 1) en masteroppgaverapport som gir et metaperspektiv på arbeidet med den vitenskapelige artikkelen, 2) en vitenskapelig artikkel og 3) vedlegg.

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1 INTRODUCTION

This first chapter introduces the reader to the background and research problem of this thesis. It also explains the purpose, delimitations and clarifications of the work.

1.1 BACKGROUND

It is a common apprehension that the overall performance of the architecture, engineering and construction (AEC) industry has declined compared to that of other industries (Egan 1998; Love and Li 2000). This is typically considered a result of the industry's increased complexity and rapid growth, in response to the more rigid environmental, financial and social goals of its stakeholders (Grey and Hughes 2001). A major challenge in modern construction seems to be the lack of integration and effective communication between design and construction site teams. Even when participants make a significant effort to work together, communication difficulties occur (Pietroforte 1997). Such problems tend to hinder cooperation and learning between actors. Further, it is also observed that problems in the design phase, such as poor design quality or lack of constructability, often cause problems on site (Alarcón and Mardones 1998). This influences the whole project negatively, in terms of increased costs and reduced productivity (Baldwin et al. 1999). In this vein, an improvement of the communication taking place in the interface between design and construction is considered crucial for enhancing the total industry efficiency.

A number of researchers have emphasised the importance of effective communication as a means to overcome the problems of the contemporary AEC industry (e.g. Ballard and Koskela 1998; Bowen and Edwards 1996; Dainty et al. 2006; Grey and Hughes 2001). Wikforss and Löfgren (2007) stress the need for rapid access to information and real-time communication in both design and construction processes in order to achieve project success. In building design, this is especially important (and difficult) because this phase includes several mutually-dependent decisions. Moreover, Flager et al. (2009) show that members of the design team spend as much as 58% of their time on managing information. With a more efficient information management system, this time can be reduced and used in more value-creating activities. One such activity is the TFV (Transformation-Flow-Value) concept in construction forwarded by Koskela (2000). The aspect of flow has generally been neglected in traditional production management and this also applies to the flow of information. Nonetheless, as construction processes rely on accurate and timely information, it should be clear that information flow drastically affects all other resource flows. Furthermore, the flow view aims to reduce waste in construction processes and is therefore necessary to manage from a Lean perspective.

However, despite the wide acknowledgement of communication as one of the main challenges in construction, little progress has been made towards improving communication effectiveness in project teams. One of the main reasons for this seems to be the relatively late application of the sociological sciences in construction management research (Emmitt and Gorse 2003). Also, within the field of Lean Construction, work tend to focus on "hard" process tools. Softer issues concerned with how people interact and work together as a team has generally received less attention.

The literature review revealed a gap between the current knowledge of team communication and how this is practiced in AEC projects. However, there is a growing recognition of the necessity to understand the needs of the individuals and how they communicate within project teams in order to increase communication effectivity (Emmitt and Gorse 2007). Since the early work of Tavistock Institute in *The Communications in the Building Industry: the Report of a Pilot Study* (Higgin and Jessop 1965), qualitative and quantitative research is scarce in this area. Thus, as a first step toward understanding and solving current communication problems in the AEC industry, this study conducts applied research and collects first-hand data.

1.2 RESEARCH PROBLEM

In view of the discussion above, the research problem was divided into the following three research questions:

- *How does communication take place between design and construction teams?*
- *What communication challenges exist in the interface between design and construction?*
- *What can the Norwegian AEC industry learn from communication in the design-construction interface in the German industry and conversely?*

The two first research questions are based on a pilot study conducted by the author during the autumn of 2015. This research work showed that poor and missing communication caused many problems in the Norwegian AEC industry. Therefore, a comparative method was chosen to see what, if anything, can be learnt from Germany as one of the world's largest construction markets.

1.3 PURPOSE

The purpose of this thesis is two-fold: first to highlight communication as one of the most important factors when optimising the design phase, and, second, to compare the German and Norwegian industries in order to see what these countries can learn from each other in terms of communication between design and construction site teams.

1.4 DELIMITATIONS

For reasons of scope, some delimitations were necessary. The delimitations are presented in sections 1.4.1, 1.4.2 and 1.4.3 below.

1.4.1 Delimited to AEC projects

The study is delimited to the rules and standards used in AEC projects. These differ from those traditionally used in other types of projects. An inclusion of other types of projects would not be possible within the scope of the project. However, many of the findings are regarded as transferable to other types of projects.

1.4.2 Delimited to building design in the interface towards construction

A construction project is a large and complex process. The research is therefore delimited to focus on communication in building design, with a special focus on the interaction that takes place in the interface towards construction teams.

Representatives from both the design- and the construction teams have been interviewed, but since most of the interviewees belong to the design team member group – focus is primarily on this group.

1.4.3 Delimited to German and Norwegian projects

For reasons of scope, this thesis focuses on a comparison of the German and the Norwegian AEC industry. Findings from the Norwegian and the German AEC industry may differ from those of other countries, for example because of variations in laws, regulations and work traditions. However, since there also are several similarities between the German/Norwegian AEC industry and the AEC industry in other countries, many its conclusions can likely be generalised to AEC projects in other countries.

1.5 THESIS OUTLINE

The master's thesis report is divided into the following six sections:

Chapter 1 Introduction

Elaborates on the background for the chosen topic, research questions and purpose, and describes the delimitations of the study.

Chapter 2 Research methodology

Provides a detailed description of the methodological approach used in the research work and highlights the methodological issues encountered by the researcher.

Chapter 3 Theoretical framework

Gives an introduction to the key concepts necessary to discuss and answer the research questions, as well as a critique of the literature on the different research areas.

Chapter 4 Findings and discussion

Presents and discusses the findings of the comparative study of the Norwegian and the German AEC industry.

Chapter 5 Conclusions

Concludes and summarises the result of the research work.

Chapter 6 Further research areas

Discusses and proposes possible directions for future research.

2 RESEARCH METHODOLOGY

This chapter presents the methodological approach used in this study. It gives an insight into the reasoning behind the methodological approach and the methods for collecting data. Additionally, it highlights the methodological issues encountered by the researcher. Parts of the chapter are taken from the specialisation project conducted during the autumn of 2015. This pilot study forms the foundation for the work carried out with the thesis. Hence, many of the same approaches are also used in further work.

2.1 THE RESEARCH STRATEGY

A scientific method is the systematic process of acquiring knowledge. The method explains how the work is carried out to answer the research questions (Olsson 2011). Depending on the nature of the problem statement and the desired data, different approaches toward the data collection can be taken. The different methods have various strengths and weaknesses depending on their purpose and the context in which they are used. Moreover, they place different demands on time, resources and the researcher's experience. Thus, for each research project, one has to identify the method(s) best suited to provide the most appropriate information, as well as what is doable in practice (Dalland 2000).

2.1.1 Qualitative versus quantitative methods

Qualitative methods are used to collect and process qualitative data. Qualitative data is often in a form that are hard to measure in numbers, for example statements, descriptions or observations (Dalland 2000). This type of research is known for its strength in creating an in-depth, comprehensive understanding of an issue (Dalland 2000). A qualitative study is beneficial when the researcher intends to examine issues about which one has little prior knowledge, or when the researcher collects extensive information about a few objects only. It is the range and variety of data that makes it possible to perform in-depth studies using this method. Qualitative information is typically difficult to verify. It is therefore especially important to emphasise reliability in this type of research. Moreover, qualitative data may be more vulnerable to subjective interpretations than quantitative data.

Quantitative methods are used to collect and process quantitative data. Quantitative data is typically based on numbers and give limited information about a wide range of objects. This type of research is often preferred when the aim is to generalise or clarify an issue. When conducted correctly, quantitative methods are easy to verify. The results of quantitative studies are typically presented in tables, graphs and statistics.

A researcher can use qualitative or quantitative methods, or a combination of both, in order to approach a problem statement. A combination of elements from both methods is often beneficial. For example, qualitative data can contribute to ensuring the quality of quantitative results, whereas quantitative data can be used to corroborate results from qualitative research. Additionally, by combining the two methodologies, the researcher attains cross-validation. An important note is that qualitative and quantitative methods should work complementary, meaning that the methods should render corresponding results. When this is not the case, the researcher should be suspicious.

The aim of this study is to gain an overview of how communication takes place between the design and construction site teams, as well as the different challenges and opportunities

that exists in this area. A holistic, in-depth understanding of the situation is considered most important. Hence, a qualitative approach is appropriate. Moreover, qualitative methods are suited for study of issues where there is little prior research and where it is of particular interest to have a certain degree of openness and flexibility (Thagaard 2009). This criterion applies to the present study. As explained in the introduction: communication in building design management is still a relatively untouched area, despite the common understanding that improved communication will result in more efficient projects.

A combination of qualitative and quantitative methods could have been applicable to this study, for example by using quantitative methods to confirm or debunk the results from the qualitative study. However, for reasons of time and scope, a purely qualitative approach was decided on.

2.1.2 Inductive versus deductive reasoning

In logic, two methods are used to arrive at a conclusion assumed to be true: inductive and deductive reasoning. Inductive reasoning involves collecting data and then see what patterns or meanings that can be extracted from these. Hence, an inductive approach implies that the researcher makes generalisations from specific observations or moves from data to theory. On the other hand, when a researcher uses a deductive approach, the goal is to find evidence that supports or dismisses an existing theory or hypothesis. Deductive thinking typically involves going from the theory to data, or from general to specific. One can say that inductive research seeks to establish new theory, while deductive research seeks to develop theory (Thagaard 2009).

In this study, a combination of an inductive and a deductive research approach has been used. During the autumn of 2015, a literature review was conducted which was used to establish the research questions of this study. Through qualitative research, these questions were answered and new hypotheses were formed. These can be further tested through quantitative research in order to weed out incorrect assumptions and move closer to a complete understanding of the role of communication in AEC projects.

2.1.3 Triangulating multiple sources of evidence

Three data collection methods were used. An overview of already existing knowledge was established through 1) a literature study. Thereafter, the current situation was examined directly by the use of a multiple-case study approach including 2) in-depth, semi-structured interviews and 3) a document study. Accordingly, the same research questions were answered by the use of three different methods. Yin (2014) states that a triangulation of methods helps strengthen findings and allows a more credible and accurate conclusion.

2.1.4 Evaluation of methods

There are two requirements for the quality of data collected in a research process: reliability and validity (Holme and Solvang 1991). In order to obtain credible results in scientific research, an insight into these two concepts is vital.

The term *validity* concerns the relationship between the data collected and how well these illustrate the research questions investigated. A high validity implies that there is consistency between reality and interpretation, and also that the data is highly relevant for the study in question.

Reliability is related to the research's reliability and verifiability. Reliability is often used about the consistency and stability of measurements. This means that if the same measurement is carried out several times, it should give the same results each time. In order for a method to have high reliability, research must be carried out correctly and potential margins of error must be accounted for (Dalland 2000).

2.2 THE RESEARCH DESIGN

The comparative analysis presented in this master's thesis is based on a multiple case study approach, including an extensive literature review, a study of internal documents and semi-structured, in-depth interviews. The literature review examines the theoretical foundation for the research paper and the thesis. The use of the other methods concerns collection of empirical data. The research methods are described in the following sections.

2.2.1 Multiple case study research

Justification for choice

Case study research is appropriate for gaining context-dependent knowledge about complex issues (Flyvbjerg 2006) and has several advantages. This type of research gives inspiration and makes important contributions to further work (Olsson 2011). Furthermore, it allows for extracting comprehensive information about yet relatively untouched issues. Whether one should use a case study approach depends on the nature of the research questions. When "how" or "why" questions are being asked about a contemporary set of events over which a researcher has little or no control, a case study is generally considered the most suitable choice (Yin 2014). In this thesis, the research questions and the complexity of the topic favoured a case study approach. In addition, since past research on communication in building design management is limited, it would have been difficult to conduct a more generic survey.

The aim of this study was to perform a comparative analysis of the Norwegian and the German construction industry. Therefore, the use of a multiple case design was considered decisive for its successful completion. As Yin (2014) underlines, when a researcher has the choice and resources, multiple case designs are preferred over single case designs, because they generally are considered more robust.

The choice of cases

Six cases have been studied in this research: three in Norway and three in Germany. The cases in the Norwegian industry were provided by Backe Vestfold Telemark AS former Buer Entreprenør AS, currently one of the largest contractors in the eastern parts of Norway. These cases were selected based on the researcher's personal-knowledge of the company, attained through several internships between 2013 and 2015. The projects included one residential and two industrial projects, all based on the design-build (DB) delivery method.

The German cases were chosen in order to gain better insight into general trends of common industry practice, as this appeared as a shortcoming in the Norwegian cases. Therefore, three cases from three *different* companies were selected in the German industry. The first company, Hochtief GmbH, is a large company with a strong tradition in Germany, currently operating both nationally and internationally. The second company, Goldbeck

GmbH, is an innovative, modern company based on standardisation and pre-fabrication. They have had a massive growth in recent years. The third company, Brömer & Sohn GmbH, is a relatively small, locally-based, contractor. This company prioritises knowledge of its clients and the areas in which it operates. The cases studied in the German industry include one residential and two industrial projects. Two projects are based on a design-bid-build (DBB) contract and one on a DB contract.

Some of the project teams expressed a wish to remain anonymous. Therefore, the cases are not presented in more detail than the brief introduction given above

Validity and reliability

According to Olsson (2011), a weakness of case studies is that they can be hard to validate. Their results are always dependent on time- and place, which indicates that they cannot be generalised or transferred to other situations. Flyvbjerg (2006) does, however, contradict this to a certain extent:

One can often generalise on the basis of a single case, and the case study may be central to scientific development via generalisation as supplement or alternative to other methods. But formal generalisation is overvalued as a source of scientific development, whereas “the force of example” is underestimated.

(p. 228)

The validity of the study is decreased by the fact that all of the Norwegian cases came from the same company. It is hoped that the selection of cases from three different companies in Germany to some degree weighs up for this.

Case studies are not standardised in terms of the way they are carried out. The researcher’s interpretations can thus affect the results. Consequently, conducting an evaluation of case study research is typically problematic. To increase the reliability of the research work it was important to clarify how the study was conducted. Correspondingly, a detailed methodology chapter was included to compensate for the otherwise low verifiability. Moreover, several participants have assisted in shaping the research design and the discussion of findings which helps strengthen the study’s reliability.

Strengths and weaknesses

The main strength of a multiple case study research design is that it provides highly detailed information about yet untouched issues. Moreover, case studies allow collection of data through multiple methods and help researchers produce new theories and hypotheses.

The main aim of this study is to create a foundation for further research. It is therefore considered a disadvantage that the results cannot be generalised to the same extent as those who could have emerged from the use of other methods. Additionally, case studies are known to generally consume more time compared to other methods. Hence, for research projects of short duration (such as this study), one can argue that other methods may have been more suitable.

2.2.2 Literature review

Justification for choice

An extensive literature review was conducted in conjunction with the pilot study, which was complemented in further work with the master's thesis. However, the approach is the same. The literature review focused on communication in building design and was carried out in accordance with the procedures described by Blumberg et al. (2011).

A literature review is an essential part of scientific work and a necessity in an academic report. A well-executed review provides a foundation for further research by contributing an overview of existing research on the area researched and current trends (Pasian 2015). Such a foundation is essential for understanding the issue and identifying the potential of the study in light of previous work (Blumberg et al. 2011). The theory chapter constitutes the foundation of the thesis by allowing the identification of communication success factors and issues. Further, an examination of the existing literature makes it possible to identify knowledge gaps and is a necessity when analysing research findings.

The process

The literature review was conducted as a systematic process divided into three separate steps. Firstly, appropriate keywords were identified through an analysis of the research questions. English, Norwegian and German keywords were searched for. Secondly, keywords were combined and searched for in research databases (Scopus, Compendex and Google Scholar) and library databases in Norway and Germany. These databases were chosen in order to ensure a good scope and depth of data. The main keywords that were used in the process are:

- Construction industry/byggeindustrien/Bauwesen
- Design/prosjektering/Planung
- Communication/kommunikasjon/Kommunikation

These keywords alone resulted in a vast number of hits. Consequently, it was necessary to narrow down the search by the use of the Boolean method. In a Boolean search, keywords are combined by the three operators *AND*, *OR* and *NOT*, for example "*communication AND construction*". Moreover, several of the databases allowed for search limits such as *subject* or *field of study*. Whenever this was the case, these utilities were used. All relevant hits were systematically organised in a table and saved in the research and reference manager EndNote®.

The next step in the review process, was to search for literature in the references of already reviewed articles. In addition, some literature was received from professors and fellow students. The relevant literature found in this step, was added to the same table as the ones from step one. Step one and two resulted in a total amount of 43 sources potentially relevant for research. Therefore, as the third and final step of the process, it was necessary to go through the sources once again and sort them according to their relevance for the study. By excluding the sources found least relevant, a final list was composed.

All sources included on the final list were assessed against the four criteria: reliability, objectivity, accuracy and relevance. All sources are scientific and include books, journal articles, conference proceedings, reports and dissertations. Some of the publications are

pure literature studies whereas others are based on case studies or qualitative or quantitative studies. Some of the literature is peer-reviewed. The year of publication varies from 1948 to 2015. All present information is regarded highly relevant for this study.

In addition to the initial search, literature was searched for and reviewed throughout the study, and the methods for searching and evaluation remained the same. When it was decided to submit a paper to IGLC, a thorough search for relevant literature in their database was made. In this way, an overview of how the conference publications have discussed the issue of communication in previous years was gained, which was considered beneficial. This search resulted in many relevant sources and some of these are cited in the final paper.

The main focus of the literature review was to find relevant literature and to look for knowledge gaps. By identifying any existing knowledge gap(s), the researcher avoids that the theoretical framework becomes a resume of current literature by taking a critical approach to existing theory and finding proof that more research is needed in this area.

Validity and reliability

In order to validate a literature review, one can evaluate whether the identified literature is adequate for the research questions posed (Olsson 2011). In other words, if the method does examine what it is supposed to examine. The literature review was conducted on the basis of the research questions posed in the pilot study and the main study. The identified sources cover parts of the topic, but far from everything. The process revealed that there is a lack of research and literature in this field. In conclusion, one could thus say that the validity of the study could have been better, but that this is mainly due to the paucity of research in the area.

A high degree of reliability or verifiability was strived for throughout the literature study. Consequently, the whole search and all relevant findings were carefully documented during the process.

Strengths and weaknesses

The analysis of the research questions has its strength in opening for the identification of other relevant issues and other good keywords. That said, it is almost impossible to detect all relevant literature using this method and it does not assure that the sources found are the best ones. To compensate for this, discussion with professors and fellow students was used as a supplementary method. Additionally, the other research methods in this study gradually revealed new literature as the research process progressed.

2.2.3 Document study

Justification for choice

Thagaard (2009) recommends the use of a document study as a preparatory activity even when the data mainly is collected by the use of other methods, such as interviews or observation. Yin (2014) further claims that the study of documents is also suitable to verify data already collected by the means of other methods. Based on these statements, both a preliminary and a closing document study were conducted in this research. This method was used to create a deeper understanding of the cases and the field of study.

The process

The document study is conducted in line with the recommendations of Yin (2014). Before the interviews in Norway and Germany, a description of the project was studied. In addition, a brief overview of the companies and the main features of the construction industry was obtained before conducting interviews in the German sector. This was considered essential because the researcher had little prior knowledge in this area. Most information was received from the informants, but some was found on the respective companies' webpages. The preparatory activities ensured that the researcher was well prepared for the interviews and had gained an understanding of the projects in advance.

The concluding document study consisted of documents received from the respondents, mainly reports from progress meetings, schedule plans and organisation maps. These documents were analysed in order to attain a better understanding of the contractor's internal systems and execution of projects. Notes were taken throughout the process whenever relevant information was found. The selection of which documents to review was mainly based on recommendations from the interviewees.

Validity and reliability

The document study was used to increase the understanding of the information shared by the informants during the interviews, and made the researcher able to make the right judgements and interpretations. However, validity also depends on whether the right documentation is reviewed. In this study, none of the documents studied were directly related to the research questions. Nevertheless, a study of internal documents potentially reveals that problems with communication in building design management can arise as a consequence of poor project management, lack of structure or other problematic issues, and the validity of the document study is therefore considered satisfying. The validity could, however, have been improved by exploring documents depicting how the participants communicate with each other, for example e-mails or project intranets.

