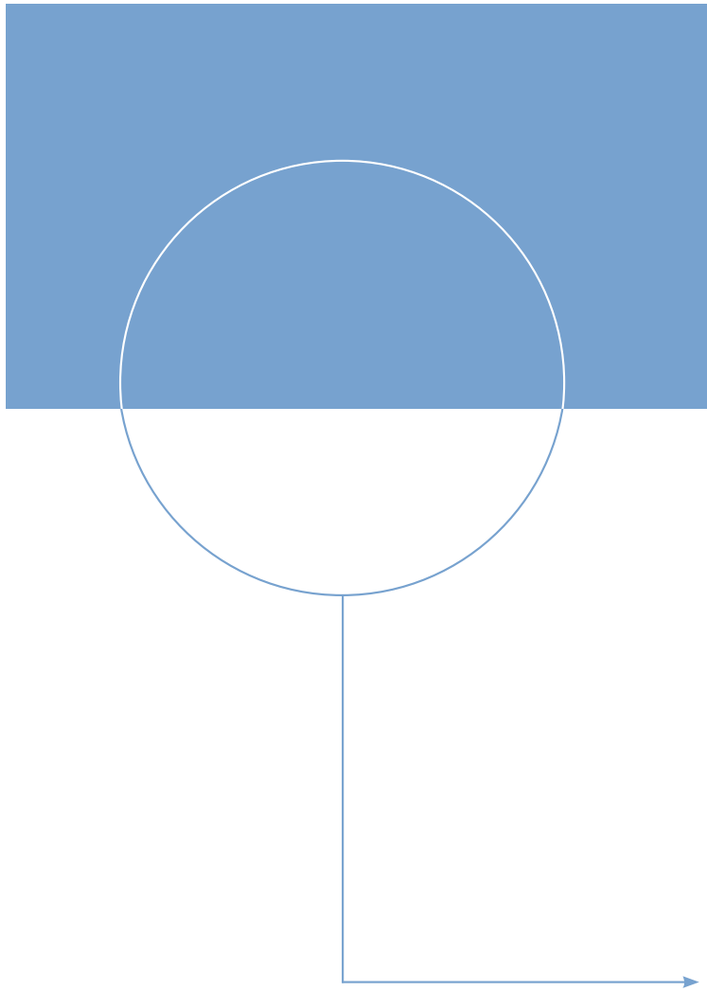

Master's thesis

2021

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Strategies to improve the handover of building adaptation projects

From project team to the operation and maintenance team

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Strategies to improve the handover of building adaptation projects

From project team to the operation and maintenance team

Patrick Penacerrada

Project Management (Production and Quality Management)
Submission date: June 2021
Supervisor: Nora Johanne Klungseth

Norwegian University of Science and Technology
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Preface

This master's thesis is written as part of the graduation requirements of Norges Teknisk-Naturvitenskapelige Universitet (NTNU). It aims to contribute to the existing literature about the handover of projects in the architecture, engineering and construction (AEC) industry as well as improve my knowledge about the subject. I worked as a Project Manager in the facility industry as well as Property Manager which is why I am interested in all the topics connected to facilities. With this, Property Managers, Operation and Maintenance Managers as well as Project Managers who implement building adaptation projects can benefit in reading this master's thesis.

In the beginning of the conceptualization phase, the target was to focus on one company and dive deep into the details of a phenomenon or a problem they are having. One thing was sure, it had to be a facility management company and the phenomenon should be about their project/s. Me and my supervisor met with a target company who we can partner with. During the meeting, they brought up that they are encountering challenges in the handover phase of one of their rehabilitation projects. This made me focus on rehabilitation projects. After a while, it was discovered that the target partner company does not have the enough resources to partner for a master's thesis. Our(me and my supervisor) strategy shifted, but the topic remained. We focused on contacting different companies that fits the criteria of this master's thesis and conducted qualitative interviews to gather a broader perspective on the topic.

There were challenges encountered. At first, looking for interview objects was difficult, but this was solved by sending a lot of invitation to participate to different facility management companies. When there were enough interview objects from the project management department, the next challenge was encountered - improving the diversity of interview objects by having more operation and maintenance(O&M) department. More efforts were put to solve this concern but only 27% of the participants came from the O&M. The third challenge was conducting the interview in norwegian, three out of the eleven participants chose to have the interview in norwegian as they are not comfortable with english. It was challenging to (1) ask follow up questions, and (2) transcribe the whole interview. The first one was solved by transcribing and understanding the whole interview afterwards and asking follow up questions through email.

Even though there were challenges, I was able to conquer them with the help of my support system. First and foremost, I would like to thank my supervisor, Nora Johanne Klungseth, for the time and guidance she gave starting from my specialization report in the autumn semester of the year 2020 until the end of this master's thesis, spring semester of the year 2021. Next is my family for being an avenue in letting out frustrations. Last but not the least, my wife, Eunice, for her patience and presence all through out the way.

Abstract

Building adaptation projects are prominent nowadays as there are a lot of changes in the end-user and government requirements. Within the lifecycle of these projects, the handover phase is one of the most important phase as assets and information are transferred from the project team to the end-users or operation and maintenance (O&M) team. There are two existing problems that is related to the handover phase of building adaptation projecs: (1) Different challenges are plaguing the handover phase of building adaptation projects, and (2) there is a lack of literature that study the mentioned phase. The purpose of this thesis is to address these problems by identifying potential strategies to solve the problems in the handover phase resulting to its improvement. Three data gathering methods were used. Literature review was conducted to improve the knowledge on the topic and to jump start the creation of a qualitative codebook. The next method was a review of public documents, mostly national standards, that gave idea about strategies which can be implemented about the gathered information from the first method. The third one is qualitative interview, wherein eleven (11) interview objects were asked about their thoughts on the handover phase of their building adaptation projects. Everyone had a direct experience with this type of projects. The interviews were transcribed and analysed using the qualitative software Nvivo. The data led to four (4) categories of challenges; namely, project output related, information and communication related, management related, and competency related; and different solutions which can be implemented starting from the design and planning phase of the project until the operation phase of the project output. Most of the solutions confirm what were concluded in previous studies of different authors while some bring forward additional set of ideas. The different levels of facility management also have their tasks and responsibilities in implementing these solutions. These findings will be useful for finding improvements not just in the handover phase of the project, but also in the whole project lifecycle.

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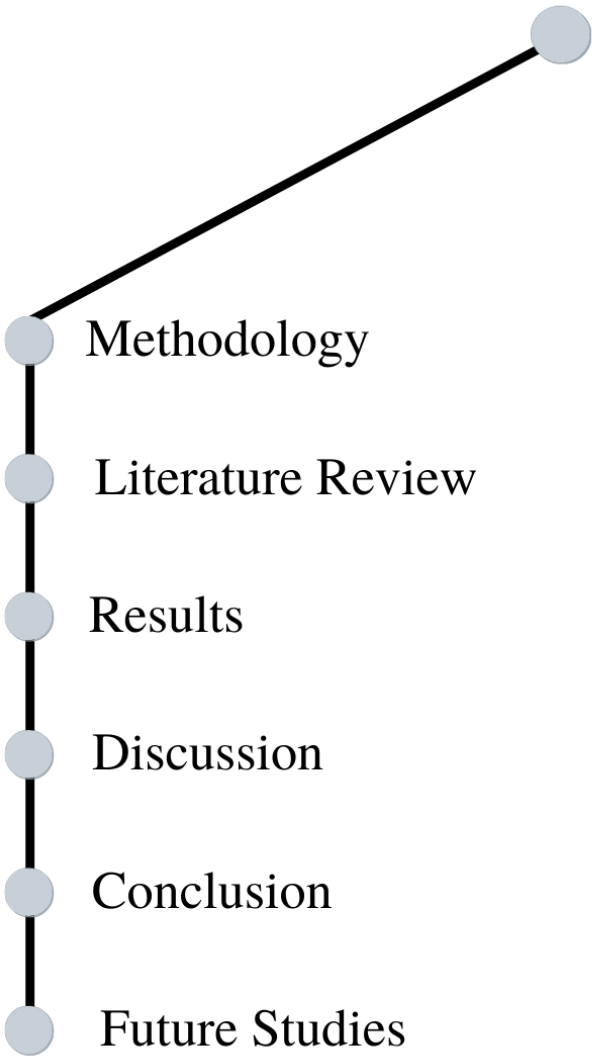


- Background
- Research Questions
- Purpose
- Scope and Limitations
- Thesis Structure

1 Introduction

1.1 Background

A building's operation and maintenance(O&M) phase constitutes the longest period in its lifecycle. This phase spends more than 85% of the whole lifecycle cost of the building (Tan et al., 2018). This is one reason why a huge effort should be exerted in order to make this phase as efficient as possible. These efforts involve implementing the right building adaptation projects effectively and handing it over efficiently to the operation and maintenance team.

Building adaptation projects are conducted within the facility during the O&M phase. These projects have different purpose and goals. One of which is to bring back the performance level of the facility and address functional obsolescence (Remøy and Wilkinson, 2012). Adaptation projects in buildings helps achieve different sustainability goals by reducing carbon emissions and construction wastes from demolition (Alba-Rodríguez et al., 2017), and preserving the embodied energy (Yung and Chan, 2012). Building adaptation projects such as deep energy refurbishments improve energy efficiency of the building and addresses issues such as Global Warming Potential (GWP) (Ghose et al., 2017). Alba-Rodríguez et al. (2017) concluded in their case study that building adaptation project in the form of building rehabilitation is more economical than demolition and new construction.

Shahi et al. (2020) created a definition framework for building adaptation projects during the O&M phase of a building. In the framework, they divided the projects into two major categories namely, *refurbishment* and *adaptive reuse*. Refurbishment is the process of improving the existing conditions of a building such as environmental, operating cost, and appearance. Under this are three sub-categories namely; retrofitting, rehabilitation, and renovation. Adaptive reuse is the process of prolonging the useful life of old buildings. Under this are conversion and material reuse. These projects are implemented by the project team and then transferred to the O&M team who will, as their title says, operate and maintain the output of the project e.g. new equipment, rehabilitated building facade, etc. This process of transferring is called the project handover phase.

The project handover is defined as the key transition phase between the project team and the end-user (Zhu et al., 2019). Data and information about the project in the form of drawings, data sheets, manuals, and warranty forms are transferred from the project teams to the building operation teams. These information serves as the lifeblood of the O&M team of a facility (Tan et al., 2018) as they will use these in taking care of the building's asset and operations. Building adaptation projects are not a one-solution-fits-all (Sesana et al., 2016), therefore careful planning and analysis prior to implementation (Shahi et al., 2020), and proper handover to the O&M team is necessary for them to be successful. Challenges in the handover phase decrease the efficiency of the O&M of the building (Tan et al., 2018).

1.2 Research Questions

As the title of this master's thesis states, the research topic is about the improvement of the project handover phase. This phase is zoomed in using the lens of the PM team and O&M team. The main type of projects that are focused are the building adaptation projects. Given these information, it is essential to understand the different challenges encountered in the handover phase, thus the first research question (RQ1):

RQ1: What are the main challenges encountered in the project handover phase in the eyes of the PM team and the O&M team?

Researching for the challenges has a huge impact for the industry as this creates opportunities to identify and implement solutions, but in order to proceed with creating these solutions, the root cause of the challenges should be determined first. This is the rationale behind the second research question (RQ2).

RQ2: What are the causes of these challenges?

RQ3 targets to achieve the goal of this master's thesis which is to identify improvements that can be implemented or added to the existing practice. Answering this question also includes analyzing existing solutions from the different resources and compare their effects and pre-requisites in order to propose a set of filtered solutions.

RQ3: How can we improve the handover phase?

1.3 Purpose

The project handover phase is the main phase that serves as a conveyor of information and data about the project. This conveyor connects different actors such as project owner, project managers, contractors and operations and maintenance team. Huge amount of transferred information and knowledge comes from the PM team and transferred to the O&M team. This is because the project manager has, or should have, the overall overview of the whole project; while the O&M team are the representative of the end-users as they will inherit and take care of the output of the project after the handover. Therefore, it is important to ensure quality and efficiency of this phase.

The purpose of this master's thesis is two-fold. First, it aims to explore and develop different possible solutions to the challenges experienced in building adaptation project handover. Second, it aims to contribute to the project handover literature with the focus on the building

adaptation projects as it sorely lacking. Methods of inquiry include systematic literature review, qualitative interviews of project managers and O&M managers, and document review. The solutions and challenges identified is categorized based on the project life-cycle and the different theoretical organization level of facility management; namely, strategic, tactical and operational.

The result of this thesis report may be used by Facility Management Organizations (FMO) that are managing the development, operations and maintenance of an existing building or facility. Project managers can also benefit from this research as they may handle building adaptation projects of a facility.

1.4 Scope and Limitations

There are different types of projects during the O&M phase of a building such as digitalization projects, process improvement projects, and building adaptation projects. The scope of this master's thesis only includes the last type of projects. The definition of building adaptation projects as well as the other types of projects under it are defined by Shahi et al. (2020). They created a definition framework which will be defined in the literature review chapter. The different methods used to gather data were focused on the handover phase of these projects.

The following sentences describes the limitations of this thesis. The views represented in this master's thesis are only of those from the PM team and O&M team. While the contractor is another major stakeholder in a rehabilitation project, the author chose to set the said actor aside as time to collect data and conduct the research was limited. More interview object from the OM side could have given a more balanced view on the researched topic. In addition, even though the interview objects came from two different departments (PM department and O&M department), they also came from the same company which may limit the identified challenges; causes; and solutions in a building adaptation project. Lastly, only publicly available documents were only used due to the limitations with the access.

Another limitation of the research is that only qualitative interviews were done to gatherdata from the participants. Adding other methods such as observation and internal documentreview could have improved the validity of the research more by spending time in the fieldwhich can give a more in-depth understanding of the handover phase. In addition, thetranscription was sent back to the interview objects for them to check and validate thedata, but using validation interview instead of the said method could also have increased thevalidity of the interview answers.

1.5 Thesis Structure

This chapter presents the background, purpose and limitations of this master's thesis, while the next chapters are structured as follow:

- Chapter 2: Methodology - This chapter introduces the author and his background that affected the options chosen in this master's thesis. It discusses the different philosophical

worldviews and the one that governs this project. The different research methods are also expounded as well as the details of how these methods were used. After these, the procedure of how the data were analyzed is explained. Lastly, the different methods to improve the quality of the research are presented.

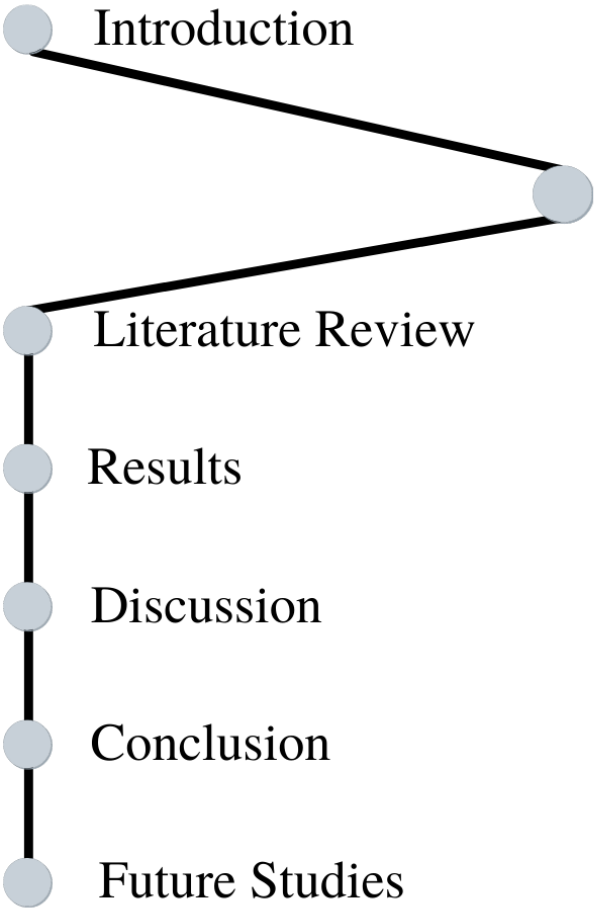
- Chapter 3: Literature Review - This chapter's goal is to improve the understanding of the chosen topic as well as serve as a part of the synthesis of the answer to the research questions at the end of this master's thesis. This chapter is divided into the different key topics that surrounds this master's thesis i.e. facility management, project management, building adaptation projects, and handover challenges and strategies.

- Chapter 4: Results - This chapter presents the results from the two other data gathering methods i.e. Document review and Qualitative interview.

- Chapter 5: Discussion - This chapter interprets the answers from the qualitative interview as well as synthesizes the ideas from the different research methods. This is done in order to answer the three (3) research questions: the first part presents the challenges and defines their causes while the second part discusses the strategies to solve these challenges.

- Chapter 6: Conclusion - This chapter states the final conclusion of this master's thesis and briefly summarizes the answers to the three (3) research questions.

- Chapter 7: Recommendation for Future Study - During the period of the study, there were topics that were found to be interesting and seemed to be important to be researched on. In this chapter, these topics are proposed to the reader to improve the literature about the subject of building adaptation projects



Methodology

- About the Author
- Research Approach
- Quality of Research Design

2 Methodology

This chapter presents a brief introduction of the author, the research approach, the research design and the research methods that were used in this master's thesis (Creswell, 2014). The purpose of this chapter is to ensure that the readers are fully-informed about the processes of choosing, capturing, and analyzing of the data. The structure of this chapter is based from the checklist created by (Creswell, 2014, pg. 183-184). The last part explains the tactics used to increase the quality of the research using the criteria reliability and validity.

