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Utilizing Digital and Methodical Potential in Construction projects:

A Case Study of a Lean and Digital Construction Project

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Abstract

A primary concern of the construction industry in Norway is the significant decline in labor productivity compared to other on-land industries. Statistics show a relative difference in labor productivity, compared to the ICT industry from the year 2000 up to 2016, of 106.4%. The research identifies an industry utilizing old methods, with the use of new technology. The change in technology is causing new roles and more complex constructions—this change made for utilizing agile management and software supporting these methods. This case study looks at the new life science building project, of the University of Oslo, to explore the primary conditions for Norwegian construction projects, utilizing Lean and BIM, to achieve the potential of both the applied methodology and digital tools.

Using semi-structured interviews and observations, with participants from all disciplines from the project organization, a thematic analysis of the interviews identified two key problems: (1) Overlapping Software Functionality and Software Usage and (2) Lack of Fundamental Methodological Knowledge. The research identified a challenge with the use of different software in the project, making the actors using other tools - hence, the problem of overlapping tools. Furthermore, the project does not utilize the potential of applied BIM technology.

Based on these observations, the project proposes two new initiatives for better the utilization of Lean and applied software in the construction industry. First, new research is needed to find a method of writing task descriptions used in the Lean Design process. Moreover, investigate the need for such a framework in Lean Construction. Second, more research is needed in using cloud computing in BIM modeling.

Preface

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Trondheim, May 14, 2020

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Chapter 1

Introduction

1.1 Background and Motivation

The Construction Industry (CI) has been a significant part of engineering throughout history. Over the past century, the requirements of constructions have become more and more complex [Wood and Ashton, 2009]. The buildings are getting higher, the tunnels are getting longer, and the roads are getting wider. Sure, the size of things is not equal to the complexity of the construction; however, when considering automated systems, multipurpose functionality, and multiple communication platforms, and BIM, which all introduce multiple new roles – the complexity is increasing [Arayici et al., 2010]. The increased complexity leads to a significant decline in labor productivity (LP), seen over the past two centuries, mentioned in the article written by SSB [Todsen, 2018]. As well, managing these projects is much more intricate then it used to, because of the increased numbers of actors participating in the project.

One can argue that the negative progress in LP in the CI has to do with the increasing complexity, and therefore not a number to consider. Even so, better productivity and efficiency are always something management dicier, simply because of improved marginal cost. Therefore, this study is interesting for managers from other industries than only construction.

One has often turned to software when wanting to improve productivity. So is the case in the CI as well, moreover, changing the working process and working methodology, introducing agile methodologies in Lean Construction. The implementation of software in a large, complex organization is discussed by many and adequately challenging to accomplish. In particular, the description of the top-down contra bottom-up strategy in implementation [Robey and Sahay, 1996], promotes the importance of making slow change supported by the users. Furthermore, the intention of increasing productivity, by deploying new software is argued by Hammer, to be less sufficient [Hammer, 1990]. Hammer promotes changing the process of work, rather than improving bits by pieces using specific software. Moreover, the introduction of software supporting collaboration is challenging. Relevant in this context is that software breaks with the social taboos, and adaptation is, as mention, difficult [Grudin, 1994].

Frank Garry, in 1997, first introduced 3-D modeling in CI, when constructing the Peter B. Lewis Building (PLB). 3-D modeling was introduced both in managing the complicated installation, but also led to increased cooperation between different parties within the project. The paper, describing this project [Boland et al., 0002], is reporting a change in how actors in the construction react to using computer-aided constructions, in 3-D. Today 3-D modeling is used in almost all construction projects and is known as Building Information Modeling (BIM). Even though the PLB-project showed promising results in means of cooperation and interaction, the introduction of 3-D modeling was not a single solution to the problem. BIM interaction has shown huge potential in Cloud and in Software-as-a-Service solutions [Das et al., 2014]

Using BIM and ICT-solutions has previously been the driving force of facing the aforementioned issues [Arayici et al., 2010], but seeing how this initiative changes the construction process is, hence, important. Furthermore, one has introduced Lean in the CI. A book [Holm et al., 2018] describing the making of the Bergen Academy of Art and Design-building, where Lean was one of the essential strategies. The case object of the case study in this research is using experience from this book when managing the constructions.

The motivation for this research is, therefore, to examine a construction project utilizing Lean in project management. Furthermore, looking at how a project makes use of digital tools, aiding Lean has not been examined before.

The case object chosen for this research is the project constructing the new life science building. The reason for choosing this project is, first, the construction is highly complex, becoming the most extensive educational building in Norway, with both advanced technical and environmental requirements. Second, the announced strategies for the project includes both a Lean strategy and a digitalization strategy.

The conduction of this research was done throughout two phases. The first phase, conducted in the fall of 2019, resulted in a project thesis, while this thesis is the result of both phases, including data from the whole period.

1.2 Research and Question

Based on the background and motivation, the research of this project tries to identify the baseline for the CI to utilize agile methodologies and digital tools, for then again, better the LP. The main research question is, therefore:

> *What are the primary conditions for Norwegian construction projects, utilizing Lean and BIM, to achieve the potential of both the applied methodology and digital tools?*

This is then broken into four sub-questions, which this master thesis tries to answer, using a case study of the Life Science Building project.

RQ1: How does the project facilitate excellent communication and interaction as a basis for achieving the potential?
RQ2: How is the project suited to meet the requirements in realizing the requirements of a construction process and Lean methodology?
RQ3: How does the project realize its digital potential through the use of BIM and different groupware?
RQ4: What are the challenges and conditions needed to be addressed in the project and future work?

1.3 Thesis structure

Chapter 2: Literature Review provides an overview of key findings, concepts and development relevant for the research question. Furtheremore, support the discussion as well as the case.

Chapter 3: Method describe the mothodology used in the project. The methodology description describe and discuss the approach, data collection as well as method of anaylysis of the genereated data. Also, an evealuation of the method i provided.

Chapter 4: Case Study: The Life Science Building Project gives an introduction of the case as context for the project. Furhteremore, descibe and discuss the result of the anaylysis of the case data.

Chapter 5: Discussion takes the data form the case study, and discuss the results with prior research identified in the literature review. The chapter is outlined by four sections answering the four previously defined sub-questions.

Chapter 6: Conclusion answer the main research question raised in the Research and Question section. Furthermore, proposing further work.

Chapter 2

Literature Review

This research's objective is to identify the primary conditions for Norwegian construction projects, utilizing Lean and BIM, to achieve the potential of both the applied methodology and digital tools. For the research to identifying this conditions, this thesis looks at how the construction industry, or precisely how the LSB-project, makes use of agile project management methods and digital tools to aid project management. The CI's lust for digitalization is ever-present, and often projects consist of entire departments responsible for digitalization.

First, the chapter takes a historical look at the CI and which factors made for the utilize of agile project management in the first place – what were the symptoms needed to be fixed?

Secondly, the chapter discusses organizational cooperation, where one looks at software as a tool aiding organizational interaction and interaction. Furthermore, the chapter gives a brief overview of a traditional CI project, as well as a short overview of different agile project management methods as a context for the project.

2.1 Construction Engineering

This section will introduce the CI as a context for the project, as well som implications and motivation forcing a change in the way CI-projects are managed.

2.1.1 A Brief History of the Construction Industry

Construction Engineering has been a significant field of engineering throughout history. Originates from the construction of the pyramids. Continuing with Da Vinci, and some of the most skilled people, in the middle ages, forming some of the most known structures of today. In the raging of wars and through the industrial revolution, one could witness the rapid development of both civil and military engineering; as a result, one could now construct both faster and better than ever before.

Over the last century, the requirements of constructions have become more and more complex. The buildings are getting higher, the tunnels are getting longer, and the roads are getting wider. The size of things is not equal to the complexity of the construction. Adding automated systems, multipurpose functionality, and multiple communication platforms, the complexity is ever so present. Take for example a university building, which is no longer simply a place where one can lecture and read. A university building now requires to host highly sophisticated labs for various purposes, as well as several other rooms for different kinds of purposes, and some also multipurpose. Besides, that is just the requirement of the rooms; one needs to consider all the systems added in regards to, among others, ventilation, electricity, sewage treatment, internet, and telecommunication. All these systems- and room requirements, as well as other requirements, makes the construction of the modern building way more complicated than it used to be.

Even though the complexity of the construction is increasing, the process management has, for the most part, been the same — resulting in an unfortunate progress of productivity in CI.

2.1.2 Construction Industry Project as a Context for the Project

The process of constructing, in Norway, follows a pattern described by The Norwegian standard agreements (SSA). The construction process divides into five steps: (1) the early phase: where deciding both the vision of the project and process of project conduction; (2) the procuring of architect or adviser: starting by publishing the project and at the end awarding the best actor with a contract; (3) the design phase: where one produces different levels of design; (4) the procuring of entrepreneur(s): includes deciding on contracts, and choosing the correct contractors for the job; and (5) realization: where conducting the substantive implementation.

The third phase, designing, is typically conducted in three levels of granularity. First, the architect is sketching the over-all concept of the construction and delivering the concept as a set of drawings, models, and specifications. Furthermore, the concept is to realize the intention and vision of the project. Second, often called the pre-project, a team often consisting of architects, project managers, and engineers, is to define the project. The definition results in a set of user- and technical requirements, as well as further developing the functional and physical structure of the project. It is here one sets the budget and goals of the project. The pre-project is ending by handing the result and a proposal of decision for political treatment. The political treatment is known to be time-consuming, often spanning a one-to-two year period. Given the political decision, the requirements and budget set, limits and sets the basis for the rest of the project, as well as the goals used to measure. Third and finally, the detailed design is happening. The result of the detail design is the sketches used in the procurement of contractors — plus, an outline of the awarding strategy used in the next phase. Because of the time-consuming political decision, a new team is often responsible for the detailed design. Documentation of the pre-project is therefore vital. When going into the realization, it is the detail-design-team that is responsible for the project to keep the budget and achieving the goals set by the political decision, which can seem unfair if the pre-project requirements are not manageable.

A typical case is a change of requirements, required by a stakeholder, either during detailed planning or the production-phase. A change often leads to budget-breach, or if not feasible, dissatisfied stakeholders.

2.1.3 The problem of Labor Productivity in the Construction Industry

The Norwegian CI is, as mentioned, accused of having a decline in LP. An Industry that is one of the most significant industries in On-Land Norway, with 466 billion Norwegian Kroner accumulated in 2017 [vek, 2019]. A common fact shared among the industry stating that CI is facing an LP decline of 10%, since the year of 2000 [of Norway, 2018]. Often these numbers are justified by a complex and ever-changing industry and considered not representative of the industry of today. Sure the numbers are correct, but do these numbers show us the big picture?

In this section, the question of declined LP in Norwegian CI will be discussed, and if LP is *not* declining. A reminder; the goal of this thesis is *not* to measure the LP in CI, instead explore the issues causing this phenomenon to happen.

Definition of Labor Productivity

LP is a description of the value created relative to the resources used, as seen in equation 2.1. Practically speaking, a company or business achieving a high degree of LP, work less, and achieve more.

$$LaborProductivity = \frac{\textit{Labor dividends in quantity or value}}{\textit{Labor effort in hours or count of employees}} \tag{2.1}$$

Having increased productivity, make sure that a company gets the right turn on investment, rather than barely be able to endure. There are lots of different factors that come in to play why some industries have a increasing LP-rate, and some have a decreasing LP-rate, but how can this decline be, when the Industry see turnover growth?

Aspects of Labor Productivity in the Construction Industry

An article [of Norway, 2018] posted by Statistics Norway (SSB) proclaiming that the constructing Industry (CI) suffer a substantial decline of 10%, since the year of 2000. The article shows that this trend is also present in both Sweden and Finland. Comparing these numbers, seen in figure 2.1 with the same statistics in LP in all on-land private sector businesses, where there has been an overall increase, by 30%, one can arguably state that the decline is a fact. What do these statistics represent? SSB' definition of CI used in this calculation is labor that is directly involved in the on-site constructing, which is not representative of what is considered CI of 2019. Much of the work done on today's building site is prefabricated, and to get construction completed, one has to cooperate with a lot of businesses and industries. SSB explains that the reason for the small definition of CI is because of an EU-standard; hence, the comparison of the northern countries. If we consider the entire supply chain, there is a minor, in fact, increase in productivity of about 2% from 2000 to 2016, as seen in figure 2.2.

An issue paper [Langlo et al., 2013] posted by Sintef in 2013 raises the discussion about this topic. The issue paper states three central observations: (1) The numbers does not tell the whole story about productivity, (2) the numbers can't be used in scientific research and (3) the numbers can not be used in comparing businesses, projects or corporations, because each project is so vastly different from one another.

Looking at observation two, stating that the numbers are not to be used, measuring increased productivity in CI overall. We need, therefore, to look at a process, a specific project, or a corporation to conduct a sufficient scientific analysis. This holds for a case study, where one looks at an individual project, analyzing the internal processes and project management to identify the measurements taken to boost internal productivity. Moreover, complexity makes for no comparison between different projects, because when creating a complicated construction, sometimes new invention needs to happen, and this is not something to be compared. In the same way, comparing productivity in different software development projects is not relevant. If one is to construct the same

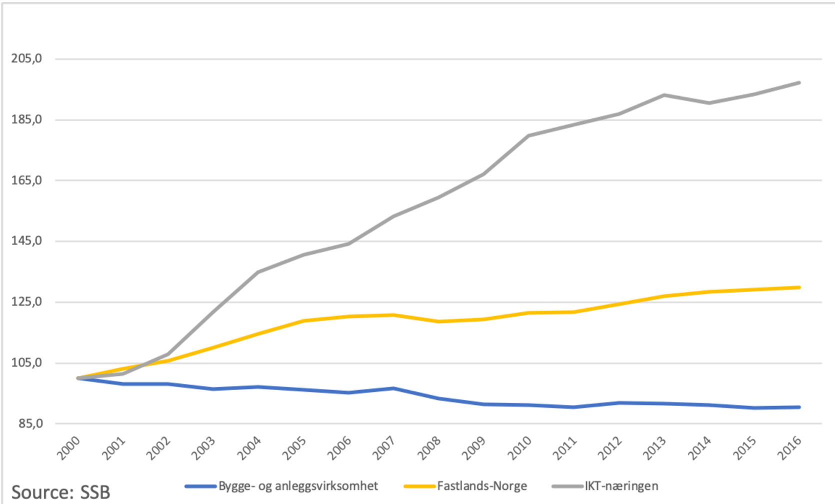

Figure 2.1: Labor productivity in the constructing industry, compared to average on-land industries in Norway, from 2000 to 2016.

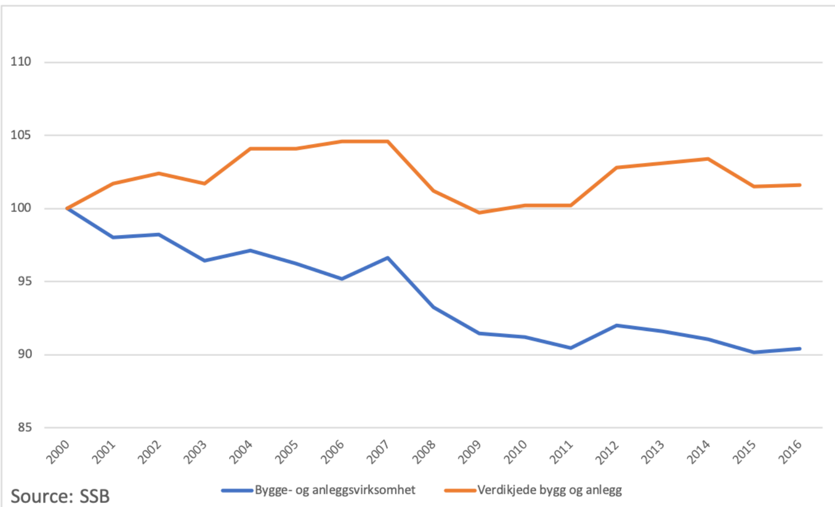

Figure 2.2: Labor productivity in the constructing industry supply chain, from 2000 to 2016.

house, or the same piece of software, time after time, then a comparison is very legit. Then again, in this case, the ingenuity is discussable.

Stating that CI has declining LP is therefore not unilaterally correct - still, if we consider the total value chain, the result is considered poor. The industry is taking action to get LP closer to the average rate. The focus is to make each project as efficient and productive as possible, but that is always the case. Simply because of the marginal cost gained.

Thus yields for a bottom-up approach: Starting with a process in a project and perfecting it, continuing with each process will eventually lead to a resulting better efficiency and productivity in the entire project. Which, if done in the entire constructing industry, will lead to increased LP overall. Therefore, the industry needs to overcome the challenges, mentioned earlier, (starting with a breach of planned timeline and budget, with symptoms such as requirements change during design, increased complexity, and struggling to complete the products,) were digitalization, Agile (hereunder Lean), is promising and populare solutions to the problem.

2.1.4 Building Informantion Modeling

BIM is of many seen as a significant contribution to increasing productivity in the CI [Boland et al., 0002; Das et al., 2014; Chuang et al., 2011]. Statsbygg defines it as follows [Holm et al., 2018]:

B = Building

I = Information

M = Modeling (Process) or Model (the product)

The introduction of BIM implicates a significant change, not only in software with three-dimensional models, but also in the workflow and the process [Azhar et al., 2012]. With a common model shared among all stakeholders, BIM integrates all disciplines throughout the construction process. What differs BIM with traditional 2D- and 3D-modeling (CAD) technologies? The traditional technologies offered a view of the model, with its dimension in either 2D or 3D. Such as plans, sections, and elevations. If one of these views require for a change, every other view is needed to be checked and updated. Also, these models only showcase entities such as lines, boxes, and circles. Whereas BIM keeps the same traditional view but includes its physical and functional characteristics. In the BIM-model, every element and system is defined as walls, sockets, tubes, and valves. Thus, a single entity in the model, such as a socket, could include dimen-

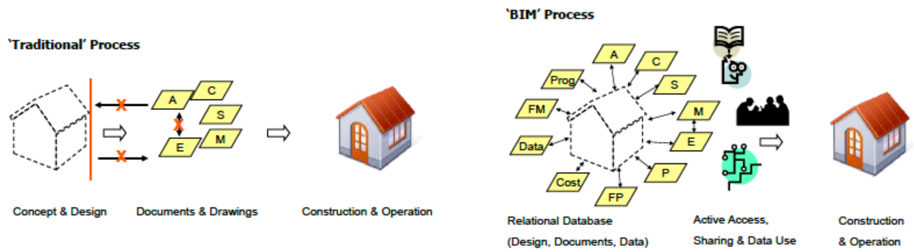

Figure 2.3: A comparison between traditional and BIM construction process. (Courtesy of: Holder Construction, Atlanta, Georgia, USA)

sions, name, manufacturer, price, and ID. BIM is, in practice, a large relation database, where every entry is defined by a set of core information, with different foreign keys to specific information about the object. Different software providers keep their BIM data in different file formats, but `.ifc` is a common non-propriety file format, which is shared among most BIM software suppliers.

Introducing BIM is, as mentioned, influencing the process and the workflow of construction. Figure 2.3, illustrates the difference between a traditional (old) process of construction versus the BIM (new) process.

3D modeling is an essential tool in construction engineering. Since the introduction of 2D data generated drawings (CAD), the evaluation has been rapid. Frank Gehry's introduction of 3D in the Peter B. Lewis building is, by many, the birth of 3D modeling in the construction business. This introduction led to a burst of innovations due to the complex construction, and the visual context 3D modeling gave the engineers [Boland et al., 0002]. The evolution of BIM has been tried synthesized by many [Liang et al., 2016]. Figure 2.6 is commonly used representation by Bew and Richards [Bew and Richards, 2008]. Level 3 is where one wants to be nowadays, but most are still at level 2. The difference is in the level of interaction between actors and how they can use a shared model. A distorted BIM model eventually leads to a distorted construction process. Moreover, if the coordination and interaction between disciplines are not in place, the model will eventually fail and lack much information. Hence, the process of BIM.