The review of the internal documents was conducted without any trouble, resulting in good conditions for verifiability. The amount of data could, however, have been larger.

Strengths and weaknesses

The document study provided information that was useful when conducting the actual interviews and processing the findings. Additionally, some information only emerged from the concluding document study and was not discussed by the informants.

A weakness of the document study is that only a limited number of documents were reviewed. Additionally, all of these came from the executing contractors. In order to obtain a broader perspective, it would have been beneficial to also analyse documents from other groups, such as for example architects.

2.2.4 Interview

Justification for choice

According to Yin (2014), interviews are an important source of case study evidence. The purpose of an interview is to increase information value by creating a deeper and more

complete understanding of the issue in question (Holme and Solvang 1991). On this basis, conducting interviews was considered vital for the successful completion of the study.

Compared to quantitative methods such as for example questionnaires, the use of interviews provides access to more thorough information: the data is typically more nuanced and the interviewees have the opportunity to elaborate on their answers and opinions. In addition, it is possible to ask supplementary questions whenever this is needed.

The process

The identification and selection of interviewees were based on a strategic choice. People who could contribute to finding an answer on the research questions were singled out. The following three criteria defined by Dalland (2000) informed the process:

- Increase the amount of information by ensuring the greatest breadth possible.
- Use interviewees who have expert knowledge on the area.
- Ensure that interviewees have the ability to communicate their experiences to others.

Architects, building design managers, project managers, site managers and foremen were interviewed. This ensured that different perspectives were accounted for and that the viewpoints from both the operational and the tactical levels of the organisation were included.

The first interviews were conducted in the Norwegian industry during October 2015 and February 2016. These interviews indicated that poor communication cause many problems in Norwegian AEC projects. Interviews in the German industry were then conducted during the first quarter of 2016 in order to see what (if anything) can be learnt from one of the world's largest construction markets. The problem areas and the preventive actions that were identified during the process were processed and aggregated before the comparative analysis was conducted. Some data was congruent for all cases whereas other data differed between the various projects.

A total of 20 interviews in Norway (9) and Germany (11) were conducted, in line with the recommendations of Yin (2014). An overview of the interviewees in terms of location, company, years of experience in the AEC industry and role in project is presented in Appendix A. The interviewees decided the time and place of the interviews. All interviews were conducted in the respondents' workplaces. Around one week before the interviews, the respondents received an e-mail asking them to confirm the agreed meeting. This e-mail also contained a brief presentation of the author and the topic. However, the complete interview guide was not included. In this way, the researcher avoided that the respondents "prepared" their answers up-front. Two sets of interview guides were developed, as it was necessary to make a few adjustments in conjunction with the interviews in German industry (see Appendix B and C). Both sets were entirely based on the research questions.

The interviews were semi-structured. This means that the researcher has a structured plan for conducting the interview, but also focuses on promoting dialogue. An advantage of this type of interview is that it makes it possible to adjust the structure during the interview, so that it better adapts to the interviewees (Holme and Solvang 1991). Additionally, it allows follow-up questions. An interview guide was used to ensure reliable and comparable data. The procedure enabled the interviewer to pursue interesting answers

or unexpected themes that could appear during the interview. In order to obtain comparable data, all of the interviewees were posed more or less the same questions.

All interviews were recorded. Because the researcher's mother tongue is Norwegian, this was considered a huge advantage in the German industry. In addition, it ensured safeguarding of the meaning and a correct reproduction of the information. Moreover, it led to a more relaxed interview situation, as the researcher focused on listening to the interviewee, instead of focusing on writing down the information as fast and correctly as possible. A disadvantage of recording interviews is that some informants may restrain their descriptions and not answer as detailed as they would have done without. In case of any technical problems, handwritten notes were taken as a back-up.

All interviews started out with an informal conversation, to make the informants feel comfortable in the situation and to get to know each other better. In the German industry, this was considered especially important because the interviewees were not familiar with neither the researcher nor the Norwegian University of Science and Technology (NTNU). Thereafter, followed a short presentation of the research and the plan to write an academic paper. Furthermore, how the information from the interviews would be treated was accounted for. Some of the respondents did not want their name or the name of the project to be published. For this reason, only the name of the companies taking part in the study is revealed in this thesis.

During the interviews, questions were asked in the same order as in the interview guide. However, some adjustments were made along the way. When it felt natural, follow-up questions were asked or a desire to receive an elaboration was expressed. Active listening was used by nodding and asking whether the information was understood correctly. Towards the end, informants were asked if they had something to add and if they would be available for questions at a later point. The average time for the interviews comprised 64 minutes. A summary of every interview was written, and the sections considered most important were transcribed in order to retain most of the meaning of the interviews and avoid confusion. The transcripts and summaries were sent to the informants for review and written approval.

Validity and reliability

Validity indicates the extent to which the data collected represents what the researcher wants to measure. High validity implies that the collected data is highly relevant for the research questions (Holme and Solvang 1991). For research interviews, this means that the most suitable informants are used and that their credibility is considered high. In this study, the selection of informants was based on Dalland's (2000) criteria presented above. All informants met these and were thus considered credible. Furthermore, it is important that the quality of the interviews is good. To ensure this, open, non-leading questions allowing comprehensive answers were used. In addition, all informants had the chance to add something in conclusion.

According to Holme and Solvang (1991), validity is also dependent on the researcher's ability to be critical of his or her own work and interpretations. It is therefore important to perform an assessment of the researcher's role and how this may or may not affect the results. In this study, the researcher's personal knowledge to many of the informants in the

Norwegian industry can pose a danger to the objectivity of the results. At the same time, it can be seen as an advantage, considering that many of the interviewees seemed to feel very relaxed in the interviews. In addition to being critical to his or her own performance, it is also important that the researcher is critical to his or her findings. How a person perceives a situation is subjective and the answer may be coloured by the person's role in the project. The interviewees' answers are thus interpreted with a critical eye. Overall, the validity of the data collected through the conduction of interviews is considered to be high.

Reliability is related to the verifiability of the research (Holme and Solvang 1991). In qualitative research, it is typically challenging to achieve high reliability. Nevertheless, a number of actions increase the reliability of the study. An interview guide was used in this study and virtually identical interviews were thus performed. The interaction and chemistry between the interviewee and the interviewer are, however, not possible to reproduce. The use of more or less the same interview guide in all interviews contributed to ensuring comparable data. To assure high quality of the results, the interviews were recorded and thoroughly summarised. Moreover, the informants read through the summarises and had the chance to weed out any misunderstandings. Additionally, name, contact information and summaries are saved for any future use.

The amount of interviews conducted should preferably have been larger. Additionally, in the Norwegian industry, it would have been beneficial if the research included data from more than one company. However, one will always be able to collect more data, as it is always areas that are not investigated yet. Nonetheless, the reliability of the results could have been better by having a larger data foundation.

Strengths and weaknesses

The use of interview as research method has its strength in allowing the in-depth study of an issue. Informants have the chance to explain and elaborate on their experiences and views. Whenever something is unclear to the researcher, follow-up questions can be asked by using semi-structured interviews.

Interviews have several drawbacks that need to be considered carefully. Firstly, the information provided by the informants is based on what they remember only. Further, it is entirely up to the informants to decide how much they want to share. Some respondents may for example have selective memory so that the information given does not correspond to reality. Moreover, people are typically more comfortable talking about what they do right than what they do wrong. Consequently, positive elements get more attention than negative elements. Another potential weakness of interviews is that the way questions are asked often impacts on the response. The same applies to the use of questionnaires, but then it will be consistent and equal for all informants. In interviews, however, the way in which the researcher asks questions may vary from interview to interview. Additionally, the researcher may fail to remain neutral during the interview, resulting in the interviewees being affected and providing the answer they think the interviewer wants. Another weakness is that interviews are suitable for the investigation of various issues and their impact on the environment, but it is often difficult to investigate why these problems have occurred. The reason for this is said to be the informants' tendency to colour their answers in agreement with their vision and agenda. In spite of these challenges, however, interviews

were considered the only appropriate method to obtain adequate answers to the research questions posed in this study.

2.3 DIVISION OF LABOUR

2.3.1 Part 1: The master's thesis report

The author has been responsible for the development of the entire master's thesis report including appendices. The main supervisor, Ola Lædre, and assistant supervisor, Stefan Plaum, have assisted with the construction of the document. I have also had many interesting discussions with fellow M.Sc. student at the NTNU, Frode Gresseth, who writes about the same topic although with a different approach. This has been of great help along the way.

2.3.2 Part 2: The academic paper

The authors who contributed to the development of the academic paper are, in the following order:

- *Josefine Aasrum*, M.Sc. student, NTNU, Trondheim, Norway.
- *Ola Lædre*, Associate Professor, NTNU, Trondheim, Norway.
- *Fredrik Svalestuen*, Ph.D. Candidate, NTNU, Norway.
- *Stefan Plaum*, Professor, Dr.-Ing., RheinMain University of Applied Sciences, Wiesbaden, Germany
- *Jardar Lohne*, Researcher dr.art., NTNU, Trondheim Norway

The author was responsible for the complete paper and A3 (see Appendix D), including the collection of data through a literature review, a document study and interviews, as well as the actual writing process. Ola Lædre and Fredrik Svalestuen have assisted in the development of the research questions and research design. The idea to write an academic paper was developed in consultation with Lædre and Svalestuen.

All supervisors have contributed with professional knowledge and advice throughout the process, and have also suggested relevant literature, focus areas and academic structure. Many of their suggestions have been implemented as the paper has been revised. In addition, Jardar Lohne has helped with linguistic improvements and academic formulations.

The layout and design of the article are based on the guidelines from IGLC and follow their predefined template. This includes the number of pages, type of text, line spacing, references etc.

3 THEORETICAL FRAMEWORK

This chapter presents the key concepts necessary to discuss and answer the research questions posed in this study. Additionally, a critique of the literature is given. The chapter is based on the literature review and therefore has a theoretical approach.

3.1 MODELS OF HUMAN COMMUNICATION

As it is such a multidimensional and nebulous concept, defining *communication* is difficult. It can have a variety of different meanings, contexts, forms and impacts and therefore tend to mean different things to different people in different situations (Dainty et al. 2006). However, in order to support the analysis of the current communication practice in AEC projects, which follows in section 4, there is a need to establish a working definition of human communication and its elements.

The term *communication* originates from the Latin word *communicare*, which means “to make something common”. This implies that communication has not occurred unless the exchange of information results in a mutual understanding. When we communicate we share our thoughts and experiences with each other – we make them something common and thereby increase our mutual knowledge. Communication is said to be the lifeblood of any system of human interaction, since without it no meaningful or coherent activity can take place (Thomason 1988). Angeltveit et al. (2006) argue that all behaviour is communication. Watzlawick et al. (2011) take this further by saying that one cannot *not* communicate. As Polzin and Weigl (2014) explain: when two (or more) persons are in each other’s presence, they will communicate because every action made by a person is a form of communication. In other words, communication between humans can take place unconsciously and non-verbally, as well as consciously and verbally.

In its simplest conception, the model of human communication has been perceived as the transfer of information, ideas, attitudes and feelings from one person to another (Jacobsen and Thorsvik 2007). More precisely, one can say that communication is the transmission of a message from one person (or team or organisation etc.) via a channel, and the receiving and successful understanding of that message by another person (Kaufmann and Kaufmann 1998). Figure 1 presents a model of this simplified view of communication.



Figure 1: The Linear Model of Communication

The linear model of communication presented in Figure 1 provides a good foundation for understanding the process. Nevertheless, it fails to consider important factors affecting communication, such as interpersonal issues and internal- and external factors. Furthermore, it ignores feedback and mutual interpretations, which are essential for the accurate completion of the process. Without these elements, the sender cannot know whether the message is received and understood. A set of elements vital to understand the theory of human communication was revealed through the analysis of various models of the communication process presented by Dainty et al. (2006); Emmitt and Gorse (2003);

Kaufmann and Kaufmann (1998); and Shannon and Weaver (1949), respectively. The identified elements are depicted in Figure 2.

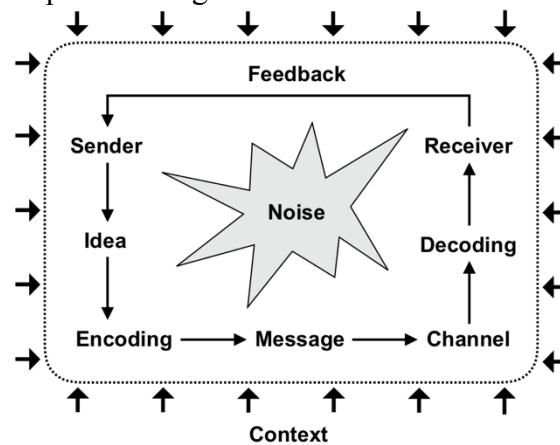


Figure 2: The Model of Human Communication

The model of the communication process presented in Figure 2, reflects the continual and dynamic nature of human interaction and also incorporates the different factors that potentially impact on the effectivity of such interaction. An elaborated description of the different components in Figure 2 is provided in the following sections.

The sender

As the originator of communication, the sender communicates the message to the receiver with some objective in mind. This objective is translated into the sender's expectations and may be conscious or unconscious, structured or unstructured (Bowen and Edwards 1996).

The idea

The idea is the subject matter of the message that the sender wants to convey, i.e. the topic of the information. This may be an opinion, a feeling, an attitude or a special view.

Encoding

Encoding is the process of translating information into an understandable message in the form of symbols, in order for it to be successfully communicated to others. The symbols can take on various forms, for example gestures, languages and words.

The message

The message is the combined set of symbols that the sender conveys to the receiver through a chosen channel and can be conveyed in the oral, written or non-verbal mode.

The channel

A communication channel is the conduit used to transmit the encoded message from the sender to the receiver. It may be an e-mail, a telephone or an old fashioned letter. The appropriateness of the different channels depends upon the characteristics and complexity of the message sent (Jacobsen and Thorsvik 2007). "Richness" in terms of communication channels, refers to the amount of information that can be transmitted and the content's complexity. Figure 3 highlights the relationship between communication effectiveness (y-

axis) and richness of communication channel (x-axis). As can be seen, verbal channels tend to be richer than written ones. This is because they typically convey more nonverbal information.

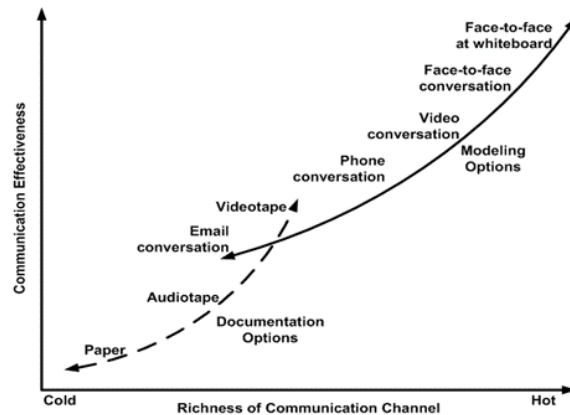


Figure 3: Richness of communication channels (Ambler 2002)

Decoding

Decoding is the process in which the receiver extracts and interprets the message, with the end goal of arriving at the sender's intended meaning. The decoding process equals the inverse operation of what was done by the sender (Shannon and Weaver 1949). Successful communication takes place when the receiver correctly interprets the sender's message.

The receiver

The receiver is the person (or group or organisation etc.) who receives the message or for whom the information is intended.

Feedback

The receiver's response to the message provides feedback to the sender. The feedback-loop is the final link in the chain of human interaction. It is essential for the accurate completion of the communication process. Without receiving feedback, the sender does not know whether the message was received and correctly interpreted. Equally, feedback allows the sender to take corrective actions in order to clarify any misinterpreted information. Consequently, the use of feedback is vital to ensure effective two-way communication.

Noise

By accounting for any type of distortion or distraction potentially affecting the quality of transmission between parties, "noise" constitutes a barrier to effective communication regardless of how suitable and rich the chosen channel is. Noise will thus always interfere with the effectivity of the communication process (Dainty et al. 2006). Hence, noise constitutes one of the main types of failures in the communication process along with an absence of communication. Rothwell (2010) defines four types of noise:

- *Physical noise* – noise in the literal sense, e.g. people talking in the background or sounds from the machinery on a construction site.

- *Psychological noise* – results from the preconceived notions we bring to our conversations, such as assumptions, biases and stereotypes.
- *Physiological noise* – noise caused by natural distractions from the body, which may include pain, tiredness or headaches.
- *Semantic noise* – occurs when the receiver fails to grasp the meaning intended by the sender as a result of not understanding the language used. This typically occurs when the sender uses jargon, technical- or complex terms.

Physical noise is often considered hard to control because it is an external or environmental stimulus in our surroundings. In contrast, other types of noise are easier to control. These types of noise solely exist in a person's mind and arise in the coding and decoding of messages, for example as varying frames of reference or the current mood of a person.

Context

All human interaction is influenced by the context in which it takes place (Grenness 1999). Accordingly, depending on the given context, how we communicate will differ. In this regard, the term *context* is understood as the physical, social, cultural, economic and political circumstances surrounding a message. For example, a meeting in a café provides a completely different framework for communication than a meeting in an office. The context acts as an overriding determination of the content of a message and thus either hinders or promotes the success of the communication process (Dainty et al. 2006; Grey and Hughes 2001). For organisations, it is essential to have a good understanding of the context in which they operate, in order to successfully define, organise and manage their work.

From the first major model of human communication developed by Shannon and Weaver (1949), several attempts have been made to try to explain the process of human interaction. These models provide a visual representation of the various aspects involved and thereby simplify the process. However, even the most complex models are not able to recreate what individuals experience in an encounter with communication. Yet, it is important to become aware of how human communication operates. This helps us consider the communication we encounter in a more systematic and deliberate fashion and thus prepares us for the various communication situations we may meet in the future.

3.2 ORGANISATIONAL COMMUNICATION

An organisation is defined as a group of people working together to achieve a common goal. The prerequisite for a successful collaboration in organisations is communication (Kaufmann and Kaufmann 1998). It follows that communication is decisive for an organisation's overall performance. Johannessen and Rosendahl (2010) say that within an organisation, communication is used as a tool to reduce ambiguity and complexity. Grenness (1999) defines human communication as the most important attribute of an organisation, because communication creates the structure that determines what is being said and what is being done by whom. The main functions of communication in organisations are to create motivation, facilitate cooperation, establish strategies for management and coordinate business activities. It is important to mention that even in poor communication environments, organisations can exist, but if so, they will not be able to

function optimally since issues like discontent, stress, injuries and poor productivity typically occur (Tourish and Hargie 1998).

Within an organisation, communication takes place in many different forms and variations. They all have different uses, advantages and limitations. The most suitable type of communication in a situation depends on the nature of the information and the recipients as well as the desired outcomes. The following sections give a short introduction to the main types of communication that are prevalent in modern organisations. Lastly, the importance of effective communication in an organisation is accounted for.

3.2.1 Verbal, written and non-verbal communication

In broad terms, communication is divided into three main groups: verbal, written and non-verbal (Kaufmann and Kaufmann 1998). Verbal communication involves the use of spoken words to exchange information with others, understand diverse points of view and solve problems. This type of communication typically takes place in face-to-face conversations, by means of telephone or through holding a presentation. In an organisational context, verbal skills are among those most valued (Grenness 1999), primarily because they allow immediate feedback and are considered flexible and effective.

Written communication involves any type of interaction that makes use of written words or symbols (e.g. e-mails, notes, drawings and text messages). Because we live in the so-called *information age*, communicating through writing is becoming increasingly important in the modern world. An advantage of written communication is that it does not demand any direct interaction between the sender and the recipient. Further, written messages do not have to be delivered immediately, but can be revised and edited until the sender is sure that the content successfully conveys the message. In addition, these types of channels provide a permanent record of the communication if desired (Dainty et al. 2006). On the other hand, a disadvantage of written communication is the time it takes to receive feedback. Equally, it sets great demands on the actors' ability to express themselves clearly. A poorly written message creates confusion and decreases the chance of achieving the intended purpose.