2.1 About the author

The author is a master's student taking up the master's program in Project Management. He has a 3-year experience in managing building adaptation projects focusing in installation of new equipment. He also worked as a property manager for two years wherein he lead the operations and management of a 24-storey office building in the Philippines. Some of the tasks included are: creation of annual maintenance plan of the building equipment, implementation of building adaptation projects, and proposal of the building's budget to the building owners.

The author encountered challenges when he was managing the O&M of a building. Due to these challenges, the proposed research topic is considered relevant by the author. In addition, these experiences also helped the author in understanding the thoughts of the PM team and O&M team better.

2.2 Research Approach

In planning a study, researchers need to think through the philosophical worldview assumptions that they bring to the study, the research design that is related to this worldview, and the specific methods or procedures of research that translate the approach into practice (Creswell, 2014, pg. 5). These three key items are discussed in this section.

2.2.1 Philosophical Worldview

Creswell (2014) defines worldview as "a basic set of beliefs that guides action" which he based from Guba (1990). He further explained that these are the ways how the researcher thinks or the general philosophical orientation about the world and the nature of research the researcher uses. He discussed four different worldviews that are commonly found in the literature namely, postpositivism, constructivism, transformative, and pragmatism. Definitions of these four based from Creswell (2014) are stated in the next paragraphs.

The postpositivist worldview or sometimes called the scientific method came from thinking after positivism - challenging the existing understanding of the absolute truth of knowledge. It is deterministic wherein causes determine the effects or outcomes, but the absolute truth can never be found (Phillips and Burbules, 2000). The knowledge that develops from this

worldview are objective which comes from careful observation and measurement. Postpositivist researchers aim to reduce ideas into small sets to test them such as variables in an experiment. This worldview is thus typical for quantitative approach.

The next one is the constructivist worldview and is commonly seen in qualitative researches. In this worldview, the researcher believes that individuals create subjective meanings of their experiences. These meanings are formed through interaction with others and not simply imprinted on the individual. In this type of worldview, researchers inductively develop a theory or pattern of meaning.

Another worldview is called transformative worldview that started during the 1980s and 1990s. This worldview focuses on transforming lives of the marginalized people. Transformative worldview research should be connected with political change agenda. It places importance on the study of lives and experiences of different groups that are marginalized and focuses on inequities based on gender, race, ethnicity, disability, sexual orientation, and socioeconomic class that creates unbalanced power relationships.

The fourth worldview is called pragmatic worldview. In this philosophical orientation, researchers are not committed to any system of philosophy and reality which appeals to mixed methods research. This worldview emphasizes for researchers to use what works at the time and they have a freedom of choice. The importance is focusing the attention on answering the research problem

This master's thesis followed the *pragmatic worldview* which means focusing on the research problem while using all methods possible to gather answers. At the same time, the conclusion is also based from the data from the participants towards the studied event as much as possible i.e. content of their interview answers. In this case, the studied event is the project handover phase. With this worldview, the mixed method approach suits best. It also tends to be more comprehensive (W Lawrence, 2014, pg. 167), but because of the limited access to the partner organizations and time constraint, it was decided to stick with the qualitative approach. Therefore, a qualitative research approach was the better option compared to the quantitative approach.

2.2.2 Research Methods

Research method is defined as the specific instrument in which data are gathered. The following sections discuss the three research methods used in this master's thesis together with the specific steps taken in conducting them.

2.2.2.1 Literature Review

A Literature review is a thorough and critical analysis of relevant literature on the topic being studied (Parija and Kate, 2018, pg. 157). The goals of a literature review in general are plenty. The literature review on this master's thesis has three goals; (1) to synthesize, compare and contrast existing knowledge in the topic; (2) to improve the understanding

to the topic; and (3) to contextualize this master's thesis in the existing literature. It is widely accepted in the scientific community that conducting a literature review helps in accomplishing the said goals.

The process of choosing and filtering the literature used in every report should be organized, recorded and systematized. The systematic literature review process was inspired from the work of Zhu et al. (2019). Modifications were done in order to fit in the goals and purpose of this master's thesis. The literature review method is composed of three major steps: selection of academic journals, identification of relevant articles, and qualitative discussion of the main findings. An additional step which is called "snowballing" was added. This process is illustrated in Figure 1.

Selection of academic journals

The process started with identification of keywords. The keywords came from two sources: keywords from the initial set of literature and suggestions from the supervisor and company contact. Everyone are knowledgeable about the subjects project management and facility management. The first one is an academian and researcher in the field of FM while the other one is an employee of a huge FM company with more than 7 years of working experience. The initial set of literature consists of a critical literature review and literature from completed courses in the university.

The search was limited to articles as document type. Recent literature published from the year 2016 until 2021 were included in order to capture the current themes about the topic. Only articles published in english were used. The subject areas engineering; business, management and accounting; social science; energy; and decision science further filtered the literature search. These subjects areas covers both project management and building adaptation projects, which is why they were chosen. The initial search resulted to 189 articles from 112 journals.

The TITLE-ABS-KEY (T/A/K) field of the search engine *Scopus* was used to search for literature. The keywords input into the T/A/K field mainly came from the critical review of Zhu et al. (2019) such as building handover, practical completion and building, as-built handover, handover and initial occupancy, project handover problem and building, handover and information management, closeout and building, turnover and building as constructed, building defects, commissioning and handover, handover and maintenance, and building lifecycle and handover. The query string used is as follows:

(TITLE-ABS-KEY (building AND handover) OR TITLE-ABS-KEY (practical AND completion AND building) OR TITLE-ABS-KEY (as-built AND handover) OR TITLE-ABS-KEY (handover AND initial AND occupancy) OR TITLE-ABS-KEY (project AND handover AND problem AND building) OR TITLE-ABS-KEY (handover AND information AND management) OR TITLE-ABS-KEY (closeout AND building) OR TITLE-ABS-KEY (turnover AND building AND as AND constructed) OR TITLE-ABS-KEY (building AND defects AND handover) OR TITLE-ABS-KEY (commissioning AND handover) OR TITLE-

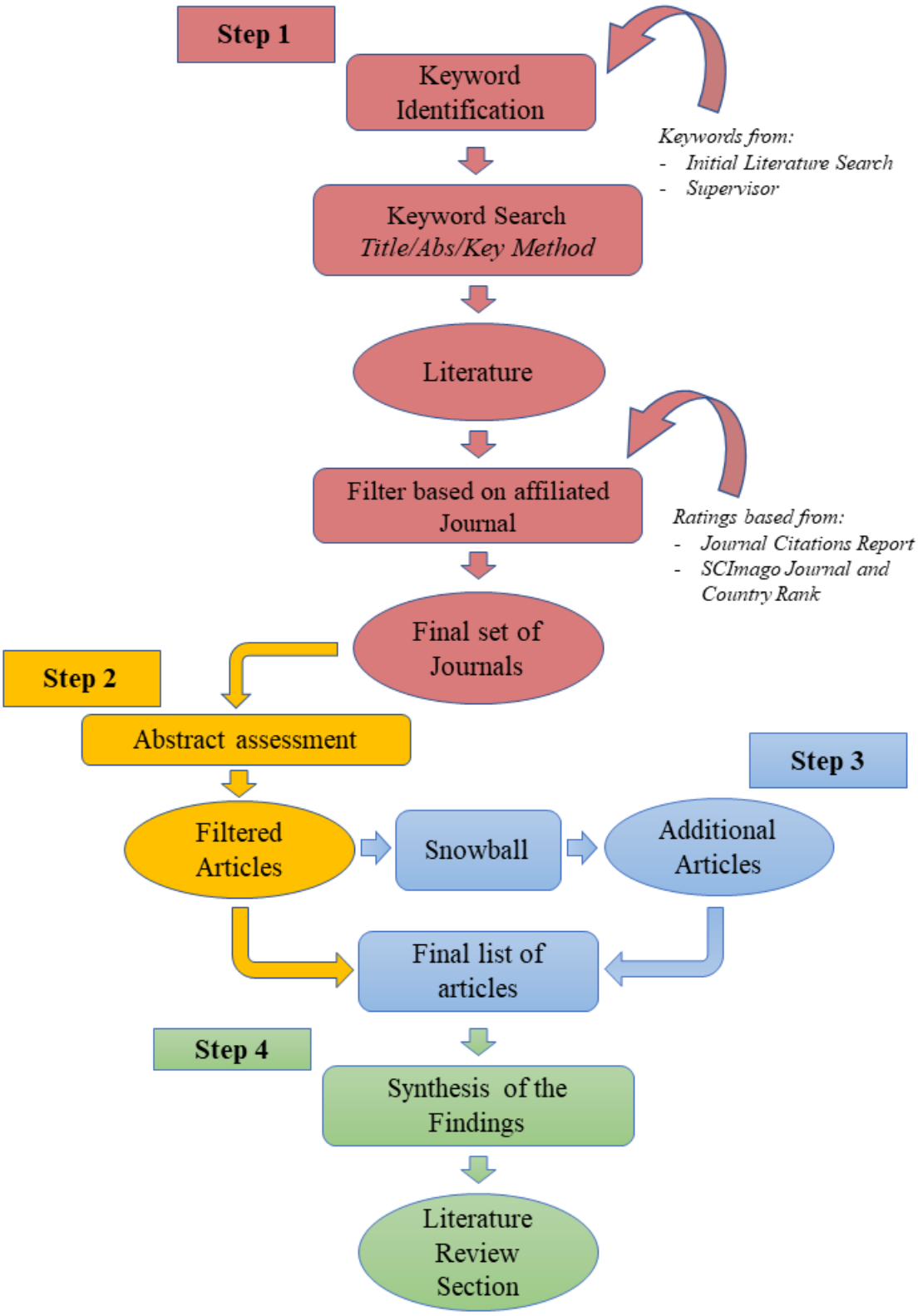


Figure 1: Literature Review Process*(Own Production)*

ABS-KEY (handover AND maintenance) OR TITLE-ABS-KEY (building AND lifecycle AND handover)) AND PUBYEAR > 2005 AND (LIMIT-TO (SUBJAREA , "ENGI") OR LIMIT-TO (SUBJAREA , "SOCI") OR LIMIT-TO (SUBJAREA , "ENER") OR LIMIT-TO (SUBJAREA , "DECI")) AND (LIMIT-TO (SRCTYPE , "j")) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (LANGUAGE , "English"))

The relevance of these articles were then assessed based on their title. This resulted to 31 articles from 20 journals. The journal ratings from both Journal Citation Reports and SCImago Journal and Country Rank were used to ensure the quality of the chosen journals. Both JCR and SCImago provides an updated rating of different journals. Journals with higher than 1 citation per published article were chosen. Finally, a total of 23 articles from 12 journals were considered after this process.

Identification of relevant articles

Irrelevant article are still possible to be included in the filtered list. In order to verify the relevance of the articles, their abstracts were read and the articles that did not really focus on the research subject were taken out from the list. This process reduced the articles to thirteen (13).

Synthesis of the main findings

This study took a closer look at the process of handover of the building adaptation projects. The main subjects considered in the literature review are the challenges, their causes and concluded solutions.

Snowballing

In addition to the identified articles from step 3, this step was conducted for two reasons. First is to widen the range of the researched materials; and second, to gain deeper understanding on the topics in the literature.

2.2.2.2 Document Review

Wolff (2004) defines documents as *standardized artifacts, in so far as they typically occur in particular formats-, as notes, case reports, contracts, drafts, death certificates, remarks, diaries, statistics, annual reports, certificates, judgements, letters or expert opinions*. These documents are written and produced for some form of use or purpose, therefore documents are not just source of data but can also be used as a topic of research (Flick, 2018). Therefore, it is essential to ask the following questions (Flick, 2018, pg. 257): Who has produced the document? What is the purpose of the document? To whom are these documents addressed? As Prior (2003) wrote, content is not the most important feature of a document, the dynamics involved in the relationship between the production, consumption and content should always be in mind.

Document review and analysis is the process of systematically evaluating documents in order to understand a subject, gather meanings, and develop empirical knowledge (Bowen, 2009). It is often combined with the other qualitative research methods such as qualitative interview and observation. This forms triangulation of methods - using different research methods to examine the data (W Lawrence, 2014) Bowen (2009) identified specific purposes of document in a research. These are to provide background and context, additional questions to be asked, supplementary data, a means of tracking change and development, and verification of findings from other data sources.

In conducting a document analysis, the first step is to identify the type of documents that you want to analyze followed by establishing a selected body of documents for analysis (Flick, 2018). Assessing the quality of the documents are also useful. Flick (2018) suggested criteria from Scott (1990) which are summarized below.

1. Authenticity: Assesses if the source of the document. Is it a primary document – the original document; a secondary document – summary of the original document from someone who did not took part in producing the original document; or a tertiary document – sources to find other documents.

2. Credibility: Refers to how accurate the document is plus the credibility of its producer. It also asks the question: is the document free from errors or distortion?

3. Representativeness: Asks the question: Is the document a representative of its kind?

4. Meaning: Described as the different meanings of the document. It can have an intended meaning by the author, a different meaning for the readers, and a different social meaning to those who is the object of the document.

Identifying the type of documents

Scott (1990) distinguishes different types of documents based from two specifications: who produced the document and how to access it (Flick, 2018). The first specification is divided between official and personal. He then divided the official documents into private and state documents. To explain further, Flick (2018) gave an example of the birth of a child. Personal documents include photographs taken during the birth of a child. Official private document includes the birth certificate of the child while birth register used by the government for statistics and other purposes is a official state document. An example of an official private document stated by Bell et al. (2018) are organizational documents that can span from the company's mission and vision statement to their meeting minutes. For official state documents, these are public documents that are sourced out from the government (Bell et al., 2018).

The second specification is divided into four classification: closed access which are only accessible to the producer and target consumer, restricted which are only accessible to specific professional groups due to the confidentiality concerns, archival which can be accessed by everyone but in a specific archive, and open published which are documents that are produced

and accessible to anyone.

I gained access to only one (1) closed accessed official private document - internal building standards of PubCom1. This left me with the options of state, archival and open published documents. As emphasized in the limitation section of this thesis, aside from PubCom1's building standards, all the organizational documents only include publicly available or posted document - these are only external documents that are published on major companies or organization's websites and standards that are available thru NTNU's access.

Establishing a selected body of documents

The documents reviewed are combination of public documents / state and organizational / private documents (Bell et al., 2018) - all in electronic format (Bowen, 2009). Table 1 shows an overview of all the documents used and their sources. These documents were chosen based from the suggestions of the interview objects and advisor. All have relevance with how to ensure that the studied event - handover phase, is experienced with as less challenges as possible.

Table 1: Documents reviewed*(Own production)*

Document Name	Document Type		Source
	Producer	Accessibility	
BA2015: Systematisk Ferdigstillelse Veileder	Official & Private	Open published	http://atkinsglobal.no/wp-content/uploads/2016/01/Systematisk-ferdigstillelse-veileder.pdf
PA0701: Systematisk Ferdigstillelse	Official & State	Open published	https://dok.statsbygg.no/wp-content/uploads/2021/02/PA-0701-Systematisk-ferdigstillelse.pdf
NS6450:2016 - Idriftsetting og prøvedrift av tekniske bygningsinstallasjoner	Official & State	Closed access	NTNU License (https://www.standard.no/)
NS3424.E:2012- Condition survey of construction works Content and execution	Official & State	Closed access	NTNU License (https://www.standard.no/)
Soft Landing Framework	Personal & Private	Closed access	https://www.bsria.com/uk/product/QnPd6n/soft_landings_framework_2018_bg_542018_a15d25e1/
Internal Building Standard	Official & Private	Closed access	PubCom1

These documents served as sources of knowledge for this research. They revealed standard procedures about the project handover phase as well as identified solutions from experienced challenges. However, there are weaknesses in using documents as sources of data. For example, there might be a gap in the translation of document from the authors to the users as confirmed in the study by Bell et al. (2002) in Bell et al. (2018). The documents' context,

use, and function should be focused together with its contents (Flick, 2018, pg. 261). In the case of this master's thesis, documents that can provide a deeper understanding to companies' use and functions were not available i.e. internal documents. Therefore, the next method was used in order to complement the data gathered and analyzed from the document.

2.2.2.3 Qualitative Interview

Qualitative interviews aim to gather views and opinions from the participants (Creswell, 2014, pg. 190). One advantage of qualitative interview is that the researcher dictates the line of questioning (Creswell, 2014, pg. 191) in order to gather the needed data for the research. As this is one of the main goal of this master's thesis, semi-structured qualitative interviews were chosen to gather data. The following texts explain the process for the this type of qualitative data collection specifically used in this master's thesis.

Creation of interview guide

An interview guide based from the literature review was prepared before the interview (Bell et al., 2018). The guide was comprised of 18 interview questions which is shown in Appendix A. These questions were created and chosen based on how they can answer the research questions and achieve the research objectives. Prior to the actual interview, a pilot interview was conducted with one of company coordinators. The goal was to ensure that the words used in the questions were comprehensible to the interviewees as suggested by (Bell et al., 2018, pg.477). After three (3) revisions, the final guide was formulated.

The guide was divided into five sections namely, introduction, defining the handover phase, challenges and their causes, implemented solutions, and closing. The introduction part aims to learn about the project model used in the companies and familiarize about the understanding of each interview objects about these project models. The second, third and fourth part was dedicated in gathering the thoughts, views and opinions of the participants about the handover of building adaptation projects. Lastly, the fifth part encourages them to bring out additional information that they think are relevant to the thesis topic.