The BIM process includes the whole lifecycle of the construction, from programming to demolition, represented in figure 2.4. It is clear to see the utilization of BIM in the Programming- and Design-phase, where architects and engineers create a digital model of the construction to build. Furthermore, in the Construction-phase, the drawings

Figure 2.4: Phases in the construction lifecycle.

Figure 2.5: MMI with different stages of the construction process.

are utilized in the installation and construction of the building. It is, though, in the last phases of the construction lifecycle that BIM is outstanding. Since the BIM model includes all the data about every system and element of the structure, a caretaker can easily follow up systems and fix an element with the exact products used in its origin. Furthermore, if demolishing a building, BIM can be used to secure this process by identifying every system and element in the building needed to be removed before takedown.

Even though the process of using BIM should promote productivity and interaction between disciplines, this is not easily done in practice [Hartmann et al., 2012]. The traditional way of working, in silos, still influence the construction business. Aiding the BIM process, several methods and processes have been developed. One is the model maturity index (MMI = Modell Modenhets Indeks) [Fløisbonn et al., 2018]. This index, seen in figure 2.5, make sure the model is in the correct level detail throughout the project. Also, making sure different actors uses the same language and know what to expect from each other during different phases of the project.

For a project to utilize BIM, the organization's software is critical. The goal is for the project to include all drawings from all disciplines into a central model. This central model makes for a better flow of information throughout the project [Nitithamyong and Skibniewski, 2006]. A neat feature of BIM is the possibility of collision controls. Collision control is the act of checking if there is any collusion between the different objects in the drawings. Thus, reducing the chance of conflict later in the process.

Every discipline has its preferred software conducting the modeling. Thus, the diversity of software in BIM is substantial. By Norwegian law, an owner can not dictate which tools to be used in a project. What can be dictated is that every tool to be used in the BIM sphere should be able to produce and read files of the IFC-format. Cloud

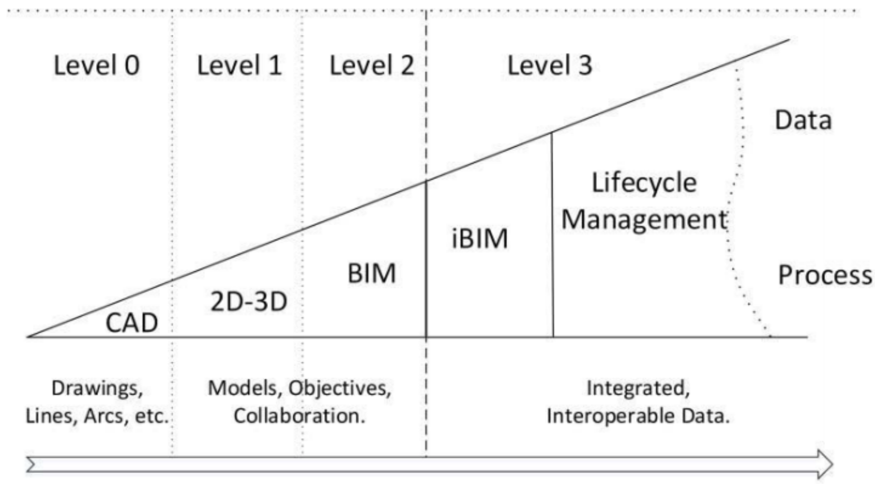

Figure 2.6: BIM Maturity Diagram [Bew and Richards, 2008]

technology has made it easier to access the BIM model everywhere [Azhar et al., 2012]. This access is the case in the shared model, put together by the models of every discipline. For the most part, every discipline and modeler work on their own, using their preferred tool. Thus, the data is stored on their local computer until exported and put together in the shared model. Using BIM promotes cooperation, and using Cloud-based BIM communication is shown to be a cost-effective implementation [Das et al., 2014], also cloud-based BIM technology is the next step in the BIM evolvement to improve the efficiency of BIM [Wong et al., 2014]. The problem is that still, a considerable amount of data is not shared; hence the data stored on the local computer. Autodesk BIM 360 is a platform collecting all relevant disciplines with a shared platform, which includes risk management, procurement, design, and more—using a Software-as-a-Service solution, which makes for effortless view and manipulation of the model.

Designing in a web browser, using a Software-as-a-Service, is shown to be complicated. The main issue is the high demand for usability [Chuang et al., 2011]. Thus, most users tend to stick to local computer software.

2.2 Agile Project Management

This section will give an overview of Agile in the context of project management, as well as provide an introduction of different Agile management methods as context for the reader. Furtheremore, a discussion of Agile as a management method, and if the introduction of Lean is in fact just a hype.

First, when discussing this topic, project methods need to be defined. Different from the *process*, which is more concerned about the different phases of the project, the *method* is about how one can manage within a given stage of a project. Thus, project management methods are about making the most effective utilization of resources within a given phase.

2.2.1 The Motivation for Agile Project Management

Agile project management is applied in different industries throughout history, with its origin in car manufacturing at Toyota [Liker, 2004; Association et al., 1986; Shook, 2002]. An industry adapting agile early on was the information and communications technology industry (ICT). In the ICT-industry, the urge for change in project management within distinct phases of projects led to the introduction of agile software development. The move was motivated by having a way of handling late requirements and the growing amount of documentation needed in the ever-more-complex projects. Furthermore, utilizing testing, that way, bugs can be fixed during production, when most uncomplicated. Pushing was also the headlines describing yet another software project failing to meet the schedule. All these symptoms made the software industry move into using agile software development methods as a basis for their project management, starting at the beginning of the '90s and has since been introduced in most software development developments, where needed.

As we have mentioned increasing productivity and efficiency in a project is desirable for every project, hence marginal cost. This added to the fact that LP in the CI is decreasing made the industry wanting to take action. This research is, therefore, concerned about the bottom-up approach securing more cost-effective and labor-productive management, leading to a more solid industry in the end. The LP-problem is not the only motivation for CI to utilize Agile project management methods. One can identify most of the same issues ICT had when introducing Agile. Most present, as mentioned, is: (a) increased complexity, (b) extensive documentation, (c) reporting of issues leading to change of design during production, and last (d) delivering a construction without errors.

2.2.2 Agile Project management

Seen the motivation for both the ICT and CI to make changes and introduce APM. This section will give a short introduction to APM: the bases as well as some disussion of the use. Furtheremore, the section will introduce some known ASDs, as context for the reader. These methods promote smaller teams of 5-12 people; therefore, included is also an elaboration of ASD in large scale corporations, as well as, Lean, which encourages comparison between SD and Construction.

APM diverse from linear processes; by the way, a project, or the workers, can rapidly adapt to circumstances. This lines with the problem of requirement change in SD. Moreover, it corresponds to the reporting of issues during production in the CI. The initiatives done since the adaptation of agile in SD was expressed in the Agile Manifesto [Beck et al., 2001], when published in 2001. The manifesto gave a tangible reference for project leaders, as well as developers, to steer the project with the correct mindset and focus. Moreover, the manifesto gave a baseline for creating new and potentially better APM methods. The Agile Manifesto says:

> **Individuals and interactions** over processes and tools
> **Working software** over comprehensive documentation
> **Customer collaboration** over contract negotiation
> **Responding to change** over following a plan

Including these four sentences, the manifesto also includes a set of twelve principles. Theses principles emphasize always having a working product, an enjoyable working environment, and a proper dialog with the customer. Wich eventually results in a team able to adapt to change, also late in the development. The manifesto emphasize that face-to-face conversation is the best way of proper conversation, even though much of the interaction can be supported by software.

2.2.3 Agile software development in smaller teams

The above mentioned agile manifesto, says a lot about principals and values when conducting APM and ASD. The manifesto says nothing about the actual process, that is for the different agile methods to explain. Known methods such as SCRUM [Sutherland, 2014], Extreme Development (XP) [Beck, 2000], and Feature-Driven Development[Palmer and Felsing, 2001] are among other descriptions and practices on how to implement scrum as a work method. Abrahamsson, identify that common for all is that they are incremental, straightforward, cooperative, and adaptive [Abrahamsson et al., 2002]. Different from the waterfall process, Abrahamsson concludes, agile emphasizes

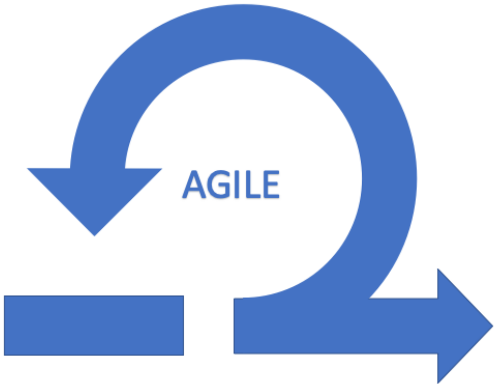

Figure 2.7: Illustration of the generic agile loop.

on being people-centric.

A generic view of the agile method is iterative development, seen in figure 2.7. Using the example of SCRUM, the iteration involves sprint-planning, implementation, and review. The method emphasizes growing the team, and after every iteration, a retrospective meeting is being held. Also, worth mentioning is the daily scrum, a meeting where the team discusses the progress, and issues can be raised. Most of the artifacts and events applied in SCRUM has comparable ceremonies in other ASDs.

Still, the process of creating a product has to involve more than just sprint planning. Most of the agile methods also include prior planning before the iterations start. This planning is to be found both in XP and SCRUM. When agile development methods are applied, a problem with estimation often occurs [Lang et al., 2013]. This problem is very present for the managers [Dybå and Dingsøyr, 2008]. Traditional project managers utilize a Gantt chart, scheduling project tasks. Sutherland, on the other hand, argues the use of Gantt is mostly a waste of time:

> *The only problem with them is that they are always, always wrong.*

Even though most of the methods encapsulate planning in the process, Abrahamsson, in his paper [Abrahamsson et al., 2002], discovers that there are only two of the methods implementing concept creation in the process. This is an essential part of the CI project process. Still, one can argue that this is not a part of the development and is supported by the SSA e-procurement process [e-p, 2019].

Agile methods are, as the title of this sub-section implicates, planned for smaller teams. Challenges, when extending the team-size, of more than the recommended 5-12 people, are decision-making, communication, and control [Xu, 2009]. Also, when wanting to use the methodologies in large organizations, some adjustment is needen. This made for the introduction of large-scale agile organization methodologies discussed in the next sub-section.

2.2.4 Agile in Large Scale Organizations

As mentioned, most agile methodologies are designed for smaller teams. Challenges applying agile in large-organization are mostly communication and coordination [Dingsøyr and Moe, 2013]. These issues are well-known when considering large organizations, but are very present when the agile mindset emphasizes harmonization between different actors [Miller et al., 2002]. When considering large-scale agile, one often want the whole organization to utilize agile with diverse teams. Understanding the concept of agile methodology is problematic. This applies to the managers, and team-members not known to agile beforehand [Svorstøl, 2017].

When considering large-scale agile organizations, one can divide between organizations using consultants and large in-house scale organizations. When considering projects and organizations of that size, the complexity of management is very present. Still, most of the problems are the same, including knowledge sharing, clear practices, and interacting [Smite et al., 2019]. In the case of Spotify, they promote continuously improving their practices, as well as communicating in a face-to-face fashion.

Often directors tend to employ old tools and practices not suited for agile, such as Gantt charts, detailed plans and documentation, and set-dates for production [Benjaminsen, 2019]. Both in the case of Spotify and the A-team-project, the discovery is that autonomous team is way more effective than typical teams managed by some leader. Thus, the managers and directors are to facilitate the best infrastructure for the teams.

2.2.5 Lean

As we know, the term agile was first introduced by Takeuchi and Nanaka in the article *The new new product development game*. They explained how Toyota utilized agile methodology in its construction line. Moreover, the systems used at Toyota are formally named Lean manufacturing and was developed by Ohno and Shingo [Becker, 1998]. The idea of the build-measure-learn loop has later been adopted by many other industries, especially after the international bestselling book: *the lean startup* [Ries, 2011]. The constant focus on added value to the product is a quintessential aspect of the methodology, which is yearned for many managers out there.

The lean startup was written by Eric Ries, which origin is software developer, and the approach explained in the book is, therefore, primarily suited for software startups. The act of creating a minimum viable product is not as applicable in the CI. Lean thinking, on the other hand, could still be beneficial for the CI [Owen and Koskela, 2006], thus leading to the introduction of Lean Construction.

The cornerstone in Lean thinking is adding value and eliminating waste. Therefore, identifying what is defined as waste and what is value-adding is essential. For example, the CI suffers a significant waste problem. 30% of construction, in the UK, is rework. In Australia, the number is 35%. [Aziz and Hafez, 2013].

Lean Construction

Agile Construction origins from the Lean Manufacturing, and share many mutual ideas, despite operating on vastly different products [Salem et al., 2006]. While in manufacturing, one can move the product around, the physical size of a construction project induce other measures in Constructing. That is why Lean Construction has rejected many of the ideas from Laan Manufacturing [Howell, 1999].

Applying Lean Thinking in the CI is hence different. Thus, to gain maximum benefit from the lean methodology, there are five fundamental principles to follow proposed by Aziz[Aziz and Hafez, 2013]:

1. *Specify Value:* Specify value from customer's own definition and needs and identify the value of activities, which generate value to the end product;

2. *Identify the Value Stram:* Identify the value stream by elimination of everything, which does not generate value to the end product. This means, stop the production when something is going wrong and change it immediately. Processes which have to be avoided are miss production, overproduction (repeat production of the same type of product, etc.), storage of materials and unnecessary processes, transport of materials, movement of labor workforces and products, and finally production of products which does not live up to the wished standard of the customer as well as all kind of unnecessary waiting time;

3. *Flow:* Ensure that there is a continuous flow in the process and value chain by focusing on the entire supply chain. Focus has to be on the process and not at the end product. However, the flow will never get optimal until customer value is specified, and the value stream is identified;

4. *Pull:* Use pull in the production and construction process instead of push. This

means produce exactly what the customer wants at the time the customer needs it and always prepared for changes made by customer. The idea is to reduce unnecessary production and to use the management tool "Just In Time";

5. *Perfection:* Aims at the perfect solution and continuous improvements. Deliver a product which lives up to customer's needs and expectations within the agreed time schedule and in a perfect condition without mistakes and defects. The only way to do so is by having a close communication with the customer/client as well as managers, and employees are between.

The essential aspect of Agile Construction is flow. For the method to accomplish the perfect flow, it does, as in other Agile methodologies, stack each iteration with a clear set of objectives to be conducted in the planned timeframe, and the flow is kept by planning the correct amount of tasks before the set deadline. The Norwegian Lean Construction translation uses a train as an image of the flow. Where the idea is for the train to move through the construction. The movement happens when every task within a specific area is completed. The train is represented with a set of carts, each a representation of a discipline. Alining the carts, so that the correct disciplines are in succeeding order.

The output of every flow is the percent planned completed (PPC). The managers can adjust the order of carts, or the number of tasks to make the production more efficient. When utilizing Lean Construction, a top-down approach recommended [Holm et al., 2018]. This emphasizes the problem raised by Ingvaldsen, in her article, that the teams lose autonomy when applying Lean in, which conflicts with the Norwegian working model.

Measuring productivity on project-, process- and process level

Lean is an excellent method but offers no mechanism measuring the achieved improvements, such as the burndownchart in SCRUM [Sutherland, 2014]. Skappel, in her master thesis [Skappel, 2017], suggests using KPIs measuring the improved perfomence. These KPIs are yet to be tested, but still promising ensuring LP in the first phase of a traditional CI-project evolve in the appropriate direction.

In addition, by recommendation of a issue paper [Langlo et al., 2013], a project started in 2015, establishing a state-of-the-art performance measurement tool. In 2017 the resulting Nordic 10-10 [nor, 2019] program was finished. Nordic 10-10 is a version of the CII 10-10 program[CII, 2019], designed and translated for the Nordic countries. The CII 10-10 program is a survey-based measurement tool based on the concept of anonymously surveying members of a project, regarding their project's performance, team dynamic, and organizational relationship. The surveying is done at the end of each of the five faces of the constructing project. Opposite to a standard approach, where such analysis is done only one time; at the end of the project. Using Nordic 10-10 results in more agile project management, where changes are implemented throughout the project. In some projects, they even do the analysis even more often, allowing the project manager to make changes also within each phase of the project.

2.2.6 Agile, a populare fade in management?

Over the past decades, many new trends in project management have emerged and later faded away. A paper [Padalkar and Gopinath, 2016] exploring six decades of project management trends illustrates the different perspectives of project management. Every trend argues its sovereignty. This illustrates the argument of Rolfsen, in her chapter in the book *Key Issues in Organizational Communication* [Rolfsen, 2004], stating that managers are slavish following new fashions of project management. Rolfsen argues that the project management literature is a significant industry of its own. Often the literature is the one answer to every problem and criticizes the older theories, often written using pathos influencing the reader. Even though the literature promotes new methods into the organization, Rolfsen emphasizes that every fade has some good points.

Even though the focus on different fades promotes different ways of management, the goal is always the same; boost the marginal cost. The results of applying agile in the ICT-industry are promising, hence the increased LP over the past decades. The effect utilizing lean construction, on the other hand, is not to be seen in the statistics, though some papers can report on increased LP [Aziz and Hafez, 2013; Ballard and Howell, 1994].

Applying agile and lean has, for the most part, had a positive impact on projects. Also, every project management trend bring good points into the organization. The deployment of agile is, as mentioned, a way for managers to control the production. Moreover, a tool to control a phase of the process, that has to do with designing and implementation. Added to the process management, the coordination of people in a complex organization is equally as important. The next section is going to discuss this multifaceted area of administration.

2.3 Cooperation in Large Organizations

The work of constructing a highly complex and costly structure is, as we have understood, difficult. There is no straightforward way of doing it, and the focus on project management is an essential part of it. Though, in the end, the act of design and project management is primarily making people work together. Make people interact, coordinate, and synchronize for them to create something that could not happen, if not cooperating. The challenge of making people meet and work together on a common goal, not being self-centered, is something the industry finds difficult. It is seen both in CI, in ICT, and most other industries that have to coordinate different domains of competence.

This section will discuss this challenge and examine what are the ground principals of cooperation and look at different measures one can make. How may computers support cooperative work? Furthermore, how do contracts influence the interest of different actors to cooperate?

First, a short introduction to cooperation: Cooperation is the act of communicating and share knowledge in a way that makes different actors coordinate, interact, and synchronize. The act of talking starts with a desire, or at least a reason, for various individuals to talk.

One must take for granted that the will is there, but in some cases, contracts, politics, or even physical barriers hamper this to happen. Regarding physical barriers, the internet and telecommunication have been a significant leap towards decreasing the boundaries. Computer-supported cooperative work (CSCW) is how technology supports teams cooperate in a project. CSCW will be discussed later in this section. Furthermore, this section will give a brief insight into Norwegian CI- contracts and politics as a context on how for the project, which is an import backdrop for why individuals and parties act the way they do.

2.3.1 Comunication and Knowledge sharing

The act of talking among project actors and team members is, in most cases, sharing knowledge. One often divides knowledge into tacit- and explicit knowledge. Tacit knowledge is something that is known to actors, but not written down, or otherwise, for somebody else to learn and understand. Where, on the other hand, explicit knowledge can be assimilated simply by reading a manual, or a document.

A known problem in the CI is knowledge sharing. The motivations for knowledge sharing is as Dainty describes mostly social [Dainty et al., 2005]. The contractors do what others do, are following the leaders' example, and the feeling of taking part in something bigger than their problems is vital for making people share knowledge. Also, the fact that people need to get something in return when sharing [Zhang and Ng, 2012]. They get a positive effect through feedback and the effectiveness of their work. Furthermore, Zhang and Ng note that the problem causing people not to share is the fear of losing face. For the managers to contribute to knowledge sharing, they have to create a strategy of capturing and distributing the knowledge [Kamara et al., 2002], often tacit, created in each project.