Non-verbal communication is often neglected when discussing communication. It is, however, just as important as the other two types. As Johannessen and Rosendahl (2010) explain, non-verbal communication represents more than half of all communication taking place in the world. To be able to manage non-verbal communication is thus essential in order to develop good communication skills. Non-verbal signals include face expressions, tone of pitch and voice, body language and physical distance between the communicators. These types of signals are often used as a supplement to the spoken word, by conveying the nuances of meaning and emotion that reinforce or contradict the verbal message in a given situation (Dainty et al. 2006). In many ways, one could say that non-verbal messages are more powerful than the verbal messages they usually are combined with. Yet, academics argue that this type of communication is vague and imprecise, which often leads to confusion and uncertainty in the process.

The three types of communication mentioned above all have their advantages and disadvantages which affect their use. Verbal communication is suitable for the conveyance of emotions and important information, among others because it allows immediate

feedback. Written communication has its strengths in allowing asynchronous communication, documentation and reaching many readers simultaneously. Both verbal and written communication can be combined with non-verbal messages, which helps to portray messages both vocally and with body signals or gestures.

3.2.2 Formal and informal communication

A further distinction between the types of organisational communication can be drawn by acknowledging the existence of both formal and informal interaction (Dainty et al. 2006). Formal communication is typically defined as the skeleton of the company. This type of communication takes place through pre-defined channels and follows the hierarchical chains of command established by the organisation. In general, formal communication is used to exchange information related to the business and its operations, for example information about economic conditions or the production planning. Because it moves through a set of pre-defined channels, the use of formal communication ensures clear and effective information flow within organisations, which results in employees always being aware of where and how to send a message. On the other hand, practitioners use longer time to achieve their goals when formal communication is used (Jacobsen and Thorsvik 2007). Because formal communication usually takes place in the written form and is regarded committing, actors generally show more caution in the communication process.

Informal communication is used as a supplement to formal communication in order to convey information between employees and generate interest and motivation. It is considered so important that it is described as the organisation's central nervous system, i.e. the system that drives the collective processes and action of the different business units. Informal communication is usually created through friendship or contact between people who are willing to cooperate. It may be seen as the more spontaneous interaction happening "on the back of the organisational chart" (Kaufmann and Kaufmann 1998), for example in the form of a chat by the coffee machine or in the cue waiting for the printer to become available. The content of informal communication is primarily characterised by what all employees have in common, such as workplace conditions, managers and colleagues. This communication method is often used when it is difficult to convey a message through formal information channels (Jacobsen and Thorsvik 2007).

In organisations, people communicate because of the situation or because they want to, not only because the organisation tells them to. Hence, the full understanding of organisational communication requires knowledge of both formal and informal aspects. Research indicates that informal communication spreads information much faster than formal (Jacobsen and Thorsvik 2007). Moreover, subordinates tend to have more confidence in information transmitted informally than in formal communication from the management. On the contrary, too much informal communication may create uncertainty in organisations because it typically becomes unclear if actors have been given the information they need (Jacobsen and Thorsvik 2007).

3.2.3 Synchronous and asynchronous

The theoretical framework clearly emphasises the necessity of using both synchronous and asynchronous communication in successful organisations. Due to the ever-evolving

technology, synchronous communication is much more prevalent today than it was ten years ago. Otter and Emmitt (2007) define synchronous communication as a direct in time information flow, i.e. a collaboration between participants regardless of time and place. Historically, this type of communication was only available by the means of face-to-face interaction. Today, however, synchronous communication also includes the use of telephone, video conferencing and messenger services.

In contrast to synchronous communication, asynchronous communication takes place distant in time and space. Common asynchronous channels include drawings, e-mails and discussion forums. A key advantage of this type of communication is that it provides more time for actors to formulate their thoughts. Moreover, it is considered helpful when conveying information across different time zones. Nonetheless, asynchronous channels do not have the same richness as synchronous channels. Messages must thus be kept simple in order to be understood. If asynchronous channels are used to transmit complex information, recipients should be provided with an additional explanation of the content of the message by the means of synchronous channels (Otter and Emmitt 2007). This helps reduce uncertainty in the process and so enhances the receiver's understanding.

For most organisations, synchronous and asynchronous communication will prove to be valuable in their own way. In some situations, synchronous channels work best, while asynchronous channels are more beneficial in others.

3.2.4 Vertical and horizontal communication

Formal communication takes place internally in an organisation and is defined as either vertical or horizontal. Figure 4 illustrates how these types of communication move between participants in the different hierarchical levels in an organisational chart.

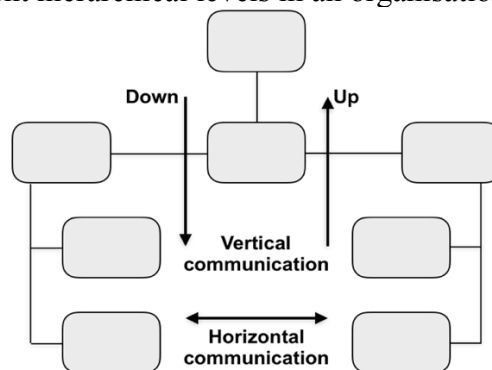


Figure 4: The flow of communication in organisations (Jacobsen and Thorsvik 2007)

As can be seen in Figure 4, vertical communication refers to the formal communication taking place between the different hierarchical levels in an organisation. This type of communication is further divided into downward and upward communication. Downward communication is information flow between managers and their employees. It usually has a commanding or guiding function. This type of communication is used to give instructions, clarify roles, inform about procedures and to give feedback on the work being done (Jacobsen and Thorsvik 2007). When information is communicated downwards in the organisational chart, it has to pass numerous hierarchical levels. Importantly, a message can be very accurate at the first level, but become distorted as it moves down through the

hierarchy. This results in confusion and misunderstandings in the final joint, a phenomenon defined by Dainty et al. (2006) as “Chinese Whispers”.

Upward communication describes the flow of information from the lower to the higher levels in a hierarchy, e.g. from a co-worker to a leader (Kaufmann and Kaufmann 1998). This type of communication typically contains the information managers need in order to make decisions, such as status reports, improvement ideas or information about own or others’ work (Jacobsen and Thorsvik 2007). When communication goes upward in an organisation, there are two particular issues one should be aware of (Jacobsen and Thorsvik 2007):

- *Employees typically have a tendency to distort information from managers* – Employees need recognition and respect from their leaders. Thus, they tend to hold back information or communicate positive information only, which typically results in misunderstandings or lost information.
- *The amount of information that can be communicated is limited* – Because there are fewer people on the higher levels of authority in organisations than on lower levels, the capacity to process information through the hierarchy is often limited.

When communication takes place between members at the same hierarchical level it is called horizontal communication (Kaufmann and Kaufmann 1998). Horizontal communication is partly conveyed through formal channels and partly through informal channels. However, it is always used in conjunction with coordination of activities between employees or management functions in autonomous groups (Karlsen 2005). Message distortion rarely occurs in horizontal communication. The main reason for this, is that it takes place between people at the same levels of authority. Hence, the communicators work with similar tasks and have the same reference framework. This provides a good foundation for establishing frequent, fast and easy communication.

Traditional theorists hold that communication within organisations should move vertically through the hierarchy in order to safeguard structure and control. More modern literature, however, emphasises the importance of horizontal communication and argues that by allowing a widespread sharing of information and open lines of communication, one enhance learning capability and cooperation within organisations. As of today, there is thus no consensus on how to best relate to these aspects in terms of organisational work.

3.2.5 The importance of effective communication

The importance of effective communication to individuals, teams and organisations cannot be overstated (Dainty et al. 2006). Research shows that a normal engineer uses as much as 60% of his or her day on communicating, whereas managers can use up to 90% of their time on the management of information (Karlsen 2005). Armstrong (2012) summarises the importance of effective communication to an organisation in the following points:

- *Achieving coordinated results* – organisations are reliant on the collective actions of people. Independent actions may lead to outcomes incongruent with organisational objectives. Thus a coordinated outcome demands effective communication.

- *Managing change* – most organisations are in constant change. Employees are more willing to accept this change if the reasons for it are well communicated.
- *Motivating employees* – employees’ motivation is dependent on their feeling of responsibility and attachment to the company. Feelings in this regard are further dependent on the quality of communication from managers.
- *Understanding the needs of the workforce* – an open and honest dialogue between managers and employees at all levels is vital for an organisation to be able to respond effectively to the needs of the workforce.

The benefits of effective communication as presented above show how poor or missing communication typically decreases the performance of a company. Therefore, a successful organisation depends on the establishment and maintenance of effective communication. Dainty et al. (2006) state that effective communication rests upon four factors:

- The effectiveness by which information is *encoded* and then *transmitted* through communication systems, channels and networks.
- The appropriateness of the communication *channel(s)* used.
- How those receiving the communication *decode, interpret* and *act* upon it.
- The abilities of those communicating to minimise “*noise*”.

Academics have developed a range of different tools and theoretical perspectives which try to explain how to facilitate effective communication in organisations in accordance with the above mentioned factors. Yet, there will always arise situations where communication fails. Potential barriers to effective communication exist in several formats (such as noise as discussed in section 3.1) and different authors have taken different perspectives on how to define these. Figure 5 presents the most common communication barriers, as defined by Kaufmann and Kaufmann (1998).

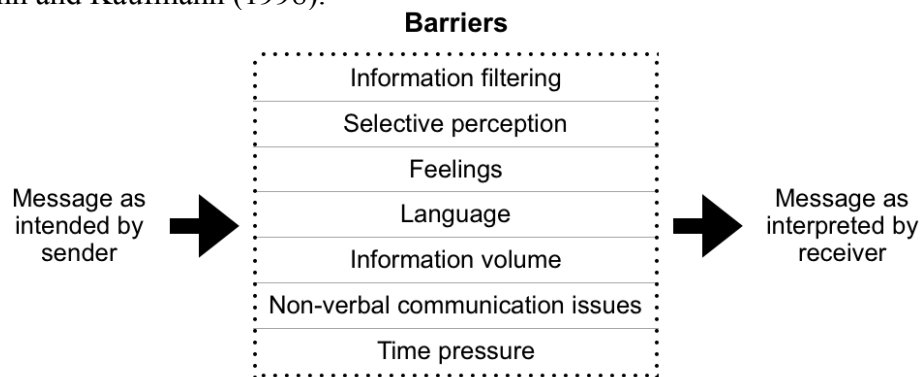


Figure 5: Barriers to effective communication (Kaufmann and Kaufmann 1998)

The barriers in Figure 5 show how basic cognitive processes may prevent effective communication and create uncertainty in organisations. For example, time pressure and information overload can increase the chances of sending or receiving inaccurate information.

To sum up, it can be concluded that an abundance of literature describes communication and its significance in an organisational context. The main lines to be drawn from the theoretical framework is that effective communication is vital for the attainment of

organisational goals. Thus, working to reduce the impact of communication barriers is important. There is no easy, universal solution describing how to do this. However, being aware of the different barriers and their impact provides organisations with a distinct advantage.

3.3 BUILDING DESIGN MANAGEMENT AND COMMUNICATION IN IT

Having an understanding of building design and its processes is a necessity for establishing effective communication in building design management. Depending on the given context, the way we communicate will differ. Hence, the characteristics of building design will colour the interaction taking place between design team members.

Building design management is characterised as a type of project-based work. It takes place in a dynamic and fragmented environment, with individual teams consisting of an ad hoc coalition of people and organisations (Emmitt and Gorse 2003). Two of the main goals of the design phase is for the client to communicate his or her needs and objectives to the design group and for the design group to transfer these into possible solutions and concepts. Therefore, as Knotten et al. (2015) state, building design management might be one of the most challenging forms of management in the AEC industry. Not only does it involve management of outputs such as drawings, but also the creativity of minds.

3.3.1 The process of building design

The building design process is a multidisciplinary process. It is performed in a series of iterative steps, in order to conceive, describe and justify increasingly detailed solutions and meet the needs of the client (Baldwin et al. 1999). According to RIBA (2013), the design of AEC projects is typically divided into four steps:

- *Preparation & brief* – involves the development of an initial project brief, which may include carrying out feasibility studies, risk assessments and site studies.
- *Concept design* – represents the design team’s response to the project brief and comprises, amongst others, preliminary information about cost, relevant project strategies, structural design and building services systems.
- *Developed design* – prepares a developed design, including coordination and updated proposals of the concept established in stage two.
- *Technical design* – by the end of this stage, all aspects of design will be completed, including architectural, structural and building services information, as well as specialist subcontractors’ design and specifications

The early stages of design are defined as creative, iterative and innovative. Project stakeholders share their ideas and thoughts with each other, which results in a constant change of information flow, focus point and planning goals (Knotten et al. 2015). Consequently, it is of vital importance that one keeps every opportunity open until one has enough information to make an informed decision. Contrastingly, the final part of the process involves concrete deliverables (drawings, models etc.) and is thus easier to manage.

The management of production can be planned sequentially, i.e. activity A must be completed before activity B can start. For the design of AEC projects, however, this is seldom the case. As mentioned earlier, this process has an iterative form and the goal of each iteration is to contribute to the end value of the project. Many design problems and

solutions are therefore defined as interdependent (Pietroforte 1997). This further complicates the management of these processes. Research shows that there are four different types of interdependencies in building design: pooled, sequential, reciprocal and intensive (Knotten et al. 2015). These four types of interdependencies are linked to the degree of team task complexity and communication need as illustrated in Figure 6, and therefore need to be handled and coordinated differently. Thus, the successful management of building design is dependent on having an understanding of these dependencies and their impact on the process.

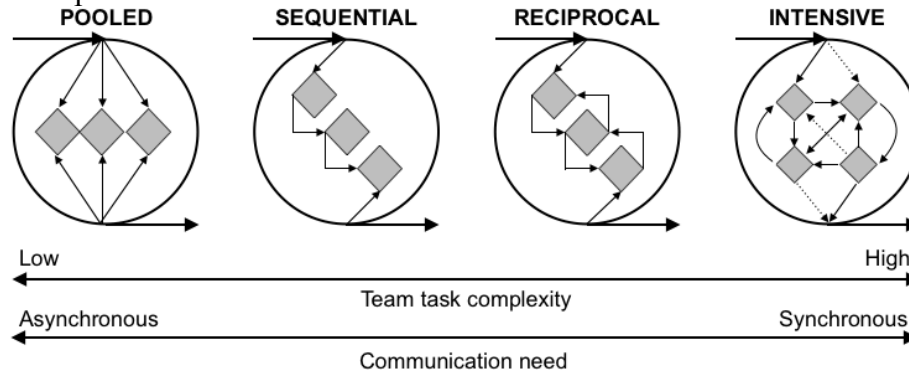


Figure 6: Types of interdependencies (adapted from Bell and Kozlowski (2002))

The least interdependent type of interdependency is termed *pooled*, which indicates that work and activities are performed separately by all team members before they are combined in a finished product. In the second type, *sequential*, work and activities flow unidirectional from one member to another. The third type, *reciprocal*, is characterised by work and activities that flow back-and-forth between team members, one-by-one, over time. In the final and most interdependent arrangement, *intensive*, team members must diagnose, problem solve, and/or collaborate simultaneously as a team, in order to accomplish their task.

The complexity and fragmentation of building design processes are growing steadily because of the increasing demand for specialist knowledge. Consequently, it is increasingly difficult for information to be synchronised and communicated at various lifecycle stages (Dave et al. 2015). This has proved to result in suboptimal solutions, lack of constructability and a great number of design and construction rework (Alarcón and Mardones 1998). In order to successfully manage the challenges of modern building design processes, much more research is therefore necessary in this area. To date, research on building design management is unfortunately rather limited. However, the last year's activity in academic circles indicate that efforts are being made towards improving current methods. Among others, research is conducted on the different interdependencies in building design and how to coordinate them. Additionally, attempts made to attain a closer cooperation between the different actors and phases involved were identified.

3.3.2 Building design teams

Building design teams are defined as temporary, multidisciplinary and network-based, typically consisting of a client, architect, contractor representatives and various specialist consultants (Meland 2000). Accordingly, building design is rarely a product of one

person's thinking process alone; rather it is the result of many different disciplines and their collective knowledge (Emmitt and Ruikar 2013). In order to utilise every participants' full potential, the different participants ideally have distinct roles and responsibilities in the group, and these roles and responsibilities ideally support and complement those of the other team members (Dainty et al. 2006). Hence, the performance of the design team is just as dependent on the team member's ability to effectively communicate and work together as a team as it is on their diverse sets of skills and knowledge.

Because information is required and produced all the way from inception to completion, the combination of design team participants is closely bound together by mutual information dependency (Bowen and Edwards 1996). The mutual information dependency serves as the glue holding the fragmented organisation together, but also places high demands on the participants' ability to collaborate. As Grey and Hughes (2001) point out; when a project organisation is made up of several independent subgroups: the work complexity increases, which makes it more difficult to ensure information flow within the organisation. Furthermore, Svalestuen et al. (2015) emphasise the importance of trust between team members and commitment to the project as vital elements of efficient design teams. Trust is equally the single most important principle of Lean work methods such as Integrated Project Delivery (IPD) (The American Institute of Architects 2007). According to Larson and LaFasto (1989), trust consists of four elements: honesty, transparency, consistency and respect. As trust is broken whenever one or more of these elements is absent, it is essential to strive for these qualities in every AEC organisation.

In fragmented building design teams, participants have a range of needs and objectives not all of which will be complementary in nature (Emmitt and Gorse 2007). Typically, the members' competing interests result in disagreements and tension as soon as one puts an obstacle to the flow of communication (Dainty et al. 2006), and this may hinder the achievement of the overall project's objectives and values. Thus, the establishment of a set of common objectives and values at the project outset are essential in the drive for greater cooperation and reduced conflict in construction projects.

Based on the theoretical framework presented in this section, the main challenge of team work in building design management is considered to be the organisational complexity of the process. Due to the large number of players involved and that the fact most of these come from independent businesses, this complexity is almost impossible to avoid. Consequently, contemporary building design teams are struggling with basic team work principles, despite the fact that such principles have been easy to implement in other industries.

3.3.3 The interface between design and construction

As a result of the current imperative to improve industry performance by designing and constructing faster, interface issues are becoming increasingly important in the construction industry (Shohet and Frydman 2003). This creates higher demands on all actors, including demands related to coordination and exchange of information.

In the design stage, there are two types of interfaces. Firstly, technical interfaces, which comprise the distinctions between the various areas of engineering, and secondly, the phase-related interfaces, which occur as a result of the transfer of information between the

various phases and processes involved (Westergaard et al. 2012). Design and construction constitute two of the core processes in AEC projects and are separated by a phase interface. Reinertsen (1997) describes design as the generator of information, whereas production generates the products. From this definition, he derives the following differences between the design and production processes:

- The design phase is non-repetitive – it is a one-time process.
- The costs of making changes in design increase exponentially with time.
- The requirements change constantly throughout the design process.
- The source of value creation in design is its variability.
- Design is an expandable task – there will always be a better solution.

Additionally, design phase participants are considered to be mutually-dependent, whereas the construction process is largely characterised by sequential logic. Therefore, in the design process, activity A will both build on and be the basis for activity B, whereas its only function in the construction phase is to be the basis for activity B.

Traditionally, design and construction activities have been thought, practiced and researched separately. Focus has been on design *or* constructions, seldom on both. In today's industry, where design and construction are increasingly overlapping, this separation is defined as the root of many problems. As Emmitt and Gorse (2003) underline: at the heart of every successful project lies the ability to communicate abstract ideas from the design office to the site and the ability of those on site to translate this information into a physical artefact. Hence, a lack of interaction between design team members typically forces the subsequent stages to work on incomplete design. This results in issues like poor design quality, lack of constructability and a great number of change orders, which further impact the overall performance of the project organisation (Alarcón and Mardones 1998). Research has showed that these problems stem from a mismatch of values and failure to appreciate the existence of diversity and sub-cultures (Emmitt and Gorse 2003; Powell 2001). Consequently, communication and close cooperation are essential components in the achievement of integration and a level of synergy between these two phases.