Selection of interview objects

Through purposedful sampling, the interview objects were selected based on their tasks and responsibilities in their respective organizations. One criteria used was they should have experiences with the implementation and handover of building adaptation projects. It was a goal to gain a balanced number of participants from the project management side and operation and maintenance side, but only three (3) from the O&M side were interviewed while seven (7) from the project management side and one (1) from the consultancy side who has the perspective of both teams. Selection of interviewees were updated every time an interview is finished, as the last question asked the participant if they can suggest other individuals who might be able to produce relevant answers to the interview questions and research. This led to either suggesting project managers from a different company or a counterpart (either a project manager or an O&M manager) from their own company. Table

2 provides an overview about the participants and their companies.

Table 2: Overview of Interview objects*(Own production)*

Company Code	Company type	Perspective	Interview Objects	Quantity	Interview Object Code	Language	Interview Length
PubCom1	State-owned	Owner, Project Management and O&M	Project Manager	1	PubCom1.PM	English	45 minutes
PubCom2	State-owned	Owner, Project Management and O&M	Project Manager	1	PubCom4.PM	Norwegian	26 minutes
			Operations and Maintenance Manager	1	PubCom4.OM	English	46 minutes
PubCom3	State-owned	Project Management and O&M	Project Manager	1	PubCom1.PM	Norwegian	1 hour and 50 minutes
			Operations and Maintenance Consultant	1	PubCom1.OM	English	56 minutes
PubCom4	State-owned	Owner, Project Management and O&M	Project Manager	1	PubCom3.PM	English	57 minutes
			Operations and Maintenance Personnel	1	PubCom3.OM	Norwegian	45 minutes
PrivCom1	Private	Project Management and O&M	Project Manager	1	PrivCom1.PM	English	1 hour and 22 minutes
PrivCom2	Private	Owner, Project Management and O&M	Project Manager	1	PrivCom2.PM	English & Norwegian	49 minutes
PrivCom3	Private	Consultant	Consultant	1	ProvCom4.Con	English	1 hour and 17 minutes
PrivCom4	Private	Project Management and O&M	Building Manager	1	PrivCom3.CM	English & Norwegian	54 minutes
			TOTAL	11			

Interview proper

Consent from the participants were first seeked through signed consent forms. A copy of the interview guide were sent to the participants together with the consent forms. During the interview,

To get an insight into how the handover phase of building adaptation projects are conducted and plagued with challenges in practice, eleven (11) semi-structured qualitative interviews with different interview objects were conducted. Semi-structured interviews is characterized as a flexible type of interview wherein the interviewer can adjust the questions based on the answers of the interview objects (Creswell, 2014). Most of the interviews begins with identifying a specific case so that the questions can be case-specific and the participants can cite their experience from thos projects. Ten (10) interviews were conducted through Microsoft Teams while one (1) was physical. The interviews were transcribed and analyzed.

Transcription of interview

Transcription is an important step in data analysis. It involves close observation of data through repeated careful listening and/or watching (Bailey, 2008). Transcription can be done in multiple ways, the most often used are naturalism and denaturalism (Oliver et al., 2005).

Figure 2 shows the major types of transcription. According to Oliver et al. (2005), naturalism is the approach when one captures every detail as possible i.e. pauses and way of expression. Conversations can change meaning with these details which can be hard to interpret for analysts (Bucholtz, 2000; Oliver et al., 2005). Denaturalism on the other hand is the approach when the grammar of the interview is corrected, interview noise (e.g. pause, stutter, etc.) is removed, and non-standard accents are standardized. This type of transcription is focused on the content of the interview not how the answers to the interview questions were delivered.

In between these two types are different variations of transcription. Researchers can decide how detailed the transcription should be for a particular project and how it can represent the data from the interview. This decision is guided by the aim of the project, philosophical worldview and research methods of the research project (Bailey, 2008). If an analysis is focused on describing the attitudes and emotions in a social phenomena, the transcription might need to lean more towards naturalism. If the analysis is focused on showing showing knowledge and processes, the less detailed transcription might suffice. As Drisko (1997) said in McLellan et al. (2003), *"the level of transcription should complement the level of the analysis."*

The transcription used in this master thesis is leaning towards the denaturalized way of transcribing. The whole interview was transcribed while grammars were corrected. The way the answers were delivered together with the nonverbal expressions and emotions were considered not important, therefore not noted in the transcription. This is because the main focus is answering the research problem following the *pragmatic worldview* - the content of the interview that lead to answers in the research questions were more important.

One way to improve the quality of the transcription is they were sent to the interview objects for confirmation. This ensures two things: (1) transcribed data are approved by the interview object meaning they have taken out what they do not want to be written or even add things that they forgot to say in the interview, (2) ensure that the transcription is correct with no misunderstanding.

Safety and Security of Transcription

In order to ensure that the transcriptions are safe and secured, they were stored in NTNU's infrastructure via Sharepoint and Microsoft teams. Both are protected by personal password and Feide secured login. The storage of the data are in accordance with the guidelines set by Norsk senter for forskningsdata (NSD) and NTNU. Details mentioned during the interview that can be point to specific person were replaced by codes e.g. PM 1 for the interview objects and PubC 6 for companies.

2.2.3 Analysis of data

The focus of this master's thesis research are building adaptation projects. Shahi et al. (2020) created a definition framework for building adaptation projects. This was used as a guide in defining the focus to the interview objects. For example, in the start of the interviews, examples of rehabilitation or retrofit projects were discussed and explained to the interview

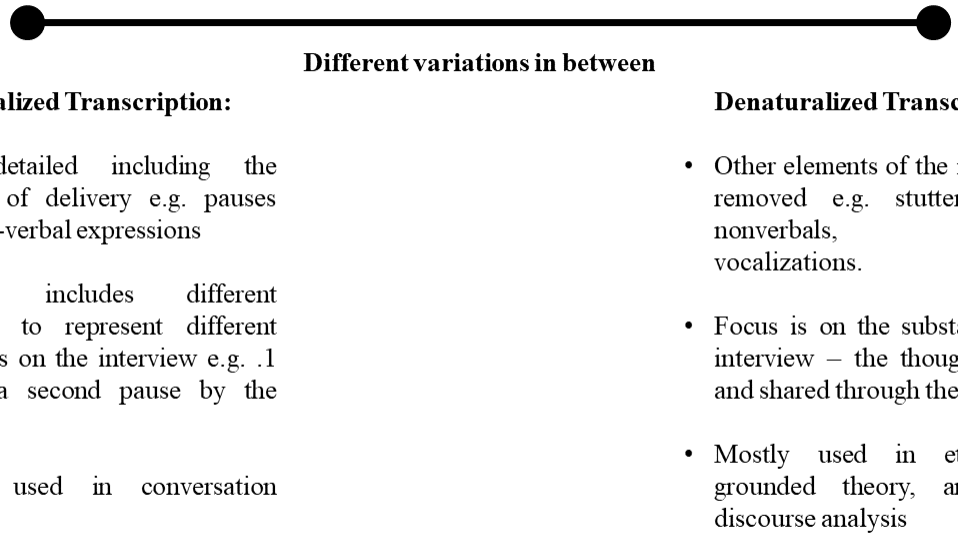


Figure 2: Types of transcription *(Adapted from Oliver et al. (2005))*

objects so that proper alignment between the interviewee and interviewer is created. The framework is discussed further in the Literature Review portion of this master's thesis.

The diagram shown in Figure 3 displays the steps taken in the analysis of the data captured from the literature review, document review, and qualitative interviews. It starts of with capturing raw data i.e. articles, documents, and interview transcripts. This was discussed in the previous subsections in this chapter. The next steps are organizing, preparing and reading through the data that will be used for analysis. These were done by compiling all the data in the qualitative analytical software, NVivo. Following these steps are coding of the data into themes and descriptions. This step will be discussed in details in the next part.

2.2.3.1 Coding the Data and Analysis of Codes

An initial codebook was created based from the reviewed literature. The codebook was created in NVivo. In the initial phase, the codes were labeled as challenges and strategies. These were based from the first set of literature reviewed. The four main challenges from Zhu et al. (2019) were the initial codes for the challenges while the strategies were based from the theoretical framework of the different organization levels in facility management from Haugen (2008) namely; strategic, tactical, and operational. Data gathered from the different literature enriched the initial codebook. For example, an additional code for the challenges part is "challenge in knowledge transfer" which was gathered from the study of Jensen et al. (2019) about the project handover from the project team to the operations team in Denmark.

The codes were gradually improved using the results from the interview results and

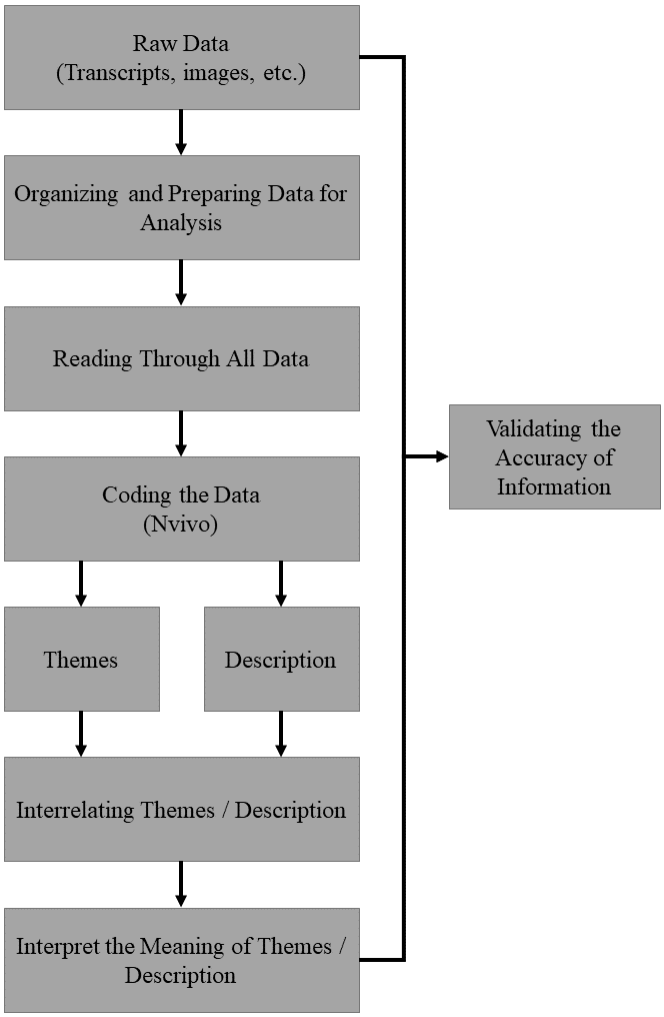


Figure 3: Data Analysis Process *(Adapted from (Creswell, 2014, pg. 197))*

document review i.e. procedures to improve the handover phase. The analysis of documents was conducted through selecting, appraising, and synthesising data found in the documents reviewed. These produced data in the form of excerpts were then organised into major themes and categories. This process of improving the codebook was an iterative process, as deeper insights were gained thru the data analysis. Appendix B presents the evolution of the codebook used in this master's thesis.

The final step of this process was the interpretation of the findings or results. One way this was conducted was asking the question "What are the lessons learned?" following (Creswell, 2014, pg. 200). My personal interpretation as well as comparison with the literature findings and results from the document review were all used to define and discuss the lessons learned which can be found in the Discussion chapter.

2.3 Quality of research design

There are two ways to ensure the quality of the research, namely, increasing the validity and reliability (Franklin and Ballan, 2001). Using the correct research method that ensures the accuracy of data collection; and it is logical, factual and verifiable increases the validity and reliability of the qualitative study (Franklin and Ballan, 2001). It has to be noted though that perfect reliability and validity is an ideal researchers strive to have but impossible to achieve (W Lawrence, 2014).

2.3.1 Validity

Qualitative validity is defined by Gibbs (2018) as the accuracy of the research findings. It involves using the appropriate tools, processes and data (Leung, 2015). Poor validity means that the ideas the researcher used to analyze the research topic and what actually happens in the real world does not match (W Lawrence, 2014). Figure 3 shows that validation is conducted throughout the process of data analysis (Creswell, 2014, pg. 201).

2.3.1.1 Methods used to increase validity

Triangulation

Triangulation in research means learning from observation through different or multiple perspectives (W Lawrence, 2014). There are four types of triangulation according to (Franklin and Ballan, 2001; W Lawrence, 2014), these are:

1. Triangulation by theory - involves using multiple assumptions and constructs from different theories to examine and interpret the data.
2. Triangulation of data / measures- makes use of different data or different measures of the same phenomena.
3. Triangulation of method - mixes different research methods i.e. qualitative and quantitative, to test the findings. This type of triangulation uses complementary strengths from the different methods.
4. Triangulation of investigator / observers - uses multiple researchers with different background to come up with alternative perspective.

Triangulation of data was used in this master's thesis. First, different challenges and strategies were collected from previous studies i.e. literature review. Second, different strategies were identified from national standards related to the research topic. Lastly, challenges experienced and strategies used in practice were gathered from the qualitative interviews. Evidences from these different data sources were used to build coherent justification for the themes therefore adding the the validity of the study(Creswell, 2014, pg. 201)

Purposeful Sampling

Answering specific questions and testing the findings through divergent cases is the basis for purposeful sampling (Franklin and Ballan, 2001). This was done by first identifying project managers who implemented or are implementing building adaptation projects. After interviewing some of them, their counterpart or the divergent case who are the personnel from the operations and maintenance team were interviewed. This brought the possibility to test if the findings can be reproduced through a cross-case analysis. Unfortunately, out of the eleven (11) interview objects, only three (3) are from the O&M team which can decrease the target validity of this thesis.

Using a Structured Codebook

Codebooks allow data to be sorted into meaningful codes and linked to themes so that the researcher can make sense of the data (Franklin and Ballan, 2001). Codebooks can be created before data collection or in the process of data analysis and interpretation (Franklin and Ballan, 2001; Creswell, 2014). By creating codebooks before data collection and modifying it during the research improves its validity (Franklin and Ballan, 2001) by having a better understanding of what processes and tools can be adapted to the research. As mentioned earlier an initial codebook was created based from the literature gathered which resulted to a list of potential themes for the master's thesis. It was then improved using the documents reviewed and finalized using the data from the qualitative interviews which then gave the final list of coherent themes found in the discussion part. The qualitative software Nvivo was used to create and analyze the codes created. Using Nvivo made the analysis of codebook more systematic.

2.3.2 Reliability

Reliability in research suggests that the same results will be achieved again under the same conditions and procedures conducted W Lawrence (2014). It refers to the degree to which other researchers would generate similar results (Franklin and Ballan, 2001). Gibbs (2018) defines qualitative reliability as having an approach that is consistent across different researchers and projects (Creswell, 2014, pg. 201). The following subsection explains the methods used in this master's thesis to increase its reliability. Most of them are based from the list written by Franklin and Ballan (2001).

2.3.2.1 Methods used to increase reliability

Audit Trail

Qualitative research designs often evolve once the researcher has started collecting data. These changes should be properly documented including the reasoning behind the changes. This documentation is called "audit trail" (Franklin and Ballan, 2001). Qualitative researchers also need to document the process as detailed as possible (Yin, 2018).

Wolf (2003) divided the steps in writing the audit trail into three parts. First, the raw

data step which includes the processes for data collection and preparation of the analysis. Second, the analysis and interpretation step which is composed of the steps taken in data coding and analysis. Lastly, the findings step which includes writing the findings and the storing of data and materials after the research.

The audit trail for this master's thesis can be seen in the entirety of Chapter 2: Methodology. It is written as detailed as possible including explanations as to why the decisions chosen for the thesis were chosen. The raw data step is discussed and explained in subsection 2.2.2 Research Method. The analysis and interpretation step is written in subsection 2.2.3 Analysis of Data. While the findings step can be found in Chapter 5: Discussion.

Examining responses of informants thru alternate-form questions

Response to various forms of the same question that points out to a similar thoughts can be used to check the reliability of the data (Franklin and Ballan, 2001). This was used in some of the interviews conducted. To give an example, questions such as the two below are different form of the same question which were asked to some interview objects.

"What are your strategies in order to solve the challenges in the handover phase?"

"I want to learn, what does your company do well for you see that there are not a lot of challenges in your projects?"

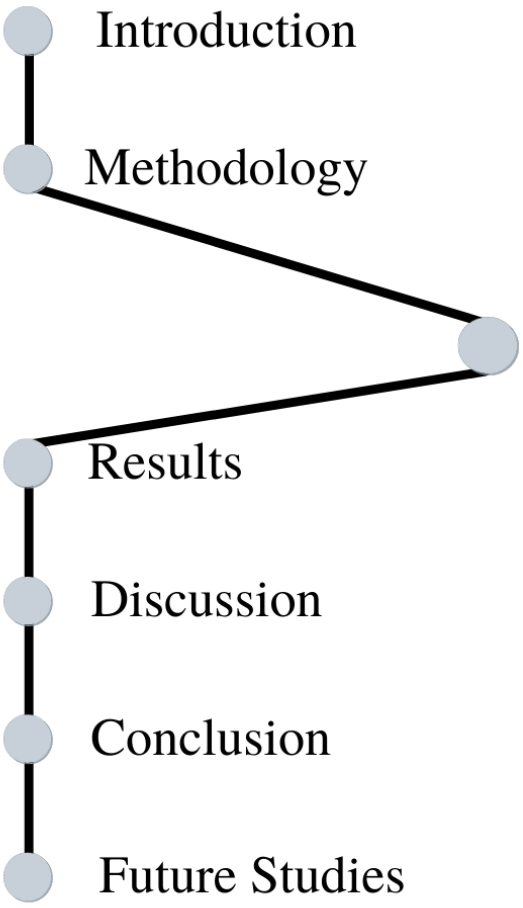
Both of these questions aimed to identify the current strategies / solutions the interview object or his / her company does to address the challenges encountered in the handover phase.