Systemizing could help digest explicit knowledge because sometimes the information is there, but how to find it could be the impediment. In modern times computers are taken in to use, systemizing knowledge. Then again, the introduction of computers leads to new tacit knowledge, on how to use the systems. A platform for knowledge sharing could serve positive for the different CI-businesses [Kivrak et al., 2008].

Boundary Objects, introduced in the original paper [Star and Griesemer, 1989], is a helpful tool when looking at complex situations. Defining objects where actors cooperate and exchange tacit- and explicit knowledge. A boundary object is part of the social world and is, in some way, a facilitator for communication between actors. Star and Greisemer argue that it has to be well-defined, as well as fluid, such that it can both adapt and maintain a collective identity between parties. An example in an engineering project would be documentation or a user manual, which contains explicit knowledge for different parties to share. Furthermore, a stand-up meeting in Lean Construction is a boundary object which emphasizes tacit knowledge sharing.

2.3.2 Computer-Supported Cooperative Work

Computer-Supported Cooperative Work, first defined by [Friedman and Cornford, 1989], is the theory of the technology's role in the work environment. Often considered in the same context is groupware. The article *Computer-supported cooperative work: history and focus* [Grudin, 1994] describe the motivation for groupware:

> *"The complexity of managing large government software contracts provided further incentive to apply technology to group work."* - Jonathan Grundin

This motivation applies to Software development as much as for CI. Software and applications as boundary objects have aided complex working groups for centuries. One of the most known, and by Kraut in [Ensor, 1990] described as the only successful, CSCW application is e-mail. CSCW could also aid knowledge sharing [Monplaisir, 2002], by, for example, make use of decision-making software. This way, teams having trouble making decisions can have a trusted source guiding the conclusions. Moreover, the use of ai and big data in the context to support the teams, in ways never seen before, shows promising results, when the ethical issues [Jung, 2017] are kept within boundaries.

Groupware has been an essential part of collaborative work, but what makes good groupware?

To make groupware work, first, it needs to meet the needs and requirements of the group [Subramanyam et al., 2010]. When the software is thoroughly developed and tested to meet the requirements, one can argue that the software should work. Still, after a proper software development process, the critical implementation phase begins. Implementing new software has to fit the users. The article *Transforming Work Through Information Technology* by [Robey and Sahay, 1996], describes how the deployment of new groupware in two different counties, ends in two different experiences. Central in the succeeding county, is knowledge sharing and grooming of users beforehand. They were conducting the implementation of the software in a bottom-up manner. In this case, the users were the ones who initiated the deployment. In the other county, who did not succeed, initiating the implementation was a centralized data processing department. As well, the knowledge had to be thought through manuals and learning by doing. Bratteteig and Wagner suggest using user participation and suggesting a partial implementation of new groupware; thus, the people already knowing the software can function as super-users guiding the rest of the organization [Bratteteig and Wagner, 2016].

A challenge in doing a partial implementation, suggested by Bratteteig & Wagner, is that people do not want to take part or use unless there is already a sizable group of people participating [Grudin, 1989]. This phenomenon called the "critical mass"-problem and is known in communication systems and other CSCW systems with similar characteristics. This problem causes a barrier in starting up the usage [Markus, 1987].

Moreover, implementing new digital tools can hamper with the way of working, causing new jobs to be made, such as the case in introducing BIM. On the other end, jobs might be lost. Thus, the help of unions in developing is beneficial [Ehn, 1993]. Implementing a new tool into an organization is, thus, not always straight forward. There is a difference between making people adapt to a new tool, or make the tool custom to the group. Sometimes, the best way is reorganizing around a new tool [Hammer, 1990].

Also, a new tool is challenging due to the way the users have to interact with a new tool, going from a way of working, with knowledge from either prior software or other tools. Thus, the way people react to the new tool has to do with prior experience [Orlikowski, 1992]. Hence, bottom-up implementation is beneficial.

In the end, to be highly successful, when fulfilled all other terms, the application has to meet a set of rules of usability. The software could still work, but often much knowledge is needed to understand the technology, if not emphasizing high usability. Jacob Nielsen defined a set of tensability heuristics, listed in table 2.1.

In regards to architectural and construction engineering, BIM is a significant enrichment in regards to collaboration. One might say BIM has the potential of being the best groupware there is, in the CI. This, because it encourages collaboration and communication through a shared interface. One might say BIM is not living up to its potential, especially in the management part of projects [Eadie et al., 2013]. Also, the resulting

Code	Usability Heuristic	Description
1	Visibility of system status	The system should always show provide information of what going on in the software, for the user
2	Match between system and the real world	Use the user's language. Concepts, words, and way of visualization that is known to the user
3	User control and freedom	Let the user have control. For example, implement "undo" at all levels
4	Consistency and standards	Consistency in the interface, follow the guidelines of the platform in use (Mobile, mac, windows etc.).
5	Error prevention	Design the system to minimize errors
6	Recognition rather than recall	The user should not need to remember information between different dialogues. Instructions should be visible when needed
7	Flexibility and efficiency of use	The user should be able to use the software to its level of knowledge. For example, provide shortcuts to advanced users
8	Aesthetic and minimalist design	Remove what has no purpose
9	Help users recognize, diagnose, and recover from errors	Help the user if error occurs
10	Help and documentation	Provide an effective system of help

Table 2.1: Jacob Nielsen's ten usability heuristics

model of the BIM process can enhance a custodian's work immensely. The implementation and adoption of BIM are quite so important for the groupware to reach its promising potential. Arayici arguments using the bottom-up approach, and let the different modelers have the learning-by-doing introduction [Arayici et al., 2011]. On the other hand, if not managed correctly, the resulting BIM model will become messy, tough for the managers to handle, resulting in expensive issues [Suermann, 2009]. Moreover, the resulting model of "As-built" will become problematic to use.

2.3.3 Contracts in the Construction Industry

This section will give an introduction to issues concerning contracts in the CI. First, a short introduction to contracts in the CI, as a context for the project.

Contracts in Construction Industry as a Context for the project

When considering how contractors work together, one has to review the contracts and the politics related. In CI and other fields where contractors are needed, the process outline, defined by SSA, often outlines how to work. During this process, in CI, the party announcing procurements creates tailor-made contracts based on the Norwegian Standard (NS), e.g., NS 8405, NS 8406, NS 8407, and others, which do not support an agile process. This yields a waterfall process.

Tailor-made deals makes for a challenging space of agreements for the entrepreneurs. This space promotes larger companies or the ones who specialize in contracts from only a few vendors. A contractor who wants to earn a new principal has to learn the contract, giving the advantage to the more experienced contractors. Often the more advanced companies are not pleased when parties introduce new contract outlines - simply because they lose their edge.

In step 4, the procuring of entrepreneurs phase of the procurement process. In this step, one has to choose an essential element of the contracts, namely, who is responsible. There are two fundamental forms of contracts: (1) Implementation Contract (*Utførelsesentreprise*): where the contractor is answerable for the implementation; and (2) Total Contract (*Totalentreprise*): where the contractor is answerable for both the design and the implementation of the construction, which imply the contractor owns the risk. In both of them, there are different ways of implementing contracts with subcontractors.

Essential in choosing the fit contract is how one expects the contractors to support one another. A deal that supports interaction is necessary when cooperation is crucial. When is not cooperation essential, one may ask? Often when constructing a modular house, where the owner (hereafter named manager) plans everything, repeatedly building the same house. When designing complex constructions, on the other hand, cooperation is highly desirable.

When constructing a highly complex construction *Utførelsesentreprise* is often chosen. This way, the risk is at the manager. Choosing the right design of the contract is crucial when aiming for a high degree of cooperation. There is three main contract design. Different is how much coordination and progress management the manager is responsible for managing. The contract models are:

- Shared Contract or Contract Management (CM) (*Byggherrestyrt entrepriser*): The manager makes all deals with subcontractors. In some cases, a subcontractor takes the lead on coordination and progress;

- Lead Contract (*Hovedentreprise*): The manager signs a lead contractor, which is responsible for a significant amount of disciplines. Furthermore, the manager establishes subcontracts with the remaining disciplines;

- General Contract (*Generalentreprise*): The manager signs a lead contractor, the general contractor, responsible for signing subcontractors, coordination and progress in the implementation;

Issues Related to Contracts

Picking the correct contract is vital in securing desired coordination and interaction, but at the same time, it needs to fit the manager's skills and resources. In the end, choosing the right sort of contract can be vital for meeting the budget. The problem with the complex domain of contracts is that managers tend to pick the same contracts [Lædre et al., 2006]. Even though construction projects often vary from project to project, the procedure of picking the correct contract for the specific project is often not done.

The politics and contracts in a fragmented CI project, with a handful of contractors and sub-contractors, makes for difficulty in cooperation. Issues related to knowledge sharing is, among others, contracts and politics [Alashwal et al., 2011] — the issue origins in the fact that every contractor has the goal of maximizing its marginal cost [Miller et al., 2002]. This problem is especially problematic in projects consisting of several different companies, such as in complex constructions. Miller, Packham, and Thomas, in the article, also points out the fact that cooperation and knowledge sharing in mixed teams is the cornerstone in APM. This makes Lean in the CI even more complicated when complex contracts and harmonization among team members are taken into a count.

Furthermore, the considerable cost of mistrust in CI-projects is shown to be a factor in the overall cost of a project [Zaghloul and Hartman, 2003]. When actors are more busy protecting their contract, rather than adding to the team, the advantages of cross-functional teams can be lost. Also, prior ties could have a significant impact on how team members interact, as described in the paper of Bruvik and Rolfsen [Buvik and Rolfsen, 2015].

> *Positive prior ties can have a substantial effect on the development of trust at the beginning of the project.*

Furthermore, the paper is concluded by identifying four aspects that can aid interaction and cooperation: (1) a common philosophy, (2) open communication, (3) clear role expectations, and (4) a shared climate of trust. Hence, prior ties will help in establishing these aspects. One can think that negative prior ties will especially defect the second and the fourth aspect.

Chapter 3

Method

This chapter will give an insight into why the research is needed and what method used conducting the research. Also, the chapter gives insight into the collection of data and the following analysis, as well as and who are the participants.

This thesis is a part of two-phased research. The first phase made its results into a separate thesis: the project thesis. Data discussed in this thesis is obtained both in phase one and two.

3.1 Methodological Approach

This study aims to understand the primary conditions for Norwegian construction projects, utilizing Lean and BIM, to achieve the potential of both the applied methodology and digital tools. The research is, therefore, adopting a case study-strategy of a single-case object, in the CI in Norway. Utilizing a single-case study approach, preferably than multiple, will give a more in-depth look at the problem, rather than a thin description provided by the multiple-case study [Yin, 1993]. This research, therefore, aims to examine a case using lean methodology, utilizing digital tools to support both the method as well as cooperation and interaction between different actors. The project selected is the construction of the new Life Science Building, managed by Statsbygg [sta, 2019].

The problem of using a case study is that it is hard to produce a generalized answer to a question. The aim of the research is not to obtain generalizable findings but to explore the phenomenon. Furthermore, identify different measures that can help this specific project. This thesis is based on a preliminary project committed in the fall of 2019. The intention is not to measure productivity, but rather understand the phenomena and propose coherent actions.

This study is related to the interpretivism paradigm — the use of empirical observation of the participants and a desire to identify how they act on the new software and methods used. Using interviews can lead to being subjective as all collection of data is done in interaction with the participants. This yields a qualitative collection of data. The purpose of this master thesis is to identify issues causing a lack of productivity and identify actions fixing these issues. Moreover, implement some actions and observe how the project react to those changes.

Due to the Covid-19 virus, this thesis could not implement the identified actions, and therefore only propose a set of actions.

RQ1: How does the project facilitate excellent communication and interaction as a basis for achieving the potential?
RQ2: How is the project suited to meet the requirements in realizing the requirements of a construction process and Lean methodology?
RQ3: How does the project realize its digital potential through the use of BIM and different groupware?
RQ4: What are the challenges and conditions needed to be addressed in the project and future work?

3.2 Access to Case

Obtaining the LSB-project was rather by chance, and followed no formal theoretical sampling procedures proposed by the literature [Yin, 1993]. In the fall of 2018 the researcher came in contact with Patrick Stormo Hjerpseth, former Project Manager of Digitalization in the LSB-project. After a conversation, where the researcher told about motivation and interest in methodology and software utilization, Hjerpseth came up with the idea of writing a master thesis on the LSB-project. The researcher was at the same time offered a job in Progit Consulting AS, where Hjerpseth is CEO. Moreover, signing with Progit in the fall of 2019. Hjerpseth helped gaining access to the LSB-project, and in the fall of 2019 the first phase of this research began. During the first phase of the project Hjerpseth became sick leave. Giving a new point of contact, Darre Brecke Brenden, from Statsbygg. Also, a agreement with Statsbygg was secured for the project to continue into the next phase. Which gave more access, both in terms of participants, and the posibility to use the project office doing the interviews.

3.3 Litterature review

A literature review offering a qualitative research method and serves as an essential part of the study. A systematic search of relevant literature gives insights into different selected subjects and disciplines relevant to the research. The researcher followed no formal method in the literature review.

Utilizing google scholar as a search engine, the primary source of literature is, thus, theses, research papers, and books. Moreover, using books and literature already known to the researcher. The researcher developed a set of search words and combinations. Based on the research theme, and findings in the interviews, different combinations appeared. Search words used frequently are Lean Construction, Lean Design, Lean, Agile, BIM, CSCW, with a different combination of pre- and postfix.

Often a set of literature was picked based on its title and thereafter minimizing the set based on the abstract and introduction. Moreover, reading the papers, the reference named is checked and evaluated.

3.4 Data Collection

Interviews

The interviews for this research was done during two phases, as seen in the 3.2.

The first phase of the research, resulting in a project thesis, was conducted in the fall of 2019. Due to a hectic period of the project, the researcher made use of video chat conducting the interviews. Using Skype and other video chat services can be cost-effective due to the ease of planning, compared to face-to-face interviews. On the other hand, because of the small window the web camera provides, it could be challenging to read the participant's body language [Cater, 2011]. Also, the utilization of digital interviews is reliant on highspeed internet, and that the subject is familiar with the digital tool for the interview to work well enough.

In the second phase, the interview took place at the project office, near the building site, in Oslo. The project gave up a small meeting room for a week for the researcher to use. Opposite of digital conduction, face-to-face interviews lead to more waste of time caused by the difficulty of planning and waiting. On the other hand, the conversation

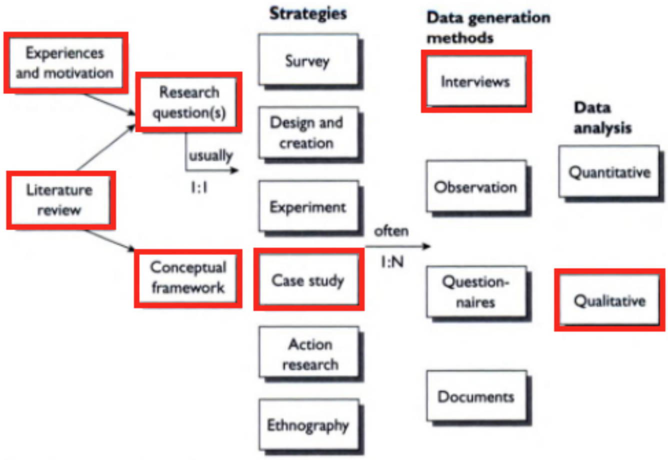

Figure 3.1: The research process used, marked with methods applied in the research.

will not suffer from a lack of body language or depend on technical tools to work, but the recording device. Also, the researcher felt the conversation had a better flow face-to-face.

On the other hand, every interview can be a source of error because of the communication element and how the actors interpret. What the interviewee sais is not only in words, but mimics, cadences, body language as well. Hence the difference in the face-to-face and video chat interviews. Using follow-up questions helps in the case of insecurity. Also, the researcher could correspond with the participants over email and telephone after the interviews. Thus, increasing the validity of the data.

Before an interview, an email was sent to the participant, preparing for the conversation. The email consisted of a description of the research, the researcher. Moreover, the consent and interview guide described later in this section. The preparation gave the researcher more in-depth and thought-through answers. Not every participant had spent time preparing for the interview.

The conduction of the interviews followed a set of standardized questions. The researcher, beforehand, developed these questions. The guide consists of a small collection of themes relevant to the research question, listed in Appendix A. The order in which the questions where asked was not of importance, and often changed based on the interviewee—moreover, the participant was indeed the dominant part of the interviews.

Obervation	Meeting	
1	Blackboard-meeting	
2	Table-test meeting	
3	Digitalization-meeting	
4	BIM and dRofus introduction	
5	Being in the Project office	
Total observations		5

Table 3.1: List of observations conducted in the project thesis.

The interviews are, therefore, consisting of several follow-up questions. The purpose of an unstructured interview was for the interviewee to speak freely, and therefore more receive more genuine answers. The research process used is shown in figure 3.1.

In line with Norsk Senter for Forskningsdata AS (NSD), the researcher, signed an informed consent with the participants. The contract gives the researcher allowance to do the interview; keep personal data throughout the project, such as name, title, and company; and do recording of the interview. The purpose of the recording was for the researcher not to take heavy minutes during the interview, instead focus on the conversation. Also, a recording will give an exact version of the interview.

The transcription became more or less the exact recording of the interview. Sometimes, not writing the follow-up questions, if the sentence made sense. The resulting text was hard to read, due to its spoken tone of voice. The purpose was not to make a perfectly readable text, but to have documentation of the thoughts and experience of the subjects, for further analysis. Moreover, after the interview, the transcript was sent to the participants for them to approve. Every interview lasted between 15 minutes and up to half an hour.

3.4.1 Observations

This research has, in addition to interviews, as one can see from figure 3.1, utilized observations to obtain information and data. Moreover, the research has used a set of documents describing the project, project vision, and strategy.

The observations took place over the first phase of the research. During two days at the project office, observing different meetings, the researcher recorded with notes what was happening and said in the meetings, and transcribed after the fact. The list of observations is placed in table 3.1.

The transcription of the records was to write out the notes written during the observations. Besides, writing down questions and thoughts connected to obtained literature. Except for the Digitalization meeting, the researcher was not able to ask questions during the meeting. Questions who came up was later answered by managers, or directly with participants, after the meetings. In addition to the observations and answering questions, talking to the managers and PLs, on-site, gave valuable insight into the project.

3.4.2 Documents

Documents were vital in gaining insight into the project. Statsbygg, as the manager, documents the construction in [sta, 2019]. Moreover, UiO, as the final user of the building, gave valuable documentation of the construction and the final building, used in describing the construction [uio, 2019]. Also, documentation of the prior constructed Bergen Academy of Art and Design [Holm et al., 2018] gave valuable insight into how the manager planned for the LSB-construction. Moreover, propose the overall strategy used in the LSB-project, described in section 4.1.1. Besides, giving birth to the ide behind the Cogito Project resulting in the tool used.

3.5 Participants

The project researcher, Morten Bujordet, is involved in the project, creating the plans, and conducting the research.

Supervising the project is Eric Monteiro. Monteiro is contributing with experience in research in the implementation and use of new digital tools in large scale, as welle as complex organizations.

Furthermore, Statsbygg, as the manager, has an interest in the project: giving access to the participants in the study. With Darre Brecke Brenden as the point of contact.

In the research, the actors in all layers and disciplines of the project organization will be an aim for the data collection. The thesis conducted a total of 18 interviews. Selecting the first two interview objects was based on a list of 6 interviewees, proposed by the first contact person. Only two subjects had the opportunity to participate, due to a hectic period of the project. The second phase of interviews started with a list of 32 potential interview objects. Every proposed interviewee was contacted; only 16 had the opportunity. The initial list of persons was handpicked, by the assisting project director, to get an insight into all different levels of seniority and different disciplines of the project. The resulting set of interviews represent a wide range of project seniority. From a month of experience and up to the very start of the project, back in 2014. Also,

Interviewee	Function	Gender	Phase 1 (November 2019)	Phase 2 (February 2020)
1	Assistant Project Director & Project Manager	Male	x	
2	Assistant Project Manager	Male	x	
3	Project Manager	Male		x
4	Engineering Manager	Male		x
5	Engineering Manager	Male		x
6	Progress Planner	Female		x
7	ITB Manager	Male		x
8	Associate	Female		x
9	Discipline Leader	Male		x
10	Discipline Leader	Female		x
11	BIM Manager	Male		x
12	Associate	Male		x
13	Associate	Male		x
14	Discipline Leader	Male		x
15	Assiciate	Male		x
16	Ass. Project Group Leader	Female		x
17	Engineering Manager	Male		x
18	BIM Coordinator	Male		x
Total interviews			2	16 = 18

Table 3.2: Overview of interviews and phases of data collection.

the set represents every discipline in the project. The interviewees are listed in table 3.2.