One strategy of reaching greater synergy between design and construction may be the adoption of the philosophy of Lean thinking. Lean thinking has been adopted relatively quickly in the construction phase, but has been rather slow to catch on in design processes (Emmitt et al. 2004). The traditional approach to management of design and construction focus on the transformation of an input to an output (Koskela 2000). Lean Design and Construction on the other hand, combines the transformation view with the maximization of value without sacrificing efficiency. Lean thinking is thus described as a focus on maximising the effectiveness of construction processes while at the same time maximising their efficiency. Womack and Jones (2003) summarise the theoretical foundation of Lean in the following points:

- Precisely specify value by specific product.
- Identify value stream for each product.
- Make value flow without interruptions.
- Let the customer pull value from the producer.
- Pursue perfection.

These five principles indicate that given the strong argument for a greater synergy between design and construction, there would appear to be a great potential in moving the Lean thinking also to the design process.

The two most important contributions from Lean thinking in the AEC industry are the Transformation, Flow, Value (TFV) theory of production (Koskela 2000) and the Last Planner® System (LPS) (Ballard 2000). Koskela (2000) argues that the vast focus on transformation in production has led to a neglect of the flow and value views, resulting in a wasteful process. The LPS developed by Ballard (2000) is a method compatible with this view, because it combines control and improvement to reduce variability and the waste caused by it.

Despite providing many benefits for design and construction teams, the implementation of Lean Design and Construction is not completely hassle-free. Mossman et al. (2013) underline that the successful use of Lean principles necessitates a need for dedicated and experienced workers. By moving towards a Lean approach, the complexity of the work will increase. Furthermore, since more traditional methods may contradict with the Lean philosophy, a change in organisational structure and work procedures is typically needed.

This section has showed that there is every indication that the discrepancies existing between design and construction site teams have caused barriers for the successful completion of projects. Yet, a review of the current literature of design- and construction processes revealed that neither the processes nor the interface between them are rich in underlying theories. There is thus a need to develop new and more comprehensive solutions for coordinating the activities in this interface. In this regard, there are clear indications that effective communication is the key factor to success.

3.3.4 Communication in the design-construction interface

Communication is an essential tool for coordinating the different goals and achievements within fragmented building design teams. Moreover, it helps manage changes in the organisation and understand the needs of the workforce, as well as create motivation and build trust. Grey and Hughes (2001) describe the importance of effective communication flow in construction projects as follows:

Successful collaboration must allow the continual exchange of information and knowledge without any barriers being put in the way. There should be clear lines of authority but no restrictive boundaries so that the communication can flow freely between organizations.

(p. 74)

The realisation of building design leaves a trail of written, graphic and numeric documents. This reflects the enormous amount of information that is searched for, generated and communicated during its implementation (Pietroforte 1997). Much of this information can be characterised as questioning and ambiguous, as the team members do not know neither process nor product well enough to be distinct. Design team members communicate formal or informally, as well as synchronously and asynchronously. Figure 7 gives an overview of the most common communication channels, structured by their time and place relationship.

	Same time	Different time
Same place	Dialogues Informal meetings Formal team meetings	File management Bulletin board Paper project dossier
Different place	Telephone Tele conferencing Video conferencing Instant messaging	Postal + Interoffice mail Facsimile Computer network Email MS-outlook calendar

Figure 7: Commonly used communication channels (Otter and Emmitt 2007)

Otter and Emmitt (2007) claim that effective design teams use a balanced mix of synchronous and asynchronous communication: the more complex the process, the higher the need for synchronous communication. Hence, in the early design phases when reaching consensus is on the agenda and less information is made explicit by drawings and documents, synchronous communication is a vital tool. The synchronous communication is supported by the approach of Integrated Concurrent Engineering (ICE) and Building Information Modelling (BIM). These tools are powerful when trying to manage reciprocal or intensive processes (Knotten et al. 2015) and therefore contribute to an integrated and interdisciplinary design process. In contrast to synchronous communication, asynchronous communication might be the most appropriate choice when the aim is to get an overview of design information and when information exchange is on the agenda (Otter and Emmitt 2007). In addition, this type of communication is often beneficial when one wants to prevent double or outdated design information.

Reinertsen (1997) summarises the characteristics of design team communication in four key dimensions: real-time, self-documenting, leverage and bandwidth (see Table 1).

Table 1: Team communication systems (Reinertsen 1997)

System	Real-time	Self-documenting	Leverage	Bandwidth
Meetings	X			X
Telephone	X			
Voice mail		X	X	
E-mail		X	X	
Paper documents		X	X	
Web sites		X	X	
Video tapes		X	X	X
Video conference	X			X
Chance encounters	X			X

The real-time dimension comprises channels like meetings, phone calls and video conferencing, i.e. tools that allow the immediate sending and receiving of information. In building design, practitioners deal with many problems of complex art, which require a lot of interaction to be handled. The time factor is thus especially important. The second dimension is self-documenting, which considers the degree of documentation achieved. In this regard, written communication such as e-mails and memos excel, because they are inherently self-documenting and leave a paper trail. This may be a disadvantage, but is in general considered critical to function efficiently. For example, all sorts of agreements are usually more reliable when they are documented.

Leverage is the third dimension of design team communication. The term is used to depict the time spent by the sender vs. the time spent by the receiver of communication. From the sender's perspective, leverage is a good thing. The receiver, however, may experience an information overload whenever the leverage is too high. Leverage exists in any type of communication that can be stored and reproduced. The danger in leverage is that it causes the volume of information to grow very rapidly, e.g. it only takes a few seconds to send a one-hundred-page e-mail to one hundred people. Leveraged communication channels must therefore be used with care, as overuse can result in information overload. The fourth and final dimension is bandwidth. Bandwidth describes the amount of information that can be conveyed in a particular time. Methods that rely on visual communication have the highest bandwidth, such as a face-to-face meetings and video conferences. Written communication has lower bandwidth and takes longer time to disseminate. In addition, written communication requires more time to prepare.

Reinertsen (1997) argues that facilitating effective communication requires a reduction of current information flow in AEC projects. When too much information simultaneously circulates, it is difficult to separate what is important from what is not. By decreasing the number of team members and establishing clear roles, the amount of organisational levels is reduced and information flow decreased. In addition, the implementation of modern tools like the LPS, BIM, ICE and Integrated Project Delivery (IPD) can help to overcome some of the current barriers of effective communication. Research has shown that these tools contribute to increased process transparency, project commitment and collaboration, which further facilitates streamlining of information flow (Al Hattab and Hamzeh 2013).

The development and use of information and communication technology (ICT) has been seen as one way of improving the performance of building design teams. These tools are implemented in construction, with the purpose of improving communication, control and coordination processes, and to break down barriers between professionals (Wikforss and Löfgren 2007). The implementation of ICT tools in construction projects has certainly brought about benefits. However, at present, the high expectations on improved industry performance have not been met, and the use of ICT tools is still not able to improve the core processes of construction. Dave et al. (2008) argue that this is partly because most of the new concepts (BIM, Lean, etc.) are developed in isolation and do not sufficiently balance the people and process aspects. As Pietroforte (1997) explains, it is vital that the development of ICT tools are pursued via an understanding of the nature of the information to be communicated and the organisational context that supports such an exchange.

Caldas and Soibelman (2002) state that current information management systems are generally based on “push” and only release information based on demand and due-dates. In contrast, pull-based systems release material and information based on system status (e.g. the amount of work in process) or event occurrence. With the LPS, Ballard (2000) emphasises the importance of pull-based information systems as an essential requirement for Lean project deliveries.

The literature review showed that there is a lot of research on organisational communication. As this section has shown, researchers have also examined how these thoughts can be adopted to the AEC industry and more specifically the design-construction interface. Still, communication issues cause many problems in contemporary AEC projects. This indicates that there is not always a connection between theory and practice. Hence, it will be important to acquire first-hand experiences from actors in the future.

3.4 CONTRACTUAL ARRANGEMENTS IN AEC PROJECTS

In an effort to avoid some of the drawbacks of the traditional approach, the increased complexity of AEC projects has brought about the development of various new project delivery methods. The term *project delivery method* refers to the system in which design, procurement and construction is managed. Pietroforte (1997) claims that the choice of contract type has a major effect on how communication patterns develop within organisations. From a communicative perspective, it is thus important with an understanding of the organisational context supporting information exchange. Even though there are several project delivery methods in contemporary construction, the Construction Industry Institute maintains that only three of these are really fundamental: DBB, DB and Construction-management-at-risk (CMAR) (Construction Industry Institute 1997)

3.4.1 Design-Bid-Build

DBB is the traditional project delivery method and involves three main participants: the owner, the design team and the general contractor. The owner contracts with an architect or engineer (A/E) to design the project and enters into a separate contract with a general contractor (GC) for construction (Kelley 2013). Figure 8 shows how the owner is situated squarely between the designer and the contractor in a DBB contract.

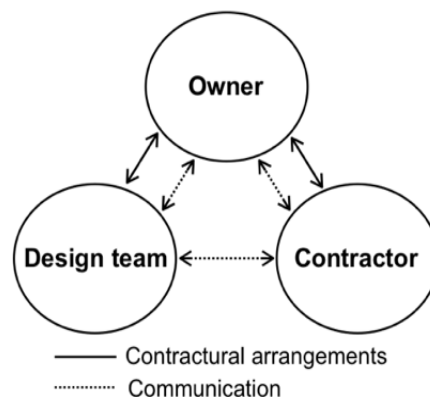


Figure 8: Project organisation structure for DBB

The use of DBB is attractive to the owner for a number of reasons, but at the same time there are several drawbacks using this delivery method. The defining characteristics of the DBB approach as defined by Kelley (2013) are depicted in Table 2.

Table 2: Advantages and disadvantages of DBB

Advantages	Disadvantages
Well-known – Ease of implementation	Requires owner experience and resources
Owner has a great degree of control	No contractor input in the design process
Competitive fixed-price bidding	Owner at risk to contractor for design errors
Flexible during design	Lack of interactions between participants
Fixed cost at contract award	Sequential – can be timely

A DBB contract potentially saves a lot of time and resources for the owner in small, simple projects. In more complex projects, however, its fragmented approach may cause problems, especially in the interface between design and construction teams. As a consequence, there has been an increased use of alternative project delivery methods in recent years.

3.4.2 Design-Build

In the DB approach, the owner contracts with a single entity that is responsible for both the design and the construction phase (Kelley 2013). The DB approach differs from the traditional approach in the single line of responsibility between the owner and the design-builder. Figure 9 shows that from an owners standpoint, the DB approach significantly simplifies the chain of responsibility in the project.

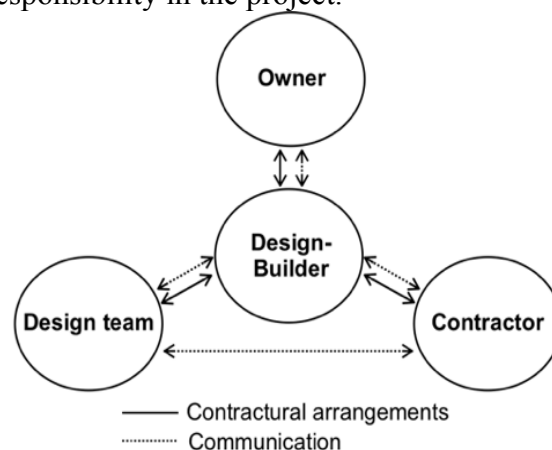


Figure 9: Project organisation structure for DB

In contrast to the DBB approach, the use of the DB method allows the design, procurement and construction phases to overlap, which results in much shorter project times (Kelley 2013). With today’s rising demand for “fast-track” projects, this method is increasingly popular. Table 3 summarises the main advantages and disadvantages of the DBB approach as presented by Kelley (2013).

Table 3: Advantages and disadvantages of DB

Advantages	Disadvantages
Owner has single point of responsibility	Owner has less involvement and control
Allows fast-tracking	Higher risk for the design-builder
Close design-construction collaboration	Detailed project definition required up-front
Owner reduce risk	Reduce competition
Owner needs less experience	Owner lacks independent advice form A/E

The DB approach is generally not appropriate when aesthetics is an important concern for the owner or if the owner has specialised program needs. However, on straightforward projects where the requirements are clearly defined, this method is generally preferable.

3.4.3 Construction Management At-Risk

The increased complexity of AEC projects has led to the development of CMAR. Using the CMAR delivery method, the owner contracts with a Construction Manager (CM) that commits to deliver the project within a guaranteed maximum price. The CM supports the owner in the design stage, by acting as a consultant and providing expertise in scheduling, estimating and cost-control (Kelley 2013). In the construction phase, however, the CM is seen as equivalent to a GC. The CM firm does accordingly not necessarily perform any design or construction activities of their own, but rather act as the owner’s representative, controlling and managing the flow of information during the life cycle of the project as illustrated in Figure 10.

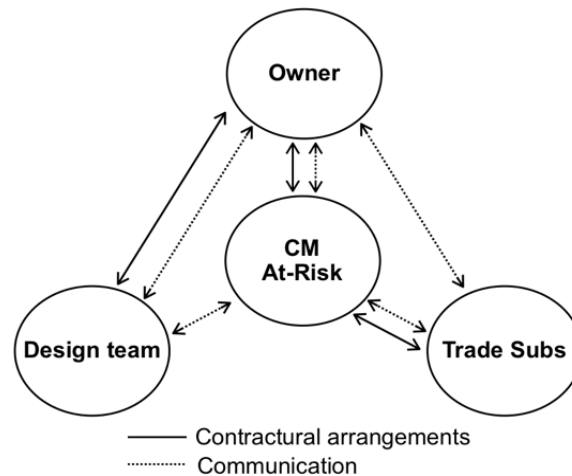


Figure 10: Project organisation structure for CMAR

Like the DB delivery method, CMAR is a time-conscious alternative to the traditional DBB approach. Its defining characteristics, according to Kelley (2013), are presented in Table 4.

Table 4: Advantages and disadvantages of CMAR

Advantages	Disadvantages
CM is hired based on qualifications	Reduced owner control
Responsibility and risk assigned to CM	Perception that price competition is limited
Allows for fast-tracking	Possible adversarial A/E and CM relationship
Transparent - High level of cost control	The CM selection process may be timely
Fosters close team collaboration	Resistant to change design in construction

Constructability and speed of implementation are often defined as the main reasons for selecting the CMAR method. Accordingly, the method is suitable for large, complex projects that are difficult to define and/or subject to change.

The three principal models of project delivery have been presented in this chapter, these are: DBB, DB and CMAR. By choosing the project delivery system that is most suitable for the situation, project teams will be able to overcome many of their current communication challenges. The key distinctions between the three types of delivery methods are related to the allocation of work and distribution of risk between the parties. Furthermore, the literature review proved that how communication takes place within project teams is to a large extent dependent on which project delivery method is used.

4 FINDINGS AND DISCUSSION

The fourth chapter presents and discusses the findings from the comparative study of the Norwegian and the German AEC industry. This part of the thesis aims to create a deeper understanding of the conclusions presented in chapter 5. The chapter is divided into three sections based on the research questions of this study.

4.1 COMMUNICATION PATTERNS

This chapter aims to provide a better understanding of how communication takes place in the interface between design and construction site teams. Accordingly, the following sections discuss reasons for communicating, flow of information and common communication channels identified in the German and the Norwegian AEC industry.

4.1.1 Reasons for communicating

The respondents in Germany and Norway described many of the same reasons for one team member to contact another. The four most common reasons in both countries were to: 1) plan, coordinate and schedule work, 2) give/receive information, 3) give/receive information because of changes and 4) request late/missing information. German practitioners defined giving and receiving information because of changes as more common than requesting late or missing information. In the Norwegian industry, however, actors often had to request information from other team members. Findings indicate that there are not necessarily more changes in the German industry, but rather that they are better noticed there. Compared to Norwegian actors, German actors seemed more reluctant to make changes after the initial decision was made. Moreover, Norwegian practitioners explained that they often had to request information, whereas German actors did not describe this as a problem. This distinction was found to be a result of the differences in workplace culture, as is discussed later in this chapter.

In both countries, informants wished to communicate more with the purpose of sharing knowledge and determining level of ambition (e.g. cost, time and quality). This indicates that important teamwork principles such as the definition of a common goal and application of positive and negative sanctions are often overlooked and underestimated in both countries. If so, the effect is potentially damaging. These are important value creating activities, contributing to a successful final product. Therefore, when they are not prioritised, the probability of rework, delays, cost overruns, etc., increase, which further affects the overall performance of the project team.

4.1.2 The flow of information

The analysis of information flow between members of German and Norwegian building design teams, indicates that the choice of project delivery method greatly affects how communication patterns develop in the organisation. In Germany, traditional procurement methods such as DBB are widely used, whereas it is becoming more and more common with DB contracts in the Norwegian industry. By using DBB, the client is at the centre of the information flow, as illustrated in Figure 11. Unfortunately, clients often lack the experience and skills necessary to effectively manage and coordinate project teams. Hence, the use of DBB contracts often result in an absence of information flow between design

and construction team members. This is problematic in contemporary construction where communication and close cooperation is decisive for the successful project completion. An advantage with DBB projects, however, is that the scope and stages are rigidly defined. Therefore, the different roles and responsibilities are evident to all actors, which simplifies the flow of information across the existing interfaces.

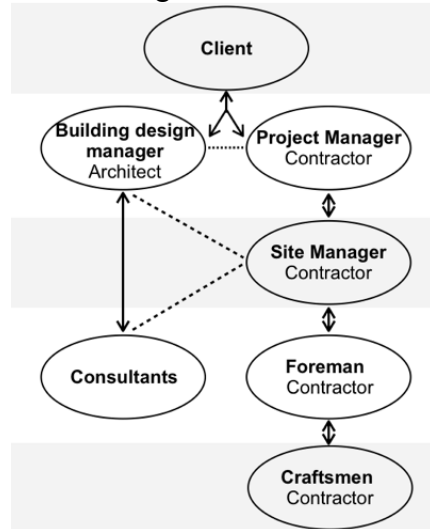


Figure 11: Communication patterns in German project teams

In contrast to the DBB project delivery, the DB method organisationally integrates design and construction processes as depicted in Figure 12. Additionally, the Project Manager becomes accountable for the management of the different interfaces. Both German and Norwegian actors defined this as an advantage, because project managers are more likely to possess the required personal- and professional skills for such management. However, the study showed that DB contracts typically results in unorganised and confusing information flow in parts of the organisation. Figure 12 illustrates how site managers and foremen often seemed to be equated from a communicative perspective in Norwegian projects, and equally how the Project Manager typically took direct contact with the design team members instead of communicating through the building design manager.

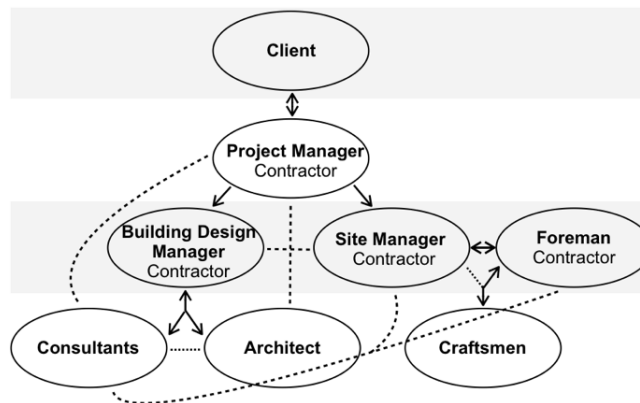


Figure 12: Communication patterns in Norwegian project teams

In the German organisations, practitioners described a more evident hierarchy than what was described by Norwegian practitioners (see Figure 11 and Figure 12). Accordingly, the German actors seemed to have an inherent confidence about their own and other actors' role in the team. Accompanied by the use of the DBB delivery method, a greater respect for responsibilities as defined in the project's Responsibility Matrix was found to be the reason for this. A more distinct hierarchy have several positive aspects for building design teams, including clear reporting lines and chains of command. Also, the German teams were less prone to spontaneous communication and showed a greater caution in conversation with colleagues from higher hierarchical levels. In some cases, this may hinder effective communication flow and result in team members missing out on vital project information.