Staying close to the empirical data

Staying close to the empirical data means being in accordance with the verbatim answers and subjective meaning of the participants (Franklin and Ballan, 2001). This is done by thoroughly checking the interpretations of data with the descriptive answers of the participants (Franklin and Ballan, 2001). Qualitative researchers use exact quotes from the interview in order to support the interpretation about the data (Franklin and Ballan, 2001).

In order to verify which among the empirical data are stronger, researchers may use quantification of qualitative data. This is done by counting the number of statements that supports a theme in the result (Franklin and Ballan, 2001).

Based from what was discussed above, direct quotes from the interview is written in this master's thesis. These quotes from the interview objects is used to support the statements written before them. Table 8 presents the frequency of the challenges that were discussed during the interview.



- Facility Management
- Building Adaptation Projects
- Project Management Models
- Project Handover Challenges and Strategies

3 Literature Review

This chapter is divided into four sections. The first part explains key topics under Facility Management: management levels and roles and responsibilities, facility development, operations and maintenance management, and facility life cycle. This section brings sense as to why building adaptation projects are essential, how they are planned, and who plans them. The next part presents a framework from the literature defining different building adaptation projects. It clarifies the scope of the projects considered in this master's thesis. In the third section, the focus turns into project management processes, including the handover. Lastly, the fourth part zooms into the project handover challenges related to construction projects and building adaptation projects, including their causes and strategies to address them.

3.1 Facility Management

Barrett and Baldry (2009) describe Facilities Management (FM) as *"an integrated approach to operating, maintaining, improving and adapting the buildings and infrastructure of an organization to create an environment that strongly supports the primary objectives of that organization"*. This definition fits this thesis as it defines FM as the body that operates and maintains the building. At the same time, they adapt the buildings to achieve their objectives - support the main organization. Facility management puts the users of the building, i.e. supported organization, at the center of attention by conducting different scopes (Haugen, 2008) which is shown in Figure 4.

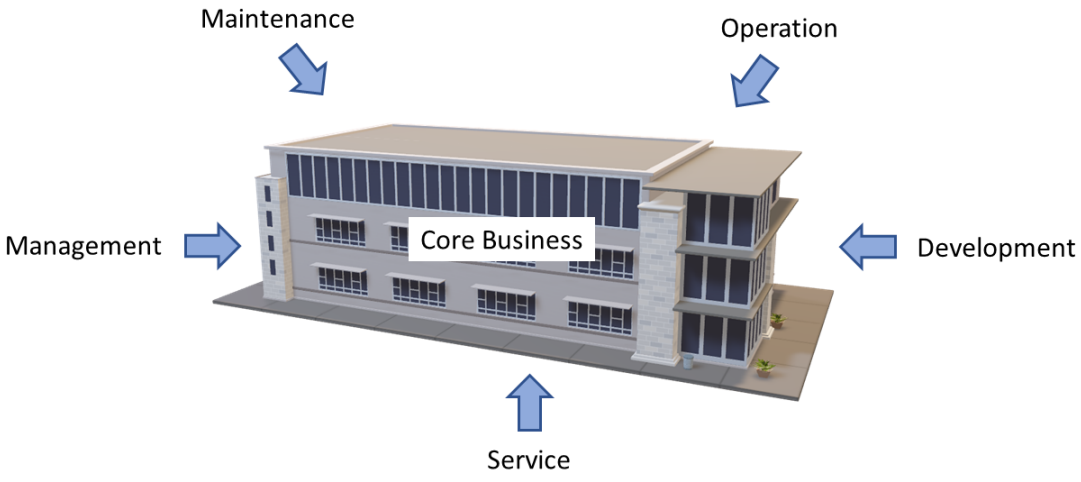


Figure 4: FM as a support to the core organization *(Adapted from Haugen (2008))*

A typical FM organization has different management levels, namely, strategic, tactical,

and operational. These management levels are displayed in the model made by Haugen (2008) and is represented in Figure 5. Each of these levels has different tasks, responsibilities, and requirements. This has to be acknowledged to solve challenges and capture opportunities (Haugen and Klungseth, 2017). The *strategic* level is mainly concerned with setting the direction for the organization and ensuring that the means for achieving its objectives are in place (Atkin and Brooks, 2015, pg. 46). On this level, long-term decisions in connection with the main organization's goals are made e.g. building expansion or new construction projects (Mørk et al., 2008). The *tactical* level turns the broad strategies into workable plans and might call for new processes and procedures as well as improvements to those that exist (Atkin and Brooks, 2015, pg.46-47). They are responsible for the management of the daily operations of a facility. In addition, they are the ones to implement the projects decided on the strategic level (Mørk et al., 2008). Lastly, the *operational* level is concerned with performing the works according to laid down procedures by the tactical level. They conduct the day-to-day operations and maintenance of the facility (Atkin and Brooks, 2015, pg. 47). Typical actors on this level are cleaners, maintenance personnel, etc. (Mørk et al., 2008).

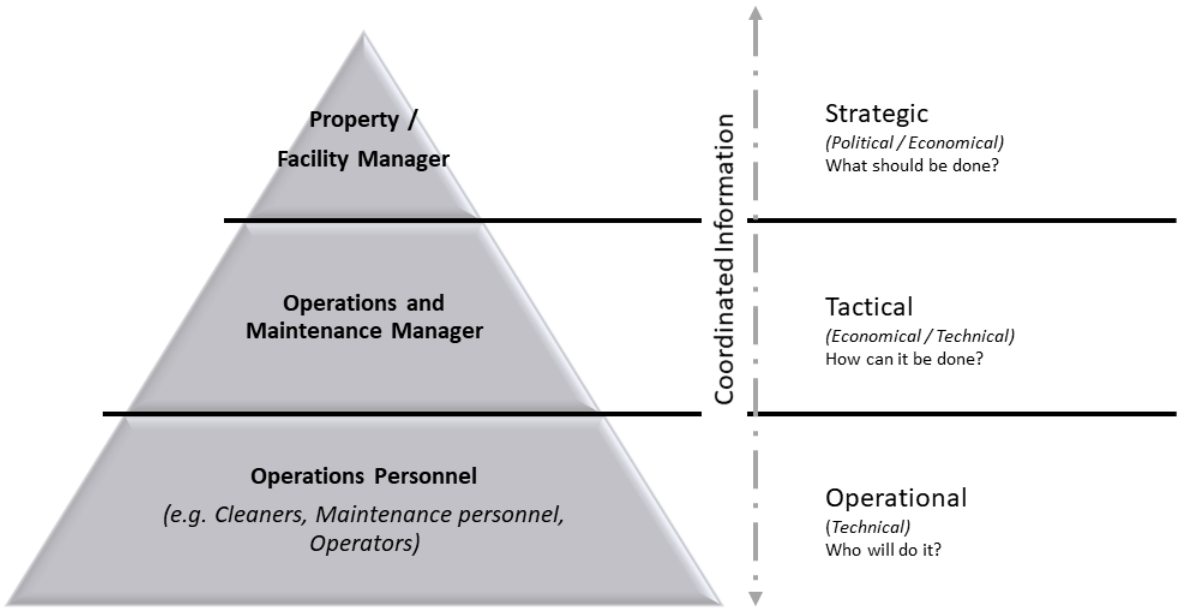


Figure 5: Different organizations level, roles, and responsibilities in facility management *(Adapted from Haugen (2008))*

3.1.1 Facility Development, Operations Management, and Maintenance Management

Facilities Management is an integrated approach to create an environment that supports the main organization. Part of this integrated approach are the facility development, operations management and maintenance management (Barrett and Baldry, 2009). The last two different disciplines are often hard to distinguish from each other in practice (Mørk et al., 2008) as they have overlapping scopes. The following parts describe the roles and responsibilities of these disciplines in connection with facility management.

Facility Development comprises different activities performed to develop and upgrade a building's value over time. These are usually based on new requirements from users, the market, or the authorities (Haugen, 2008). Some of these activities include upgrading the ventilation system for improved zone control and demolition and relocation of wall partitions to comply with new regulations (NS 3454:2013, 2013, NS3454:2013). The concept was defined in Norway in the year 1993 during the construction of the new Rikshospital in Oslo (Valen et al., 2011).

Operation represents the daily resources that the end-users need to meet their requirements while operations management ensures that the facility with its technical installations is functioning efficiently and economically daily (Haugen, 2008). Part of the operations are tasks and routines that are necessary to achieve this goal e.g. operational task planning, service agreement responsibility, control of different technical systems (electrical and mechanical), plant operations, energy management, hazardous waste management, recycling, inventory management, wired and wireless communications management, furniture installations (Haugen, 2008; Roper and Payant, 2014). The operations plan includes inspection and monitoring wherein building components and facilities are checked, adjusted, and if necessary, serviced; energy usage plan; cleaning plan; and security plan (Haugen, 2008).

The most important goals for an operations plan are (Haugen, 2008):

1. Comply with the defined service level using the least possible resource
2. Ensure an appropriate and well-functioning working environment for the users
3. Prolong the lifespan of building components and facilities using efficient operations

Maintenance management aims to maintain the quality of the facility and its assets, both technical and structural, to an agreed level. Another goal is to ensure that the building will operate according to its planned purpose throughout its planned lifespan (Haugen, 2008; Atkin and Brooks, 2015). A function of maintenance management is to identify the best option or combination of options for the delivery of maintenance-related services that best aligns with the organization's objectives and processes (Atkin and Brooks, 2015). Haugen (2008) gave an example of maintenance model wherein condition analysis and maintenance tasks are performed and recorded at the operational level; the data and records from the operational level are then used by the tactical level to report the maintenance requirement

of the facility; and projects are prioritized based from this report together with the budget framework given by the strategic level.

Maintenance plans are created to support the core organization's business objective including business continuity, to protect the value of the facility's assets, to ensure the availability and reliability of the facility at the most efficient cost, to provide performance data for benchmarking, to create a Service Level Agreement (SLA), and to demonstrate commitment to sustainability. All of these while satisfying stakeholder's interests and end-user requirement (Atkin and Brooks, 2015). According to Haugen (2008), maintenance management has three main types:

1. *Annual maintenance and renovation project plan* - Plans the maintenance tasks based on surveys and reported requirements that need approval for the annual budget.

2. *Long-term plans* - Plans that come from the need for interval maintenance or replacement of building components. These are usually based on the recommended maintenance intervals of the building component supplier.

3. *Operations and maintenance plans* - plans that specify work tasks for internal and external operations personnel. These are usually divided into days, weeks, or months.

3.1.2 Facility life-cycle

This master's thesis focuses on the handover of building adaptation projects. Even though it only occurs in the operation phase of a building, it makes sense that the whole building life-cycle will be discussed to give an understanding as to who the actors are in the said projects and why are they conducted. The following paragraphs briefly discuss the facility life-cycle based on the different models used in Norway such as RIBA's Plan of Work (RIBA, 2020), Bygg21's Next Step Model (Bygg21, 2016), and Multiconsult's OSCAR project model (Multiconsult Norge AS, 2017).

The first phase is the *strategic definition* which contains the creation of the rationale, identification of the overall goals, and preparation of business plan i.e. business case (Bygg21, 2016). In addition, the best solutions for achieving the client's requirements are identified in this phase (RIBA, 2020). This is followed by *Program and Concept Development* which identifies appropriate concepts in delivering the overall goals created in the first phase (Bygg21, 2016). The next one is the *processing of the selected concept*. Here, more details i.e. technical solutions and strategies, become more concrete (Bygg21, 2016). The end goal of this step is that the final decision on the implementation has a proper basis (Bygg21, 2016). The *detailed designing* process includes the structural, electrical, and other major equipment (RIBA, 2020). In addition, the output is a sufficiently detailed and quality-assured work, so that safe and correct execution is possible (Bygg21, 2016). After this, *production and construction* commence. One of the most important tasks within this step is the preparation of correct operation and maintenance(O&M) documentation which will be given to the operations team in the handover phase (RIBA, 2020; Bygg21, 2016). The *commissioning and turnover* phase is the transferring of responsibility from the construction and project team to the FM

operation team or end-user (Bygg21, 2016; RIBA, 2020). It also includes some minor repairs and punchlist closeout to conclude the construction contract. Activities such as training, functional testing, and use evaluation, are completed in this step (Bygg21, 2016) to ensure that the goals are met (RIBA, 2020). After completing the turnover, the *operation phase* starts. This is the core of the Facility Management Organization (FMO). Their purpose is to ensure that the operation is efficient, economical, and environmentally-friendly (Bygg21, 2016). Lastly, the *development/termination* phase wherein the end-of-life of the facility is achieved. Here, owners aim to assess the viability of different options such as major renovation, decommissioning, or resell (Bygg21, 2016).

Figure 6 represents the facility life-cycle in relation to the maintenance and development of quality over time. The phases starting from the strategic definition to commissioning and turnover are represented as the project and construction phase. The operations until the development/termination phases are under the operations phase (Management, operation, maintenance, and development). Under the second part, different projects are completed, and the responsibility for taking care of the project output falls to the FM, specifically the Operations and Maintenance (O&M) team. Some of these projects are called building adaptation projects.

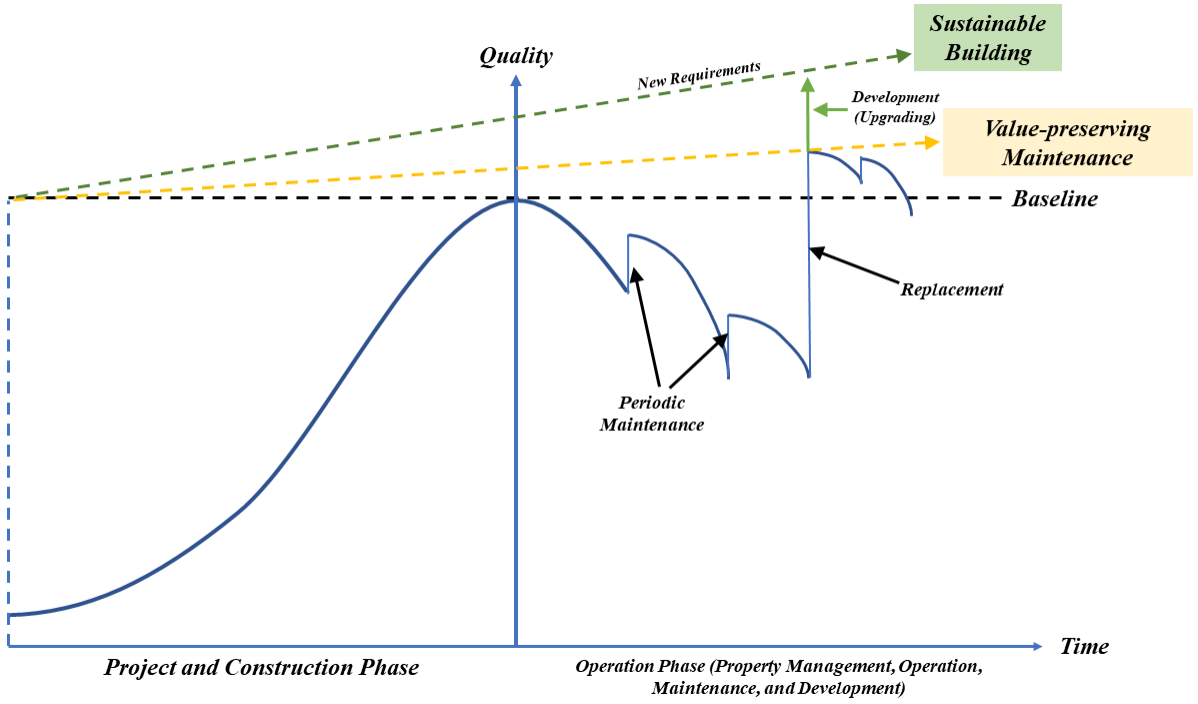


Figure 6: Facility life-cycle and how maintenance and development contribute to sustainable buildings and value preservation *(Adapted from Valen et al. (2011))*

3.2 Building Adaptation Projects

Building adaptation projects are construction activities that aim to improve the building's condition and performance and extend the effective lives of the building (Shahi et al., 2020). These projects are supported as a choice to mitigate climate change, but Ghose et al. (2017) warn project owners about the trade-offs.

It is known that building adaptation projects come in different names such as retrofit, modernization, rehabilitation, refurbishment, renovation, modification, etc. These inconsistencies of use create confusion in the industry. For example, the word retrofit is defined by the Merriam-webster dictionary as follows:

1. *"to furnish (something, such as a computer, airplane, or building) with new or modified parts or equipment not available or considered necessary at the time of manufacture"* or
2. *"to install (new or modified parts or equipment) in something previously manufactured or constructed"* or
3. *"to adapt to a new purpose or need"*

An article written by Ruiz et al. (2021) is titled *"BRB retrofit of mid-rise soft-first-story RC moment-frame buildings with masonry infill in upper stories"*. The article's title is written with the word "retrofit" on it, but the main goal of the study is about building rehabilitation. This is just one example wherein the use of different terms interchangeably may create confusion to readers outside the Architecture, Engineering and Contractor (AEC) industry. Therefore, it is important for this master's thesis to search and follow a logical set of definitions and categorization of different building adaptation projects.