All personal information gathered will, safely, be stored in a GDPR-compliant Cloud Service, served by NTNU. In the final report, no personal information will be published, and all participants will be anonymized.

3.6 Data Analysis

The analysis started by transcribing the interviews and sent to the participants for approval. Furthermore, utilizing a thematic analysis approach. The thematic analysis followed a set of steps

1. **Perusal of all the material:** It was essential to get to know the material, and read through all the interviews. The interviews were already familiar because of listening to the recordings when transcribing and conducting the interviews. Reading through the interviews gave a more in-depth understanding. Moreover, it allowed the researcher to reflect on the answers with the preliminary literature

review.;

2. **Generation of codes**: After getting to know the material it the focus was to identify parts of the text based on the project question, marked with an identifying code. The focus of the coding was identifying text of interest, based on the literature review, the researcher's technical view, and the research question. Every code is an attempt of generalization of the corresponding text. When logging the codes, the code itself, a snippet of the corresponding text, and the context the sentence appeared was listed in a excel sheet. After coding, the researcher changed the naming of some codes which had a relation or the same meaning. Making the collection of themes easier;

3. **Collection of themes**: Based on the codes, a set of themes evolved. The codes find most connected were put into groups, based on the connection between them. Utilizing mind map grouping the different themes. Drafting different groupings, based on themes and relevant literature;

4. **Reviewing the themes**: The researcher wrote a list of potential discussions and findings for each of the five collected themes. The literature review, polarizing answers, and the technical level of the theme made the basis of the collected themes. Also, the researcher's considerations made for the final choice of themes;

5. **Defining and naming the themes**: The previous step resulted in two themes for this step to name. From here, every code, every theme, every interview was written in Norwegian. The first iteration of naming was, therefore, a direct translation of the theme and, thus, not well articulated. The resulting themes are: (1) Overlapping software functionality and software usage, (2) Lack of fundamental methodological knowledge;

6. **Producing the report:** Describing the findings in the thematic analysis, using the chosen themes as a guideline. Moreover, discussing the themes with relevant literature, previous experience, and context.

The data produced in this process is in the Appendix. The initial codes identified Appendix C. The collection of themes and eviewing of themes did not produce much data, due to its subjective manifestation.

After the initial step of *Perusal of all material*, the researcher started the generation of codes. Identifying the two codes, listed in table 3.3, was identified because of the mention of two essential software and processes used in project collaboration. In both cases, the codes have the origin in the second phase of the interviews. Moreover, the

Code	Excerpt of the Quote	Context/theme	Participant
Communication in BIM	*"There you talk and discuss on a reasonable basis"*	Collaborate across - BIM	ITB Manager
Communication in Cogito	*"...but you lack the communication element"*	Collaborate across - Cogito	ITB Manager

Table 3.3: Two example codes from the thematic analysis

attention of BIM came from the first phase, and later in the inspection of literature, accepting BIM as essential groupware in a construction process. In the case of Cogito, the first phase of the project argued for further investigation in the tool, hence why the generation of the code.

Furthermore, the *excerpt of the quote* gave a context, later used in the collection and review of themes. In the case of BIM, the resulting theme did not end up in the defining of the final two hemes. Moreover, it gave valuable data for the later discussion. The Cogito code, on the other hand, was used in the final theme 4.2.1; Describing the reason for the case. Moreover, alongside other codes in the theme, adding to the later discussion.

3.7 Evaluation of the Method

The single-case study, as well as the use of unstructured interviews, produce results that cannot be generalized beyond the sample group. Still, they provide a more in-depth understanding of participants' perceptions, motivations, and emotions.

One can always argue that utilizing interviews for data collection can tend to be subjective. However, the use of a qualitative approach is best when wanting to describe, contextualize, and gain an in-depth insight into specific concepts or phenomena, which was the case in this empirical study. Furthermore, the project researcher has a part-time job developing the Cogito tool, which can argue for the researcher for being subjective. Though, in this case, 14 of 16 participants mentions Cogito, without the researcher asking them. Also, the participants did not know the relation the researcher had to Cogito; thus, the interviewees spoke freely. Moreover, based on the interviews, the Cogito tool was the one subject getting the most tension; therefore, discussing Cogito and themes related is arguably based on a valid reason.

The objective of this thesis was to test some of the concluding proposals and observe the change it might bring. Though, due to the Covid-19 virus, the implementation phase was not feasible. Thus, this thesis only consists of a set of proposed actions. Testing of the actions is, therefore, up to a later project, or for the LSB-project to do. The project owner has received a summary of this research, including the proposed actions.

Further exploration of the project question is needed to conclude on the matter, moreover, testing of the suggested actions.

Chapter 4

Case Study: The Life Science Building Project

Figure 4.1: The Life Science Building illustrated exterior (Statsbygg v/Ratio Arkitekter as).

This chapter will, first, introduce the case object, namely the Life Science Building-project. The presentation is an introduction to the project in itself, and the vision and strategies essential for project management. Furthermore, the case study will examine and discuss the findings of the empirical study. Section 4.1 inherited from the project thesis conducted in the fall of 2019, only upgraded where the information was lacking or inexact.

4.1 Introduction of the Life Science Building Project

The project case will examine the construction of the new life science building of the University of Oslo. When finished, the building will reach a cost of approximately 6,8 million Norwegian Kroner (NOK), and cover 66,700 square meters, with this, becoming the most extensive, detached university building in Norway. Construction owner is the Norwegian Directorate of Public Construction and Property Management (Statsbygg). The construction started on the 8 of February 2019 and is expected to finish in 2024, while the project management of this report started in 2017. The project group, designing the project, however, started their work in 2014.

The manager, Stasbygg, is a significant organization in the Norwegian construction industry. They are on a state mission, which means that they are to realize the politics decided by the government, achieved in architecture, cultural legacy, spatial planning, and environment.

Each year, Statsbygg constructs about 100 construction projects. Some are more complex than others. The life science Building is one of the more complex. In addition to the construction of new buildings and projects, Statsbygg managing about 600 properties of these 90 outside of Norway. Examples of properties managed by Statsbygg are embassies, royal properties, colleges, and cultural buildings.

In regards to complexity, the new life science building has to meet several complex requirements: (1) the environmental: The property is to achieve Excellent in the BREEAM NOR classification of sustainable properties; (2) usability: a group of the final users has given their feedback on what they expect from the final building; and (3) technical requirements: The building is to house several faculties, some requires highly technical labs.

4.1.1 Project Vision and Strategies

The construcionn of the new Life Science Building is, in many ways, a prestige project. Defined in the vision:

"An even better project"

The project is following in the line of previous two large projects running Lean Construction, with Statsbygg as manager. Starting with the Domus Medica construction concluded in 2013. This project was the first Norwegian group applying Lean. This construction was followed by the raising of the new Bergen Academy of Art and Design (BAAD). During these projects, Lean Construction was a significant part of the project management. The first project suffered substantial scope creep, which made the managers take action, applying Lean Design and Systematic Completion *Systematisk Ferdigstillelse* on the BAAD-project. The moves made gave results, and when finished in 2017, the project was by many considered one the most successful (complex) building-constructions completed in Norway.

Based on the the BAAD-project a the *Lean methodology in design and construction*-book [Holm et al., 2018] descibing the experience from the project, was made. With the previous history and recomendations from the book, Stasbygg, as a manager, defined five superior strategies in the upcoming LSB-project:

1. The Contract strategy
2. The Lean strategy
3. Stretegy of Systematic completion
4. Digitalization strategy
5. Logistics strategy

These strategies affect how the project should run and emphasize the focus of the project managers, hopefully leading to a sustainable and productive project. Following are a brief introduction to the different strategies as a context for the case. An holistic view of the strategies in the project are illustrated in figure 4.2.

The Contract Strategy

The project has made use of a customized version of the Total Contract, named by Statsbygg as Total Contract with Prior Interaction *(Totalentreprise med forutgående samspill)*. Instead of signing single contracts with each subcontractor, the managers have assembled eight arrangements, each covering different divisions of the project. Hereunder a more Lead Contract type is applied. Figure 4.3displays the eight contract divisions. Responsible for each of the contracts, from management, is either the project manager

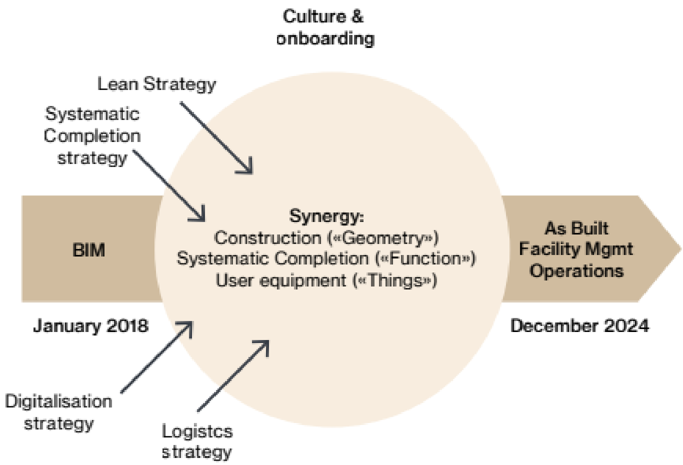

Figure 4.2: A hollistic view of Strategies in the Life Science Building-project.

from construction or technical. Prior Interaction applies to the design phase, where entrepreneurs are involved prior to the job they are to perform.

The motivation for this model is, first, shielding the contractors from some of the risk running the project. The project is, as mentioned, very intricate in construction, as well as in management. Moreover, getting contractors willing to apply on the project, the managers will take much of the risk. Regarding cooperation the projects adds Lead Contracts. The intention of this is cooperation; besides, sharing a contract has the plan of shared responsibility and incentives for collaboration between subcontractors. Even though there is a lead contractor per division, the hope is that the group of subcontractors should feel shared responsibility. Why not have a shared responsibility,and no leading contractor, one may ask? The answer is partly laws and politics, but moreover for simplicity in regards to management; a single point of contact. As well, motivation for adding the prior interaction creates a foundation for the Lean strategy.

The Lean Strategy

The Lean Strategy applied in the LSB-project is tailor-made from experience from both the Domus Medica- and BAAD-project. Two Lean strategies are applied in the LSB-project:

1. **Lean Design:** A method conserning design management and design coordination to ensure that the progress and knowledge sharing, in the Design Phase, is as good

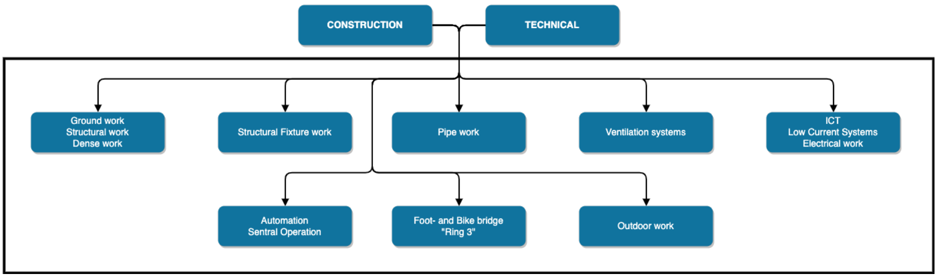

Figure 4.3: Contruction Contracts in the Life Science Building Projects, each managed by either the construction- or technical project manager. (Statsbygg)

as possiblble.

2. **Lean Construction:** A method conserning the scheduling of tasks and the availability of skills and materials to ensure that the work progresses as smoothly as possiblble during the construction.

Different from the traditional design phase described in section Construction Industry Project as a Context for the Project, the LSB-project made use of an iterative method. The *Lean Design*-method has been developed by Statsbygg, after designing the Domus Medica and BAAD projects. In all projects utilizing Lean as their project methodology, the LSB-project also iterates over a product. The product, in this context, is the BIM model. Moreover, the project makes use of Level of Development (LOD), mentioned in the 2.2.5 section, where each iteration, named sequence, has the intention of getting the BIM model more mature. Also, based on the Contract strategy, the result of this process is not procurement, but the final product ready for implementation - hopefully without bugs.

A problem with the traditional design phase was evaluating the overwhelming amount of documentation at the end of the phase. Furthermore, it is an argument in the Agile manifesto. Having sequences, the Lean Design method, therefore, made it easier having control over all interdisciplinary correlations. In LSB-project, these sequences last up to two weeks. In every sequence, the project leaders are assigned a set of packages. Ending the sequence, the project leaders need to deliver on the packages assigned. This way, the project can identify tasks that are, or can be, risks for the project. Every week in the designing the project starts with a cermony named blackboard-meeting. In this meeting all project leaders, project managers, and responsible goes through the packages and deliveries due to that meeting, or the status if not the end of a sequence. The project chair the meeting, while the rest need to the status of the their area of responsibility.

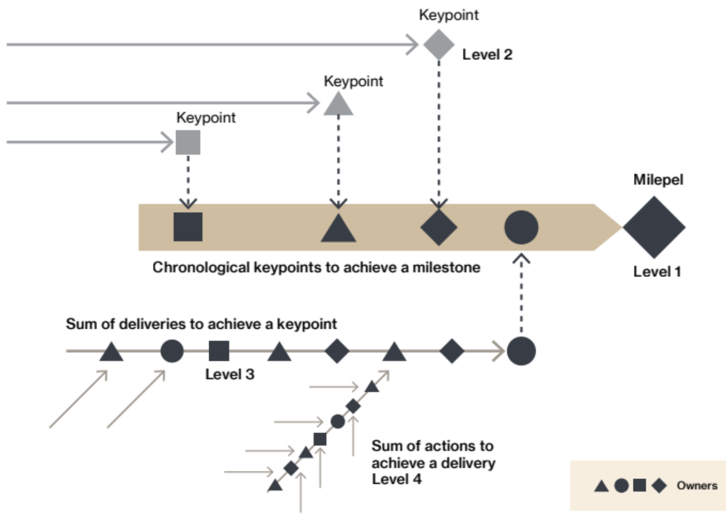

Figure 4.4: Contruction Contracts in the Life Science Building Projects, each managed by either the construction- or technical project manager.

The Detail project started with a two-week planning session, which made all trailing package-planning possible. The session resulted in the process map. The process map includes four levels of tasks, illustrated in figure 4.4: (1) the Milestones: A significant planned completion of a part of the project, e.g., steering document approved; (2) Key Points: Key Points is less significant, and with a shorter time frame than milestones, but in the same way an indication of completion; (3) Deliveries: A Key Points consists of several deliveries, e.g., finishing a room or design of a floor; and (4) Actions: Actions is everything needed to be done to complete a Delivery.

Both the Lean Construction, described in section 2.2.5, and Lean Design, make use of large planing tables. These can look like the old roadmaps used when planning the coding in Waterfall. Depending on how one makes use of the plans, the result of such planes is that they often than not end up wrong. Therefore, as Sutherland points out in his book [Sutherland, 2014], the plan is not the final solution, the plan is what is needed, and adapt thereafter. Though, in this case it seems like the time was well spent giving the project leaders valuable insight into the project. Not spendig too much time planning ahed.

The Strategy of Systematic Completion

As described in section 2.1.2, the construction process ends with the Realization phase. It is after this phase, the project, or building in our case, is tested. If tests run smoothly and the owner approves the construction, the building handover occurs. The mission of testing is to verify that the final product meets the initial requirements and specifications defined. A typical case, when conducting these sorts of tests, is discovering errors. Problems getting wors when there is no control of these errors. If the final construction has too many errors, the owner can decide not to take over the building. Consequently, the project fails to deliver on schedule. Sadly, this happens quite often.

Managing this issue, the LSB-managers has developed a method, checking the systems, functions, and geometry of the construction. The method is named *Systematic Completion* (SC). Throughout the project, SC is conducted, reducing the risk of not deliver the final project. SC follows the LOD-version, which makes for successful completion, with the correct level of quality, at the right time.

The Digitalization Strategy

The Digitalization strategy is, both important in itself, but also supportive in regards to the other strategies. The project using a digital 3D visualization of the building as the product, driving the Lean Design method. Revit, the BIM modeling tool, is, in many ways, the core of the project, supported by dRofus, which is the room database. Prominent in the strategy is connecting all software used in the project and making all entrepreneurs use the same. Hopefully, one can trace the socket implemented in a room, by an electrician, through the drawings given, back to the BIM-model, and the dRofus database, where it was first planned. The resulting system can later be used by janitors, running the building, to identify errors in the system. Figure 4.5 visualize the connected systems in the project.

A significant part of the digitalization, and unique for the LSB-project, is the deployment of the Cogito Project-system. Cogito is a tool used to visualize the planning done in the design phase, supporting the Lean Design method. The tool are beeing used tracking actions, deliveries, and Key points and milestones, who is responsible. Furthermore, calculate Planned Percent Completed (PPC), which is an excellent way of identifying delays. The project is planning to use Cogito tracking both the design- and the implementation phase of the project.

The project utilizes, added to Cogito, several other software supporting Agile project management and cooperation. Under following a list of the most crucial software, concerning Agile and collaboration.

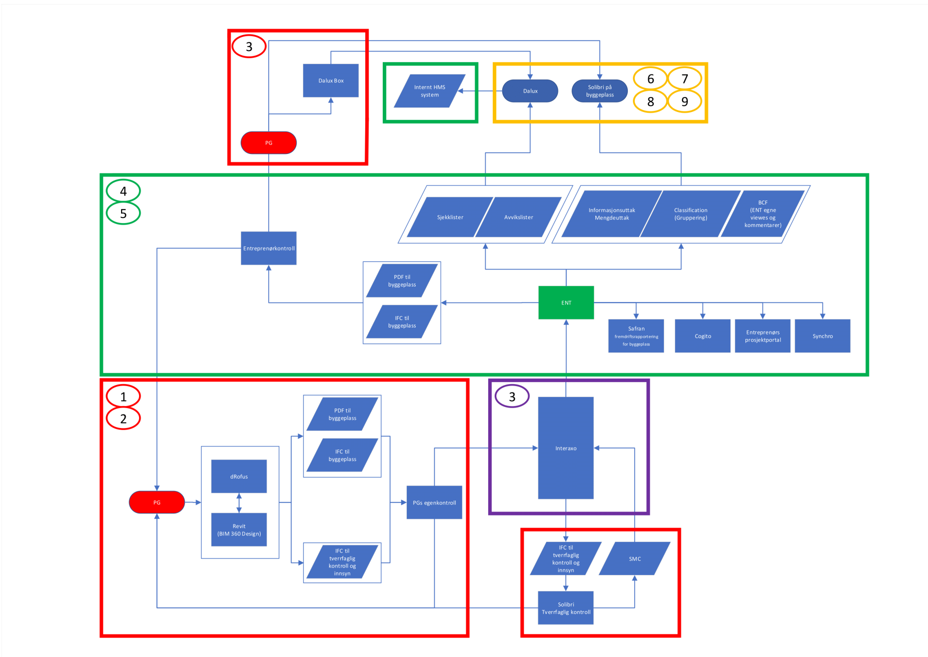

Figure 4.5: Overview over the system architecture used in the Life Science building project. Outlines representes the actors using the systems, by color: (red) Project group, (green) Entrepreneurs, (yellow) HSE, and (blue) cloud service sharing documents

- **Revit:** BIM modeling tool, used in the design and construction of the project. Revit is a local software for every modeler, architect, and worker modelling. The software is developed by Autodesk, which also developed the much popular Autcad; a computer aided design tool for architects, engineers and proffesionals in the construction business. Creates drawings in 2D and 3D. When finished modeleing the modeler has to export what is done so available for the rest of the project. The exportation from every dicipline is put together in the common model, once a week.