The Norwegian interviewees described a flatter organisational approach in comparison to the German interviewees. A flat structure allows information flow crisscrossing the organisation to a greater extent than in a more hierarchical structure. This was defined to be an advantage by Norwegian practitioners, since it was associated with short communication paths and effective information flow. However, at the same time, Norwegian actors portrayed an unstructured environment with participants often feeling unsure about their role and responsibilities in the team. In addition, the areas of responsibility in the execution phase typically differed from what was defined in the early-phase. This raises a question as to whether the Responsibility Matrix has been clearly communicated to all team members and moreover, whether issues such as loss of control and work relation struggles are difficult to avoid when operating with a flat approach.

4.1.3 Communication channels

Results show that in both Germany and in Norway, many different channels are used to convey information between design and construction site teams. Table 5 presents an overview of the various channels that were identified in this study and depicts how important they are in today's building design management (as ranked by the interviewees).

Table 5: Common communication channels in rank order (1 = most common)

Channel	Germany	Norway
Meetings	1	1
Telephone	2	3
E-mail	3	2
Drawings	4	5
BIM	7*	6
Project intranet	6*	4
Tablets	5	7
Video conferencing	8*	8

* Only mentioned by practitioners from one German project team

The ranking in Table 5 is somewhat surprising since the theoretical framework for construction communication has a different list of channels. In the theoretical framework, also other types of channels such as project status reports, work breakdown structures and minutes are described. These were, however, not discussed by the informants in this study and are therefore not treated in the following sections.

In both countries, traditional channels such as meetings, telephone and e-mail were common. Newly developed tools such as project intranets and BIM are often used in the Norwegian industry, but rather rarely in Germany. Only one project team was familiar with the use of interactive channels such as the ones mentioned. Moreover, the findings imply that ICT tools used in both countries (e.g. tablets and applications for registering errors and deficiencies) are better developed and integrated in Norway, despite the fact that some of them were ranked as more common by German practitioners. This may suggest that German AEC organisations are slower to react to new opportunities, which is a big disadvantage in today's dynamic industrial environment. An elaborated description of the various communication channels identified in this study is provided below.

Meetings

In Germany and in Norway, face-to-face contact through formal- and informal meetings was described as the most common communication channel and was also regarded as essential for project success. Formal meetings are pre-planned activities. They have a predetermined set of topics that one wishes to discuss and a set of objectives that one aims to achieve. In formal meetings, actors typically exchange information, generate ideas, discuss problems and make decisions. Informal meetings, in contrast, have no requirements and can thus take place anywhere, and at any time. This is an advantage since construction projects often require fast decisions without time for discussion in formal meetings. Therefore, the use of informal meetings is essential, in order to manage the uncertainty and instability that exists in AEC projects. Moreover, informal meetings offer a lower threshold for actors to take part in decision-making, and also help to generate ideas and to build a sense of unity among team members.

Common to all types of face-to-face communication is the ability to transmit rich information. The interviewees emphasised how such rich information makes it easier to detect and avoid misinterpretations and ambiguities. Also, in communication theory, face-to-face channels are considered extraordinary powerful tools. They are real-time, unleveraged and has high bandwidth, which are characteristics that facilitate effective communication. Meetings were further found to be important for the reduction of organisational fragmentation. In project teams with an extensive use of face-to-face communication by means of meetings, the relationship between the different actors, disciplines and phases appeared to be stronger than when communication mostly took place by means of long-distance tools.

Despite being considered a vital communication channel both in theory and practice, meetings certainly do have their limitations. Firstly, it is considered hard to achieve effective face-to-face communication, especially in large organisations and gatherings. The reason for this is partly that types of noise such as physical and physiological easier affect the messages sent, and partly that large organisations increase the chance of being affected

by issues like “Chinese Whispers”. Secondly, the effectiveness of face-to-face communication is closely linked with the listener’s attentiveness and concentration, which is typically more difficult to ensure in large gatherings. Meetings are thus often considered time-consuming. Finally, information sharing in meetings has a drawback in not being self-documenting. This is particularly problematic in conjunction with informal meetings.

Telephone

The telephone is considered a vital communication tool by the practitioners in both countries. Its main advantage is that it can be easily adjusted to different situations. By opening for different types of communication: oral and written, one-way and two-way, synchronous and asynchronous, practitioners have the opportunity to choose the type of communication that is best suited for each context. For example, when there is no need for direct response, one-way, asynchronous channels like text messages can be used, but whenever direct feedback is needed, voice calls might be better suited. The following section primarily addresses the telephone as a tool for voice calls, since text messages are similar to e-mails which is discussed later in this chapter.

The interviewees emphasised the telephone’s ability to facilitate effective communication in spite of actors operating from diverse locations. The theory on construction communication attaches importance to the real-time dimension of the telephone (see section 3.3.4). These two characteristics ease cooperation and reduction of organisational fragmentation. In addition, they are important factors when dealing with complex design problems. The disadvantages of the telephone include its relatively low bandwidth and the fact that it is not self-documenting. Consequently, telephones are not always suitable when one wants to convey rich information. Additionally, voice calls are considered more vulnerable to noise than for example face-to-face conversations.

The Norwegian interviewees preferred the use of e-mail over the telephone, despite the fact that the literature ranks telephone as a more valuable tool (see Figure 3). Actors told that one generally achieves higher-quality information in e-mails than in telephone conversations since there is more time to prepare the message. Additionally, communication by the means of e-mail is self-documenting. Yet, one cannot escape from the fact that the telephone has unique properties when it comes to conveying information quickly over longer distances.

E-mails

Communication by the means of e-mail is increasingly common both in the German and in the Norwegian AEC industry. Respondents in both countries found this tool to be well implemented, although the study revealed that there are many problems associated with its use. For instance, in theories of communication, issues such as low richness, high leverage, low bandwidth and lack of real-time communication are pointed out as potential complications in e-mails. As a consequence of the channel’s low information richness, misunderstandings tend to occur when e-mails are used for long and complex information. Channels with a high leverage is especially controversial in contemporary construction, where there is an urgent need to reduce the current information flow in order to avoid information overload. The interviews showed that information getting lost or ignored

because of information overload is one of the most common issues in contemporary construction. Furthermore, the interviews revealed that e-mails are particularly problematic for German actors. One of the reasons for this is that the majority of the construction sites visited in Germany lacked satisfactory access to the internet. This obviously prevents efficient use of e-mail as communication tool.

The fact that AEC practitioners in both countries increasingly choose to interact by means of e-mail is interesting considering that the characteristics of the channel do not indicate that e-mails are particularly suitable for the transmission of complex design information. Nevertheless, e-mails do offer many advantages for building design teams. As highlighted by the Norwegian practitioners: e-mails definitely have the advantage that the flow of information is documented. Moreover, the majority of the informants found it easier to express themselves correctly via e-mails since they had more time to formulate the message. The channel also allows for multiple types of files to be added in the same message. Additionally, e-mails increase the flexibility of information flow, by opening for a combination of synchronous and asynchronous communication. The study indicates that these advantages are regarded as more important than the disadvantages. This may help explain why AEC practitioners seem to defy the theory on construction communication and choose to use e-mails to an increasing extent.

Drawings

In spite of the significance of verbal communication in building design teams, both German and Norwegian actors emphasised the importance of conveying some information in written form. Examples of such information include thoughts and ideas related to design. The traditional drawing is one tool that may be used to visualise information. As all executing work are based on the information they convey, traditional drawings are defined as the foundation for all work on-site. Drawings are thus regarded vital to the successful sharing and understanding of design information.

From the perspective of communication theory, drawings offer several benefits to construction teams, such as self-documenting, high richness and high bandwidth but they also include drawbacks such as a high leverage and a lack of real-time communication. Still, as of today, there are no other tools that are better suited to convey visualised information. It appears that new technologies like BIM will take over for drawings sometime in the future, but these utilities are still not deemed sufficiently developed or implemented in the two countries studied.

Building information modelling

BIM has become relatively widespread in the Norwegian industry during the last decade, but still has not completely taken over for traditional drawings. The use of 3D-models in BIM is a modern tool for visualising building design. In Germany, practitioners seemed rather unfamiliar with the use of BIM in practice, in spite of being well acquainted with the theory behind this utility.

In addition to providing many of the same benefits as drawings, BIM is a major contributor to the reduction of interface issues in construction projects. For instance, it opens for running collision tests and aligns the different areas of responsibility to the

various project team members. Accordingly, Norwegian actors argued that the use of BIM helps simplify the flow of communication in AEC projects. BIM is said to have a high bandwidth, to be self-documenting and to allow the transfer of rich information. The tool is, however, not facilitating a low leverage and real-time communication flow. Notwithstanding these disadvantages, BIM should be considered an important part of the development of the construction industry. In comparison to other visualising tools, the features of BIM play in a higher league and may be seen as one of the keys to gather the fragmented industry in the future.

Tablets

Tablets are increasingly used as a communication channel. Tablets provide many of the same opportunities as the telephone and can help shorten the physical distance between the different actors. One of the main advantages of tablets is that they make the use of other channels such as drawings and e-mails more convenient for practitioners. For example, provided internet access, they enable access to up-to-date drawings anywhere, anytime. Tablets are defined as a rich, high bandwidth channel. Their use does unfortunately also cause high leverage in the communication process, which may result in information overload.

The German and Norwegian practitioners explained that tablets are commonly used in most construction projects. The tool is particularly useful on-site, where access to project information is typically problematic without. It should be added that the software used in Norway was described as better functioning and more developed than in Germany. Norwegian actors mainly used tablets to access project information and to register error or deficiencies whereas actors in the German industry did not feel that they could rely on the use of tablets alone, mostly as a consequence of unreliable internet access. In the German industry, tablets were mainly used to complement traditional drawings and the telephone. In this context, the German actors pointed out that issues related to the use of new technology often cause problems in the communication process. This was not an equally prominent opinion among Norwegian interviewees, which may indicate that Norwegian project organisations are better at adapting to the constant changes in the industry.

Project intranets

Project intranets are defined as a centralised database for construction information, where all project members can upload, share and download project material. The utility also allows participants to ask questions and give feedback to their colleagues. In the Norwegian industry, project intranets were said to improve the speed of which information is transferred between actors. Equally, it ensures that all players have access to up-to-date information at all times. The channel allows transfer of information through rich, high bandwidth channels such as drawings, but also cause leverage to arise in the process. Leverage pose a special threat in contemporary construction and one should therefore try to avoid overuse of leverage tools.

In Norwegian project organisations, intranets have become a part of everyday life whereas the majority of the German practitioners found intranets problematic. All teams had tried to implement this tool in their processes, but with widely varying success. The

usability of the software was described as the reason for not succeeding. In sum, the findings indicate that project intranets have a huge potential as communication channel in the AEC industry. Just like BIM, the channel may help improve cooperation between the actors, disciplines and phases involved. However, before actors in Germany can benefit from its full potential, there is a need for development of the software used there.

Video conferencing

Both the Norwegian and the German actors described communication by the means of video conferencing as a new way of conveying information, but there was a slight tendency that its use is somewhat more common in Norwegian industry. By allowing real-time, high bandwidth information flow also over long physical distances, video conferencing is an advantage whenever project participants are not based in the close proximity of each other. The utility is further considered to have a low leverage, which is very beneficial in the effort to reduce the current amount of information in AEC projects.

The interviewees explained that video conferencing, just like meetings, facilitate a stronger relationship and trust between the different actors involved. This is partly considered a result of the channel's ability to convey non-verbal communication. In the fragmented construction industry, video conferencing may thus act as a means for creating a feeling of unity among team members. In sum, video conferencing was not found to be very widespread in neither Germany nor in Norway, but the findings suggest that it is merely a question of time before it becomes a part of information flow in all project organisations. All indications are that one can benefit greatly from this tool in the future.

4.2 COMMUNICATION CHALLENGES

Corresponding to the findings from the literature review, the informants described the assurance of effective communication as a challenging, but yet vital, part of AEC projects. Whenever a project team fails to communicate effectively, it becomes increasingly difficult to achieve their objectives, manage change and facilitate an environment built on motivation, trust and synergy. The interviewees attached special importance to six problem areas considered particularly problematic in terms of establishing first-rate communication in contemporary construction. These six issues are treated in the following sections.

4.2.1 Volume of communication and planning activities

In construction projects, project participants conduct dozens of conversations by means of a variety of channels every single day. Some of these conversations are of great importance to the project, but many are considered insignificant. The interviewees in Germany and Norway stressed the significance of reducing the types of communication episodes that do not add value to the project. However, such reduction is not straightforward. When a lot of information circulates simultaneously, it is typically difficult to separate what is important from what is not. So, the chances of information overload increase. Using time on trying to handle large amount of senseless information results in less time available to solve more important tasks.

The theoretical framework suggests that by reducing the amount of organisational levels, information flow decreases. This study, however, indicate that this may not necessarily happen in practice. That is, in spite of operating with a more hierarchical

organisational structure, the German actors seemed somewhat better at eliminating unimportant information. In flat structures such as in the Norwegian industry, information overload often seemed to arise because of an unstructured environment.

Among practitioners in both countries, there is a common perception that most project teams underrate the need for communication. Additionally, the pre-construction time is typically found to be too short. The majority of actors had experienced a need for more extensive communication and up-front planning than originally scheduled. According to the theoretical framework, the development of a coordinated set of project objectives is hampered when participants undervalue the importance of these activities, which then increases the chances of conflicts related to time, cost and quality.

The respondents emphasised the importance of the pre-construction stage as an arena for team members to get to know each other at a personal level and identify each other's strengths and weaknesses. This is essential to the establishment of trust and commitment. As highlighted in communication theory, these values are vital to the successful completion of AEC projects. Nevertheless, by allocating sufficient time to communication and planning throughout the project life cycle the facilitation of these aspects is automatically ensured.

4.2.2 Choosing the right channel

Findings from both the literature review and the interviews highlighted the correlation between choice of communication channel and effectivity of communication. Hence, the choice of a channel suitable for the communication task is an important part of establishing and maintaining effective communication in design teams. In such instances, the most common problem is that the desired recipient is not reached, which is typically detected through a lack of response. Another recurring issue arises when a channel is used to convey richer information than it is suitable for. In such cases, recipients typically gain only a shallow understanding of the content or, in the worst case scenario, do not deal with it at all. The answers from the practitioners and theory further underline the potential danger of asynchronous channels since these channels can reduce the overall project performance if used in the wrong context. A common method used to avoid these issues is the use of multiple channels simultaneously, e.g. by ensuring that an e-mail has arrived by asking for a confirmation in a text message. This ensures that the message reach who it is supposed to reach and in the format it is wanted. Nevertheless, to avoid information overload, multiple channels should be used with caution.

The choice of the right channel is first and foremost seen in conjunction with an assessment of their advantages and disadvantages, as well as what type and amount of information they can convey. However, due to the different practices of project teams, practitioners in both Germany and Norway found that the choice of channel is even more problematic. Whereas some teams mainly used project intranets to share and discuss information, other teams still swear to the use of e-mail or meetings. The informants explained that this irregularity often leads to the emergence of uncertainty concerning the choice of channels in project teams. Such uncertainty may result in project information becoming disorganised at the best and to loss of information at worst. This finding highlights the importance of pre-defining a set of communication ground rules in project

teams. These guidelines should include information about where, when and how to use the different channels.

4.2.3 Teamwork

In order to ensure good collaboration and effective communication in building design teams, practitioners in both the German and the Norwegian AEC industry emphasised the importance of strong interpersonal relations and trust between project team members. Even more than in other industries, human factors seem to determine whether construction projects develop in a good way or not. The respondents maintained that when there is a good “chemistry” in project teams, dedication and collaboration are typically stronger, and planning, coordination and information flow run smooth. Unfortunately, attributes like these seem difficult to establish in AEC teams because of the project-based and fragmented environment.

Teamwork theory suggests that trust has excellent complexity-reducing properties, since trust creates interpersonal relations also at an emotional level. However, to build trust takes time. The process of building trust can be compared with the process of building a wall brick by brick. A brick that does not fit makes the wall collapse or means that construction continues on a faltering foundation. Trust is in other words in constant motion. One step in the wrong direction can result in a complete loss of trust between individuals or groups. In temporary and dynamic AEC teams, trust is particularly difficult to establish. Informants in the German and Norwegian industry explained that as soon as team members get a sense of being a cohesive unit, the project is typically completed and the organisation dissolves.

To create a sense of belonging to the project group was further described as an essential part of effective information flow in building design teams. When people feel that they belong to the team, the degree of involvement and knowledge sharing is generally higher. Additionally, actors that are feeling connected to their workplace and their co-workers often perform better, are more satisfied and has higher commitment to their work. Just as trust, a sense of belonging is considered difficult to establish in the AEC industry because of the loose and temporary coalition of different people and organisations.

The practitioners in the Norwegian project teams described a tendency to make changes in the project organisation also after project start-up. In the already unstable and fragmented environment surrounding construction projects, such changes add to the issues above. The informants agreed that when several changes in the project team are undertaken after project start-up, the chance of communication errors increase. This is illustrated by the substitution of the Architect and the Landscape Architect carried out in the middle of one Norwegian project. The uncertainty arising from this change, resulted in an error in the contour line being transferred to the new architect and then passed on to the site team. The mistake was not discovered before the foundation was already finished. To fix this error cost the project team a lot of time and money.

An interesting note is that one of the German companies had chosen to base their work on standardisation, co-location and pre-fabrication. Both the literature review and the case study gave strong indications that these work methods offer many advantages considering the establishment of trust and interpersonal relations.

4.2.4 The project delivery method

The analysis of the AEC project teams conducted in this study indicates that many of the current communication challenges in the German industry arise as a result of the project delivery method. The DBB method allows many actors to take part in the decision-making and so leads to increased process complexity. Moreover, DBB contracts increase the number of links in the hierarchy, which raise the chances of phenomena such as “Chinese Whispers” and “noise” to impact the clarity of the conveyed message.

As was explained in chapter 4.1.2, a DBB contract places the client at the centre of the information flow. Because the client typically lacks the skills and experience to successfully manage this interface, the use of the DBB method often results in poor cooperation between design and construction site teams. Therefore, as pointed out by the informants: a DBB project delivery method increases the chance of competing interests and different jargons affecting communication in the interface between design and construction. Construction projects are comprised of actors from many different disciplines. They all have their own terminology, which they tend to use regardless of context. Between fellow specialists, this may function well, but whenever the technical terms are not known to the receiver, problems can occur. An example of this was given by one of the interviewees, who told that a pipe installer had misinterpreted the architect’s drawings because he was familiar with another use of symbols. Because the pipe installation had to be redone, this mistake caused increased time and costs for the project team. This example shows how semantic noise may affect the interpretation of information and underlines the importance of pre-defining a set of team rules and guidelines in order to ensure that ambiguities and misunderstandings between sub-groups are maximally reduced.

In terms of ensuring first-rate communication between design and construction site team members, both theory and research findings underline the advantage of choosing DB as the project delivery method. The organisational integration of design and construction processes by this type of contracts has already been pointed out in section 3.4.2. Consequently, to ensure a synergy between these teams is not up to the client alone. Rather, a DB delivery method is thought to promote stronger cooperation and more effective communication in the design-construction interface. This type of contract is, however, not suitable for all contractors as it places a higher demand on the size and economy of the company. In addition, when the client is experienced or wants to be involved in the project, the DBB delivery method were defined as an equally good (if not a better) choice.

4.2.5 Organisational culture

Organisational culture is a complex issue that includes everything from the values, attitudes, beliefs, assumptions, artefacts and behaviours existing in a group, and is formed by the history and experience of the actors. Accordingly, the organisational culture encompasses the degree of hierarchy existing in an organisation. Moreover, the culture in an organisation affects the attitudes and commitment among its practitioners. Consequently, this concept is considered decisive for how communication takes place. Regarding organisational culture, the German informants highlighted the importance of practitioners’ experience for successful project teams. Through experiencing high and lows, actors form an idea of what it takes to succeed in projects and gain an overall perspective on the construction process,

and this knowledge can then be taught to other team members. Having too many inexperienced workers in the same organisation thus makes it difficult to achieve the transfer of professional know-how and understanding without “outside-help”. Receiving “outside-help” may in its turn counteract the establishment of a strong culture within the organisation. The extent to which an inexperienced team hinders the achievement of project success was clearly illustrated by Norwegian actors. In one of the Norwegian teams, the Building Design Manager, the Project Manager, the Site Manager and the Foreman were all novices in their roles. For this reason, the project team faced many challenges which are normally avoided. A more experienced site manager was eventually transferred to the project as additional assistance, which led to a drastic improvement of efficiency.