Shahi et al. (2020) created a definition framework for these building adaptation projects. They categorized the building adaptation projects into two main categories, namely, building refurbishments and adaptive reuse. As mentioned in the literature review part, this framework is used in this master's thesis as basis for clear and consistent categorization of the different building adaptation projects. The framework is shown in Figure 7.

3.2.1 Building Refurbishments

Building refurbishments are concerned in the improvement of the existing condition and performance of the building. Refurbishment projects are viable options when the building has reached its useful life or does not perform as planned (Shah Ali et al., 2009). Flanagan et al. (1989) in Shah Ali et al. (2009) noted that these projects are triggered by physical deterioration and obsolescence such as change in technology, social, image, legal and environment.

Retrofitting

Retrofitting is a sub-category of refurbishment projects. It aims to improve energy efficiency and performance by upgrading systems or adding new systems/components to the

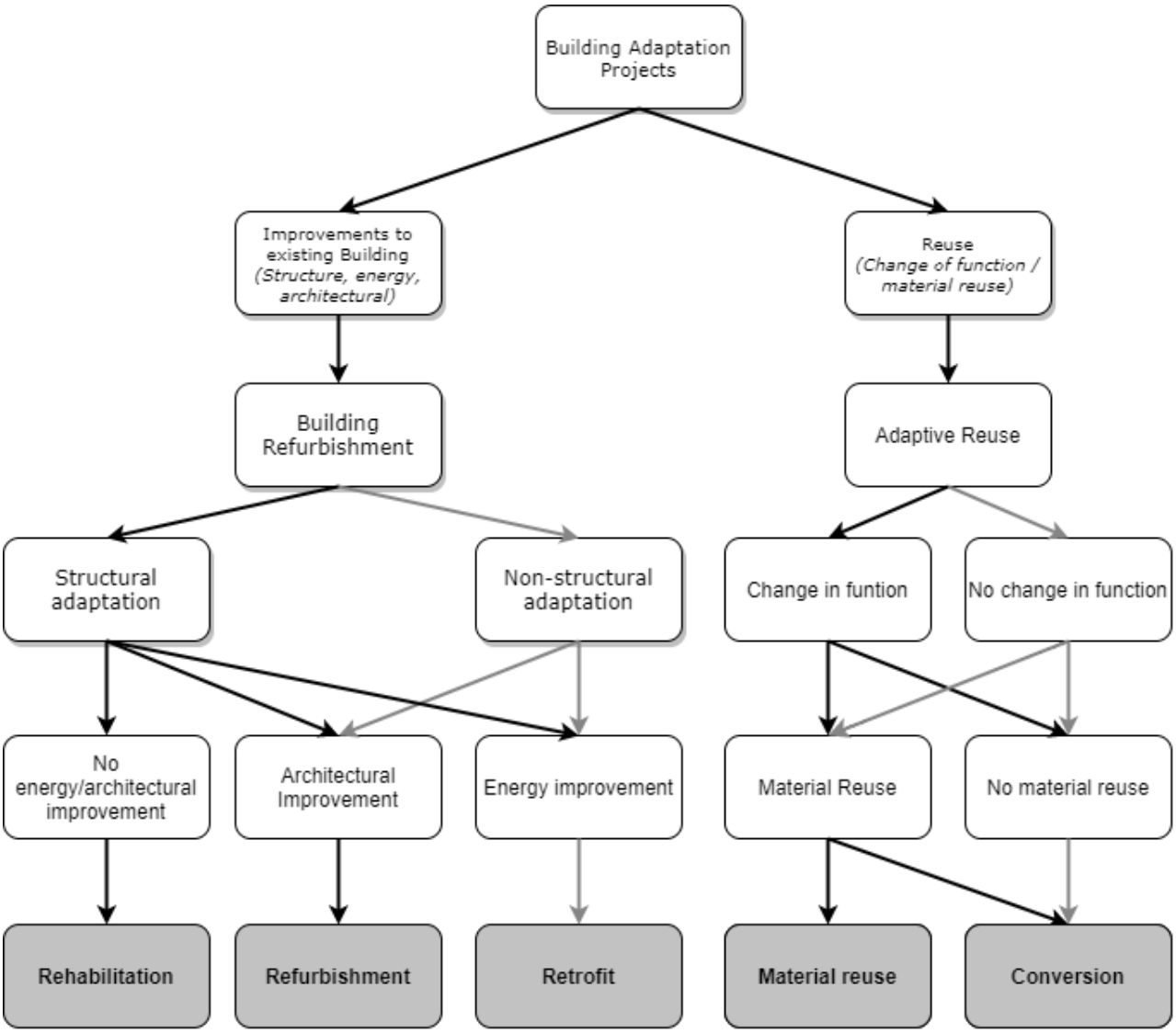


Figure 7: Definition Framework for Building Adaptation Projects*(Adapted from Shahi et al. (2020))*

building (Shahi et al., 2020). Filippi (2015) added improvement of water usage efficiency and performance to the goal of retrofit projects. The scope may be composed of non-structural components e.g. replacement of lighting system into LED lighting and installation of new and more efficient heating or cooling system, and structural e.g. insulation of walls and addition of more efficient windows (Ferrari and Beccali, 2017).

Shahi et al. (2020) further categorized retrofit projects as active and passive strategies. Examples of active strategies are installing a grid-connected photovoltaic (PV) plant, replacing existing heating and cooling plants, installing sensor-activated lightings, and installing a mechanical ventilation system with heat recovery. These are all included in the case study conducted by Ferrari and Beccali (2017). On the other hand, passive strategies include facade refurbishment (Passer et al., 2016) and addition of envelope insulation (Sesana et al., 2016).

Benefits of retrofitting differ from project to project (Ferrari and Beccali, 2017) as they are not one-solution-fits-all (Sesana et al., 2016). Nonetheless, these projects improve maintenance costs, reduce dependence on energy sources, produce better indoor air quality and building comfort, and reduce global warming potential (Shahi et al., 2020; Ferrari and Beccali, 2017; Sesana et al., 2016; Passer et al., 2016).

Rehabilitation

Rehabilitation, another sub-category of building refurbishment, focuses on structures or structural systems of the building. Its aim is to (1) bring back its previously acceptable condition and (2) make buildings safe and habitable by strengthening or replacing deteriorating or damaged structural element (Shahi et al., 2020). One example is the study about renovation strategies such as buckling restrained braces (BRB) conducted by Ruiz et al. (2021). Their aim was to improve the seismic performance i.e. structural strength, of the building.

Some authors write different rehabilitation terms such as energy/energetic rehabilitation (Silva et al., 2021), thermal rehabilitation (Pescaru et al., 2021), and others. To prevent confusion, this master's thesis follows the definitions set by Shahi et al. (2020); therefore, rehabilitation projects mean structural rehabilitation projects and the others may fall into either retrofit or renovation. Renovation is discussed in the next part.

Renovation

Renovation refers to building adaptation projects that target to restore the building's original conditions or improve a building's architectural aspects and appearance for enhanced comfort levels and attractiveness. The scopes of these projects cover both structural and non-structural components of a building (Shahi et al., 2020).

3.2.2 Adaptive reuse

Adaptive reuse is the process of extending the useful life of historic, old, obsolete, and derelict buildings by either (1) changing the function of the building or a part of it, (2) recovering and reusing the existing materials of a building, or (3) combination of both (Shahi et al., 2020).

Conversion

Conversion projects are defined as the process of *converting* the use of an existing building or a part of it into a new one (Shahi et al., 2020; Remøy and Wilkinson, 2012). These types of projects is an alternate choice to building demolition and result in reduced construction waste, consumption of fewer natural resources and raw materials, decreased energy consumption, emission of less greenhouse gas, control of urban sprawl, conservation of embodied energy, improvement of quality of living, and enhancement of property value. The scope of building conversion projects are broader than refurbishment projects which makes it more challenging (Shahi et al., 2020).

In a mixed-method study conducted by Remøy and Wilkinson (2012), they studied five (5) cases in Amsterdam and fifty-one (51) cases in Australia wherein office buildings were converted due to social, environmental and economic drivers, and functional obsolescence. All the cases from Amsterdam were post-war office buildings converted into residential buildings. Some of them were perceived as buildings with architectural character that should be conserved because of their importance in history.

Material reuse

This strategy focuses on the reduction of the amount of material consumption, reusing and recycling existing materials. Material reuse is mainly associated with the process of new construction or with a new addition during a building adaptation project (Shahi et al., 2020).

3.2.3 Benefits and Goals

Continuous change in organizations requires adjustments, refurbishment and the expansion of technical systems i.e. building adaptation projects. This in return, offers high use value to the organization in the operation phase (Artto et al., 2016). These activities are covered by facility development, operations and maintenance management as mentioned in the first part of this chapter.

Sustainability

Building adaptation projects, especially retrofit projects, aims to improve energy performance towards nearly Zero-Energy Buildings, lower greenhouse gas emissions, and decrease operational expenses of the building (Ferrari and Beccali, 2017; Caucheteux et al., 2016). These are done by upgrading a system or adding a new one to the existing facility (Shahi et al., 2020). Reduction of water consumption is also a benefit and goal of retrofit projects

(Filippi, 2015) which can be done by retrofitting existing water fixtures into more efficient units.

Renovation projects or rehabilitation projects are sustainable alternatives to demolition by reducing construction consumption and waste (Thuvander et al., 2012). In terms of socio-economic sustainability, renovation projects in the housing industry improve the social life of the end-users by giving them pride due to the improvement in the attractiveness of the area (Stenberg et al., 2009). Improvement in the quality of life is another benefit achieved from renovation projects (Ferreira et al., 2015). A comparison of a renovation project versus a theoretical new-built replica of a historic building in Portugal showed positive impacts in terms of environmental sustainability while resulting to a negative effect in terms of economical benefits (Ferreira et al., 2015).

End-user satisfaction and comfort

While providing energy savings, retrofit projects also provide better comfort conditions in the living space. An example is the retrofit of building insulation which creates a uniform temperature distribution and better thermal comfort condition. Another is by using flexible heating systems that are easily controllable by users which can lead to improvement in users' psychological feeling and satisfaction (Albatici et al., 2016). Also, in retrofit projects, the use of materials with higher technical performance and a renewed attention to the building windows can bring forth direct benefits from an acoustic, visual, and indoor air quality point of view (Filippi, 2015).

Renovation projects, on the other hand, improve customer satisfaction by improving building's architectural aspects and attractiveness (Shahi et al., 2020) and building comfort (Thuvander et al., 2012).

3.3 Project Management Models

The main focus of this master's thesis is the handover phase of building adaptation projects, but it has to be noted that a project is not just a one-process phenomenon. It consists of different integrated and interfaced processes (Project Management Institute, 2008). Therefore, it is important to discuss the whole picture of project management. Two of the most discussed and used PM methods, namely, Project Management Body of Knowledge (PMBOK) and PRoject IN Controlled Environment 2 (PRINCE2) (Siegelaub, 2004), are discussed below. In addition, a project strategy connected with building adaptation project handover is also discussed in this section.

3.3.1 PMBOK

The PMBOK was published by the Project Management Institute (PMI) to guide actors within the project by setting common methodology and vocabulary for implementation and discussion, respectively (Project Management Institute, 2008). It is a comprehensive framework comprised of five Project Management Process Groups; namely, initiating, plan-

ning, executing, monitoring and controlling, and closing. These processes are integrated and interact with each other as seen in Figure 8. Under these process groups are specific and smaller processes that are categorized by their core technical subject matter called *knowledge areas* (Project Management Institute, 2008).

The five process groups under PMBOK are:

- Initiating process group: includes processes that define a new project or a new phase of an existing project. These are done by gaining authorization to begin the project or the phase.
- Planning process group: are those processes required to establish the scope of the project, refine the objective, and define the approach needed to achieve these objectives.
- Executing process group: are performed to complete the work defined in the project management plan to satisfy the project specifications.
- Monitoring and controlling process group: are the tracking, reviewing, and regulating the progress and performance of the project. They identify any areas in which changes to the plan are required and initiate these changes.
- Closing process group: are processes performed to finalize all activities across all process groups to to close the project or phase formally.

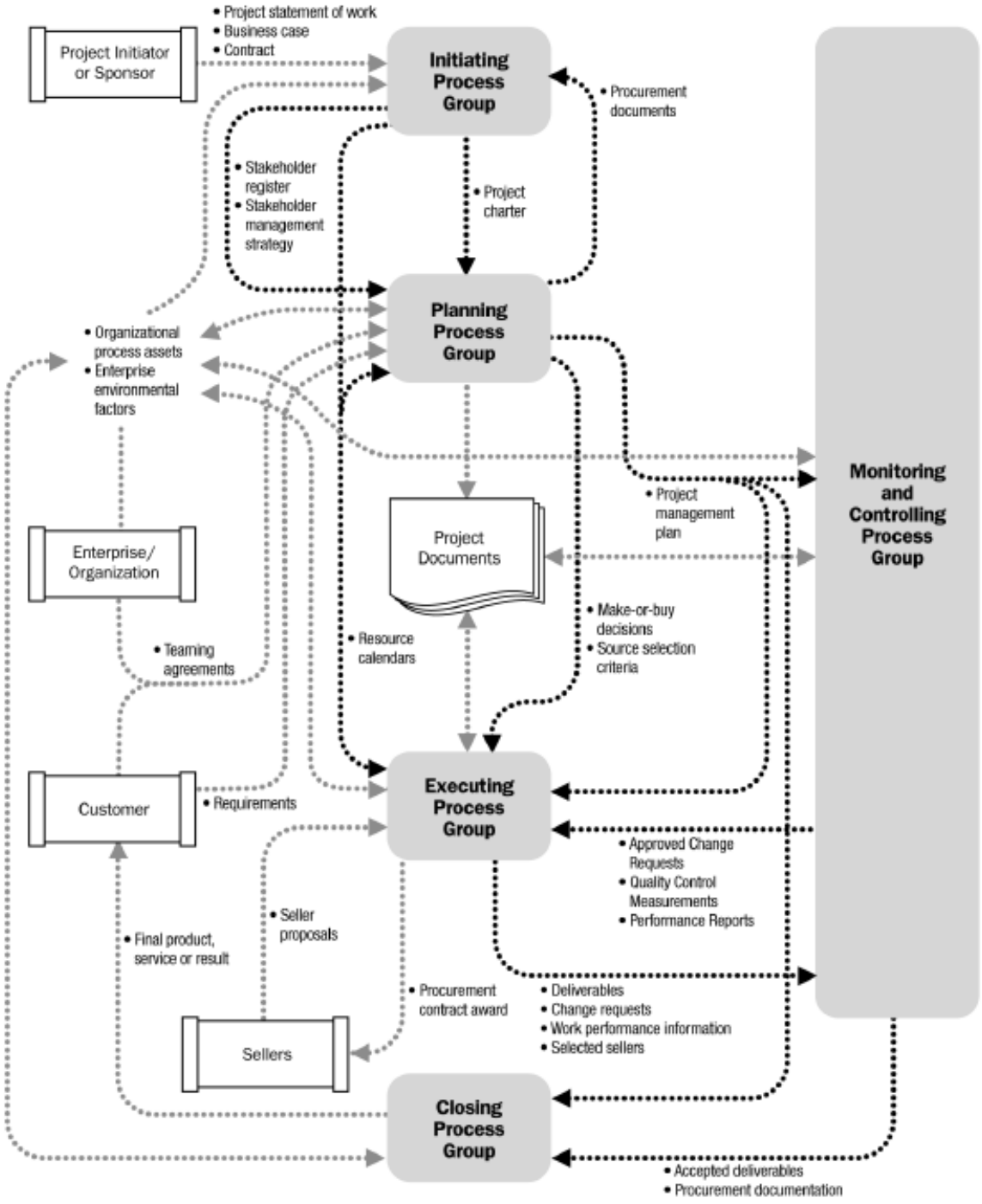


Figure 8: PMBOK's project management processes interaction *(Copied from Project Management Institute (2008))*

3.3.2 PRINCE2

PRINCE2 is the most used project management methodology(PMM) in the United Kingdom(UK), Scandinavia, and Australia, among others (Wells, 2012). It was introduced by the UK government and was initially intended for Information System(IS) and Information Technology(IT) projects (Wells, 2012), but it was later modified to be used in projects in general regardless of scale, type, organization, geography, or culture (Bennett et al., 2017*a*). PRINCE2 is not meant to be prescriptive (Tuttle and Martin, 2018), but some project managers in the field see it the other way (Wells, 2012). A solution to this is that PRINCE 2 should be tailored-fit to the project depending on the level of rigidity or flexibility (Wells, 2012).

PRINCE2 projects are governed by a broad philosophy that guides them throughout their life-cycle irrespective of the changes (**?**). These philosophies are called "principles" in PRINCE2 literature. These principles are: *continued business justification, learn from experience, defined roles and responsibilities, manage by stages, manage by exception, focus on products, tailor to suit the project environment* (Siegelaub, 2004; Tuttle and Martin, 2018; Bennett et al., 2017*a*). A project can not be considered a PRINCE2 project if it does not follow these principles (Siegelaub, 2004).

In addition, PRINCE2 has themes - project management concepts that need to be addressed all throughout the life-cycle (Bennett et al., 2017*a*; Tuttle and Martin, 2018). These are designed and integrated in a way that strengthens the PRINCE2 PMM (Bennett et al., 2017*a*; Tuttle and Martin, 2018). The themes are: *business case, organization, quality, plans, risk, change, and progress.* Some of these themes are comparable with the different knowledge area of Project Management Institute (2008) (Siegelaub, 2004). Table **??** shows the definition of these themes.