- **dRofus:** Software supporting BIM. Whats defined in dRofus is known as the truth if there is a mismatch between BIM and dRofus. The software is used as the database for the BIM model and used in the planning of every room. Furthermore, the data stored in dRofus is being used in the procurement of systems and objects to the project. Every element in the project is given a specific id; a TFM number. This number is later used in implementation, when a object is placed in the building it recieves a corresponding TFM-tag. Later, when the building is running a janitor can fix an object and know exactly what type it is based on the object's TFM.

- **Cogito:** Visualization of ongoing and planned packages, in both the design phase and construction phase of the project. The project director and other managers of the LSB-project have formed the Cogito project, through experiance and some are also invested in the tool. Though, has to take thus are invested in the project. The idea of the tool came from the needs encountered in previous projects [Holm et al., 2018]. The tool is a supplement for a Lean Design and Construction process, specialy shapet for the construction business. The software is developed by a company named Tasctrl, and was only partly finished when introduced to the project.

- **Interaxo:** Cloud service for documents. Servicing onboarding, breach handling, and offboarding. Ineraxo is a platform gathering almost all the documents needed in a construction project. The high demand for documentation is simpler using this tool. After finishing a task in Cogito the final documentation ends up in Interaxo. Often there is a link to Interaxo in the preluminary field in Cogito.

- **Blink:** Communication tool and intranet for the project. Using BLink, interactions can happen rapid and informally without booking meetings and writing extensive emails. Moreover, Blink has wide variety of features like News feed, documentation, messaging and in depth analysis of the workforce. Though, the project main requirement was the newsfeed, the software was chosen due to its confidentiality and security policies. Other services like this are Facebook Business manager and

Atlassian Confluence.

- **Solibri:** Bringing all models from all dicipline in to one view. Gives all actors access to the model, and offers advanced checking and quality assurence, like collision tests. The tool give everyone involved the possibility to collaborate and solve any found issues. A user can view the model and minimize the model as needed.

- **BIM 360:** BIM 360 brings together all aspects of construction in BIM into one platform. Autodesk develops the product, thus integrates with Revit. The software aims to remove the silo structure, often appearing in a project including different themes and disciplines. Offering a shared platform for them to see, collaborate, and develop the Revit model online. Moreover, set up teams, restrictions, and team workspaces. Also, supporting LOD throughout the model. The project has procured BIM 360 Design, hereby refered to as BIM 360, which is one of seven products offered in the BIM 360 sphere.

The Logistics Strategy

Last, the Logistics Strategy. When coordinating a large number of people and paraphernalia, having control is a major challenge. In the LSB-project, there will be up to 800 people and equipment worth over 1 million NOK. These numbers argue for the logistics strategy. The strategy involves planning for goods arriving the lot, as well as where one should tossing the garbage. Considered in this strategy is also removing packaging before arriving the lot, where the goods should arrive, securing the most effective utilization of construction workers. Should the project construct a cantina, so the workers do not have to walk to the nearest McDonald's or grocery store when having lunch? Furthermore, alining workers, equipment, and goods needed to support the train in the Lean Construction strategy. This strategy could be a significant impact when considering the overall labor productivity of the project.

4.1.2 Project management in the Life Science Building-project

To manage a project, this significant, the constructing organization makes use of several different management approaches. One can divide the project management into two levels: (1) process management: The support of the process and how the teams are working together, and in what order; and (2) implementation management or method management: The management of design and implementation of the final product. The organization structure used in the project supports the two levels of project management. The first of the two, process management, is using customized phase-based process management, inspired by agile thinking. Second, implementation management utilizing the

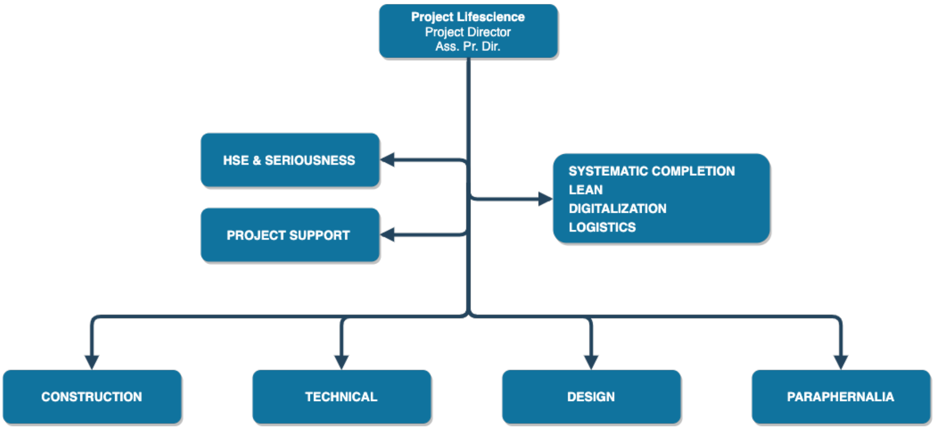

Figure 4.6: Organizational structure in the Life Science Building Project.

above strategies.

The construction project organization structure is, as seen in figure 4.6. Starting at the top, in charge of the project, is the project director (PD), supported by the assisting project director (APD). The board, seen on the right, consists of four managers, each responsible for different strategies of the project. On the left HSE and project support, which is responsible for i.a. Communication, economics, progress. Beneath the four divisions in the project, where design is responsible for process and management. Paraphernalia is responsible for equipment in the final building. Construction and Technical are two divisions responsible for the eight contracts. In each of the division a Project Leader (PL) is responsible. The PL in Construction and Technical the PLs are responsible for the projects concerning their contracts.

4.2 Results of the case study

The research, described in chapter 3, resulted in three themes. These themes were selected based on their significance toward the research question. This next section introduces these themes, with general observations, such as recurring points of agreement and disagreement, trends, and patterns.

The themes chosen are as follows: (1) Overlapping Software Functionality and Software Usage: The project uses a lot of digital tools. Some overlap in their function and different actors in the project use them differently; (2) Lack of Fundamental Methodological Knowledge: The project makes use of newer, and self-made, methodology and techniques, in which require knowledge and understanding.

4.2.1 Overlapping Software Functionality and Software Usage

The project makes use of a lot of digital tools, some of them mentioned in section 4.1. In addition to all the tools that are decided by the governing organization, every contractor or team can choose to introduce new tools aiding their work. This makes for an extensive set of digital tools utilized in the project. When considering that a considerable amount of workers are only working part-time on the project, one can imagine the difficulty of getting an overview. Furthermore, throughout the project, the tools differ in use; Causing a competition in which tools to use.

By the law, a project can not dictate which tools the modelers, architects, and workers use to do their work due to competition rules. For example, when contracting a contractor doing the modeling, the governing organization can only decide on the resulting file-type in which the contractor is to enrich the model. Thus, giving a variety of tools throughout the project. Even though the governing organization can not decide all the tools, some are, and the project itself contracts these. Examples of tools chosen, and contracted, by the governing organization are project management tools for collaboration, documentation, and overview, such as Cogito, Interaxo, Blink, Solibri, and BIM 360.

A project like LSB includes a variety of different disciplines, and with that follows a wide variety of working habits. Still, the PLs need to utilize some structure to control and monitor the project and project progress. Thus, implement Cogito, Interaxo, Blink aiding this control. The idea is for everyone to use these tools, giving traceability and transparency to the PLs. This full use is not so much the case in the project. Several workers were reporting they do not or seldom use these tools. Especially Blink, where almost everyone reported they did not use it, or see it as no necessity.

Blink is later proven critical because the project is posting all information regarding the measures taken on the Covid-19 outbreak.

Moreover, a tool giving a direct overview of the project progress is Cogito. Everyone should have access to Cogito, giving them access to what is going on in the project and what is due the next days and weeks. It is, therefore, striking the disagreement about the tool. Some have chosen not to use it within their discipline. While others use it in meetings, showing the progress and the future deadlines, for the team to deliver. The method of use is also different in various disciplines and managers.

This span in adaptation is an example of how new software is difficult to inject into an organization. Let alone when the software supports a new way of working. Following this new way of working, this tool is leading others to choose not to integrate this tool with the team.

Several teams have been reporting using other task management tools and different tools within the team. Some of these tools offer services, which the tools set by the governing organization does not support. Though, some of them contribute to overlapping functionalities. Thus, the overlap could result in double-entry or not using the common tool, which will hamper the transparency. The implementation of other tools will be reviewed later in this section.

The different use of tools such as Cogito may have roots in the different understanding and use of the tool. How the project uses Cogito is based on Lean Construction and Lean Design. Thus every package has some predefined fields of input, including deadline, prerequisites, title, and description. The project does not have a standard way of filling these inputs. Thus, every team and package reporter operates differently throughout the project. Especially how to write package descriptions and prerequisites wearies a lot. One engineering manager reports using previous packages as a baseline for new packages. Thus, giving consistency to the rest of the team and other disciplines reading the packages. One can argue a lack of knowledge, as of the next section, but in this case, there is no standard way defined in the methodology on how to write package descriptions. Moreover, how to set deadlines, and notifying others about it, is not defined in common ground. Thus, leading to surprises and late deliveries.

> *"I have been part of several themes. The same tools are not used."*
> - Associate, about different tools applied

Table 4.1 illustrate the overlap in software utilization. The list of different task management tools and issue trackers, illustrate the variety of different tools available. The project only dictates the use of Cogito in interdisciplinary and Lean Design process tasks. Thus, the different disciplines and teams are free to use the task management and issue tracking tool of choice to conduct the discipline-specific assignments. Every consultant is bound only to the small set of software dictated by the manager. Hereafter they are free to use every tool needed to fulfill their task. Thus, in a project with a large number of firms, the number of different tools will increase. The people suffering in this environment are the engineers working in different teams. Hence, the comment about different tools applied.

Some of the tools implemented by the owner have much functionality, which overlaps with other software applied. The idea with the software applied is to solve a purpose; Cogito is for package follow-up, Interaxo for documentation, BIM 360 is for BIM-collaboration in real-time, Solibri is to look at the model, Revit is for modeling, and e-mail is for communication. All these software offers a lot more actions then described here. Some of these actions overlap with actions to be done in other tools. Thus, the project has to define which tools to do specified assignments: this way, PLs, and management can follow-up tasks, teams, and packages, without having to seek for it.

An example is in Cogito, a project member reports an action, and the responsible starts discussing this package with a contractor over e-mail, rather than using the discussion panel in Cogito. Thus, the transparency is lost, and going back to see how one solved the package could be challenging because of where the discussion took place is not known. Also, different parts of the project use different tools for the same process. Where one theme-group does issue management in 3D modeling in BIM 360 Design, others tend to use BIMcollab. While project management does not care how modelers work, this could be difficult for an engineer working on several theme-groups and teams throughout the project.

All these different tools make for a competition against which tool to use, between the different actors. Moreover, several tools do not just overlap in functionality, but one actually can replace the other.

What causes all these different software to be deployed, one may want aks. Often the answer is as simple as what came first. In the case of BIMcollab versus BIM 360, that is the case. Before procuring BIM 360, several teams and consultants used BIMcollab. BIM 360 was recently procured when the interviews took place, early February. Hence, the comment on going from BIMcollab to BIM 360. Over time the issues will change from being stored in BIMcollab, but for now, they have to face using two separate tools. As one can see in table 4.1 BIM 360 and BIMcollab offers the same functionality for the project.

Different participants report using Microsoft Teams (Teams). Teams offer a wast variety of features, from direct messaging (chat) to task management and video chat, as seen in table 4.1. Here, prior experience is the reason for use. Using teams makes for overlap with different predefined tools, giving either double reporting, using both tools, or using the wrong tool, not using the project tool. One can argue that Teams overlap with both Blink and Cogito. Blink supply the chat service. Moreover, Cogito is the primary task management tool in the project; thus, it works in smaller team management as well, which will eventually result in transparency for both the team and the rest of the project. A participant even proposed using Teams for much more than an issue manager, removing Cogito as a hole. Arguing Teams can visualize the project in the same way or better than Cogito.

Prior experience is also the reason for the different Modeling tools applied. The majority is using Revit, but some stick to Civil 3D. The modeling tool is for the modeler how the hammer is for a carpenter. Therefore forcing someone using a specific tool is foolish. As long as the different actors can cooperate, the tools they use are negligible. Hence, all overlap is not foolish.

Furthermore, in Interaxo, the documentation tool, one can see a different way of use between various teams. So much that several project members do not know of the structure set by the project management.

Using these tools is a part of the process set by project management, and one can not blame the tools themself. The project has defined a process of onboarding new project members. Though, it seems like several new members have not received this. Part of this process is a course in Lean, as well as how to use the applied tools. Onboarding will give an overview of the tools applied, also why the project is using them. Moreover, the underlying methodology and processes are to be understood before utilizing the tools supporting them. Hence, the next section is discussing the lack of fundamental knowledge.

Software	Function	Comment
Cogito	Task management Process management Risk management	"Provisionally we have not used Cogito in our team." - Progress Planner, about Cogito "Often, there is suddenly a package in Cogito. There are no notifications in cogito, which indicates that a package is given to you. If it is, it is not so intuitive, as it is now." – Discipline Leader, about notifications in Cogito "...there is a notification functionality, but that does not work optimally." – Engineering Manager, about notifications in Cogito "Cogito is a project overview-tool, but the presentation it gives is not always apparent" - Project Leader, about overview in Cogito "After finishing my tasks, I am checking Cogito for something to do. Although it should have been the other way around." – Associate, about Cogito "...as well as being a great way of visualizing the plan for the rest of the team." - Engineering Manager, about using Cogito in meetings
SharePoint	Task management Information Sharing Document Collaboration	"I wish we were using SharePoint for everything in the project ... Instead of using Cogito" - BIM Coordinator

Software	Function	Comment
Microsoft Teams	Task management Direct messaging (chat) Video chat Calendar	"We have used e-mail and Teams for internal tasks, but we do not put these into Cogito." - Discipline Leader, about Cogito
Email	Direct messaging Information sharing	"Using email is very easy, I think" - Associate, about using email "Unfortunately, a lot of communication takes place over email. That is a cumbersome process, I think." - BIM Coordinator, about using email "I am struggling to keep up with all the emails." – Ass. Project Group Leader, about using email "It is not unmitigated where to communicate. We have email(...), then we have Interaxo (...). Lately, BIM 360 has been introduced." - Associate, on communication.
Skype	Video Chat Direct Messaging	"We use Skype, and when they are at the office, we take it here." - Discipline Leader, about using Skype
Blink	Information sharing	"Have not received an invitation, but I have heard about it. That is the social network?" - Associate, about Blink "Everyone in the project has Blink, but I think it is quite uninteresting. I see it more as a social thing, which could be nice." - Discipline Leader, about Blink
Interaxo	Documentation	"In Interaxo, the same structure is not applied in all directories." - Associate, about Interaxo

Software	Function	Comment
Solibri	Model viewing Model extraction	
Revit	BIM modeling	"It is stated that in this project Revit is used. Revit is not as suitable for parts of our discipline's work, hence we use Civil 3D" - Discipline Leader, about modeling tools
AutoCAD Civil 3D	BIM modeling	
BIMcollab	BIM communication Issue tracker Collision control Model viewing	"We used BIMcollab, before BIM 360. We have spent time and money teaching people using BIMcollab. Let alone created all the issues. We can say that we are to use BIM 360 with all its features, but that is large and difficult task, hard to complete. Thus, BIM 360 will be used, but not all the features." - BIM Manager, about switching to BIM 360
BIM 360 Design	BIM communication Issue tracker Collision control Model viewing	

Table 4.1: Software map. Overview of different functions, coherent tools used, and quotes from project members.

4.2.2 Lack of Fundamental Methodological Knowledge

To construct a building like LVB is, as we have seen, a complicated project, to complete the task of constructing this building depends on ingenuity, a good process, and solid management keeping everything in place. Moreover, one needs a whole lot of people to perform and cooperate. The people collected for the LSB-project are hired because of their specialty in their discipline. Some are the best Norway has to offer in terms of expertise. That does not mean they have worked in a project this extensive or complex as the LVB-project. Perhaps they are not familiar with the process applied in the project, namely Lean Construction, Lean design, and Systematic Completion. Thus, project workers, both experienced and less experienced, can feel a lack of understanding, ignorance, or possibly a shortage of knowledge.

Lean heavily influences the LSB-project. Therefore, an introduction to Lean is mandatory in the project's onboarding process. As mentioned in the previous section, this onboarding is not fully accomplished. Hence, several project members lack knowledge of the process applied.

It is clear to say that many of the project staff do not know Lean. Some have made their interpretations; others do know something, but not enough to understand the power it can provide adequately.

> *"I do have a Lean mindset, but I am not quite sure what Lean is."*
> - Associate, about Lean

Moreover, there is only one mentioning articulating using Lean Design in the design phase. Most of the interviewees seem not to understand that there is a Lean process present in the ongoaing phase. Moreover a process come constructing.

> *"That is something applicable come constructing, I have understood."*
> - Discipline leader, about Lean

Furthermore, when not familiar with Lean, they will not recognize how and where Lean is applied.

> *"We need to know how the strategies are to influence our actions."*
> - Engineering manager, about Lean

A challenge when actors do not know the central method, the tools applied which are supporting the methodology is not understood. Hence, many interviewees mentioned issues with Cogito. Several mentioned reports of missing overview. Due to the fact that Cogito is under development, one can imagine that some functionality is missing. Though, what some actors are missing is the old Gantt-diagram, which the Lean Construction methodology does not support. Thus, the frustration against tools like Cogito often builds upon the lack of understanding.

The fact that most of the actors interviewed do not recognize Lean Design in their description of the design process can point to other problems, also in the previous section. When not aligned with the same process or methodology, it is hard to cooperate and communicate. How one should assign tasks, write package descriptions, and do planning is often a part of a project methodology, and especially when considering agile project management. Therefore, the lack of knowledge considering Lean, and especially Lean design, is of a serious matter. It makes the basis of how the project is run, and therefore the tools applied and how to interact.

Added to Lean the project applies several other project management strategies, which, for some, could seem new, including Systematic Completion and Level of Detail/Level of Development (LOD).

The LOD is, in the project, implemented somewhat in a unique approach. Usually, when talking about LOD, one consider the 3D-model; the BIM-model. The LOD variant applied in the LSB-project is known as MMI: Model Development Index. This approach, in itself, has shown to be difficult for some actors in the project. Especially defining the steps of the MMI-latter for every discipline, and what this means when writing package descriptions adding deliveries and actions to different parties. Actors articulate the suffering from the unawareness of LOD.

> "Everything we do is done a new way. At times, it is unclear what the goal is. Thus, the planning of MMI has been difficult."
> – Engineering group leader, about MMI

Furthermore, the project has implemented a sort of LOD in the rest of the project as well. Including both the digitalization and paraphernalia. Thus, project managers use this when deciding on procurement. Hence, some will say they spend too much time discussing the matter. The argument used by the owner is thus that they do not want to make the wrong decisions early on, and rather wait until their level of knowledge is acceptable. Then again, when the actors are not used to this way of working, it is difficult both in use and understanding.

The project suffers from a lack of knowledge. The project base the decisions and way of working on some pillars of methodology supported by the strategies. Though, it seems like there is a variety in the actors understanding of some these pillars.

Chapter 5

Discussion

This chapter discusses the question of the research question and discusses the results. By using knowledge from both the literature review and the case study, the chapter will give the foundation for the conclusion and further work discussed in chapter 6.

This research tries to understand the primary conditions for Norwegian construction projects, utilizing Lean and BIM, to achieve the potential of both the applied methodology and digital tools. The results indicate that the use of Lean and groupware requires a change in project setup, moreover, challenge in low utilization if not appropriately managed. This challenge identified in the LSB-project and in the interaction between the workers, where a lack of basic methodology understanding and overlapping software utilization making a critical impact on the project's utilization of the digital and methods applied.