Several of the challenges described by the Norwegian informants, e.g. unclear roles and responsibility, lack of initiative and motivation, and too much informal communication, were regarded a result of the prevailing organisational culture. These issues result in a confusing information flow, and can give rise to uncertainty and decreased productivity. Additionally, Norwegian practitioners described it as a huge problem that team members often show up unprepared for meetings. In such situations, valuable time is wasted on repetition of agenda and key topics. Furthermore, the findings indicate that the vast focus on organisational decentralisation in the Norwegian industry over the last few years has reduced the clarity of organisational structure. Without a distinct structure, effective communication seems difficult (maybe even impossible) to establish and maintain. Additionally, lack of clarity often results in team members going past important levels in the hierarchy when exchanging information or taking decisions. This is an important point since it is of crucial value in building design management that actors get the information they need. In the worst case scenario missing or inaccurate information can lead to the site team producing on the wrong foundation.

The findings show that organisational culture has an impact on the use of communication channels, especially on meetings. Interviewees in both countries indicated that efficient meetings are difficult to conduct. The German practitioners noted that formal meetings typically become *too formal*, whereas *too informal* meetings were a more common issue in Norway. This distinction can be related to a difference in organisational culture in Norway and Germany. In Norway, actors are provided with freedom and responsibility for their own work. In Germany, however, the informants described a more rigid structure which to a greater extent locks the actors to a predetermined set of guidelines. Too formal meetings result in valuable time being wasted on formalities and rituals such as reviewing past minutes. On the contrary, too informal meetings typically lose their direction and focus point, and may result in important decisions not being made. In addition, irrespective of whether they are too formal or too informal, the meetings typically become very long. In lengthy meetings, it is hard to remain concentrated and the quality of the work is at stake. In Germany, a tendency that actors typically have a lot of pride in their work was observed. This makes German actors reluctant to receiving help from others and to admitting mistakes, which hinders the organisation from developing.

The Norwegian actors indicated that the establishment of strong interpersonal relations, trust and organisational culture are interdependent. In companies with a strong and prominent culture, good collaboration seems easier to attain. Equally, when project team

members trust each other and have a good “chemistry”, it has a positive impact on the organisational culture, for instance by facilitating motivation and involvement.

4.2.6 Multiculturalism

Multiculturalism, considered in terms of the culture associated with an ethnical group, is an increasingly prominent feature of the modern construction industry. Both in Germany and in Norway an increasing number of foreign workers and companies are involved in AEC projects. Simultaneously, it is becoming more common for companies to execute projects across national borders.

Differences related to languages and cultures might result in misunderstandings and misinterpretations when they are not properly managed. This can in its turn cause uncertainty and confusion in the project organisation. For example, semantic noise can occur as a result of the receiver not understanding the language used by the sender. Cultural differences such as how on-site workers are used to receiving orders from the management or treating their colleagues may complicate the cooperation between the project participants. Consequently, effective team communication that overcomes differences in language- and culture may be hard to establish. If one does not focus on reducing the inequalities, such differences can result in delays and reduced quality of the final product.

4.3 LEARNING BETWEEN NORWAY AND GERMANY

The study of the German and the Norwegian AEC industry showed that the different approaches of contemporary construction in various ways impact on the effectivity of the communication process in various ways. In both countries, several initiatives to facilitate effective communication in the design-construction interface were identified. The main contributions are described closer in the following sections.

4.3.1 Lean thinking in construction

The concepts of Lean Design and Construction are increasingly popular in the Norwegian construction industry. In practice, these concepts imply that any organisation should undergo a careful examination of its people and its work processes, in order to reveal and remove any waste that exists and prevents value from being delivered.

Practitioners in the Norwegian industry described how the use of the LPS as production system has contributed to increasing the team members’ project commitment and responsibility for the end-product. Furthermore, the LPS supports the management of any uncertainty in construction projects, for instance by addressing the flow aspect by means of constraint analysis and commitment planning. In the Norwegian project organisations, collaborative scheduling with Post-it notes had increased schedule predictability and helped ensure that work was completed as, and when, it was promised. In addition, Lean was facilitated through the use of ICT tools such as BIM, as discussed in section 4.3.2.

The study indicates that Lean thinking and its principles are not yet very widespread in German industry. Many respondents had heard about Lean, but most could not explain what it entails in practice. Nevertheless, a tendency of increased use of Lean assembly principles such as preassembly and standardisation was observed (see section 4.3.4 for a discussion of this). It was however clear that the German interviewees did not acknowledge the connection between Lean thinking and these work methods.

The Norwegian interviewees had as yet not experienced any drawbacks with the adaption of Lean thinking in construction processes. In the literature, however; it is emphasised that the successful implementation of these methods demands dedicated and experienced actors according to section 3.3.3. Moreover, for an organisation to follow Lean principles, it has to make changes in its existing organisational structure and work procedures. These findings may help explain why Lean is somewhat uncommon in the hierarchical and traditional German companies. Equally, they help to justify why companies chose not to adopt such methods.

4.3.2 Information and communication technology

The use of ICT tools has evolved rapidly in Norwegian AEC projects in recent years. Of particular importance is the use of project intranets, video conferencing and BIM, which was defined to have a huge potential in terms of easing the flow of information. In German project teams, these tools are generally not present. The exception being a small number of companies that strongly stand out from what is considered “normal” practice. Again, the hierarchical structure of German companies was found to be the reason for the somewhat slow implementation of new ICT tools in Germany. Communication by the means of e-mail and tablets is worth mentioning when talking about ICT tools. E-mail is, however, a more traditional method and used by practitioners in both countries. Tablets are not further described in this section because they are mainly regarded as an aid for the use of the other technologies.

Project intranet

In Norwegian project teams, project intranets are used to simplify communication patterns and provide all team members immediate access to project information. The respondents especially emphasised the importance of project intranets to create an arena where all participants come together to exchange and discuss project information. Moreover, it is an advantage that visual information such as drawings and pictures can be easily uploaded and shared on this platform. In combination, these benefits imply that project intranets increase the speed and the quality of which information flows through temporary AEC organisations.

Video conferencing

Video conferencing is a relatively new tool from a construction industry perspective. Use of this utility provides many benefits for the management of the temporary and fragmented environment in which project teams operate. Firstly, the use of video conferencing allows real time, face-to-face communication, which facilitates long-distance communication. Thus, video conferencing can save organisations a lot of time and money. Importantly, the majority of the respondents found that to see each other in real time pictures compares to face-to-face conversations which is necessary in order to build trust and interpersonal relations. Furthermore, video conferencing opens for the duplication of computer screens. A Norwegian practitioner expressed this as a huge benefit because visualising tools such as drawings and sketches can be shared during discussion.

Building information modelling

The findings show that an active use of BIM and 3D models in planning and execution is an important contributor to the facilitation of effective communication in building design work. These utilities have prominent error-reducing features. An informant in Norwegian industry pointed out that because it helps visualise the end-product, the error in the contour line (from the example in section 4.2.3) could have been revealed if BIM was used also in the final stages of the project. BIM provides several benefits, the most important of which may be a coordinated project delivery. Moreover, the interviewees emphasised the importance of clash detection, easy access to information anywhere and the coordination of steps. Lastly, its simulation and visualisation features are essential for project success, especially in relation to the presentation of projects to clients and other “non-professionals”.

Despite wide acknowledgement of their advantages, the implementation of ICT tools in construction projects is not without problems. The practitioners described how ICT tools have reduced the overall understanding of the project on some occasions. For example, it is a fact that when all participants have continuous access to information it is impossible to control who receives what and at what time. In the worst case scenario, this results in information overload. Equally, actors may end up making their own “image” of the project, which, however, might not always correspond to the overall project objectives. Problems with the software of these tools had also been experienced, which in part explains the failure of the German teams to implement these utilities in their processes. In some teams, software errors had resulted in the loss of important work, both in the form of information and documentation. Nonetheless, the interviewees in both countries pointed out that the issues associated with ICT utilities should be possible to avoid in the future. Today, they primarily arise as a result of underdeveloped technology and a lack of standardisation and guidelines on how to use these tools.

4.3.3 Co-location

In the German industry, the advantage of co-located building teams was emphasised by the respondents, although only one of the teams had used this in practice. Particularly in ensuring effective communication and information flow in project teams, this method was considered as hugely important. A few of the practitioners in the Norwegian industry also suggested co-location as an approach to improve communication in the design-construction interface. It should be observed, however, that none of the teams had real-life experiences with the method.

The theory on Lean construction emphasises the importance of co-location through work methods such as IPD and ICE. These delivery systems seek to align interests, objectives and practices through a team-based approach with strong collaboration as the main focus. In the German company that had implemented co-location in practice, many of the team members worked under the same roof through the entire project life cycle, including engineers, architects and some technical consultants. The main advantage of co-location is that it allows for two-way and informal communication, while simultaneously opening for team members to get to know each other better. This leads to stronger interpersonal relationships and trust. Practitioners in both Germany and Norway reported that when team members know each other well, they typically feel more committed to

delivering timely and high-quality work. Equally, the general perception among actors is that it is easier to ask for help and admit mistakes when one feels belonging and trust in the group. Relative to co-location, it was also mentioned how such values help ensure shorter communication paths.

The findings showed that many of the advantages of co-location mentioned in the theoretical framework and in the interviewees were present also in practice. The German project team primarily used co-location in the design stage, but partly also in the execution process. This team had exceptionally strong interpersonal relations and trust between the different participants, which was mainly reflected by the seamless cooperation between the design and construction site teams. In this regard, the participants stressed the indisputable significance of co-location in terms of creating a feeling of unity and making actors work towards a common goal.

In spite of the above-mentioned advantages, it is debatable whether co-location is a method that can be adapted by every company. There are several reasons for this. Firstly, only companies of a certain size typically have the workforce and economy to defend its use. Co-location is a costly method with a high need for in-house specialists. Smaller companies thus typically exclude this approach. Secondly, it is unclear whether this type of work method is suited for introverted companies who like to solve their own problems. This is underpinned by the fact that co-location was only seen used in the German industry, where practitioners defined themselves as reluctant to receiving “outside-help”. As discussed previously, a disadvantage with such thinking is that organisations typically experience a slower development because they do not get as much input from other parts of the industry.

4.3.4 Standardisation and pre-fabrication

The study revealed that German project teams have a great faith in standardisation and pre-fabrication as a way to manage many of the problems in contemporary construction. From the interviewees it emerged that several German companies practice these methods either completely or partially. In contrast, none of the Norwegian informants mentioned these principles, which tentatively indicates that their benefits are currently rather unknown in Norway.

The principles of standardisation and pre-fabrication may be implemented separately, but maximum benefit accrues when they are used together in an overall project strategy. Some of the main advantages of applying these concepts in contemporary construction projects (as defined by the German actors) are presented in Table 6. These underline how the use of these work methods potentially saves time and costs, which are of huge importance in conjunction with the achievement of project objectives and good Key Performance Indicators (KPIs).

Table 6: Benefits of standardisation and pre-fabrication

Both	Standardised processes	Pre-fabrication
Improved time, cost and quality	Easier to handle congested sites	Predictable high-quality finishes
Increased productivity through familiarisation	Tried and tested tools and work methods	Off-site inspection
Less waste, noise, dust, time on-site etc.	More predictable activities	Reduction of on-site rework

It should be mentioned that just as for co-location, standardisation and pre-fabrication are not suitable for all companies. One reason for this is the high requirements on company size and economy. In addition, a high focus on the standardisation of processes may lead to a loss of uniqueness and responsiveness, and also makes the company unsuited for aspects related to business or clients beyond its area of specialisation. The last aspect was discussed particularly by the company in this study that to a large extent standardised their processes. This company claimed that the loss of clients or business areas not necessarily is a disadvantage, as long as there exists a common agreement among the employees that the opportunities that do not fit into the pre-defined frames should be rejected. Similarly, all effort and funding must be used on those fields of business where one has specialised.

4.3.5 A hierarchical versus a flat approach

The comparative analysis of Germany and Norway indicate that German and Norwegian practitioners have different views on how to structure their AEC organisations in order to best facilitate for effective communication. In Norway, there is a strong focus and emphasis on the use of a flat organisational structure. The advantages of this approach include open and more effective communication, decision-making and collaboration. On the other hand, the analysis of communication processes in Norwegian teams showed that the use of a flat structure has a tendency to foster role confusion and uncertainty in the organisation, characteristics which typically hinder employee's motivation.

As opposed to the Norwegian actors, German informants stressed the need for maintaining a certain degree of hierarchy in the AEC organisations. The study showed that this approach results in more distinct reporting lines and chains of command. These features, in turn, ensure clear divisions of roles and responsibility within project teams. In addition, German actors underlined the importance of motivated and well-prepared participants. This was considered easier to achieve when all actors have a clear picture of their role and responsibilities. On the other hand, a purely hierarchical system also involves several disadvantages. Firstly, hierarchical companies often have less effective decision-making and information flow. These issues are regarded as a result of the increased bureaucracy in a hierarchical versus a flat company structure. Furthermore, hierarchical organisations are known for being less dynamic and thus slow to react upon new opportunities. In today's rapidly changing environment, characteristic such as these typically hinder company success. For instance, this may help explain why the German

AEC industry seems to be slower in adapting to new technology and work methods than the Norwegian industry.

A respondent who had worked several years in both the German and the Norwegian AEC industry made an interesting point. He claimed that the right balance between a hierarchal and a flat approach is necessary to create effective communication in organisations. This particularly applies to the interface between design and construction site teams. Efficient collaboration across this boundary is just as dependent on strong interpersonal relations and trust (features of the flat approach), as it is on clear division of roles and responsibilities and distinct reporting lines (features of the hierarchical approach). The study implies that one of the German companies had achieved exactly this. By basing their work on standardisation, pre-fabrication and the supply of a total design-build service (DB contracts); this company succeeds in safeguarding a distinct structure while at time same time allowing for an increased involvement in decision-making and the adaption of new work methods and technologies. The results of the study of this project team gave clear evidence that these characteristics increase the effectivity of communication in the organisation. Furthermore, equally good results were observed in relation to project performance. It is however important to point out that only a minority of companies have the opportunity of structuring their practice in this way, because as already mentioned: these work methods set considerable demands on the quality of the workforce and the economy of the company.

5 CONCLUSIONS

This study set out to explore the communication between design and construction site teams in AEC projects. The fifth chapter summarises the main findings of the research, and presents the recommendations that were derived from the analysis and interpretations of the empirical data. Despite being limited to the design-construction interface in the German and the Norwegian AEC projects, several of the research findings are considered transferable to other countries and other projects. The structure of the chapter is based on the three research questions of the study.

5.1 COMMUNICATION PATTERNS

The way in which communication flows within building design teams was found to differ significantly between the German and the Norwegian cases. This was considered a result of the countries' different ways of structuring and approaching projects. Table 7 outlines the main distinctions of the two countries as they were identified in this study.

Table 7: Characteristics of the German and the Norwegian AEC industry

Germany	Norway
Resistant to change	Constantly developing
DBB project delivery	DB project delivery
Hierarchical approach	Flat approach
Traditional communication channels	Widespread use of ICT tools

According to the characteristics presented in Table 7, German construction teams are generally characterised by stability and control, as well as internal focus and integration. The study revealed that the vast focus on a well-defined structure through a strong hierarchy is the main reason for these features. For instance, the hierarchal approach hinders flexibility and external focus in organisations. This helped explain why German project organisations seemed more reluctant to change than their Norwegian counterparts. Accordingly, the prevalence of conventional procurement methods and limited use of ICT tools may be regarded a result of this type of organisational culture. The features of the German construction industry also affect how communication patterns develop in AEC organisations. Firstly, the DBB project delivery method typically limits communication between design and construction site teams. Secondly, the hierarchical approach is often described as an obstacle to informal communication. Lastly, the limited use of ICT tools seems to prevent organisations from achieving their full potential in terms of communication effectiveness.

In contrast to the German industry, the Norwegian industry favours dynamic development and continuous adaption, rather than stability and control. Moreover, Norwegian actors place strong value on cohesion, commitment and trust in their organisations. These features are known as characteristics of a flat organisational structure. The extensive use of modern work methods, tools and communication channels in the Norwegian teams may thus be regarded a result of this type of organisational culture. From

a communication perspective, the properties of the Norwegian approach help AEC teams increase their efficiency. The overall impression is that modern utilities like BIM and project intranets help streamline the communication process, in spite of their drawbacks. Use of the DB method facilitates first-rate communication also in the complex interface between design and construction. In addition, a flat structure seems to shorten the communication paths between project team members, making the flow of information more effective. On the other hand, some negative consequences can be associated with the Norwegian way of working. The findings indicate that the flow of information typically become bewildering in very flat organisations. In its turn, this can foster uncertainty and confusion among actors, which further complicates an already complex communication environment.

The study identified a tension between the need for documentation through formal channels and the need for dynamic information flow by means of informal channels. Table 8 presents the formal- and informal channels that have been discussed in the thesis.

Table 8: Formal and informal communication channels

Formal	Grey zone	Informal
Formal meetings	Tablets	Informal meetings
Drawings	E-mails	Telephone
BIM		Video conferencing
Project intranets		

In many parts of the design and construction processes a direct conflict between the need to work collaboratively and the need to document project information was observed. Formal communication channels ensured systematic flow and documentation of information. However, formal channels are sometimes ineffective and time consuming. Therefore, informal channels are necessary as a supplement to formal communication. Informal channels help practitioners handle the uncertainty that exists in the rapidly changing AEC environment. Equally, they facilitate knowledge-sharing and generation of ideas across the organisational structure. Nonetheless, too much informal communication can be harmful to any workplace, for instance by breaking trust, transfer vague information and create uncertainty in the communication process.

The section above highlights the need for both formal *and* informal communication in AEC organisations. Simultaneously, it points out that it is necessary to be cautious with the use of informal communication in order to maintain healthy relationships and a structured information flow. New formal communication tools such as BIM and project intranets have been developed during the past years. These do in many ways ensure a strong collaboration between team members without the drawbacks of informal communication. A further development of these utilities may help minimise the differences between formal and informal communication, and thus facilitate effective communication in building design teams.

5.2 COMMUNICATION CHALLENGES

The comparative analysis of German and Norwegian AEC industry showed that there is a need for an improvement of communication in the design-construction interface in both countries. Several challenges that affect the effectivity of communication flow between participants in contemporary construction, emerged from the interviewees. These challenges are depicted in Table 9, sorted by the country/countries in which they are present.

Table 9: Challenges of communication in Germany and Norway

Both countries	Germany	Norway
Underrated communication need	Client “in charge”	Unclear roles and responsibility
Short pre-construction	Long message chain	Need to request information
Information overload	Competing interests	Lack of motivation and initiative
Unstructured information	Different jargons	Much informal communication
Interpersonal relations and trust	Averse to receive help	Too informal meetings
Multiculturalism	Too formal meetings	

The communication challenges in Table 9 once again underline the importance of organisational structure and culture for the establishment of first-rate communication in construction teams. The communication challenges described only by German practitioners were deemed to occur mainly as a result of the focus on safeguarding a hierarchical approach. As already stated, hierarchical organisations favour stability and control, which makes the adoption of new work methods and technologies more difficult. Moreover, it typically hinders the use of informal communication. Correspondingly, issues like competing interests, long message chains and too much formality are currently threatening the effectiveness of communication in German AEC projects.

Also in Norwegian project teams, the organisational culture is considered as a big issue. Several of the current communication problems were considered to arise as a result of the vast focus on a flat structure, which proved to foster uncertainty and confusion within organisations. These features give rise to obscure roles and responsibility, as well as a lack of motivation and initiative. Furthermore, a flat approach facilitates the use of informal communication in organisations. In many ways, this is an advantage, but as previously specified; informal communication needs to be used with caution. If not, its use may for example result in information overload and lack of interpersonal relationships.