Lastly, PRINCE2 follows a set of procedures. All studied literature (Bennett et al., 2017*a*; Tuttle and Martin, 2018; Siegelaub, 2004) define the processes the same way and are discussed below.

- PRINCE2 projects begin with the *starting up process* where a decision maker (executive)/s with sufficient authority to steer the project and a project manager are appointed. The following are also done during the start-up process: Information necessary for the initiation of the project are gathered, project approach is selected, high-level business case and project brief are created.

- The next process is the *directing of the project* which the appointed executive own. His/her responsibility in overseeing the whole project is defined (Siegelaub, 2004). This process also operates all throughout the project. Its purpose is to allow the project board to be accountable for the success of the project by making key decisions and directing overall control while the project manager does the day-to-day management (Bennett et al., 2017*a*).

- Another process is *initiating a project* which occurs only once in the project life-cycle (Siegelaub, 2004). This process is done to establish solid foundations for the project by ensuring that the reasons for doing the project, the scope of what needs to be done,

Table 3: PRINCE2 Themes (Bennett et al., 2017*a*)

Theme	Description	Answers the question
Business case	The project starts with an idea which is considered to have potential value for the organization concerned. This theme addresses how the idea is developed into a viable investment proposition for the organization and how project management maintains the focus on the organization's objectives throughout the project	Why?
Organization	The organization commissioning the project needs to allocate the work to managers who will be responsible for it and steer it through to completion. Projects are cross-functional so the normal line function structures are not suitable. This theme describes the roles and responsibilities in the temporary PRINCE2 project management team required to manage the project effectively.	Who?
Quality	The initial idea will only be understood as a broad outline. This theme explains how the outline is developed so that all participants understand the quality attributes of the products to be delivered and then how project management will ensure that these requirements are subsequently delivered	What?
Plans	PRINCE2 projects proceed on the basis of a series of approved plans. This theme complements the quality theme by describing the steps required to develop plans and the PRINCE2 techniques that should be applied. In PRINCE2, the plans are matched to the needs of the personnel at the various levels of the organization. They are the focus for communication and control throughout the project.	How? How much? When?
Risk	Projects typically entail more risk than stable operational activity. This theme addresses how project management manages uncertainty.	What if?
Change	This theme describes how project management assesses and acts upon issues which have a potential impact on any of the baseline aspects of the project (its plans and completed products). Issues may be unanticipated general problems, requests for change or instances of a product not meeting ins specification	What is the impact?
Progress	This theme addresses the ongoing viability of the plans. The theme explains the decision-making process for approving plans, the monitoring of actual performance and the escalation process if events do not go according to plan. Ultimately, the progress theme determines whether and how the project should proceed.	Where are we now? Where are we going? Should we carry on?

the products to be delivered, the people involved in the decision-making, and others are understood by everyone. These information that set the foundation is written in the Project Initiation Documentation(PID).

- The process *controlling a stage* guides the project managers in their day-to-day basis. In this process, the project manager implements activities such as work approval, information gathering, risk management, situation review, reporting, escalation of issues and risks to the board and possible corrective actions.

- In the process of *managing product delivery*, the work to be performed, report on progress, how to complete and validate the work are agreed upon by the project manager and the technical work teams. This clarifies to everyone(Project manager, team members, suppliers) what needs to be produced and the expected deliverables from them. During this process, accurate progress information is fed to the project manager at an agreed frequency.

- *Managing a stage boundary* ensures that the transition from one management stage to the next is smooth. Here, the Project Manager assures that the completion of the stage is within the requirements, reports to the board, and gets approval to commence to the next stage. One important activity here is updating the business case to adhere to the principle of continued business justification.

- The last process is the *closing of a project* wherein the objectives set out in the original or refined PID have been achieved or that the project needs premature termination due to some events. During premature termination, the project manager must ensure that the work in progress are not simply abandoned but salvages anything of value. In closing a completed project, the Project Manager plans for the closing activities, handover and evaluation of the project.

3.4 Project Handover Challenges and Strategies

The project handover process is a key transition phase from the project team to the O&M team (Zhu et al., 2019). PRINCE2 labels it as *closing a project process*. The purpose is to identify a fixed point at which the project output is accepted and recognize that the objectives written in the *project initiating document* have been achieved (Bennett et al., 2017*b*).

The whole world encounters challenges during the handover phase. In Australia, these challenges decrease the overall performance of buildings (Tan et al., 2018). Forcada et al. (2013) analyzed handover defects from four (4) builder firms and seven (7) residential development projects in Spain. The Danish government recorded 12 Billion Danish Kroner related to building defects, some of which are found in the handover phase (Schultz et al., 2015). Also, in Denmark, Jensen et al. (2019) carried out a case study about knowledge transfer between the PM team and the O&M team. He concluded that knowledge transfer needs to be improved between the two teams. The quality and relevancy of information transferred in the handover phase is paramount for the success of its future use - the building's operation and maintenance (Zhu et al., 2019). Norway is not safe from the list. Firing et al. (2016)

conducted a case study of a shopping mall, specifically its expansion projects and focused on the delays and defects found in the handover phase. These challenges, their causes, and solutions are the focus of the following section.

There are only few literatures that focus on the handover of building adaptation projects; therefore, some of the literature presented are based on studies of whole building project handover. These projects may be bigger than some of the building adaptation projects in terms of scale and cost, but the complexity in terms of documentations and stakeholders are comparable such as the findings of Shah Ali et al. (2009). This is why they were still included in this section.The researched subjects from the literature also formed the basis of the initial codebook that was used for the thematic analysis of the results.

3.4.1 Project output defects

The word defect is defined in the Oxford English Dictionary as a *"lack or absence of something necessary or desirable"* and *"the state or fact of being deficient or falling short"*. Schultz et al. (2015) defines defects as the manifestation and identification of a non-conformance in the performance of a produced physical product. According to Project Management Institute (2008), a defect is an imperfection or deficiency in a project component wherein requirements and needs are not met. These need to be either repaired or replaced. Watt (2007) defined defects as the *"failing or shortcoming in the function, performance, statutory or user requirements of a building, and might manifest itself within the structure, fabric, services or other facilities of the affected building"*. Due to its comprehensive definition, this master's thesis follows Watt's definition.

Different classifications of defects are identified from the literature. Some are classified based on the source while the others are classified based on which phase in the project's life-cycle occur. The latter type of classification from Forcada et al. (2016) is considered in this master's thesis as they present when the defect is discovered. Table 4 illustrates this classification and gives some examples. In addition, most of the literature studying handover defects focuses on social housing as they contain more similarities to commercial buildings i.e. the builder/developer is usually dealing with one professional client (Egan, 1998) in (Sommerville and McCosh, 2006).

Causes

Typical causes of defects in building projects are workmanship, management practices, design problems (Chong and Low, 2006). At the beginning of the project, poor definition of the functional requirements by the clients is also a source of defects (Forcada et al., 2012). In addition, not all details of the project can be anticipated and planned (Schultz et al., 2015). After the handover, design-related failure such as weather impact, impacts from occupants, and loads and moisture from the wet areas causes latent defects to appear (Chong and Low, 2006).

In the quantitative study of building defects in Danish construction conducted by Schultz

Table 4: Classification of Defects *(Own production)*

Classification of Defects	Definition	Example of defects in the literature
Construction defects	Defects that are present in the construction phase which are mainly solved in the construction stage (Forcada et al., 2016) Called "Absorbed snags" in the UK because they are rectified by particular trades as they progress from one task to another (Sommerville and McCosh, 2006)	Structural and waterproofing defects (Forcada et al., 2013)
Handover defects	Defects that are present prior the practical completion (Sommerville and McCosh, 2006) These can also be defects resulting from attempts to resolve construction / handover defects which can be passed on to the post-handover period (Forcada et al., 2013)	Soiled wall from the fixing of water pipe by a plumber (Forcada et al., 2013)
Post-handover defects	Defects that still remains after handing over the project, but are repaired during the liability period (Forcada et al., 2016) These can also be defects resulting from attempts to resolve construction / handover defects (Forcada et al., 2013)	Uneven painting surfaces, nail pops, poor finishes, poor flooring, poorly fixed door and window handles, poorly installed kitchen units, building cracks, poorly fixed toilet/WC, and locks and concreting (Rotimi et al, 2015) Soiled wall from the fixing of water pipe by a plumber (Forcada et al., 2013)
Latent defects	Defects that appear during the in-use phase of the building and are usually difficult to detect due to the time frame it appears (Chong and Low, 2006)	Water seepage in the ceiling and internal wall defects such as plaster cracks due to poor waterproofing which allows moisture to seep in (Chong and Low, 2006) Faster deterioration of building components than expected (Chong and Low, 2006)

et al. (2015), different factors appeared as *influencers* in the causation of defects in building projects. The most significant among these factors are *planning of budgetary conditions, time schedules, and early and continuous control.* In addition, their results indicated that it is easier to achieve less defects in a *design-and-build* contract compared to trade contracts.

Strategies

According to Winch (2009), the project manager's ability to develop realistic plans by use of good planning practice, his/her problem-solving capabilities, and competence in facilitating collaboration are paramount to achieving project success (Schultz et al., 2015). Choosing competent partners i.e. designers and contractors, for a project are also important; but most of the projects are awarded to the lowest bidder (Hardeman and Van der Vlist, 2010) in (Schultz et al., 2015).

Builders have two significant opportunities to rectify defects: the first one is before the handover when inspections happen and the second is during the handover when the defects are noticed by the client (Sommerville and McCosh, 2006). The first opportunity includes commissioning, which integrates design, construction, and operation by testing and reviewing the building's status. Conducting the commissioning late in the design or during construction decreases your ability to implement needed changes quickly and cost-effectively (Forcada et al., 2013).

Understanding the nature and root cause of defects, who detects them, when they arise and when they should be resolved enables organizations to create a quality strategy that they can implement (Forcada et al., 2016). A potential countermeasure identified by Firing et al. (2016) is the continuous control of the project. This was supported by Schultz et al. (2015) in his study wherein they concluded that one significant concept that influences and differentiates projects that have many serious defects to zero / few is the early and continuous quality control. Monitoring of the project performance helps the project team solve issues as soon as it appears (Szentes, 2010).

The qualitative study done by Beste (2020) about Statsbygg, the Norwegian government's key advisor for public construction and property affairs, showed that they were able to minimize project defects at handover by using a process called *systematic completion (SC)*. In 2018, Statsbygg required all construction projects to adapt the process. Systematic completion will be discussed further in the *Document Review* section under the *Results* chapter. It has to be noted though that in the study conducted by Georgiou (2010) showed that government legislation alone cannot solve the challenge related to defects.

In addition to these processes, Chong and Low (2006) propose design-related strategies to prevent latent-defect from happening. Among these are the alignment of construction material performance against poor weather conditions; consideration of occupant impacts and loads; prevention of water leakage; improving specifications; and improving design clarity, details and layout.

3.4.2 Insufficient consideration of end-user/occupants

During the handover phase, designers and contractors have shown little interest in understanding how their buildings perform after the handover phase and teach these understandings to their clients (Way and Bordass, 2005). In addition, even though there are design standards set for different projects, sometimes O&M team still finds that these are overruled in the projects (Jensen et al., 2019). In terms of technological solutions, most often interfaces between different software have not considered the real needs of the end-users and operators (Way and Bordass, 2005).

Causes

One reason for this challenge in the handover phase is that the designers and contractors see the post handover phase as nuisance and clients do not want to pay extra cost for them to stay after the handover to learn together and improve the efficiency of the project (Way and Bordass, 2005). Another is that most of their key people leave even before the handover phase, making it difficult to supply the correct manpower to do so (Whyte et al., 2016).

End-users' lack of involvement in defining the requirements for the project causes a perceived low-quality output by the clients (Forcada et al., 2012). In addition, their behavior hugely impacts the building's performance and resource use, especially in green buildings (Zhu et al., 2019). Kärnä et al. (2009) concluded that the reason for this is that the construction industry lacks the service mindset.

Strategies

The process used by Statsbygg, systematic completion (SC), helps the O&M team save resources for training and corrections after the handover. SC also increases the potential for system optimization and energy efficiency in the O&M phase. Beste (2020) concluded that this might be an effect of good collaboration brought by the process.

Cambridge University used a more extended period wherein the contractor and designers are residents to the project until three (3) years after the "practical completion". They used soft landing wherein learning and sharing feedback covers the whole project life-cycle and is a contractual obligation to the contractor (Way and Bordass, 2005). With these, Soft Landing aims to match the as-built with the expectations of the clients and the users and the design of the designers (Way and Bordass, 2005). It also helps occupanys achieve the best out of the projects and decrease the problems during the handover and post-handover phase (Way and Bordass, 2005). The soft-landing framework will be discussed further in the results chapter under the document review section.

Holm (2000) emphasizes the meaning of both service and product quality in housing refurbishment. He finds that communication with the customers is important and that most tenants are willing to pay a price premium to companies that undertake regular quality controls. Therefore, communication is one of the central quality factors in construction production.

It may well be said that managing a work site involves a great deal of communication in which the contractor's interaction skills play an important role (Kärnä et al., 2009). Proper and timely communication can influence and diminish the problems related to schedule and affect the project's entire customer satisfaction (Kärnä et al., 2009). Lastly, Zhu et al. (2019) emphasized that developing a defect reporting and feedback system can be used to improve the quality of the project output. Another effect that this can produce is better usability and maintainability of a building.

3.4.3 Poor information management

Information is the lifeblood of FM, O&M in particular. This applies to information from delivered project output (Atkin and Brooks, 2015, pg. 301). The quality, efficiency, and reliability of these information are paramount for FM to achieve the performance, sustainability, economic, and operations goals (Cavka et al., 2015). These information also guide future decisions and shape actions within the facility (Atkin and Brooks, 2015, pg. 303). Given the importance of information for the O&M team, poor information management still occurs in facility projects (Whyte et al., 2016). Challenges related to this together with their causes and solutions from the literature are discussed in this section.

3.4.3.1 Poor information fidelity

Poor information fidelity is a significant problem during the project handover phase (Cavka et al., 2015; Zhu et al., 2019). In the study of Whyte et al. (2016), they found out that clients of civil engineering projects in the United Kingdom encounter the challenge of uncertainty with the data accuracy and completeness that are being handed over to them at the handover phase. These happened even when processes are in place. In addition, these inaccuracy requires huge investment from the project owner to correct and use in the operation phase (Cavka et al., 2015). The right information at the right time in the right format will help ensure that an organization is (1) informed and well-aware of what theirs and their end-users need, and (2) can implement decisions timely (Atkin and Brooks, 2015). In the analysis of Cavka et al. (2015) of a university, they found out that even though technical guidelines state the required project documentation, problems with these handed over documents are still experienced in the operation phase. Citing the lack of evaluation criteria for these project documents and lack of manpower from the O&M side to verify as the causes.

Causes

A cause of poor information fidelity is that some of the project life-cycle processes are fragmented and are not integrated across the project life cycle even though coordination is essential. Depending on the project, the required number of requests for information questions and drawings between project managers, architects, contractors, and subcontractors is of great number (Gallaher et al., 2004).

Table 5: Typology of Information *(Adapted from Atkin and Brooks (2015))*

Nature of Information / Data	Definition	Example
Legal	Are information in the form of formal document that complies with the law	✓ Agreements and Contracts ✓ Layout of the facility for compliance i.e. Building codes ✓ Permits ✓ Health, safety, and environmental documents
Commercial	Mainly covers the whole facility and is concerned with the valuation of the whole property and agreements between end-users and landlords including FM	✓ Valuation of real estate (For whole facility) ✓ Insurance policies ✓ Service Level Agreements (SLA)
Financial	Refers to the cost and accounting part	✓ Budgetary information ✓ Purchase orders
Technical	Information and data required for the safe, correct, effective and sustainable operation of the project / facility	✓ Updated as-built information and specifications ✓ Certificate for the repair of defects ✓ Maintenance requirements
Managerial	A more strategic set of data for the seamless operation and maintenance of the project / facility	✓ Human resources documents i.e. roles and responsibilities ✓ Post-occupancy evaluation (POE) documents

Strategies

Atkin and Brooks (2015) wrote a whole chapter about information management in their book. The starting point is to understand the typology of the needed information for the O&M phase of the project. Table 5 shows the definitions and examples of the different types of information.

Due to the challenges in information exchange and management, facility owners were motivated to streamline BIM (Building information model) for O&M. This aims to cut portions of wasted costs from failed information management by creating a more organized method of data storage that are relevant to the O&M team (Thabet and Lucas, 2017). Several literature also have presented potential benefits of Building Information Model (BIM) for information management in FM. Atkin and Brooks (2015) wrote that the application of BIM for building adaptation projects offers great advantage in capturing facility information, managing asset registers and logging maintenance and service data; and at the same time entails significant cost and change. Some of the changes are organization structure, information representation and exchange, and configuration and execution of work processes. These changes are both internal within the organization and external in terms how the project team produce and exchange information (Cavka et al., 2015).

Cavka et al. (2015) developed a framework which can be used to analyze and understand how aligned or misaligned the different components of an organization are to efficiently implement BIM-based information exchange and FM practices. They defined alignment as to the degree to which all components of an organization work together as a system to efficiently achieve organizational goals. Figure 9 shows their framework which is based from strategic alignment model of Henderson and Venkatraman (1993). The three main dimensions are *Organization, Technology and Artifacts*. *Artifacts* represent the building information exchanged which are then stored and accessed using *technology* by the O&M team who performs FM functions using defined organizational processes. They recognized that to perform the handover efficiently, these three dimensions should be aligned i.e. work together and support each other, while complying to the organization's requirements. Compliance to requirements also act as a indicator of how 'aligned' these dimensions are.