This chapter will discuss the case results around three principal subjects. First, as reviewed in chapter 2, constructing a complex construction is making people interact, coordinate, and communicate. Furthermore, an effective process and methodology will benefit both the project and management. Moreover, the interviews exposed huge digital potential, in which the project can benefit. Thus, the three subjects are Cooperation and interaction, Construction Process and Methodology, and Digital potential. Also, the chapter will discuss different recommendations for the project and further research. Each of the sub-sections of this will, thus, answer to the sub-questions of the main research question accordingly:

RQ1: How does the project facilitate excellent communication and interaction as a basis for achieving the potential?
RQ2: How is the project suited to meet the requirements in realizing the requirements of a construction process and Lean methodology?
RQ3: How does the project realize its digital potential through the use of BIM and different groupware?
RQ4: What are the challenges and conditions needed to be addressed in the project and future work?

5.1 Cooperation and interaction

Introducing cooperation in the CI implies some introduction of legal papers and contracts. How these contracts influence interaction in the project vary with every contract. Some managers tend to what is known as "contract managing" – making the contract dictate the management. Also, prior interaction between actors is quintessential for cooperation for a new project [Buvik and Rolfsen, 2015]. However, for a project to work, communication and knowledge sharing is vital in project cooperation.

5.1.1 Contracts and legal issues

Managing a large scale construction project, or a large scale project in general, will introduce some contracts. With a good foundation based on reliable contracts, the project is arguable on the right track, on the legal side, that is, although there is still one barrier in the Norwegian CI. That is the period between the programming and the design phase in the project lifecycle, described in section 2.1.2. This period of waiting from programming is done, to the design phase can begin, makes for a substantial change in the project's actors. Thus, much of the potential knowledge is lost.

The LSB-project makes use of a customized contract, named *Totalentreprise med forutgående samspill*. The implications of a new contract have shown to be a more complicated issue than the intention. The difference is the level the contract dictates the management and interactions. Prior interaction contracts are proven to improve cooperative behavior in a project [Wang et al., 2017]. Thus, the legal barriers can not be of blame in the LSB-project. The intention of the contract was for the contract to support the interaction and prevent errors in the design. Also, considering the project consist of about 30 different contracting firms. The result is a problem in harmonization between the actors, thus leads to difficulty utilization of lean [Miller et al., 2002]. In the interviews, on the other hand, the contractors explain they feel harmony in the design phase. Also, the harmonic sense is for the new contracting to blame. Usually, these issues do not come in the design phase. Therefore, the results of this can not say if the contract applied will aid the LSB-project. The indications from the contractors part in the design phase are, hence, promising.

The project has clear role expectations, as Rolfsen promotes[Buvik and Rolfsen, 2015]. The results show that even though the project has clear role expectations, it seems like the managers and PLs have problems in decision making. One might think that the contractors are up to secure their contracts and increase their revenue. However, based on prior research, one might argue that a more plausible explanation has to do with risk allocation [Zaghloul and Hartman, 2003]. Still, the problem is not the discussion, but failing to make a decision. This issue might be the case when applying LOD in the project. People are not familiar with this methodology, thus, not recognizing the use.

The implications of the insecurity can lead to delays and reduced utilization of human resources, which again leads to low LP. Then again, taking the wrong decision and spending time fixing it will cause much greater damage.

5.1.2 Communication

Cooperation and interaction heavily rely on sufficient communication, both direct and indirect communication. In both cases, the project is using digital tools, supporting communication. In the case of direct communication, face-to-face communication is to prefer. Email is the most used tool. So much, that it could be frustrating. Hence, the comment in figure 4.1. Some teams have decided to use Microsoft Teams supporting direct messaging in chat. The problem of using separate digital tools, in each team, is the forming of silos. Where every discipline work well together, but the discussion with others has to happen in different settings and using other tools. This use is arguing for a common platform for discussion.

Both Teams and Blink offers such a platform. The reports about Blink, as one can see in table 4.1, implicates the functionality of the software is not understood. Moreover, several teams have chosen to use Teams. The challenge in using Teams is that the functionally in the direct messaging is supported in Blink, while the functionality of task management is supported in both Cogito and BIM 360. Moreover, both BIM 360 and BIMcollab offers much of the same functionality in BIM cooperation. The teams chose to supplement with the tools they need, more than making the best of the tools procured by the project. The challenge is for the project manager to procure software that is the best for the project, covering what they believe is the best for the project. Hence, the rules of procurement. The arguments for applying Teams are, as we can see in the software map 4.1, mostly prior knowledge and use. Also, the manager did not intend to use and do not see the need for Blink to be a direct communication platform, even though the manager knows of the functionality.

Figure 5.1: Illustration of Cogito use before and after lockdown, shown as CPU use on the server.

The time of procurement is proven to be essential in use. Both in the case of Blink and BIM 360, the design phase had been going on for quite some time. So, in the time where Teams and BIMcollab were taken in to use, there were no other tools to use, sustained by the manager.

Email is a commonly used groupware, also in the LSB-project. In a project with a large number of actors, as in the LSB-project, email can tend to be overused, and therefore, ineffective. The difference in email appreciation is, of course, present, as seen in the software map 4.1. Hence, the different citations from participants in different roles of the project, where an Associate will appreciate using email much more than a Discipline Leader and a BIM Manager. Consequently, the project has chosen to procure other services supporting communication and, thus, also project management.

The challenge in procuring new tools is having the user take them into use; hence, Blink and BIM 360. The "critical mass"-problem [Markus, 1987] is seen in the project, for example, in the use of Blink. On the other hand, when looking at Cogito, where almost everyone is present, the tool is not overly used; thus, one can not perceive the critical-mass problem. Also, how the project is using Cogito is mostly based on face-to-face interaction, supported by the tool. This phenomenon is present in figure 5.1, showing a drop in use before and after the Covid-19 pandemic. This reduction in use was no surprise when presented to a representative from Statsbygg; thus, the use of Cogito is mostly not a part of the daily routine, rather, a part of a group exercise. This fact supported in two distinct comments about the case. First, the Associate about not checking Cogito, before everything else on the agenda, is done. Second, the Engineering Manager's quote about the use of Cogito in meetings.

The barrier utilizing Cogito aligns with Grudin [Grudin, 1989], where the tool changes the way of working. Moreover, the tool does not give equal benefits to users. Also, when not being used too often, the effect is multiplied. Moreover, SharePoint, Teams, BIM 360, and BIM collab all share the same feature of task management. Additionally, a BIM Coordinator argues for SharePoint to replace Cogito.

Another reason for the lack of Cogito use is the issues mentioned by the participant. Most of the feedback was regarding the lack of overview. Contractors used to Gantt-diagram, and not Lean Construction, has a problem with not having the general overview. Hence, the tool needs to meet the requirement of the group [Subramanyam et al., 2010]. Moreover, one can argue for different visibility in project progress, using burn-down-chart, often used in SCRUM [Sutherland, 2014]. Another issue reported is the lack of communication offered by the tool. The notification functionality does not work; thus, the tool does not communicate sufficiently with the users.

Also, Interaxo received a large amount of negative feedback. The problem reported is useability issues and the difficulty in cooperating using the tool, as seen in 4.1. The manager procured Interaxo, based on legal reasons. Constructing in Norway has to follow a certain level of documentation, using a tool qualified for use. The set of qualified tools is, unfortunately, small. Interaxo was best in class in the process of procurement. Moreover, the handling of documents often introduces interaction, and often, a team has to work together on a document; Making for an introduction of SharePoint or similar solutions.

5.2 Construction Process and Methodology

The vision and strategies are an essential aspect of the management of the organization. The results contradict the claims of Buvik and Rolfsen [Buvik and Rolfsen, 2015] that the development of a common philosophy: namely the vision, will aid the trust among team members. Arguably the "one project"-statement is helpful. What the participants have noted is the contract. Also worth noticing is that the project is still in the design phase, where the cooperation is quite harmonic in most projects. The challenge in the LSB-project is that the top-down approach heavily influences the management. Thus, giving workers with little perception of the common philosophy. Furthermore, early and clear role expectations and early development of trust are problematic in a project where there is a high degree of turnover. The turnover is exemplified in the interviews, where one of the participants was the fourth to fill the role since the start in early 2018.

The top-down approach makes for a problematic implementation of a common philosophy, but also the implementation of lean. One of the principles of the agile manifesto [Beck et al., 2001] states:

> *Build projects around motivated individuals. Give them the environment and support they need, and trust them to get the job done.*

One can argue that this statement is contrary to the approach used in the project. The managers have set a set of processes and ways of work, making the project utilize Lean on their command. On the other hand, as we have seen in the results, most of the project workers do not know lean, thus, expect them to work in an agile matter without the support from the governing organization is absurd. Moreover, *giving them the environment and support* is precisely what the manager has done when: (a) Implementing the sort of contracts eliminating potential conflicts and, thus, waste; (b) Utilizing Cogito making for early discovery of faults and avoid miss production; (c) Implementing LOD in the entirety of the project, also planning a "flow" process in the construction, using trains and wagons; (d) Making use of LOD offers a "just in time" production and unnecessary decisions to be made; (e) Working alongside the customer throughout the whole construction lifecycle, and with the implementation of Automatic Completion making sure a perfect result is achieved.

All the actions (a-e) giving the right environment and support is ultimately a complete implementation of Aziz's five principles of Lean Methodology [Aziz and Hafez, 2013]: (1) value, (2) value stream, (3) flow, (4) pull, and (5) perfection.

This implementation leads to a tendency that the workers are working in the same way as done before. One can argue that the reason for the way of working is lack of practice, hence the lack of fundamental methodological knowledge. The project does not work as previously; hence, the aforementioned actions. This observation contradicts the claims from Ingvaldsen and Rolsen that the introduction of Lean can hamper the Norwegian working model [Ingvaldsen et al., 2012]. On the other hand, Ingvaldsen's argument is more valid in the construction process, where trains and wagons promote repetitive work.

The top-down approach reinforces the challenge of people not knowing the basics in Lean Construction. Most of the actions applied are also beneficial in a project not utilizing Lean; thus, the actors not recognizing the actions made to be Lean. This preception makes the actors seek old managing tools. The use of Gantt-chart is a prime example of this issue. The managers need an overview, more than the process control, supported by Cogito. There is no defined way of looking at the progress in Lean design. Thus, the need for using Gantt is obvious. Also, using Gantt in the planning of the construction process is required due to legal constraints.

The project uses PPC to identify project progress. The PPC will only give progress as opposed to a predefined baseline, given by the initial planning. Thus, as long as the Gantt chart works as a baseline, it will serve as useful. On the other hand, Sutherland argues that Gantt-chart is always wrong [Sutherland, 2014]; thus, using something that is known to be wrong as a baseline is futile.

The project is using LOD in the entirety of the project, not only MMI in the BIM modeling. This approach is quite unconventional, not known for the workers. Let alone tricky for the workers not known to any LOD process beforehand. The underneath quote is an example of this issue.

"We do everything differently in this project. It is hard to plan for these levels of MMI"
- Ass. Project Group Leader

LOD being essential in the pull and the flow of the Lean implementation makes for an important part for the workers to understand. Even though the workers do understand MMI and LOD, it does not seem like they understand how this correlates with Lean. This quote, underneath, being not entirely correct is an indication of the lack of knowledge of the total image.

"That is our way of answering to the Lean Principles in the project, I think"
- Ass. Project Group Leader, about using MMI

Besides, LOD is not the only part difficult for workers to understand. As mentioned in the results, some do not know of Lean Design or believe Lean is something put into action come constructing. The project does have a problem with speaking out the actions taken regarding Lean, as seen below. This quote indicates workers not seeing the actions (a through e listed above) taken in the design phase.

"...everything else. There is much more than just trains and wagons, which I have seen all but nothing of."
- Associate, about Lean in the project

The project, following the principals of Lean, is not bound to a way of writing task descriptions. As seen in the case, some inputs are more free text; this makes for a set of different ways of writing package descriptions. A challenge is the variety of tasks. Take, for example, the actions: some actions are a one-man-job, while others are clarifications between actors. Also, one has to consider the LOD in what to expect.

There is no literature covering the writing of tasks, task naming, and task description in Lean Construction. The project uses natural language when writing task descriptions with no form of template or rules often makes for ambiguous tasks; the interpretation of the task can prove to be different. Moreover, problems reported corresponds with the requirements quality metrics, defined in table 5.1. Hence, a project utilizing Lean has to define a way of writing proper task descriptions. Being Lean implies minimizing waste. Writing proper requirements is, thus, an aspect of waste not covered by the project structure.

Looking at other industries implementing agile, such as Software development, Requirement Engineering (RE), is a complicated but essential process in design. Having a well-established RE-process makes for even better requirements [Pandey et al., 2010].

Type	Description
Ambiguity	The requirement contains terms or statements that can be interpreted in different ways.
Inconsistency	The requirement item is not compatible with other requirement.
Forward referencing	Requirement items make use of a domain feature that is not yet defined.
Opacity	A requirement item where rationale or dependencies are hidden.
Noise	A requirement that yields no information on problem world features.
Completeness	The needs of a prescribed system are fully covered by requirement items without any undesirable outcome.

Table 5.1: Verifiable requirements quality metrics [INCOSE, 2015]

Moreover, writing high-quality requirements will ensure unambiguity and verifiable requirements [Carson, 2015]. The International Council on Systems Engineering (INCOSE) proposes a set of standards for developing and evaluating sound requirements [INCOSE, 2015]. A subset of these are represented in table 5.1. Guided natural language [Rolland and Proix, 1992] and boilerplates [Daramola et al., 2012] are different approaches achieving sound requirements.

The challenge in agile an agile process is the rapid change in requirements, thus, leading to another way of defining task descriptions—namely, the user stories used in Scrum [Sutherland, 2014]. User Stories will not directly work in a CI-project, but the idea of making a custom method for task descriptions is good. Also, a user story is often broken into the lesser task for the developers to deliver, because a User Story could include much work influencing the lode of workers [Liskin et al., 2014]; Much like Milestones, Key-point, and deliveries, which are all broken down.

5.3 Digital potential

One of the most important pillars of the LSB-project is digitalization. Thus, the project has high expectations for digital utilization. The major digital initiative the project has done is the use of 3D modeling and the use of BIM. Several interviewees mention BIM as an essential aspect of interaction.

"Using BIM gives an exceptionally effect. This is the future of the construction business. ...It becomes very conceptual. Therefore, easier to understand a problem."
– Discipline Leader, about BIM

The literature supports this statement. The introduction of BIM can not only aid problem solving, but, also, improve cooperation and interaction through conversations. Often, in a project, every discipline design there models within the team, with little communication with others, if not needed. Using a distributed cloud system in BIM, which supports conversation and comments, will introduce a social level in the modeling [Das et al., 2014], which will reduce the silo structure. Moreover, manipulating the model through a web interface can eventually introduce a 100% web-based system for BIM modeling, which promises a gain of productivity [Chuang et al., 2011]. These predictions were the future of BIM in 2011 and 2014. The future is here, and the tools are no longer a prototype in a research paper. A tool is BIM 360 Design, featuring both manipulation and discussion through a web interface, moreover, BIMcollab supporting interaction through discussion and issue tracking in the BIM model. Multiple tools are supporting these features, but these are the ones procured and used by the project.

The design of the LSB-project started with PG, using a local server storing the BIM-files, designing the project. When the project started growing, the problem of using this local server occur. Issues with downtime and access caused the project to move, from a stationary server to a Cloud-based service run by Azure. Every designer either does the modeling in Revit or Civil 3D, as seen in table 4.1. Once every week a responsible, in every discipline, does export of the work done. The export, from every discipline, is then put together to enrich the common model in Azure. Using the cloud-based system has been a powerful enhancement to the productivity of the project, and is noticed by the project staff.

Some of the disciplines, including the architects, have set up automatic exportation of the files. They are committing the exportation using a private computer. At times the responsible forget this, closes the computer, forcing the automatic export to quit. The disciplines who have not set up an automatic export does this manually. This takes time - up to two hours every time. Also the responsible can forget about it. The exportation used to take place once every two weeks, but when the interviews took place, the every week iteration had started. Also, there were talks of twice a week. If the exportation should take place twice a week, a person responsible has to sit and wait through the exportation for up to four hours a week(!).

The project has a lot to gain using automatic export throughout the project, in every discipline. Hence, the move to a cloud-based system and how this impacts the working environment. Several responsible have expressed a need for a computer, handling the automatic export stationary in the project office.

There is much potential in digitalization and automation of the BIM- and modeling-loop. The project wastes considerable time exporting and uploading files to different platforms, depending on the recipient. Moreover, several interviewees report of having a central computer for automatic export would be beneficial, which will be time-reducing for the one responsible for the export. Though, no one in the project talks about a 100% cloud-based system, where one can extract export from the sum.

The system described, by Chuang [Chuang et al., 2011], with a Software-as-a-Service (SaaS) cloud-architecture, hence the future of 2014. This way gives the user access to both manipulate and visualize the model from where ever. Moreover, the solution promotes communication and decrease silo-structure. A challenge Chuang discuss is the need for an excellent user interface (UI) and usability. BIM 360, already procured by the project, could eventually do this. For the project, BIM 360 suits as a web portal for others to see the modal, more than an actual design tool, furthermore tools previously used are still in use. Thus, the need for a design tool is not essential when they can use Revit and ArchiCad. Also, the contractors can decide which tool they want to use, thus, changing to a new tool is problematic. One argument is the usability of the new tool, but also, the contractors do pay for using their tools, thus changing to another will be costly. Moreover, learning to use a new modeling tool will be challenging; hence, the need for a quality UI. A different challenge in applying the Cloud-BIM system is all the plugins and supporting software used to create the model. These tools are still not cloud-based.

The potential of BIM is as described at the beginning of this section - A system utilizing a SaaS architecture giving the modelers direct access to the entirety of the model through a web interface. This implementation is, as we have seen, challenging. Not in technical, the software is there, but to take it in use. As discussed, the users tend to stick to their preferred design tool. Chuang, in his research, promotes an excellent user interface. A user interface can be as perfect, following all the rules of usability, but the user does not understand how to use it. Using prior knowledge of modeling will effectively prevent the user from understanding the potential of a new tool [Orlikowski, 1992]. Also, modeling is for the modeler a private thing, something conducted on their private computer; if not finished, the model is not to share. Introducing web modeling will have the benefit of using a bottom-up approach ("learning by doing") introducing a new way of modeling [Aziz and Hafez, 2013], which will eventually also change the process—going from an iteration of modeling resulting in the shared model every week, with a tight schedule making the deadline of exportation, to continuous modeling always shared by the project.

The project has made use of several BIM-products with the potential for better collaboration and productivity. However, the utilization of the tools applied is low; thus, not fulfilling the achieved potential. Furthermore, the tools are also meeting the same problem of overlap in functionality, causing a challenge in use between the actors.

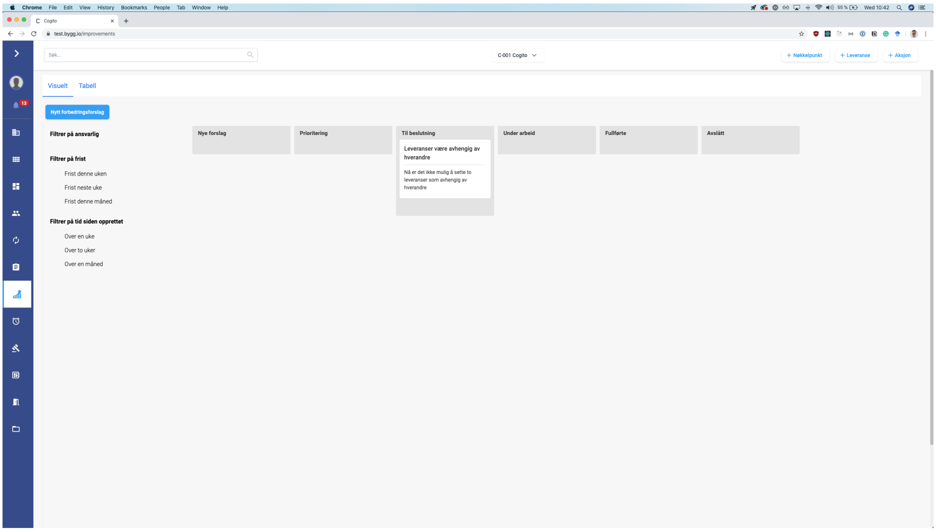

Figure 5.2: The feedback module in the Cogito tool. Serving as an continuous improvement of the tool for the project.