An interesting finding was made in relation to the use of e-mail. Actors defined a steadily increasing use of this channel, despite the fact that it causes many issues in the communication process. Correspondingly, the use of this utility appears to be unavoidable to practitioners. To ensure its effective use and avoid its biggest drawbacks, it is important to spend time on the development of a pre-set framework describing where and when to use the available communication channels. In this regard, it may be discussed whether a framework potentially hinders the transmission of information if it becomes too rigid. This study did, however, provide evidence that such a framework is the best method to manage problems related to the use of common communication channels.

In both countries, issues related to the volume of communication and planning activities, the choice of channel, teamwork and multiculturalism were defined as common. The theory on organisational communication provides clear descriptions on how to overcome these and similar problems. The fact that such problems still exist thus indicates that there is a gap between the current knowledge of organisational communication and how this is practiced in the AEC industry. For example, it is clearly stated in the theoretical framework that good communication is essential for the project team in order to achieve coordinated results, manage change and motivate employees. Still, these properties were defined as problematic to establish in both countries. These findings give clear signals that more research is needed in order to understand why the construction industry fails on these areas and, even more importantly: what can be done in order to overcome such problems.

5.3 LEARNING BETWEEN NORWAY AND GERMANY

This study reveals that Germany and Norway represent different views on how to best facilitate effective communication in AEC organisations. In Germany, a hierarchical approach was favoured, whereas a more network-like structure was seen present in Norway. The findings imply that a flat, network-like structure has several benefits. It can, however, result in a chaotic project environment because of too much independency and a weak structure. A hierarchical approach on the other hand, typically maintains the structure, but decreases the efficiency of information flow and prevents the organisation from developing.

It can also be noted that when alone, neither the German nor the Norwegian approach is capable of improving communication in the design-construction interface. However, in exploring theory and practice, it was found that from a communicative perspective, there is no *either-or* but rather a *both* on this matter. A more balanced use of hierarchy allowed German companies to apply the use of work methods and utilities more quickly. Similarly, Norwegian project teams experienced a more distinct division of roles and flow of information. Thus, by balancing the Norwegian and the German methodologies, companies can benefit from the current strengths of both countries as presented in Table 10.

Table 10: Strengths of the German and Norwegian approach

Germany	Norway
Clear communication paths	Allows for innovation
Clear chains of command	Simpler and faster decision-making processes
Clearly defined set of responsibilities	Independent employees
Motivated and committed employees	Improved speed of communication flow

Findings from the German industry support the theory that the right balance between a hierarchical and a flat approach solves many of the current communication problems. More specifically, it is evident that the company that managed to maintain a distinct structure, also kept pace with the industry's continual development. However, the structure used by this company is not feasible for most firms, because of the way it limits the range of projects while also requiring a certain size and economic capacity.

In addition to balancing the degree of hierarchy, both theory and findings highlight other possible initiatives that may help foster first-rate communication between design and construction team members. Firstly, the adoption of new tools and technologies such as Lean Design and Construction, BIM, project intranets and video conferencing, were seen to have the potential to drive up the quality of communication. Secondly, the benefits of choosing DB as project delivery method was highly emphasised and encouraged. This contract form organisationally integrates design and construction processes and thus ensures stronger cooperation between team members. Thirdly, participants emphasised that clear communication and definition of the project's Responsibility Matrix and common goals for the project group compose an essential part of communication. However, of even greater importance are the principles of co-location, standardisation and pre-fabrication. When implemented correctly, the use of these methodologies forms a solid foundation for the establishment of strong collaboration and effective communication between design and construction site teams.

Summing up, this study shows that an improvement of communication and information exchange in building design management helps increase the overall efficiency of the construction industry. Based on the findings from this research, it can be claimed that the methods and technology needed to improve communication between design and construction teams already exists. Nevertheless, the question of how these solutions are best combined and implemented, so as to avoid the present negative impacts on the industry, still remains. Thus, the answer lies in finding the right balance of a hierarchical and a flat structure, the formal and the informal, as well as the use, or non-use of ICTs. In this regard, the author recommends that project teams have a hierarchical structure in terms of decision-making, which will make the flow of information more structured and easier to control. A more informal approach is, however, suitable when generating ideas. Furthermore, the study showed that it is important to be critical to adopt new methods and technologies if the advantages these entail for the project team is not clear. As can be learnt from the Norwegian industry, an uncritical implementation of such tools can – in the worst case scenario – reduce the overall performance of project teams.

6 RECOMMENDATIONS FOR FUTURE RESEARCH

This final section discusses and proposes directions for further research, given the implications of this study.

This study has been limited to communication taking place in the interface between design and construction site teams. Furthermore, only German and Norwegian AEC project teams have been included. Additionally, the study was only based on a limited number of respondents. Consequently, a larger selection of cases is necessary for generalisation. However, several of the findings are regarded transferable to other countries and other projects.

The theoretical framework on this subject is inconclusive. Equally, it was identified a scarcity of qualitative and quantitative research on this area. There is not always a connection between theory and actual practice, and it is therefore regarded important to acquire more first-hand experiences from practitioners if communication is to be effective. More research in the vein of this study should be used in the future to support existing theory, or to show where it is wrong.

The findings presented in chapter 4 show that the German and Norwegian AEC industry are threatened by many of the same communication challenges. In addition, many of these are considered predictable. Accordingly, there is a huge potential for learning and sharing of experiences across organisations and project teams. Yet, it was a common perception among the actors that a new project always starts with “blank sheets”. Consequently, it is suggested that more research should be dedicated to the purpose of finding out how to ensure the transfer of experience, in order to avoid a continuous reoccurrence of communication problems.

The interviews revealed that the approaches of effective communication in contemporary construction are fragmented and lack a solid conceptual foundation. It was also observed that the improvement of communication processes necessitates a change of project organisations and work activities, which have become barriers to progress. Future research should be dedicated to the development of a strategy for how to accomplish a balanced approach in practice. Equally, clearly defined guidelines that explain how organisations can approach this strategy must be established. Moreover, it is recommended that the relationship between communication and the initiatives from chapter 4.3 are studied in more detail. Lastly, an important focus for future research concerns the effect of communication on the project outcome.

A combination of qualitative and quantitative methods could have been applicable to this study; for example, by using quantitative methods to confirm or debunk the results from the qualitative study. However, for reasons of scope, quantitative methods were discarded. Hence, in future work, quantitative methods should be included.

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PART 2: THE ACADEMIC PAPER

COMMUNICATION IN BUILDING DESIGN MANAGEMENT: A COMPARATIVE STUDY OF NORWAY AND GERMANY

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ABSTRACT

First-rate communication between design and construction site teams is imperative for the successful completion of architecture, engineering and construction (AEC) projects. Still, research carried out in Norwegian and German industry has identified a lack of literature and qualitative research in this area. Equally, there seems to be a tendency to underestimate the correlation between communication and efficiency in most construction projects.

By addressing different factors affecting communication, reasons for communication, communication networks, communication channels and future needs in a comparative way, this paper aims to increase knowledge about and understanding of communication in the design-construction interface. An extensive literature review, a document study and in-depth interviews were carried out, according to a qualitative approach. The findings are limited to the investigated cases. However, they do imply that there is a need for a better understanding of communication both in Norway and in Germany. Additionally, the research revealed a lack of knowledge and training in the use of ICT tools and team frameworks. By increasing the awareness of the communication challenges that exists, this study can help AEC practitioners and academics to solve communication problems between design and construction site teams.

KEYWORDS

Communication, Design, Production, Collaboration, Flow.

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INTRODUCTION

It is a common apprehension that the overall performance of the architecture, engineering and construction (AEC) industry has declined compared to that of others (Egan 1998; Love and Li 2000). This is typically considered a result of the industry's increased complexity and rapid growth, in response to the more rigid environmental, financial and social goals of stakeholders (Grey and Hughes 2001). A major challenge in modern construction seems to be lack of integration and effective communication between design and construction site teams. Even when participants make significant effort working together, communication difficulties will occur (Pietroforte 1997). Such problems tend to hinder cooperation and learning between actors. Further, problems in the design phase are often seen to cause problems on site, e.g. as poor design quality or lack of constructability (Alarcón and Mardones 1998). This influences the whole project negatively, in terms of increased costs and reduced productivity (Baldwin et al. 1999). Hence, improvement of the design-construction interface can be seen crucial for enhancing total industry efficiency.

Wikforss and Löfgren (2007) stress the need for rapid access to information in both design and construction processes, in order to achieve project success. In building design, this is especially important (and difficult), because it includes several mutually dependent decisions. Moreover, Flager et al. (2009) show that members of the design team spend as much as 58% of their time managing information. With a more efficient information management system, this time can be reduced and used in more value creating activities. Koskela (2000) presented the TFV (Transformation-Flow-Value) concept in construction. As construction processes are reliant on accurate and timely information, it becomes clear how information flow is one that drastically affects all other resource flows by introducing the aspect of flow in building design. Further, the flow view aims to reduce waste in construction processes and thus is especially important to manage from a Lean perspective.

A number of researchers have emphasised effective communication as a means to overcome the problems of the contemporary AEC industry (e.g. Ballard and Koskela 1998; Bowen and Edwards 1996; Dainty et al. 2006; Grey and Hughes 2001). However, despite this being widely acknowledged as one of the main challenges in construction, little progress has been made towards improving communication effectiveness in project teams. Therefore, the research questions addressed in this paper are:

- How does communication take place between design and construction teams?
- What communication challenges exist in the interface between design and construction?
- What can the Norwegian AEC industry learn from communication in the design-construction interface in the German industry and conversely?

A pilot study by the main author showed that poor and missing communication cause many problems in Norwegian industry. A comparative method was chosen to see what, if anything can be learned from Germany, as one of the world's largest construction markets.

RESEARCH METHODOLOGY

The comparative analysis presented in this paper is based on a multiple case-study approach. According to Flyvbjerg (2006), case-study research is a method appropriate for

gaining context-dependent knowledge about complex issues. The research includes an extensive literature review, a study of internal documents and semi-structured, in-depth interviews. The literature review focused on communication in building design and was carried out in accordance with the procedures described by Blumberg et al. (2011). Keywords were searched for in research databases (Scopus, Compendex, IGLC Papers and Google Scholar) and library databases. Useful sources were also found in the references of reviewed articles. The review provided a foundation for the identification of general communication success factors and issues. The document study consisted of documents received from respondents, mainly project presentations, schedule plans and organisation maps. These provided details that corroborated information from the interviews (Yin 2014).

A total of 20 interviews in Norway (9) and Germany (11) were conducted, in line with the recommendations of Yin (2014). The Norwegian interviewees represented three different project teams in the same company, and were selected on the basis of experience from previous summer internships. The German cases were chosen in order to gain a better insight into general trends of common industry practice. Therefore, project teams from three different companies were interviewed. By interviewing architects, building design managers, project managers, site managers and foremen, different perspectives were accounted for. The limited sample size of the study does not permit for generalising the results. However, as pointed out by Flyvbjerg (2006), even a small and limited amount of interviews can constitute an influential source of information to generate new knowledge.

THEORETICAL FRAMEWORK

BUILDING DESIGN MANAGEMENT AND COMMUNICATION IN IT

Communication in building design is a wide-ranging area, including formal and controlled exchange of information, just as informal and interactive interaction. Nonetheless, it can be separated into two main groups: synchronous and asynchronous (Emmitt and Gorse 2003). Synchronous communication is direct in-time information flow, by means of verbal channels like meetings and telephone. Conversely, asynchronous communication takes place distant in time and space, through written channels such as e-mails and drawings. Synchronous communication is defined as richer and more effective than asynchronous communication, in accordance with Figure 1.

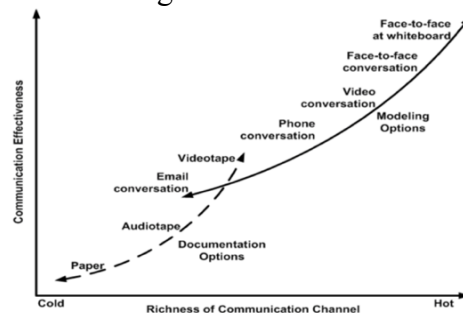


Figure 1: Richness of communication channels (Ambler 2002)

In this context, *richness* refers to the information volume and content complexity a channel

successfully can manage. In general, oral channels are richer than written ones, because they also convey non-verbal communication like gestures and tone of voice (Kaufmann and Kaufmann 1998). Effective design teams typically use a balanced mix of synchronous and asynchronous communication (Emmitt and Gorse 2007). Dainty et al. (2006) states that traditional channels such as drawings, meetings and telephone, remain the ones most frequently used in construction. Use of ICT (Information and Communication Technology) tools has, however, increased rapidly in recent years (Wikforss and Löfgren 2007). If implemented the right way, project teams can derive huge benefits from the use of these.

The AEC industry operates in a dynamic and fragmented environment, with temporary project teams made up of ad-hoc combinations of different specialists. Further, the onset of global construction markets leads to challenges related to social and cultural differences. Due to these features, actors interact in a complex environment in which different barriers combine to prevent straightforward information flow (Dainty et al. 2006). At the heart of successful projects lies the design teams' ability to communicate abstract ideas to site and the ability of those on site to translate this into physical artefact (Emmitt and Gorse 2003). Information is required and produced all the way from inception to completion, and many decisions are mutually dependent (Bowen and Edwards 1996). The mutual dependency serves as the glue holding the fragmented organisation together, but also place high demands on the actors' ability to collaborate. As Dainty et al. (2007) point out; building design is dependent on the combined effort of many individuals, their diverse skills and knowledge. Thus, their ability to work together as a team is decisive for the overall industry effectivity. Svalestuen et al. (2015) emphasise the importance of high levels of trust, project commitment and involvement in the goal-setting process as the key factors for successful teamwork. It is therefore essential to strive for these qualities in every project organisation.

Busby (2001) found that errors in actor interaction is the most common failing in building design. In this regard, absence of information and the issue of noise are of huge importance. These matters can impact the clarity of messages relayed between actors, regardless of how suitable and rich the chosen channel are (Dainty et al. 2006). Together, they constitute the major causes of communication failures in construction. Rothwell (2010) defines four types of noise: physical, psychological, physiological and semantic. Physical noise is noise in the literal sense, i.e. sounds from machinery on site. Such noise is hard to control because it is caused by people or the surrounding environment. In contrast, the other types of noise can be controlled. They solely exist in a person's mind and arise in coding and decoding of messages, for example as varying frames of reference.

Reinertsen (1997) argues that facilitating effective communication requires a reduction of current information flow. When too much information simultaneously circulates, it is difficult to separate what is important from what is not. Pietroforte (1997) further claims that an understanding of the organisational structure is essential, as this impacts upon how patterns of communication will develop. In addition, the implementation of modern tools like Last Planner® System (LPS) and Building Information Modelling (BIM) can help to overcome some of the current barriers to effective communication. Research has shown that they contribute to increased process transparency, project commitment and collaboration, which further facilitate streamline information flow (Al Hattab and Hamzeh 2013). Equally, by take into effect building design as a flow of information in accordance

with the TFV model (Koskela 2000), time spent waiting for, inspecting, reworking and moving information is minimised. This results in better coordination of interdependent flows and a stronger integration of design and construction. The literature review revealed a gap between current knowledge of team communication and how this is practiced in construction. A lack of qualitative research on this area was also identified. Effective communication is repeatedly regarded as the key to success in AEC projects. It is thus vital to continue to study this field, in order to increase the understanding of the current issues and potentially avoid these in the future.

FINDINGS AND DISCUSSIONS

COMMUNICATION PATTERNS

The analysis of the communication patterns in the German and Norwegian project teams indicated that the choice of project delivery method affects how communication takes place in the organisation. The research revealed that conventional procurement methods like Design-Bid-Build (DBB) are widely used in German industry, while it in Norway is becoming more common with Design-build (DB) contracts. By using DBB, the client is at the centre of the information flow. Unfortunately, clients often lack the experience and skills necessary to effectively manage and coordinate project teams. This may result in an absence of communication between design and construction. In contrast, the DB method organisationally integrates the design and construction processes. Additionally, with DB, the Building Design Manager becomes accountable for managing existing interfaces. Both German and Norwegian practitioners expressed that this was a huge advantage, as the design managers are more likely to be in possession of the appropriate qualifications.

In the German organisations, it was observed a more palpable organisational hierarchy in comparison to what was seen in Norway. German actors also seemed to have a great respect for roles and responsibilities as defined in the Responsibility Assignment Matrix (RAM), leading to an inherent confidence about their own and other actors' role in the team. Contrastingly, in Norway the informants described an unstructured situation with actors often feeling unsure about their place in the organisation. Additionally, the responsibilities in the execution phase often differed from what was defined in early-phase. This raises question as to whether the RAM has been clearly communicated to participants or simply been forgotten.

In both countries, face-to-face contact was defined as the most common communication channel and essential for project success. By enabling immediate feedback and transfer of rich information, it makes it easier to detect and avoid misinterpretations and ambiguities. In addition, the channel was defined as important for reducing organisational fragmentation, as it helps to strengthen the relationship between the different actors, disciplines and phases involved. The research further revealed that use of e-mail, telephone and tablets is common in both Norway and Germany. ICT tools like project intranets and BIM are commonly used by Norwegian actors, but rare in the German industry. Moreover, the findings implied that ICT tools used in both countries (e.g. applications for registering errors and deficiencies) are better developed and integrated Norway. The respondents described many of the same reasons for one team member to contact another, including to plan, coordinate and schedule

work, to give/receive information, to give/receive information because of changes and to request late/missing information. In both countries, respondents wished to communicate more with the purpose of sharing knowledge and to determine level of ambition (e.g. cost, time and quality level). This indicates that important teamwork principles, such as definition of a common goal and application of positive and negative sanctions, often are overlooked or underestimated in AEC projects. These are important value creating activities, contributing to a successful final product. Therefore, when they are not prioritised, the probability of rework, delays, cost overruns, etc. will increase, further affecting the overall performance of the project team.

COMMUNICATION CHALLENGES

A common perception among practitioners in both countries is that most project teams underrate the need for communication. Additionally, the pre-construction time is typically found to be too short. The majority of the practitioners had experienced a need for more extensive communication and planning than what was originally scheduled. When enough time for up-front planning is not allocated, the frequency of conflicts regarding time, cost and quality requirements increases. Further, the pre-construction stage is a good arena for project participants to get to know each other and identify each other's strengths and weaknesses. Both German and Norwegian practitioners underlined the importance of good interpersonal relations and trust. Even more than in other industries, human factors seem to determine whether construction projects develop in a good way or not. The respondents maintained that when there is a good "chemistry" in the project team, project dedication and collaboration are strong, and planning, coordination and information flow usually run smooth. Unfortunately, as a consequence of the industry's project based and fragmented environment, these properties are often difficult to establish.

Several challenges related to the use of e-mail were described, in spite of its important role when sharing project information. Firstly, there are often too many recipients, resulting in an information overload and actors overlooking information. Secondly, as a consequence of their low information richness, long e-mails with complex information are often misunderstood. The respondents also explained that e-mails often result in project information becoming disorganised and information getting lost. This issue concerns how actors can provide the right information to the right team member at the right time, rather than opposing the different communication channels. Hence, a pre-set framework describing where and when to use the available communication channels is important to ensure a smooth flow of information throughout the project.

The analysis of the German industry indicated that many communication challenges arise as a result of the procurement method they use. The DBB method allows for many actors taking part in decision-making, and thus leads to an increased complexity. Project participants also expressed that cooperation problems often occur between the client, contractor and architect, for example as a result of competing interests or different jargons. This shows once again the importance of establishing a common set of team rules. German actors also explained that they have a great pride in their work, which sometimes make them incapable of receiving help from others. Many of the challenges described in Norway are considered a result of organisational culture, e.g. unclear roles and responsibility, lack

of initiative and motivation and too much informal communication. These issues result in a confusing information flow, giving rise to uncertainty and decreased productivity. The findings also indicate that the vast focus on organisational decentralisation in Norwegian industry during the last few decades has come at the expense of an organisational structure with clear roles and responsibilities. Unfortunately, effective communication seems difficult (maybe even impossible) to establish and maintain without a distinct system.