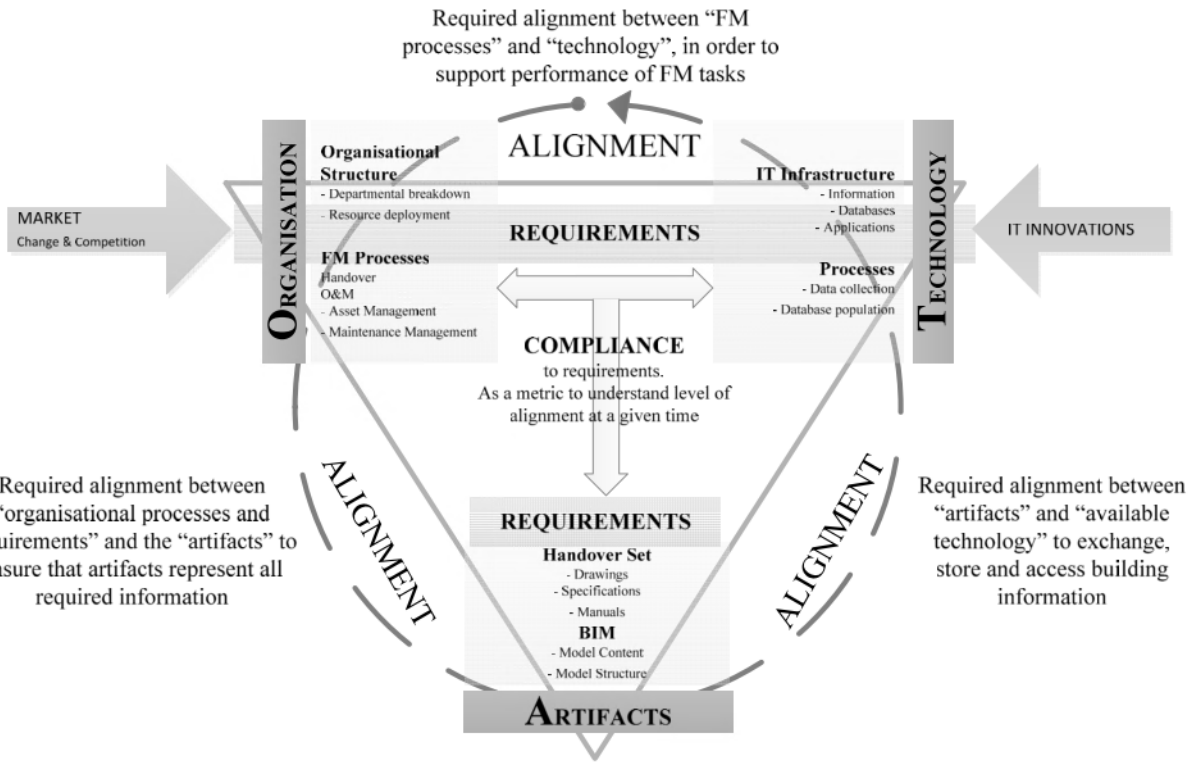


Figure 9: Alignment framework for implementation of BIM for FM*(Adapted from Cavka et al. (2015))*

3.4.3.2 Knowledge transfer

Jensen et al. (2019) conducted a case study about the *knowledge transfer* between the O&M team and project team of the FMO - DTU Campus Service - of the Technical University of Denmark (DTU). He observed that knowledge transfer between the two teams are inefficient therefore encountering challenges in the handover phase. One of these is the discovery of non-compliance with the O&M team's design in the project.

Causes

One reason is because knowledge push from O&M to PM is insufficient. Even though there are knowledge transfer mechanisms, among them is the development of design standards for new and refurbishment projects, these are not fully utilized because of lack of human resource from the PM and O&M team (Jensen et al., 2019).

Strategies

In a study about the transfer of operational knowledge from one facility to another by McBeath and Ball (2012), they highlighted two (2) key areas of attention which may help or block the transfer of knowledge, and three (3) processes for a successful knowledge transfer. The key areas are: *willingness to share information and willingness to receive information*;

while the processes are *explicit data qualification; tacit data capture; and verification*. The start of the process is qualification of explicit data - information that is captured in documents, procedures or instructions - by providing complete and relevant documents, facilitation of transfer by an effective individual from the sharing party, and validation of these data by the receiving party. The second step is the capturing of tacit knowledge - knowledge that are personal and non-articulated i.e. values and perspectives (Jensen et al., 2019) - by means of face-to-face interaction between the parties. Lastly, verification of the transferred knowledge checks if the knowledge transfer is successful by means of audits. Given all these, they emphasized that the foundation of these factors and processes are: *good communication* from the management to the team that requires transfer of knowledge; *good relationship* between the sharer and receiver of information; and *good leadership* to motivate the teams to be willing to share information.

3.4.4 Poor interoperability between BIM and FM technologies

Interoperability is the ability to communicate products and project data electronically between different process systems (Gallaher et al., 2004). While data interoperability is the ability that data generated by any one party can be properly interpreted by all other parties (Shen et al., 2010). Poor interoperability means that the format of the current handover information is inadequate to reuse by others and not conducive to computerized analysis. In the United States of America, an estimated cost of $11 billion per year results from poor interoperability and is borne by owners/operators. Out of this, 85% are incurred during the OM phase (Gallaher et al., 2004). Efficient information integration among different software application throughout the facility life-cycle is paramount for seamless operation (Sadeghi et al., 2019). An example of poor interoperability between the programs is identified in the study of Cavka et al. (2015). They found out that scanned copies were submitted during the project handover which causes difficulty in searching of important information using the *search word* function. This exposes challenges in maintainability.

Causes

One main reason of poor data interoperability is the highly fragmented nature of the construction industry and inconsistency in technology adoption among project stakeholders (Laakso et al., 2012; Tan et al., 2018). These happens when various stakeholders either use a different version of the same software or a different software at all (Gallaher et al., 2004). At times, even organizations are not aware of the types of information they need for the BIM-enabled FM technologies (Cavka et al., 2015).

Strategies

Brooks and Lilley (2006) states that a key in implementing the correct technology is by understanding the context of the organization, both the strategic and operational level. This is in line with the *alignment* framework designed by Cavka et al. (2015) - wherein organization, its technology, and information artifacts should be aligned to reap the benefits from BIM to building operations. The alignment framework can also be seen in Section 3.3.2.3.

to solve the fragmented nature of AEC and FM, Shen et al. (2010) proposed the creation of common neutral model for AEC/FM to enable data sharing or integration in heterogeneous applications. With this, building information can be created once, re-used and enriched in the rest building life-cycle.

3.5 Summary

This chapter started with the presentation of what Facility Management (FM) is together with its different management levels i.e. strategic, tactical, and operational. The strategic level is the level that sets the direction for the organization. The tactical level creates the workable plans based on the targets set at the strategic. The operational level is concerned with the actions to perform the procedures written by the tactical level.

The different disciplines under FM were also discussed under this section. These are facility development, operations and maintenance management. Facility development is the upgrading of the building's value overtime by means of building adaptation projects; operations management ensures that the value of the building is served to the end-users; and maintenance management is done to protect the value of the facility's assets.

The third part of the section was about the facility life-cycle where the different processes in the life-cycle were discussed. It also showed where the building adaptation projects happen in a life-cycle of a facility.

The next section clarifies the meaning of building adaptation projects. It was based from a definition framework created by Shahi et al. (2020). Building adaptation project has two main types; namely, building refurbishments and adaptive reuse. Under building refurbishment are rehabilitation, refurbishment, and retrofit projects. While on the other hand, adaptive reuse is comprised by material reuse and conversion projects. Each of them has their own unique difference, but they can also overlap in a project which means that one project can be a refurbishment and retrofit at the same time. Most of the time, these type of projects aim to improve sustainability of the facility and improve its end-user satisfaction and comfort.

The third section presents two of the main project management models used in the industry. These are PMBOK and PRINCE2. The overview of both these models were presented as well as key themes that the models are based from.

The last section gathered previous findings from the literature about the project handover challenges experienced in the AEC *(Architecture, Engineering and Construction)* industry plus the strategies used to address them. Figure 10 displays a summary of this section. The main four challenges are project output defects, insufficient consideration of end-user / occupants, poor information management, and poor interoperability between BIM and FM technologies. Figure 10 creates a color coded representation of its causes and the solutions to address them.

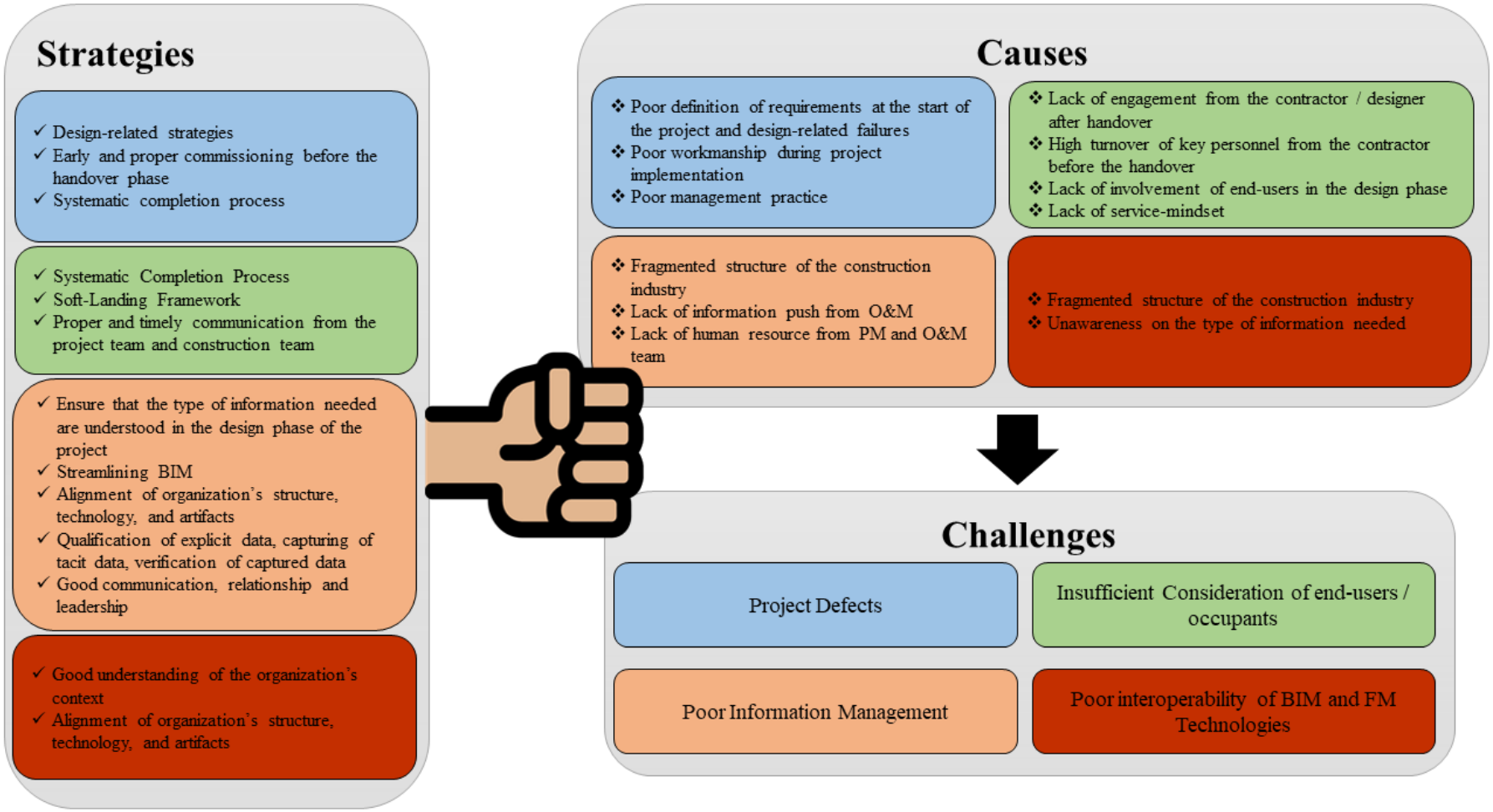
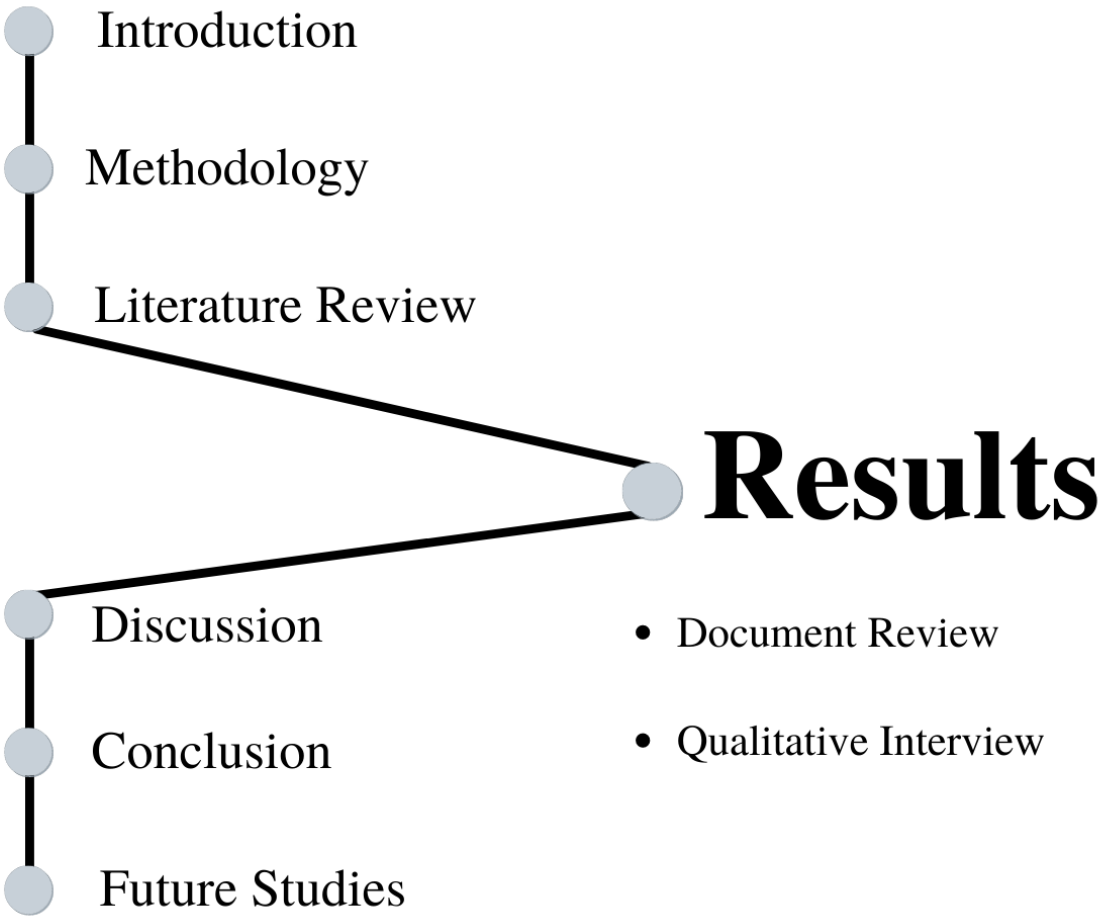


Figure 10: Summary of the challenges in the handover phase, their causes, and strategies to address them *(Own production summarized from the literature)*


Introduction
Methodology
Literature Review
Results
Discussion
Conclusion
Future Studies
Document Review
Qualitative Interview

4 Results

4.1 Document Review

This section presents the processes in the handover based from the organizational documents, international and national standards, and national guidelines. These standards further the knowledge about the processes connected to the handover phase of building adaptation projects and explains existing strategies to decrease the challenges encountered in the handover phase.

4.1.1 Systematic Completion

In this master's thesis, two main documents were used to analyze and discuss systematic completion, namely, BA2015: Systematisk Ferdigstillese Veileder (Johansen et al., 2016) and PA0701: Systematisk Ferdigstillelse (Statsbygg, 2018). BA2015 is a public document written by a collaboration of different Norwegian companies, research organization and academic bodies. It is written as a generic guideline for all the actors in the project. PA0701 on the other hand is a publicly published document by Statsbygg, the Norwegian government's building commissioner, property manager and developer (STATSBYGG, 2019). It contains specific tasks and required documents that must be accomplished during the period of the project. PA0701: Systematisk Ferdigstillelse is based from the principles of BA2015: Systematisk Ferdigstillelse Veileder, therefore it will be discussed first.

Systematic Completion is inspired by project management methods such as agile and lean. It is defined as *"an assurance that the project meets all functional requirements within given time, cost and quality requirements, planned and verified through a structured process that is management-controlled from planning to takeover"* (Johansen et al., 2016, pg. 8). It is a continuous process that starts from the early phase of the project and until the handover phase (Statsbygg, 2018) just like what is shown in Figure 11. Its main goal is to ensure that the building project are completely tested, achieves the expected quality and functionality the client asked for, and delivered to the client on time (Statsbygg, 2018). According to BA2015, with the use of Systematic Completion from the beginning of the project until handover, projects will achieve better detection of project defects before operational phase; better project quality; near accurate project operating cost; good documentation; better involvement and training for the O&M team; and satisfied end-users.