Another vital initiative is the use of Cogito. Taking the risk of totally new software could cause some issues underway. Sure, not everything has been a bed of roses. The project has cooperated with the supplier, improving the software according to the feedback from the user. There is even a page within the software where the users can give feedback directly to the developers and see the progress of their issue, seen in figure 5.2. Despite the possibility of feedback, several of the participants reported issues with the software. A repeating factor was the lack of communication within the software.

Introducing Cogito had the goal of reducing email, giving packages through the tool, rather than via email. PLs are writing packages into Cogito, but the notification is more often than not given orally, in meetings or over the desk, or via email. This Causing twice the work, rather than writing it directly into Cogito. As one can see in the two quotes below, an argument for communicating the package is for the inadequate notification in Cogito. Also, describing a package is better when communicated in a conversation. One can set up push notifications to email, but then again, the goal of reducing emails is lost.

Introducing Cogito is, as we know, based on an introduction of a methodology, meaning the working method is to change. Moreover, an interviewee said it quite so clear when describing what he did coming in for a new day. The plan for the day is set based on the day before, as well as what comes to mind, then checking Cogito. Thus, the way of working is not changed due to the introduction of Cogito and Lean Design.

Cogito suffers from being implemented in a top-down matter, which is to be more efficient in introducing new groupware [Robey and Sahay, 1996]. Moreover, usability does not follow the ten principles for user interface design [Nielsen, 1995]. Especially the first heuristic of visibility of system status, seen in table 2.1: *Visibility of system status*, hence the problem of notification. Also, the participants complain of visibility, seeing the correlation between coherent actions, deliveries, key-points, and milestones, corresponds to the rule six of the heuristics table: *Recognition rather than recall*. That said, other software used in the project does not meet all the promoted heuristics. Interaxo, as mentioned, is one of them. In general, the software used in the construction business will fail to meet all ten heuristics. Especially, the lack of *aesthetic and minimalist design* is a ubiquitous problem. This heuristic, on the other hand, is one of the stronger sides of Cogito.

The project does not lack inspiration, in regards to digital possibilities. The digitalization team is planning the use of robots in construction. Moreover, they have a VR-room for user testing of rooms. One might say they have approved to many measures, hence section 4.2.1. Furthermore, new software needs to be in place, securing the logistics and deliveries, when the construction progress.

5.4 Recommendations

The results indicate a problem in having too many tools, with considerable overlap in functionality, making a wide variety of tools to choose for the workers. Moreover, the way of use differs in different groups. The legal barrier protecting projects from dictating, which tools to be used is needing further evaluation.

Further research is needed to establish in Cloud-BIM. What makes the users stick to the tools they use, and what requirements do a Cloud solution have to meet, for the users to move. Moreover, is there a way for different actors to connect their preferred modeling tool to the cloud, with direct exportation. This way, modeling can also happen without an internet connection.

Moreover, removing the exportation from the equation, connecting directly with the modeling server, will immediately free up valuable time. This implementation will eventually change the way the modelers are working, going away from the two-week deadline, where a model has to be delivered before exportation. Also, the actors have to get used to seeing models not finished. The research recommends a planned implementation for one team at the time, with the help of users [Bratteteig and Wagner, 2016]. Also, user participation is recommended in such a change [Hatling and Sørensen, 1998; Ehn, 1993].

The research identified a lack of onboarding of the project workers. This leads to a lack of knowledge in basic Lean and project LOD, which makes for a challenge in cooperation. The result suggests that lack in onboarding is mostly present in the actors coming later into the project, but the challenge in understanding the basics is a more general problem. The researcher understands the challenge of giving sufficient onboarding to every project participant joining the project, because this happens often. Thus, the research recommends onboarding every quarter to ensure better instruction for all new project workers. The researcher emphasizes the importance of onboarding come construction, where every discipline is to work together in perfect flow.

The project has implemented Lean Construction and Lean Design following Lean Principles. Hence, the need for a better onboarding and education in fundamental Lean Principles and LOD is present. This introduction will give the actors the basic to understanding needed to utilize the procured tools with a much higher value. Further research is needed to establish a methodology writing task descriptions in Lean Design, furthermore investigate the need for the same framework in Lean Construction. The research recommends using RE as a base for what is considered proper textual descriptions.

Chapter 6

Conclusion

The previous chapter analyzed and discussed the results of the research conducted in this thesis, as well as discuss prior research and experience identified in the literature study. This chapter aims to conceptualize the knowledge and results in a conclusion, answering the main research question asked in section 6.1 and 6.2. Furthermore, giving a direction for further explorations in section 6.3.

The main research question of this research was:

> *What are the primary conditions for Norwegian construction projects, utilizing Lean and BIM, to achieve the potential of both the applied methodology and digital tools?*

Which was broken into four sub-questions:

RQ1: How does the project facilitate excellent communication and interaction as a basis for achieving the potential?
RQ2: How is the project suited to meet the requirements in realizing the requirements of a construction process and Lean methodology?
RQ3: How does the project realize its digital potential through the use of BIM and different groupware?
RQ4: What are the challenges and conditions needed to be addressed in the project and

future work?

Section 5.1, 5.2, 5.3, and 5.4, in chapter 5 outlines the answer of RQ1 through RQ4 accordingly.

6.1 A Change in Paradigm

The CI has become more and more digitalized. BIM has had a positive influence, both in cooperation and interaction [Boland et al., 0002; Gu and London, 2010], but also visibility for the project workers [Arayici et al., 2010], as seen in 5.3. Following this digitalization, a large set of new positions occurs; thus, the interaction and coordination get more complicated, which gives a more complex construction [Arayici et al., 2010; Eadie et al., 2013; Arayici et al., 2011].

There is no single answer to this sub-question, but the literature study identified an industry utilizing processes far behind its counterparts with an ever-increasing complexity hard to grasp with traditional processes. Hence, new processes, contracts, and communication mechanisms are needed to fit the requirements of new tools applied. Proper communication and cooperation are vital for every project to be more productive. Moreover, notable is the legal contracts need to mirror new work methodologies and increasing interactions in the digital sphere.

Making every new project better, and more productive, will eventually have a positive impact on the overall LP of the IC. Moreover, implement one great project will not change the overall LP in the CI, but can indeed be a good influence on other projects. Thus, the baseline for a new project needs to meet the new requirements of highly digital and agile projects.

6.2 Problems Following a Change

Based on a case study researching a project, the Life Science Building project, utilizing lean and digital tools. This research has utilized a qualitative analysis of the case study, the research has identified two themes explained in section 4.2.1 and 4.2.2. Moreover, the discussing issues with the knowledge from the literature review presented in the Discussion chapter. These are problems causing challenges and, thus, impede the potential, discovered in the research:

Overlapping software functionality and software usage: The ever-increasing complexity has led to a significant number of new software supporting the construction process. Thus, in a current construction project, every worker has to deal with numerous different tools, aiding the daily work. The problem is the overlapping functionality making for different use and challenge in cooperation between different disciplines. Moreover, the utilization of the tools applied, such as in BIM, makes for lack in potential effect.

Lack of fundamental methodological knowledge: The project has implemented a set of new methods and processes. The new implementations require a basic understanding of Lean Construction; thus, training is mandatory for the team to utilize the methodology and supplied tools fully. When following this change, this different system of working is hard to grasp for the older players of the game; this can lead to poor utilization. Besides, the new methodology does not cover how to do all aspects of the process, e.g., writing task descriptions.

Disregarded the challenges above, the LSB-project has done a great job utilizing both new contracts, a new methodology, and new software, which should help in managing a complex construction project. All literature indicates that the LSB-project becomes an influential project for the rest of the industry admire.

6.3 Further Work

Based on the results of the case study and review of the literature, this research has two main recommendations in further research.

First, further research in evolving a way of writing better task descriptions in a Lean Design process is prohibited. Moreover, investigate the need and difference in the construction phase, in Lean Construction. It will be beneficial using experience from both User stories from Scrum and how to write sound requirements from RE.

Second, the results indicate a considerable benefit in utilizing cloud technology in BIM. The personalized tools, however, addresses a different approach, namely cutting the exportation barrier, connecting the already familiar tools directly to a shared cloud database. Thus, utilizing both the interaction benefit of cloud BIM, with the powerful tools used by the modelers. This enhancement implicates further development of the technology as well as research into the actual effect.

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Appendix A

Interview Guide

Intervjuguide Navn og rolle:
Dato:

Avklaringer og informasjon:

- Avklare anonymitet/åpenhet
- Informere intervjuobjektet at det vil bli tilsendt transkribert versjon i etterkant av intervjuet.
- Informere om bruk av lydopptak
- Kandidat for mulighet til å presentere seg selv og sin erfaring.

Mitt prosjekt
Prosjektets påstand er at byggebransjen i dag opplever mange av de samme symptomene som programvareutvikling opplevde for 30 år tilbake og stadig opplever. Utfordringene opplevd er: Stadig endring av requirements under produksjon, slite med å nå tidsplan og budsjett, økende kompleksitet – hvert prosjekt er noe helt nytt, og sist med ikke minst problemer med ferdigstillelse. Programvareutvikling har derfor tatt i bruk agil

prosjektstyring og digitale verktøy for å løse flere av disse problemene.

Sett i lys av dette ønsker prosjektet (jeg) å se hvordan et byggeprosjekt med høy kompleksitet utnytter smidige metodikker (inkluder Lean), støttet av digitale verktøy i sin prosjekthverdag.

Temaer som ønskes belyst

1. Generelt om delegering, samarbeid og kunnskapsutveksling
   (a) Hvordan fungerer delegering, samarbeid og kunnskapsutveksling?
2. Bruk av digitale prosjekteringsverktøy i prosjektet
   (a) Hvordan og hvilke digitale digitale prosjekteringsverktøy benyttes i prosjektet, i dette henseende?
   (b) Finnes det noen begrensninger ved denne bruken?
3. Andre faktorer
   (a) Er det andre faktorer som påvirker bruken av verktøyene i prosjekthverdagen?

Appendix B

Contract of Interview

Vil du delta i forskningsprosjektet

"Digitalization of the Construction Industry: A Case Study of a Lean Construction Project"?

Dette er et spørsmål til deg om å delta i et forskningsprosjekt hvor formålet er å identifisere bruk og forståelse av agile metoder, samt digitale prosjekteringsverktøy i livsvitenskapsbygget prosjektet. I dette skrivet gir vi deg informasjon om målene for prosjektet og hva deltakelse vil innebære for deg.

Formål
På bakgrunn av arbeidsproduktivitetsproblemer i byggebransjen har mange aktører sett til programvareutvikling og hvordan disse jobber for å forbedre samarbeid og kommunikasjon. Vi har en hypotese om at det er endel likhetstrekk med det byggebransjen opplever i dag, og det programvareutviklingsbransjen opplevde for 30 år tilbake. Sett i lys av dette ønsker prosjektet å se hvordan et byggeprosjekt med høy kompleksitet utnytter prosjekteringsprogramvare, samt smidige metodikker i sin prosjekthverdag.

Hvem er ansvarlig for forskningsprosjektet?
Norges tekniske- og naturvitenskapelige universitet (NTNU) er ansvarlig for prosjektet.

Hvorfor får du spørsmål om å delta?
Du har en framtredende rolle som vil være relevant for denne studien.

Patrick Stormo Hjerpseth har opplyst om at du er en aktuell kandidat til dette prosjektet.

Hva innebærer det for deg å delta?
Hvis du velger å delta i prosjektet, innebærer det at du blir med på et personlig intervju. Intervjuet ta deg ca. 30 minutter. Intervjue inneholder spørsmål om bruken av agile metoder og digitale prosjekteringsverktøy i prosjektet. Dine svar blir registrert på lyd.

Det er frivillig å delta
Det er frivillig å delta i prosjektet. Hvis du velger å delta, kan du når som helst trekke samtykke tilbake uten å oppgi noen grunn. Alle opplysninger om deg vil da bli anonymisert. Det vil ikke ha noen negative konsekvenser for deg hvis du ikke vil delta eller senere velger å trekke deg.

Ditt personvern – hvordan vi oppbevarer og bruker dine opplysninger
Vi vil bare bruke opplysningene om deg til formålene vi har fortalt om i dette skrivet. Vi behandler opplysningene konfidensielt og i samsvar med personvernregelverket.

- *Student og veileder vil ha tilgang til dine personopplysninger.*
- *Personopplysningene vil bli lagret på NTNU sin skytjeneste, som er GDPR godkjent. Det vil bli benyttet 2-faktor autentisering.*
- *Publisering vil skje uten personopplysninger. Det vil bli benyttet anonymiserte roller.*

Hva skjer med opplysningene dine når vi avslutter forskningsprosjektet?
Prosjektet skal etter planen avsluttes *11.06.2020. Personopplysninger (Navn, Andre opplysninger som kan identifisere deg, lydopptak) vil bli slettet ved prosjektslutt.*

Dine rettigheter
Så lenge du kan identifiseres i datamaterialet, har du rett til:
- innsyn i hvilke personopplysninger som er registrert om deg,
- å få rettet personopplysninger om deg,
- få slettet personopplysninger om deg,
- få utlevert en kopi av dine personopplysninger (dataportabilitet), og
- å sende klage til personvernombudet eller Datatilsynet om behandlingen av dine personopplysninger.

Hva gir oss rett til å behandle personopplysninger om deg?
Vi behandler opplysninger om deg basert på ditt samtykke.

På oppdrag fra *NTNU* har NSD – Norsk senter for forskningsdata AS vurdert at behandlingen av personopplysninger i dette prosjektet er i samsvar med personvernregelverket.

Hvor kan jeg finne ut mer?
Hvis du har spørsmål til studien, eller ønsker å benytte deg av dine rettigheter, ta kontakt med:
- *NTNU* ved Professor, *Eric Monteiro, eric.monteiro@ntnu.no, 95213088.*
- Vårt personvernombud: *Thomas Helgesen*
- NSD – Norsk senter for forskningsdata AS, på epost (personverntjenester@nsd.no) eller telefon: 55 58 21 17.

Med vennlig hilsen

Prosjektansvarlig (Forsker/veileder) *Eventuelt student*

Samtykkeerklæring

Jeg har mottatt og forstått informasjon om prosjektet «Bruk av programvaremetodikk og digitale prosjekteringsverktøy i byggebransjen; Casestudie av den nye livsvitenskapsbygget», og har fått anledning til å stille spørsmål. Jeg samtykker til:

☐ å delta i *Intervju*

Jeg samtykker til at mine opplysninger behandles frem til prosjektet er avsluttet, ca. *11.06.2020*

(Signert av prosjektdeltaker, dato)

Appendix C

Thematic Analysis Codes

Table C.1: Codes produced in the first phase of coding in thematic analysis.

Code	Excerpt of the Quote	Context/theme	Participant
Mangler informasjon	Man har ikke klart å trenge ned å fortelle hva det skal bety for prosjektet	Bruk av Lean i prosjektet	Engineering Manager
Tiltak til strategiene	Vi trenger nok å lande hvordan strategiene skal påvirke oss i handling	Bruk av Lean i prosjektet	Engineering Manager
Cogito/Digital delegering	også dukker det opp oppgaver i Cogito	Delegering	Engineering Manager
Kommunisert delegering	Det er i de temaene vi får oppgaver	Delegering	Engineering Manager
Deling i møter	Det skjer jo i forum hvor vi tar opp slike ting	Deling av kunnskap	Engineering Manager
Tviler på plan	Man vet ikke om det man tar tak i får man fremover	Gjennomføring basert på planlegging av designfasen	Engineering Manager
Ikke rendyrket	Ikke rendyrket hvor vi skal kommunisere	Kommunikasjon	Engineering Manager
Dårlig prosjekteringsplan	Prosjekteringsplanen er ikke tilstrekkelig grad utarbeidet i felleskap	Planlegging av designfasen	Engineering Manager
Dårlig planlegging	Man har ikke samlet seg om en planleggingsmetodikk	Planlegging og resursbruk designfasen	Engineering Manager
Dårlig ressursbruk	Det er lagt mer ressurser i å planlegge produksjon av bygg enn produksjon av prosjekteringsmateriell	Planlegging og resursbruk designfasen	Engineering Manager
Mangler planlegging	Det er jo ikke et planleggingsverktøy, det er jo et oppfølgingsverktøy	Utfordring ved Cogito	Engineering Manager
For mange verktøy	at det er såpass mange	Utfordring ved mange digitale verktøy	Engineering Manager

Table C.1 continued from previous page

Ikke rendyrket	Interaxo, som kan brukes i mye større grad enn det det gjør per nå	Utfordring ved mange digitale verktøy	Engineering Manager
Kommunikasjon i Cogito	...det er et varslingsvindu, men det fungerer ikke optimalt	varsling i Cogito	Engineering Manager
Ikke rendyrket	Potensiale... Dersom man hadde rendyrket en eller to		Engineering Manager
Mangel på opplæring	Opplæring... Er noe man bør fikse		Engineering Manager
Bruker ikke Cogito	Jeg har ikke brukt det, men kjenner til det	Bruk av Cogito	Associate
Lite erfaringsoverføring	Det er ikke så veldig mye erfaringsoverføring med de andre fagene	Erfaringer som deles	Associate
Missforstått Blink	Har ikke fått invitasjon, men har hørt om det. Dette er det sosiale nettverket?	Kommunikasjon	Associate
Mye mail - positiv	Jeg syntes det er veldig greit å bruke e-post	Kommunikasjon	Associate
Mye mail - positiv	Med e-post så er det enklere å passe på at man har fått gjort unna de.	Kommunikasjon, delegering,	Associate
Sitte sammen	Vi sitter sammen, både her og på kontoret i Sandvika	Samarbeide internt	Associate
Avklaring på mail	mye avklaringer på mail, gjerne etter man har snakket med hverandre	Samarbeide på tvers	Associate
Deling i møter	avklaringsmøte annenhver uke... Det håper jeg skal bidra til at vi får med oss det vi trenger inn i modellen, fra begge fag.	Samarbeide på tvers	Associate
Enkel avklaring	Fordelen med å sitte her er at det er kort vei til arkitekten	Samarbeide på tvers	Associate
Mange prosjekter	...jobber jeg på mange prosjekter i løpet av en uke		Associate

Table C.1 continued from previous page

Mangler dybde	Vi bruker Cogito. Hvor det med vekslende kvalitet og hvor dypt og detaljert det kan brukes.	Bruk av Cogito	ITB Manager
Ryddig lagring	Så har vi Interaxo. Der har vi fått en fin prosess..	Bruk av Interaxo	ITB Manager
Missforstått Blink	Det fikk jeg invitasjon til	Kommunikasjon	ITB Manager
Ansvarsfordelig	...utfordringer i prosjektet med hvem som skal lage og med hvilket malverk det lages med	Samarbeide på tvers	ITB Manager
Missfornøyd med andre	Så har vi en ITB-ansvarlig i prosjekteringsgruppa som sitter å leder grensesnitts.arbeidet. Han har .. Godt verktøy for ham, men ikke for prosjektet.	Samarbeide på tvers	ITB Manager
Kommunikasjon i BIM	Der smakker man og diskuterer på et fornuftig grunnlag.	Samarbeide på tvers BIM	ITB Manager
Kommunikasjon i Cogito	Men man mangler kommunikasjonselementet	Samarbeide på tvers Cogito	ITB Manager
Mye mail - negativ	Målet med dette her er jo å eliminere e-postbruk.	Samarbeide på tvers Cogito	ITB Manager
Samspill - utfordringer	noen utfordringer i prosjektet basert på at det er en ny modell. Hvor man har samspillet...	Samspill og kontrakt	ITB Manager
Samspill - utfordringer	Hvem er det som har ansvaret for hva?	Samspill og kontrakt	ITB Manager
Samspill - utfordringer	...Men det sitter igjen et tradisjonelt tankesett	Samspill og kontrakt	ITB Manager