LEARNING BETWEEN NORWAY AND GERMANY

From the study of the Norwegian and German AEC industries, several initiatives to facilitate effective communication in the design-construction interface emerged. Among others, Norwegian project teams had implemented parts of the LPS, which had increased project commitment and feeling of responsibility for the final product. Moreover, the use of ICT tools has evolved rapidly in Norway in recent years. Project intranets provide all team members immediate access to project information, thus speeding up information flow. Video conferences makes it easier to communicate with other participants, even over long distances. Yet, it was implied that the use of these tools can be troublesome and also reduce the overall understanding of the project. For example, when all participants have access to all information at any time, it is hard to control who receives what and when. In worst case, this can result in actors making their own “image” of the project, which however might not always correspond to the overall project objectives.

The comparative analysis indicated that Norwegian and German actors have different views on how organisations should be structured in order to best facilitate for effective communication. In Norway, it is a strong focus on the flat organisational structure. Advantages of this approach include open and more effective communication, decision-making and collaboration. On the other hand, a flat structure may foster role confusion and thus hinder employee’s motivation. As opposed to the Norwegian actors, German actors emphasised the importance of maintaining a certain degree of organisational hierarchy. The research showed that this approach results in clearer reporting lines and chains of command, which further ensure clear division of roles. Moreover, German actors stressed the importance of project participants being motivated and well prepared for the work. This was defined as easier to achieve when all actors have a clear picture of their responsibilities. However, there are disadvantages of using relatively rigid hierarchical structures, such as less effective decision-making and communication flow, which arise as a result of increased bureaucracy. Further, hierarchical organisations are known for being slow to react upon new opportunities, which makes it hard to survive in today’s rapidly changing environment. This may help to explain why German industry seems to be slower to adopt new technology and work methods.

One respondent who had worked several years in both the German and the Norwegian AEC industry made an interesting point. He claimed that the right balance between a hierarchal and a flat approach is necessary to create effective communication in the design-construction interface. The case studies implied that one of the German companies had achieved exactly this. By basing their work on standardisation, pre-fabrication and the supply of a total design-build service they had succeeded in safeguarding a distinct structure, while at the same time allowing for an increased involvement in decision-making,

as well as the adaption and development of new work methods and technologies. The interviews clearly indicated that this increased the effectivity of communication in the organisation, which in turn led to an improved performance. However, it is important to point out that not all organisations have the opportunity to structure their practice this way.

CONCLUSIONS

The German AEC industry is generally characterised by the use of traditional work methods, reflected in the prevalence of conventional procurement methods and the limited use of ICT tools. The communication patterns developing in the project team are clearly influenced by the use of traditional methods, among others there was seen a lack of communication between design and construction teams in German project teams. On the other hand, the Norwegian industry looks for constant development, illustrated by their extensive use of modern tools like the LPS, project intranets and BIM. From a communicative perspective, this helps project teams to increase their efficiency. At the same time, the comparative analysis showed that there is a need for improvement of communication in Norway, just as it is in Germany. Table 1 depicts the identified communication challenges identified in this study.

Table 1: Challenges of Communication in Germany and Norway

Both countries	Germany	Norway
Underrated communication need	Client “in charge”	Unclear roles and responsibility
Short pre-construction	Competing interests	Need to request information
Information overload	Different jargons	Lack of motivation and initiative
Unstructured information	Averse to receive help	Much informal communication
Interpersonal relations and trust		

The German and the Norwegian AEC industry represent different views on how to best facilitate for effective communication. In Germany, a hierarchical approach is typically used, while a network-like structure is most common in Norway. The study implied that a flat structure has several benefits. It can, however, result in a chaotic project environment because of too much independency and a weak structure. The hierarchical approach, on the other hand, typically maintains the structure, but decreases the effectivity of information flow and prevents the organisation from developing. Thus, when alone, none of these methods are capable of improving the current situation. However, in exploring theory and practice, it has been found that from a communicative perspective there is no *either-or*, but rather a *both* on this matter. By balancing the Norwegian and German approaches, companies can benefit from the current strengths of both countries as presented in Table 2. In combination, these two approaches to effective communication can help to solve some of the challenges of contemporary AEC industry, which became further apparent from the research done German industry. These findings revealed that companies exist that have achieved to maintain a distinct structure, while also keeping pace with the industry’s

continual development. However, this structure is not feasible for most firms because of the way it limits the range of projects, while also requiring a certain organisation size.

Table 2: Strengths of the German and Norwegian approach

Germany	Norway
Clear communication paths	Allows for innovation
Clear chains of command	Simpler and faster decision-making processes
Clearly defined set of responsibilities	Independent employees
Motivated and committed employees	Improved speed of communication flow

Based on the findings from this research, it seems that the methods and technology needed to improve communication between design and construction teams already exists. The question of how these solutions best are combined and implemented, so as to avoid the present negative impacts on the industry, still remains. According to the research presented here, the answer lies in finding the right balance of a hierarchical and a flat structure, the formal and the informal, use of technology and not, and so on. Future research should be dedicated to the development of a strategy for how to best accomplish this in practice. The authors do recommend, however, that project teams have a hierarchical structure in terms of decision-making, which will make the flow of information more structured and easier to control. At the same time, it is important to be critical to adopt new methods and technologies if the advantages that these entail for the project team is not clear. As can be learnt from Norwegian industry, an uncritical implementation of such tools can – in the worst case – reduce the overall performance of project teams.

Summing up, this study has shown that improvement of communication and information exchange in building design management increases the overall effectivity of the construction industry. Further, such an improvement may involve changes in project organisations and work activities. The research is based on a limited number of respondents. This may not make the results 100% applicable to all projects. Hence, in the future, the authors recommend to extend the numbers of respondents. In addition, more research should be done on the relationship between Project Delivery Method and communication.

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PART 3: APPENDICES

APPENDIX A: TABLE OF INTERVIEWEES

GERMANY				NORWAY			
Number	Company	Experience	Role	Number	Company	Experience	Role
1	Hochtief	>10	Building Design Manager	12	Backe Vestfold Telemark	>10	Building Design Manager
2	Hochtief	>10	Project Manager	13	Backe Vestfold Telemark	<10	Project manager
3	Hochtief	>10	Site Manager	14	Backe Vestfold Telemark	<10	Site Manager
4	Brömer & Sohn	>10	Project Manager	15	Backe Vestfold Telemark	<10	Foreman
5	Brömer & Sohn	<10	Site Manager	16	Backe Vestfold Telemark	>10	Project Manager
6	Brömer & Sohn	>10	Site Manager	17	Backe Vestfold Telemark	>10	Site Manager
7	Brömer & Sohn	<10	Foreman	18	Backe Vestfold Telemark	<10	Foreman
8	Goldbeck	>10	Architect	19	Backe Vestfold Telemark	>10	Project Manager
9	Goldbeck	>10	Building Design Manager	20	Backe Vestfold Telemark	<10	Site Manager
10	Goldbeck	>10	Site Manager				
11	Goldbeck	>10	Foreman				

APPENDIX B: INTERVIEW GUIDE NORWAY

RAMMESETTING

- 1) Kort om prosjektoppgaven – Tema, bakgrunn og hensikt
 - Litt om meg selv
 - Siste års masterstudent Bygg- og miljøteknikk ved NTNU, med spesialisering bygg- og anlegg og fordypning i prosjektledelse. Har hatt sommerjobb i Backe Vestfold Telemark AS (tidligere Buer Entreprenør AS) somrene 2013, 2014 og 2015. Våren 2016 arbeider jeg med masteroppgaven ”Kommunikasjon i prosjekteringsprosessen: en komparativ studie av Norge og Tyskland”.
 - Hvorfor temaet ”kommunikasjon i prosjekteringsprosessen”? Og hvorfor sammenligne med Tyskland?
 - Dagens byggeprosess har blitt mer kompleks. Prosjektering av bygg er spesielt rammet av denne kompleksiteten, blant annet som en konsekvens av prosjekteringsgruppens tverrfaglige sammensetning. Kommunikasjon er ansett som et av de beste verktøyene man har for å bryte ned høy grad av organisatorisk kompleksitet, og dermed en av de viktigste suksessfaktorene for prosjekteringsprosessen.
 - Tyskland har et av verdens største markeder for byggeprosjekter og landet er blant de ledene på mange områder innenfor sektoren.
 - Problemstilling: Hvordan foregår kommunikasjonen i grensesnittet mellom prosjektering og produksjon? Hvilke utfordringer knyttet til kommunikasjon er det i grensesnittet mellom prosjektering og produksjon? Hva kan norsk og tysk industri lære av hverandre?
 - Mål: Kartlegge muligheter og utfordringer knyttet til kommunikasjon i grensesnittet mellom prosjektering og produksjon i både Tyskland og Norge, for så å se på hva landene kan lære av hverandre.
- 2) Taushetsplikt og anonymitet
 - Ingen navn vil bli nevnt i referatet fra intervjuet
- 3) Informer om opptak
 - Gis det tillatelse til opptak?
NB: Opptak slettes etter resultater er nedskrevet
- 4) Uklarheter eller spørsmål?
- 5) Start opptak

ERFARINGER

- 1) Kan du fortelle om din rolle som **prosjekteringsleder/prosjektleder/anleggsleder/BAS**
 - Arbeidsoppgaver
 - Egenskaper/Kompetanse/Erfaring
 - Arbeidsmetodikk

FOKUSERING

- 1) Prosjekteringsprosessen
 - Hvordan blir prosjekteringsprosessen gjennomført i din bedrift?
 - Hva gjøres i egenregi? Hva gjøres av innleide?
 - Hvilke beslutninger tar du i prosessen?
 - Hvem andre tar beslutninger i prosessen?
- 2) Hvordan foregår kommunikasjonen i grensesnittet mellom prosjektering og produksjon?
 - Kan du forklare hvordan kommunikasjons- og informasjonsflyten er mellom prosjekterende og utførende i dette prosjektet?
 - Hvilke kommunikasjonskanaler benytter dere?
 - Ser du noen problemområder som kunne vært bedret?
 - Hva slags erfaringer har du med kommunikasjon innad i prosjekteringsgruppen?
 - Hvilke erfaringer har du med kommunikasjon mellom prosjekteringsgruppen og de produserende (i begge retninger)?
- 3) Hvilke utfordringer knyttet til kommunikasjon er det i grensesnittet mellom prosjektering og produksjon?
 - Hva fungerer bra i prosjektet med tanke på kommunikasjon mellom de prosjekterende og produksjon?
 - Er det noe som kunne fungert bedre?
 - Har det oppstått forsinkelser, kostnadsoverskridelser eller kvalitetsfeil i prosjektet?
 - Hva og hvem skyldtes dette?
 - Hvordan ble det håndtert?
- 4) Finnes det tiltak for å bedre kommunikasjonen?
 - Hva mener du beskriver god kommunikasjon i et prosjekt?
 - For å sikre et godt sluttprodukt og en vellykket prosess
 - Hvordan ville du tilrettelagt for god kommunikasjon
 - Internt
 - Mellom prosjekteringsgruppen og de produserende
 - Hvilke tiltak fremmer dere for å forbedre prosessen?
 - Har dere innført tiltak som andre kan lære av?
 - Har du forslag til tiltak som andre bør fremme for å forbedre prosessen?

TILBAKEBLIKK

- 1) Oppsummere funn
- 2) Har jeg forstått deg riktig?
- 3) Er det noe du vil legge til?
- 4) Takk for hjelpen

APPENDIX C: INTERVIEW GUIDE GERMANY

EINFÜHRUNG - THEMA, HINTERGRUND UND ABSICHT

- 1) Wer bin ich?
 - Studentin an der „Norwegian University of Science and Technology“, die derzeit einen M.Sc. in Bauingenieurwesen mit der Vertiefungsrichtung Baumanagement verfolgt. Im Frühjahr 2016 schreibe ich meine Masterarbeit im Ausland, an der Hochschule Rhein-Main in Wiesbaden. Der Titel meiner Arbeit lautet: „Kommunikation in der Projektierungsphase: eine Vergleichsstudie zu Norwegen und Deutschland“.
- 2) Warum das Thema „Kommunikation in der Planungsphase“?
 - Der Bauprozess ist in den letzten Jahrzehnten komplexer geworden, als Folge erhöhter finanzieller, sozialer und umweltpolitischer Ziele der Interessengruppen. Die Projektierungsphasen von Gebäuden sind insbesondere aufgrund ihres multidisziplinären Charakters beeinflusst von hoher Komplexität. Kommunikation ist eines der besten Werkzeuge, mit der organisatorischen Komplexität umzugehen, und damit einer der wichtigsten Erfolgsfaktoren der Projektierungsphase.
- 3) Warum Norwegen mit Deutschland vergleichen?
 - Deutschland ist einer der größten Märkte für Bauprojekte der Welt, und ist in vielen Bereichen dieser Branche führend.
- 4) Die Problemstellung:
 - Wie ist die Kommunikation, die an der Schnittstelle zwischen Projektierung und Realisierung, erfolgt?
 - Welche Herausforderungen in Bezug auf die Kommunikation gibt es an der Schnittstelle zwischen Projektierung und Realisierung?
 - Was kann die norwegischen und deutsche Bauindustrie voneinander lernen?
- 5) Schweigepflicht und Anonymität
- 6) Keine Namen werden in dem Protokoll des Interviews erwähnt.
- 7) Wird Aufnahme erlaubt?
 - Die Aufnahme wird gelöscht, wenn die Behandlung der Ergebnisse abgeschlossen ist
- 8) Unklarheiten oder fragen?
- 9) Aufnahme starten

ERFAHRUNGEN

- 1) Können Sie über Ihre Rolle als Architekt/Projektleiter/Bauleiter/Polier erzählen?
 - Aufgaben
 - Eigenschaften/Kompetenzen/Erfahrungen
 - Arbeitsmethodik

FOKUSSIERUNG

- 1) Die Planungsphase
 - Wie sind die Planungsphasen in Ihrem Unternehmen umgesetzt?

- Was machen Sie selbst? Was wird von andere Unternehmen gemacht?
 - Welche Entscheidungen tätigen Sie in diesem Prozess?
 - Wer macht sonst Entscheidungen in diesem Prozess?
- 2) Wie ist die Kommunikation, die an der Schnittstelle zwischen Projektierung und Realisierung, erfolgt?
- Können Sie erklären, wie die Kommunikation an der Schnittstelle zwischen Projektierung und Realisierung in dieses Projekt fließen?
 - Welche Kommunikationskanäle benützen Sie?
 - Gibt es besondere Problembereiche, die verbessert werden könnten?
 - Welche Erfahrungen haben Sie mit der Kommunikation innerhalb des Projektierungsteams?
 - Welche Erfahrungen haben Sie mit der Kommunikation zwischen dem Projektierungsteam und den Bauarbeitern (in beide Richtungen)?
- 3) Welche Herausforderungen in Bezug auf Kommunikation, gibt innerhalb der Schnittstelle zwischen Projektierung und Realisierung?
- Was funktioniert gut in Bezug auf Kommunikation in diesem Projekt?
 - Gibt es irgendwas, das besser laufen könnte?
 - Sind Verzögerungen, Kostenüberschreitungen oder Qualitätsmängel in diesem Projekt aufgetreten?
 - Was oder wer hat das verursacht?
 - Wie hat man es behandelt?
- 4) Gibt es Maßnahmen, die die Kommunikation in dieser Schnittstelle verbessern könnten?
- Wie beschreibt man gute Kommunikation in einem Projekt?
 - Um ein gutes Endprodukt und ein erfolgreicher Prozess zu sichern
 - Wie würden Sie für eine effektive Kommunikation in dem Projekt Sorge tragen?
 - Welche Maßnahmen fördern Sie in diesem Projekt?
 - Haben Sie etwas in Ihrem Projekt gemacht, wovon andere Unternehmen profitieren könnten?
 - Haben Sie Vorschläge für Maßnahmen, die andere fördern sollten, um ihren Prozess zu verbessern?

RÜCKBLICK

- 1) Zusammenfassung
- 2) Habe ich Sie richtig verstanden?
- 3) Gibt es etwas, das Sie hinzufügen möchten?
- 4) Vielen Dank für Ihre Hilfe

APPENDIX D: A3 PAPER

Communication in Building Design Management: A Comparative Study of Norway and Germany

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I. Background

First-rate communication between design and construction site teams is imperative for the successful completion of architecture, engineering and construction (AEC) projects. Still, research carried out in Norwegian and German industry has identified a lack of literature and qualitative research in this area. Equally, there seems to be a tendency to underestimate the correlation between communication and efficiency in most construction projects. Therefore, a comparative method was chosen to see what, if anything can be learned from Germany, as one of the world's largest construction markets.

By addressing factors affecting communication, reasons for communication, communication networks, communication means and future needs in a comparative way, this paper aims to increase knowledge and understanding of communication between design and construction site teams.

II. Current conditions

The AEC industry operates in a dynamic and fragmented environment, with temporary project teams made up of ad-hoc combinations of different specialists. Due to these features, actors interact in a complex environment in which different barriers combine to prevent straightforward information flow (Dainty et al. 2006).

At the heart of successful projects lies the design teams' ability to communicate abstract ideas to site, and the ability of those on site to translate this into physical artefact (Emmitt and Gorse 2003). Information is required and produced all the way from inception to completion, and many decisions are mutually dependent (Bowen and Edwards 1996). The mutual information dependency serves as the glue holding the fragmented organisation together. As Dainty et al. (2007) points out; building design is dependent upon the combined effort of many individuals, their diverse skills and knowledge. Thus, their ability to work together as a team is decisive for the overall industry effectivity. Furthermore, as construction processes are reliant on accurate and timely information, it becomes clear how information flow is one that drastically affects all other resource flows by introducing the aspect of flow in building design.

III. Working hypotheses

The research questions are:

- How does communication take place between design and construction teams?
- What communication challenges exist in the interface between design and construction?
- What can the Norwegian AEC industry learn from communication in the design-construction interface in the German industry and conversely?

IV. Research Method

The comparative analysis presented in this paper is based on a multiple case-study approach. According to Flyvbjerg (2006), case-study research is a method appropriate for gaining context-

dependent knowledge about complex issues. The research includes an extensive literature review, a study of internal documents and semi-structured, in-depth interviews. The literature review focused on communication in building design. Keywords were searched for in research databases (Scopus, Compendex, IGLC Papers and Google Scholar) and library databases. Useful sources were also found in the references of reviewed articles. The document study consisted of documents received from respondents, mainly project presentations, schedule plans and organisation maps. A total of 20 interviews in Norway (9) and Germany (11) were conducted. The interviewees were mainly building design managers, project managers, site managers and foremen.

V. Research Findings

The German and the Norwegian AEC industry represent different views on how to best facilitate for effective communication. In Germany, a hierarchical approach is typically used, while a network-like structure is most common in Norway. Further, the German AEC industry is generally characterised by the use of traditional work methods, reflected in the prevalence of conventional procurement methods and the limited use of ICT tools. On the other hand, the Norwegian industry looks for constant development, illustrated by their extensive use of modern tools like the LPS, project intranets and BIM. Table 1 and 2 sums up challenges and strengths of the German and Norwegian approach to effective communication in the design-construction interface.

Table 1: Challenges of Communication in Germany and Norway

Both countries	Germany	Norway
Underrated communication need	Client 'in charge'	Unclear roles and responsibility
Short pre-construction	Competing interests	Need to request information
Information overload	Different jargons	Lack of motivation and initiative
Unstructured information	Averse to receive help	Much informal communication
Interpersonal relations and trust		

Table 2: Strengths of the German and Norwegian approach

Germany	Norway
Clear communication paths	Allows for innovation
Clear chains of command	Simpler and faster decision-making processes
Clearly defined set of responsibilities	Independent employees
Motivated and committed employees	Improved speed of communication flow

VI. Conclusions

Based on the findings from this research, it seems that the methods and technology needed to improve communication between design and construction teams already exists. The question of how these solutions best are combined and implemented, so as to avoid the present negative impacts on the industry, still remains. Moreover, it is important to be critical to adopt new methods and technologies if the advantages that these entail for the project team is not clear.

Summing up, this study has shown that improvement of communication and information exchange in building design management increases the overall effectivity of the construction industry. Additionally, such an improvement may involve changes in project organisations and work activities.

The research is based on a limited number of respondents. This may not make the results 100% applicable to all projects. Hence, in the future, the authors recommend to extend the numbers of respondents. In addition, more research should be done on the relationship between Project Delivery Method and communication.