Table C.1 continued from previous page

Samspill - utfordringer	Man klarer ikke distansere seg fra tanken om at man har lagdet den beste løsningen, framfor å se andre innspill	Samspill og kontrakt	ITB Manager
Rotete lagring	...så er det en utfordring å finne ting... Å vite hvor man skal legge tind. Jeg har ikke sett et system som løser dette helt	Bruk av Interaxo	Discipline Leader
Missforstått Lean	jeg har forstått det så er dette noe som kommer til anvendelse når det gjelder bygging	Bruk av Lean i prosjektet	Discipline Leader
Eget verktøy	..utviklet mitt eget verktøy i Excel og Visual Basic	Jobber på sin måte	Discipline Leader
For mye diskusjon	at det kan bli for mye engasjement. At man diskuterer for mye. I stede for å si; Okay. Det er ditt ansvar.	Kommunikasjon	Discipline Leader
Missforstått Blink	men det ser jeg mer på som et sosialt medium. Jeg bruker ikke det så mye.	Kommunikasjon	Discipline Leader
Dobbel kalender	Jeg syntes det er vanskelig der hvor vi har en egen prosjektkalender. Da operer jeg med to kalendere. Da blir jeg booket i møter i den ene, hvor jeg er opptatt i den andre.	Kommunikasjon kalender	Discipline Leader
Enkel avklaring	...ta det på tomannshånd	Samarbeide på tvers	Discipline Leader
Mye mail - negativ	Det å følge med på hva som skjer er en stort utfordring for meg.	Samarbeide på tvers	Discipline Leader
Store møter	...hvor vi inkaller alle sammen, de pleier ikke bli så veldig effektive	Samarbeide på tvers	Discipline Leader
Oversikt i Cogito	Jeg syntes det er litt vanskelig å få oversikt i Cogito. Det er krevende.	Samarbeide på tvers Cogito	Discipline Leader
Oversikt i Cogito	...og lurer på om det er lagt inn allerede. Det ville jeg brukt svært lang tid på å finne ut.	Samarbeide på tvers Cogito	Discipline Leader

Table C.1 continued from previous page

Møterom booking	så kan vi se når de er ledig. Det er ikke sånn helt optmal måte	Struktur	Discipline Leader
Rotete lagring	Hvor skal man dokumentere? Hvor skal man legge ting?	Bruk av Interaxo	Associate
Missforstått Lean	Jeg tenker jo egentlig Lean men jeg har ikke helt for meg hva det er,	Bruk av Lean i prosjektet	Associate
Ikke rendyrket	Jeg har vært med på ulike temaer. Det benyttes ikke samme verktøyene.	Bruk av verktøy	Associate
Delegering kommunisere	Så da pleier jeg som regel å snakke med dem	Delegering	Associate
Delegering mail	og noe mail er det også	Delegering	Associate
Ikke rendyrket	...når det ikke er entydig struktur på ting.	Lagring og håndtering av dokumenter	Associate
Ikke rendyrket	Det er ikke helt samme inndelking i mappene på interaxo	Lagring og håndtering av dokumenter	Associate
Ikke rendyrket	Det er noe med kommunikasjonen som er litt uklar	Lagring og håndtering av dokumenter	Associate
Rotete lagring	Plutselig ble det sagt i temaene at man heller skal legge det under de ulike fasene.	Lagring og håndtering av dokumenter	Associate
godt samarbeid	fungerer veldig bra! Vi snakker stort sett samme språk	Samarbeide internt	Associate
Cogito/Digital delegering	Det er masse som legges inn bare for å vise at det legges inn. Uavhengig på Cogito, som er en vanlig arbeisoppgave	Samarbeide på tvers Cogito	Associate
ikke rendyrket	det gjøres forskjellig der også. Det ene tema lagde man få leveranser, med mange aksjoner under. Mens andre temaer hadde man mange leveranser, med få aksjoner.	Samarbeide på tvers Cogito	Associate

Table C.1 continued from previous page

Ikke spikret	Det er ting som ikke er spikret enda.	TFM-merking	Associate
Oppdatering av modell	Derfra exsporterer vi ukentlig ut .ifc-filer, hvor de deretter legges på Interaxo	BIM 360	BIM Manager
For mange verktøy	man kan velge det ene eller det andre, for å lage kollisjoner.	Bruk av verktøy	BIM Manager
Dårlig eksortering	Verktøyet ligger på at den skal eksportere fra min maskin. Så vi burde ha en felles PC fra Statsbygg,	Eksportering av modell	BIM Manager
Oppdatering av modell	men den skal vi sette opp til å eksportere to ganger i uken. Det er veldig bra et eller annet sted.	Eksportering av modell	BIM Manager
Definisjon av MMI	Det er jo en ganske vag beskrivelse. Så vi laget en spesifikk definisjon.	MMI	BIM Manager
Delegering kommunisere	bestemt oss i ARK at vi ikke skal bruke Cogito internt..Da er det lettere å gi en oppgave over bordet	Samarbeide internt	BIM Manager
Gammel tanke	Den med mest erfaring hadde tre år. Dersom man vil ha noen som skal kunne slå gjennom med noe, må de ha noen med litt mer erfaring.	Samarbeide på tvers	BIM Manager
Cogito/Digital delegering	Jeg får det fra en fra disiplinområde.	Samarbeide på tvers Cogito	BIM Manager
Ikke rendyrket	Så vi fortsettere å bruke BIM 360, men ikke alt som det er programmet tilbyr.		BIM Manager
Oppdatering av modell	Ja, men det er mulig man skal gå oppp til 2 ganger i uken.	BIM	BIM Coordinator
Oppdatering av modell	Ideelt sett burde man hatt en felles stasjonær PC	BIM	BIM Coordinator

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Oppdatering av modell	Så sitter jeg kanskje og jobber etter lunsj på torsdag, og dette kommer da ikke med neste uke.	BIM	BIM Coordinator
Lappeteknikk	Da står vi å planlegger litt med lapper.	Bruk av Lean i prosjektet	BIM Coordinator
Netthastighet og nedetid	andre faktorer som kan påvirke hverdagen vår er netthastighet og nedetid.	Infrastruktur og fasiliteter	BIM Coordinator
Rendyrke et verktøy	Hadde man brukt SharePoint til alt i prosjektet... I stede for å bruke Cogito	Mange verktøy	BIM Coordinator
Erfaringsoverføring	Internt for oss kjører vi internmøter hver mandag. Da går man gjennom litt ting og har litt tips og triks	Samarbeide internt	BIM Coordinator
Lite kunnskapsoverføring eksternt	Det er ikke så mye... Men det er ikke så mye erfaringsoverføring fra Statsbygg.	Samarbeide på tvers	BIM Coordinator
Tverrfaglig samarbeid	Break-out-gruppe	Samarbeide på tvers	BIM Coordinator
BIM-samarbeid	Litt slik tilgang og eierskap. At folk eier ting i modeller.	Samarbeide på tvers BIM	BIM Coordinator
Cogito/Digital delegering	Det har vært litt slik at man bare legger ting inn i Cogito uten at man snakker med dem	Samarbeide på tvers Cogito	BIM Coordinator
Fast struktur og agenda på møter	Det hadde vært sykt dugg at alle må ha en agenda til møter egentlig. Ha et fast oppsett til alle møter.	Struktur møter	BIM Coordinator
Lean design	Alt det andre. Det er veldig mye mer enn takt og tog. Det har jeg kanskje sett mindre av	Lean	Associate

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Mye møter	Det er veldig mye møter her, men sånn må vel vell kanskje bli. ... Det er kanskje ikke så effektivt.	Samarbeide på tvers	Associate
BIM i møter	Jeg er endel inne i den. Det er natulig i møter, dersom man diskuterer spesifikke temaer at man kikker på etter eller annet	Samarbeide ved BIM	Associate
Beslutningsvegring	Det kan jo være et problem med hvem som faktisk tar beslutning.	Samspill og kontrakt	Associate
Samspill - fordeler	Prøver å se løsninger. Komme med forslag. Fordelene er jo at vi kan plukke ut komponenter og utstyr som skal inn.	Samspill og kontrakt	Associate
Dårlig BIM-manual	Et utkast til den har vært laget for 1,5 år siden, kanskje 2 år siden. Så kunne den vært modifisert.	BIM	Discipline Leader
Missfornøyd med Blink	Alle i prosjektet har Blink, men jeg syntes det er ganske uintressant. Men det ser jeg på som en sosial ting, da kan det være hyggelig.	Blink	Discipline Leader
Mangler oversikt	det sporingssystemet når man utfører ting og sjekker ut ting, så forsvinner det. Det er ikke så lett å se dersom man har en aksjon eller leveranse. Så er det ikke så lett å se hele nettverket.	Bruk av Cogito	Discipline Leader
Delegering bort kommunisere	I min rolle delegerer jeg masse... Det går mest muntlig og e-post	Delegering	Discipline Leader
Delegering bort mail	og epost	Delegering	Discipline Leader
Dokumentere	Interaxo er endeastasjon	Dokumentere	Discipline Leader

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Deling av kunnskap	Mitt inntrykk er ikke at folk ikke vil dele, men ....Det er ingen som giddere å forklare ting, dersom man ikke spør. Men på det personlig plan får jeg svar, dersom jeg spør	kunnskapsdeilig	Discipline Leader
BIM-utfordring	så er det varierende grad av kompetanse.	Kunnskapsmangel BIM	Discipline Leader
Motta oppgaver	Mail, Cogito, Muntlig	Samarbeide	Discipline Leader
BIM-samarbeid	Det som har en brutal effekt. Det er å bruke BIM. Det er jo det som er fremtiden i byggebransjen. ....Det blir veldig konseptuelt. Enklere å forstå en problemstilling.	Samarbeide på tvers BIM	Discipline Leader
BIM-samarbeid	jobbe med å få digitale og veldig visuelle verktøy det er det man kan samles rundt	Samarbeide på tvers BIM	Discipline Leader
Ikke rendyrket	Spørsmål om det er en enhetlig bruk av programvaren, eller om alle bruker programvaren	Verktøy	Discipline Leader
Cogito/Digital delegering	Men om jeg er så mye inne for å følge, det kunne man vært bedre til. Det er tiltak å logge seg på for å følge med på ting.	Delegering	Associate
Cogito/Digital delegering	Når jeg er ferdig med det jeg skal kan jeg sjekke om det er noe i cogito jeg burde ha gjort. Selv om det burde vært andre veien rundt	Delegering	Associate
Mye mail - negativ	Dessverre så foregår mye av kommunikasjon over mail. Det er tungvinn prosess, syntes jeg.	Kommunikasjon	Associate

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Bruk av sky	Da hadde de en lokal server, hvor de hadde sentralfilene sinde. Det var mye missnøye blant de ulike fag-gruppene som synkroniserte, fordi det tok mye tid. Det er veldig sårbart. Dersom den var nede satt det 100 stykker som ikke kunne synkronisere. VPN	Samarbeide på tvers BIM	Associate
Gammel tanke	...slik det er gjort før....Man putter alt inn i 3D, men man putter det inn som egne objekt-definisjoner. Så fyller de ikke på med rikitg informajson, i forhold til objektene	BIM	Project Manager
Ikke rendyrket	Der er potensialet mye større enn det som ser ut til at vi ender opp med her da. Da tenker jeg på BIM-modellen. Jeg mener at det kan brukes mye, mye mer.	BIM	Project Manager
Mer bruk av BIM	Dent eneste jeg skulle ønsker var at alle hadde samme ambisjonsnivå	BIM	Project Manager
Uoversiktelig	Det er jo uoversiktelig (Bruk av Cogito og Interaxo)	Bruk av verktøy	Project Manager
Delegering til ledere	men når jeg gir oppgaver til PG, så gir jeg det til sjefen	Delegering	Project Manager
Snakke med hverandre	Man må snakke med folk. Det å totaltsett bruke systemene er viktig det også... Det er jo ikke personene som skal være oppslagsverk, men det er systemene.	Kommunikasjon	Project Manager
Delegering kommunisere	ovenfra via ledermøter og samspillmøter	Samarbeide på tvers	Project Manager
Delegering mail	Ellers kommer det jo på mail	Samarbeide på tvers	Project Manager

Table C.1 continued from previous page

Legg inn selv	I Cogito skal vi legge inn oppgaver selv, på bakgrunn av oppgaver vi får på møter	Samarbeide på tvers Cogito	Project Manager
Gammel tanke	Det som irriterer meg er at byggebransjen er så utrolig sirompa. Man skal gjøre det samme som man har gjort alle andre steder.		Project Manager
Bruker ikke Cogito	Vi har forløpig ikke brukt dette i framdriftsgjengen	Ikke rendyrket	Progress Planner
Vanskelig med kommunikasjon	At de riktige folka får den riktige informasjonen. .. Man at man møter face-to-face er viktig, ikke bare digitalt.	Kommunikasjon	Progress Planner
Nevner ikke Lean design		Lean	Progress Planner
Positiv til Lean Construkting	Det er jo en smart tankegang	Lean	Progress Planner
Mange verktøy	Jeg ser utfordringen med at det begynner å blu fryktelig mange plattformer	Mange verktøy	Progress Planner
Interaxo er treigt	Jeg syntes Interaxo er ganske treigt...	Missfornøyd med Interaxo	Progress Planner
Bruker teams internt	Hvor vi bruker det som nesten chat, internt i vår entreprise.	Samarbeide internt	Progress Planner
Arbeid forsvinner	Desom man er inne og skriver en tekst og skal gjøre alt klart og må gå ut	Bruk av Cogito	Engineering Manager
Cogito er under utvikling	Tidligere slet vi med at topplinja...	Bruk av Cogito	Engineering Manager
Ikke rendyrket	Det er ikke noe fast måte å gjøre det på	Bruk av Cogito	Engineering Manager
Sløve med å lage aksjoner	Det er større utfordring med å få inn aksjoner	Bruk av Cogito	Engineering Manager

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Avklare med leder først	Når man gir noen en aksjon, så må man avklare med dem på forhånd.	Cogito nye oppgaver	Engineering Manager
Cogito er transperant	Det er også en grei måte å vise til de øvrige teamdeltakerne hva som er planlagt	Kommunikasjon	Engineering Manager
Interaxo er treigt	Så er det litt for mange klikk	Missfornøyd med Interaxo	Engineering Manager
Cogito er viktig	Jeg syntes at Cogito er noe av det viktigste vi har i forhold til fremdriften, med tanke på trekk	Samarbeide på tvers Cogito	Engineering Manager
Netthastighet og nedetid	Det kan være at nettet går tregt		Engineering Manager
Dårlig varsling	Ofte dukker det bare opp et Cogito-punkt. Det er ikke så varsling	Bruk av Cogito	Discipline Leader
Bruker ikke Cogito internt	Det vi har brukt å gjøre er at på internoppgaver brukes mail og teams, men vi legger ikke disse i Cogito	Ikke rendyrket	Discipline Leader
Bruker teams internt	Så bruker vi teams, som et internt redskap	Ikke rendyrket	Discipline Leader
Kjenner ikke metodikk	Jeg er jo ikke vant med å jobbe med et slikt verktøy	Ikke vant med metode. Skylder på verktøy	Discipline Leader
Kjenner ikke metodikk	Jeg vil ikke legge inn unødvendig punkt og jeg vil heller ikke at det skal legges inn mange unødvendige punkt på meg	Ikke vant med metode. Skylder på verktøy	Discipline Leader
Vanskelig med kommunikasjon	Det betyr jo allikevel at vi har en tilstedeværelse fra Danmark som ikke fungerer helt slik den skal.	Kommunikasjon	Discipline Leader
Ikke vært på Lean-kurs	Jeg har ikke vært på Lean-kurs enda	Lean	Discipline Leader

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Felles kalender	vi lager en slags kalender i Excel. Vi må ha en når kommer dere, hvem	Samarbeide internt	Discipline Leader
Delegering kommunisere	fra et møte	Samarbeide på tvers	Discipline Leader
Felles kalender	Så har vi ikke felles kalender her på prosjektet. Det er gjort et forsøk men det funger ikke for alle	Samarbeide på tvers	Discipline Leader
Dårlige oppgaver i Cogito	Det er jo ikke alltid det er kommuniseres så godt. Vi blir heller ikke spurt hvor lang tid det tar.	Samarbeide på tvers Cogito	Discipline Leader
Vanskelig omboarding	Jeg syntes det er vanskelig å komme inn i denne rollen...	Stort prosjekt	Discipline Leader
Vet ikke hva verktøyet er	(Er det noen verktøy dere bruker for å delegere?) Nei, det kan jeg ikke si.	Delegering	Ass. Project Group Leader
Tilgangsstyring	Så er det jo med slike hoteller at du ser bare det du har tilgang til. Så det tar veldig lang tid at du oppdager et rom som du burde ha tilgang til.	Dokumentere	Ass. Project Group Leader
BIM-samarbeid	De som sitter å BIMer, kan sende hverandre beskjeder via modellen. Det fjerner mail	Kommunikasjon	Ass. Project Group Leader
Kommunikasjon i WS	vi planlegger det å ha workshops...Det er det som blir de måtene å få folk til å skjønne hva vi jobber mot	Kommunikasjon	Ass. Project Group Leader
Mister oversikt	At de skjønner hva de jbber mot. Det har vært veldgi vanskelig. Mye frustrasjon, fordi de som ikke går i møter og ikke får samme info som prosjektleder.	Kommunikasjon	Ass. Project Group Leader

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Mye mail - negativ	Jeg sliter jo med å klare å henge med på mailen.	Kommunikasjon	Ass. Project Group Leader
Har sin egen forståelse av Lean	Jeg tenker det er vår måte å svare på Lean tankegang på i prosjektet	Lean	Ass. Project Group Leader
Risiko ved Lean	Jeg har tro på den metodikken, men det er et voldsomt stort prosjekt å gjøre noe første gang. At veien blir til mens man går. At det er en risiko med det. Det vil jeg si at det er .	Lean	Ass. Project Group Leader
Nye metoder	Vi gjør alt på en ny måte. Det er ikke klart hva som er målet hele tiden. Det har vært vanskelig å planlegge disse MMI-gradene...vanskelig å få opp ting som blir lagt i Cogito.	Nye metoder	Ass. Project Group Leader
Funker ikke med samarbeid i Interaxo	men det fungerer ikke i Interaxo. Det er ikke en sånn SharePoint-løsning...Så det fungerer ikke som en samarbeidsplattform	Samarbeide internt	Ass. Project Group Leader
Cogito er lite visuelt	Jeg syntes det er vanskelig, fordi det er så lite visuelt	Samarbeide på tvers Cogito	Ass. Project Group Leader
Positiv til samspill	Tegne dem en gang	Samspill og kontrakt	Ass. Project Group Leader
Berike modellen	Da må vi være med å passe på at den berikes såpass mye at vi får den informasjonen vi trenger.	Samarbeide på tvers BIM	Engineering Manager
Forbedret kollisjonskontroll	Så vil man gjøre slike kolisjonskontroller som sjekker at dette er mulig å bygge, eller ikke. Så blir det jo justert i forhold til det.	Samarbeide på tvers BIM	Engineering Manager
Cogito er lite oversiktelig	Cogito er jo et slags oversiktsverktøy og det er jo ikke alltid like oversiktlig.	Samarbeide på tvers Cogito	Engineering Manager

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Savner Gantt	Vi som har jobbet med prosjektet en stund har jo vært vant med den gamle prosjekt-planen	Samarbeide på tvers Cogito	Engineering Manager
Mange verktøy	Det finnes mye fine digitale verktøy, men det må liksom ikke bli for mange av dem heller.	Verktøy	Engineering Manager
Standariserte verktøy	Det er klart at hvis man kunne komme på en mer omformert standard fra prosjekt til prosjkekt	Verktøy	Engineering Manager