BA2015: Systematisk Ferdigstillelse Veileder (Johansen et al., 2016)

It is important that the Systematic Completion methodology is properly described in the project documents such as the project tender and project charter. Using the Systematic Completion should also be part of the success criteria for the project. It has a clear focus on the project output which makes it easy for all the stakeholders to achieve alignment about the project i.e. understanding what the output of the project is, its goal, when it must be delivered, stakeholder responsibilities. In addition, it emphasizes the importance of the

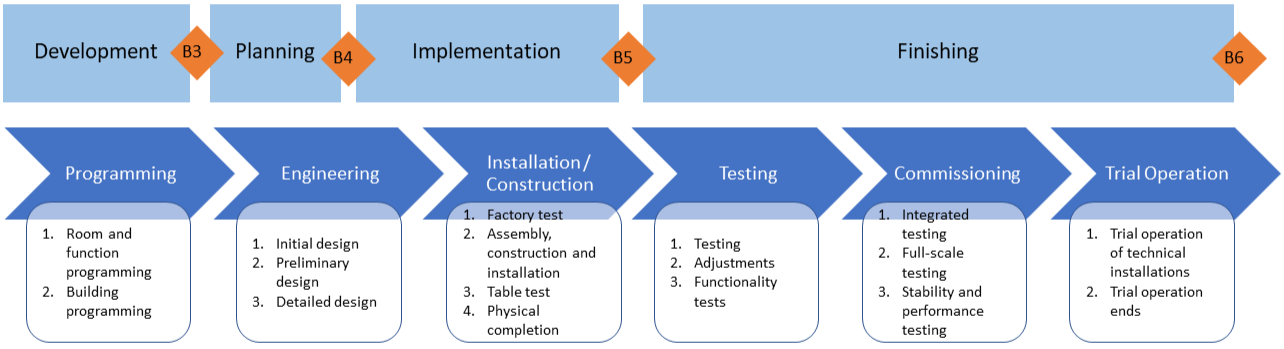


Figure 11: Typical process for systematic completion *(Adapted from Statsbygg (2018))*

acceptance criteria for the different deliverable from the design phase, construction phase, and testing and verification of the project. In other words, the project cannot move from one activity to the next one if the acceptance criteria are not satisfied.

In order to achieve the best benefits from Systematic Completion, BA2015 enumerates three elements that are important to be present in the project. The first one is that leadership or management should support the process right from the start of the project. This will help spend the necessary resources at the correct project phase, motivate project stakeholders to comply with the processes, and involvement of the correct stakeholders happens at the right time. The next element is the competence of the stakeholders associated with the project. Competence about the project features, technical solutions, and planning and organizing the project processes. Interdisciplinary expertise is also part of the needed competence when using Systematic Completion in a project as it sees and uses holistic solutions while involving all disciplines. The last element is a good system in the project which is supplemented with necessary information management tools. This system establishes sets of plan for the implementation of Systematic Completion wherein the main focus are: establishment of clear requirements for document deliveries and its quality assurance, description of requirements for the different systems in the project, establishment of early control of the first production and eliminating errors before implementing the solutions, establishment of test plans with methodologies, communicating this test plans to all actors in the project, implementation of training plan for the operation personnel, and definition of requirement in the trial operation.

PA0701: Systematisk Ferdigstillelse (Statsbygg, 2018)

PA0701 focuses on four main project processes, namely; planning and design, execution, testing and training, and trial operation. Under the planning and design, it is important to prepare a design and test plan that forms a basis and ensures that the tests are conducted all through out the phase of the project not just at the end. When creating the design and test plan, it is also important to take note of the following:

1. The geometric design of the building should fit together with how the technical systems function
2. The order of tests that should be conducted
3. How the technical systems i.e. ventilation system, electrical system, etc., are designed and constructed to serve / supply the areas that will be tested first
4. Technical support systems that supports the other systems that will serve the areas i.e. Information and Communications Technology and Building Automation System
5. Order of construction of the area / floors / system

PA0701 also enumerates the important documents that must be prepared and accomplished during the design phase. The responsibility for delivering these documents depend on the contract method of the project. By preparing these documents, there will be a good overview of all the details about the project such as technical systems and their function, and how and when should they be tested. During Systematic Completion, these documents also serves as a criteria before proceeding with the next project activity. Table 6 shows the documents and their description.

At the start of the execution phase, project managers from the owner side should lead a review of all the controls of the plans, specifications and drawing / models together with the designers and contractors. This is to achieve alignment of everyone about the tasks, to act as knowledge transfer from the designers to the contractors, to review the administrative tasks in the project, to assist in the finalization of the detailed progress plan, to establish long-lead time items list, to update and optimize the functionality specification based on the awarded contractor or products, to update the document and delivery plan for the construction phase, and lastly to ensure that everyone understand that systematic completion is ongoing all through out the project. Before all the equipment or materials are procured, a test called table-test should be done. One table-test should be done per system and another one to check the integration. Table-test are theoretical tests that checks and verifies every system that is included in the project. This is also the final step in the engineering that aims to reveal errors or missing items in the project (Beste, 2020).

During the execution phase, the project manager conducts periodic quality checks in order to ensure that the project is conducted with the thought of zero-failure, rational progress, and early testing. The contractors report the following degree of completion to the project manager: the system is physically mounted in the area, the system is finished with all the

Table 6: Overview of documents in the design phase *(Adapted from Statsbygg (2018))*

DOCUMENT NAME	DESCRIPTION
Commissioning plan	Plan that shows the desired order in which the project is to be completed, tested and used. For example, in a rehabilitation of a building, the desired order on which floors should be rehabilitated is included in this plan. This will help prepare the design strategy with the possibility for early testing.
Document and delivery plan	Plan that is agreed by all parties which states all the documents that should be produced for the project and the schedule when they should be delivered
Interdisciplinary systems list	An overview of the systems that will be supplied for the project. This forms the basis for the overall specification of the technical infrastructure, functional specifications, and interface matrix.
System and function specification for the technical systems	Defines the required functionality of the different systems included in the project. It also sets the expectation how it will work after installation. This will be the basis for the design, execution, and testing and verification.
Systems form for the technical systems	Architecture of all the systems in the project together with their components.
Components list	List and description of components per system. Each system i.e. electrical, mechanical, etc., will have their own component list.
Capacity and functions table	An overview of all the capacities and signals that all the components uses. The purpose is to understand how the loads and signals a
Interface matrix	Document that shows the interfaces between different project systems. This include the parties responsible in ensuring the interfaces work from project design to operation. The purpose is to ensure that the responsibilities for the interfaces are included in the project contract.
Integrated functional specification	A document that describes how the different systems interacts functionally together. This forms the basis for integrated functional testing.
Test plan	Overview of which systems should be tested, who is responsible for planning and executing the tests, and schedule of the tests. This ensures that the rights systems are tested at the right time.
Test procedures	This is the document that states how the systems should be tested and the acceptance criteria for the test to be declared as successful.
Training plan for the operations team	Plan that shows when and how the training for the operations personnel will be carried out. The purpose is to ensure that the operations team will be competent enough to operate the output of the project.
Plan for trial operation	Plan that states details about the trial operation such as when and how they will be conducted.

connections, the contractor has completed their own system functionality test, the system has been adjusted, the operations and maintenance documents are downloaded into the O&M system, and notice that the system is ready for the joint functionality test. The agreed O&M documents should be delivered minimum ten (10) working days before the functionality test. Both the contractor's and joint system functionality test identifies if there are defects that needs to be rectified by the contractor. These defects are registered into a database which will be used to follow up the repair of these defects. After the physical completion, the update drawings and models should be delivered by the contractors showing all the agreed deviations.

Early testing in the whole project is central to systematic completion. As mentioned earlier, the first test is the table-test which is theoretical and gradually, practical tests i.e. functionality tests, integration test, full-scale test, and stability and performance test. The phasing of the practical tests depends on the completion of system installations physically. Part of the documents required in the design phase is the test plan which maps the schedule of tests and shows how early the tests can be done. Early testing identifies defects early which will result to early repair. All the agreed tests written in the tender document should be reviewed and accepted before moving on to the next phase of the project. These are documented through test reports. The test reports include date and duration of the test, parties responsible for the test, scope of the test, basis documents (Systems document, functional specifications, adjustments protocol, etc.), test procedures, test results in conjunction with target results and acceptance criteria, and list of defects. Whether or not the tests will be repeated depends on the seriousness of the defects.

Another central principle in the systematic completion is the relevant involvement and training of operations personnel. Systematic completion emphasizes the importance of the operations team having the knowledge about the system and are comfortable using these solutions. Three sets of training include the end-users and operations team. These are the theoretical training which is the table-test, participation in the tests, and practical training sessions. The basis of these training is the training plan created in the design phase.

4.1.2 NS6450:2016 Idriftsetting og prøvedrift av tekniske bygningsinstallasjoner

The Norwegian Standard NS 6450:2016 (2016) - Idriftsetting og prøvedrift av tekniske bygningsinstallasjoner or commissioning and test operation of technical installations in english is a supplementary standard for Systematic Completion (Statsbygg, 2018). The purpose of the standard is to produce a clear description of the processes needed in order to complete a successful commissioning and trial operations of technical installation projects, regardless of the contract.

The commissioning phase is where the full-scale test is conducted after the integration test across the different systems included in the project. Both training of operations personnel required before and after the handover phase are conducted and planned on this phase. During these tests, it is recommended in the standard that the operations team join and

participate in these tests. It is also recommended that different alarms or real-life scenarios are simulated together with them in order to achieve the best possible knowledge transfer. After the full-scale test, stability and performance tests is done without the the users in the building. All agreed tests should be accomplished and documented, serious defects should be fixed / corrected, and the supplier has confirmed that the next phase can start before moving on to the *prøvedrift* or trial operation.

The *prøvedrift* or trial operation is accomplished in order to confirm that the project's specified requirements for performance, quality, functionality, capacity and stability are achieved with near actual operation i.e. end-users are already using the project output, all the climatic factors are experienced, and operations team operates the project output. This phase is also conducted to adjust and optimize the new systems while transferring the knowledge to the operations personnel. The length of this phase depends on the project or systems installed. It spans from three (3) months for light control system and access control system to twelve (12) months for Building Automation and Control System (BACS). In addition, evacuation drills are carried out during this phase for applicable projects.

The client / project manager and the contractor / supplier have an active role during the commissioning phase and the trial operation. During the commissioning phase, detailed test plans are created by the contractors and submitted to the client ahead of time - recommended is at least three (3) months before the first test is to be conducted. The client / project manager should participate in tests in accordance with the agreed plans. All significant defects in performance or quality are documented and rectified and new tests should be conducted. The documents submitted by the contractor are checked and confirmed by the client / project manager.

During the trial operation, both parties i.e. client / project manager and contractor / supplier, records unwanted incidents and defects. The main responsible for the recording is the operation personnel who operates the system. They ensure that the suppliers / contractors are informed about these incidents / errors. On the part of the supplier, they conduct regular visits and check-ups of the system. These visits should be documented by the supplier together with the rectification of the defects that are found in the trial operation.

NS6450:2016 also states some recommendations of items that should be included in the tender for the trial operation to be successful. The tender document should state who will be responsible for the trial operation. The schedule of the handover phase should also be cleared out, whether it should be before or after the trial operation.

4.1.3 NS3424.E:2012- Condition survey of construction works Content and execution

NS 3424.E:2012 (2013) is the english translation of NS 3424:2012 - *Tilstandsanalyse av byggverk Innhold og gjennomføring*. The general purpose of the standard is to serve as a tool in checking the condition of construction works in relation with a set reference in order to

reduce or repair nonconformities. Nonconformity is defined as the quality or status worse than the set reference condition.

Based on the standard, there are three levels of surveys - levels 1 to 3. These levels are determined by the scope, aim and extensiveness of the survey. Risk assessment and preliminary inspection can be made in order to identify the scope and survey level that needs to be accomplished.

Level 1 consists of visual observation combined with measurements that can verify information on the condition, and review of documents that are significant for the task. This level is done to gain a basis for rough cost estimation for maintenance, repair, renovation, and long-term budgeting. The next level is Level 2 which consists of a more close-up and comprehensive measurement and investigation. It also covers review of documents such as drawings. The purpose of this level is to have a basis for a detailed cost estimate for the maintenance, repairs, renovation, and long-term budgeting. This can also be done for organizations to assess damages or nonconformities that are discovered and add to the basis of alteration. Both levels 1 and 2 are surveys of a general nature. Level 3 on the other hand is of a special nature which normally covers selected construction work, part of a construction work or specific concern. This level includes accurate measurement or test methods as well as laboratory examination when necessary. This is usually done for damage valuation and basis for replacement and refurbishment.

4.1.4 Soft Landing Framework

The Soft Landing Framework was born from the experience of its author Mark Way. These are experiences connected to problems he had during the post-handover of building projects (Way and Bordass, 2014, pg. 8-9). The aim of the framework is to smoothen the transition of building construction or adaptation projects from the project team to the operations team and to address the common problems that the post-occupancy evaluation (POE) discovers i.e. misaligned performance of the designed and actual project (Way and Bordass, 2014, pg. 11). With this in mind, Mark Way and Bill Bordass with the help of different organizations such as Building Services Research and Information Association (BSRIA) and Usable Building Trust (UBT) created the Soft Landing Framework.

The framework is created to supplement existing project processes, and not to replace them. It provides additional support throughout the project management stages especially in the project briefing, design development, pre-handover, initial period of post-handover, and after-care - two to three years after project handover (Way and Bordass, 2014, pg. 11-12). The next paragraph briefly explains how the framework functions.

In the project brief, it is paramount that the client's expectation and performance targets are gathered. They should be based from a well-structured, logical and recorded context. Roles and responsibilities should also be clear (Way and Bordass, 2005). During the design development, it is important that everyone understands that Soft Landing is in operation

and commit to adopting its principles. This can be done by: clearly defining roles and responsibilities on the onset to highlight any gaps; conducting workshops in the briefing and early design phase to align everyone about the project; create a systematic sign-off gateway to fix decision makings; setting up clear and measurable performance targets; including FM in the design phase so that solutions can be designed relative to their capacity; and if possible, creating incentives for the contractors when the performance measures are achieved after the handover phase (Way and Bordass, 2005).

Weeks before the handover phase, different plans and activities should be completed in good time. Among these are operation readiness programme, commissioning records check, maintenance contracts, training of the O&M team, O&M manual review, and provision of aftercare team home. Right after handover starts the aftercare period. During the initial aftercare, the contractors / designers creates a team that will reside in the building to help the end-users understand the building's system and how it works and operates. The team of contractors / designers will stay in the building to provide support and help with problems that will arise. Little by little, the presence of the team diminishes as the O&M team has adjusted to the building's system. Once the initial aftercare period is over, periodic reviews will be done together with the contractor / designers. The aftercare period lasts three years after the handover phase. Year 1 of the aftercare focus on ensuring that the design intent is well understood, identifying any problems, logging of usage and change, and necessary system fine-tuning. In years 2 and 3, periodic reviews become less and will focus on recording the operation of the building and reviewing performances (Way and Bordass, 2014). There is a newer version of the framework titled "Soft Landings Framework 2018: Six Phases for Better Buildings." This version changed the use of the term "stage" into "phases" to emphasize that the framework is not connected with any plan of work, but rather it is a group of processes. Another change is that they separated the design development stage into two, which are the design phase and the construction phase (Way and Bordass, 2014).

4.2 Qualitative Interview

This section presents the results gathered from interviewing project managers and operations and maintenance personnel from both public and private companies. It starts with the different project models used by the interview objects. This is followed by the roles and responsibilities of the two main stakeholder groups, project managers and O&M personnel; their definition of the handover phase; challenges they experience in this phase; and the strategies or solutions that they are already using to address these challenges. The rationale as to why these are chosen to be written are explained in every first paragraph of each subsection.

4.2.1 Project Models for Building Adaptation Projects

As mentioned earlier, projects are not just a one-process activity, it consists of different integrated and interfaced processes as seen in Figure 8 from the Project Management Institute (2008). This subsection provides the different processes captured from the interview objects, especially the project managers, to give an overview of the whole activity. These processes are interconnected and can possibly point towards some root causes of the challenges encountered in the handover phase. The data were taken by asking the interview objects what the typical processes in implementing a building adaptation projects are.

Figure 12 displays the compiled project models from the interview objects. It can be seen that there are differences as well as similarities, but overall, they follow the processes suggested by PMI Project Management Institute (2008): Initiate, Plan, Execute, Monitoring and Control, and Closing.

4.2.1.1 Project and Construction Phase

When asked, PubCom3.PM follows their internal project model. This is shown in Figure 12. It is a detailed model that starts from end-user requirements followed by different investigations and analysis e.g. feasibility study, alternative analysis and requirement analysis.

According to PubCom4, a rehabilitation project starts with planning and development. It is somewhat the same with PubCom1 where they have a section dedicated in developing the projects - *Seksjon for plan og utvikling*. This section creates the document called *project mandate* wherein a general overview of the project is written e.g. requirements and budget. For PrivCom2, they start the projects planning with their O&M Team. The O&M team serves as their initial advisor to the project as their needs are discussed together with the project management team. PrivCom1.PM served as a consultant in the initial phase of the project. They conducted feasibility studies and analyzed different alternatives for the owners of the building to choose from. PrivCom3.Con's answer, being the consultant, supports PrivCom1.PM's statement as he suggested that discussing the strategy of the project with the client at the start of the project is very important. He does this by asking the client:

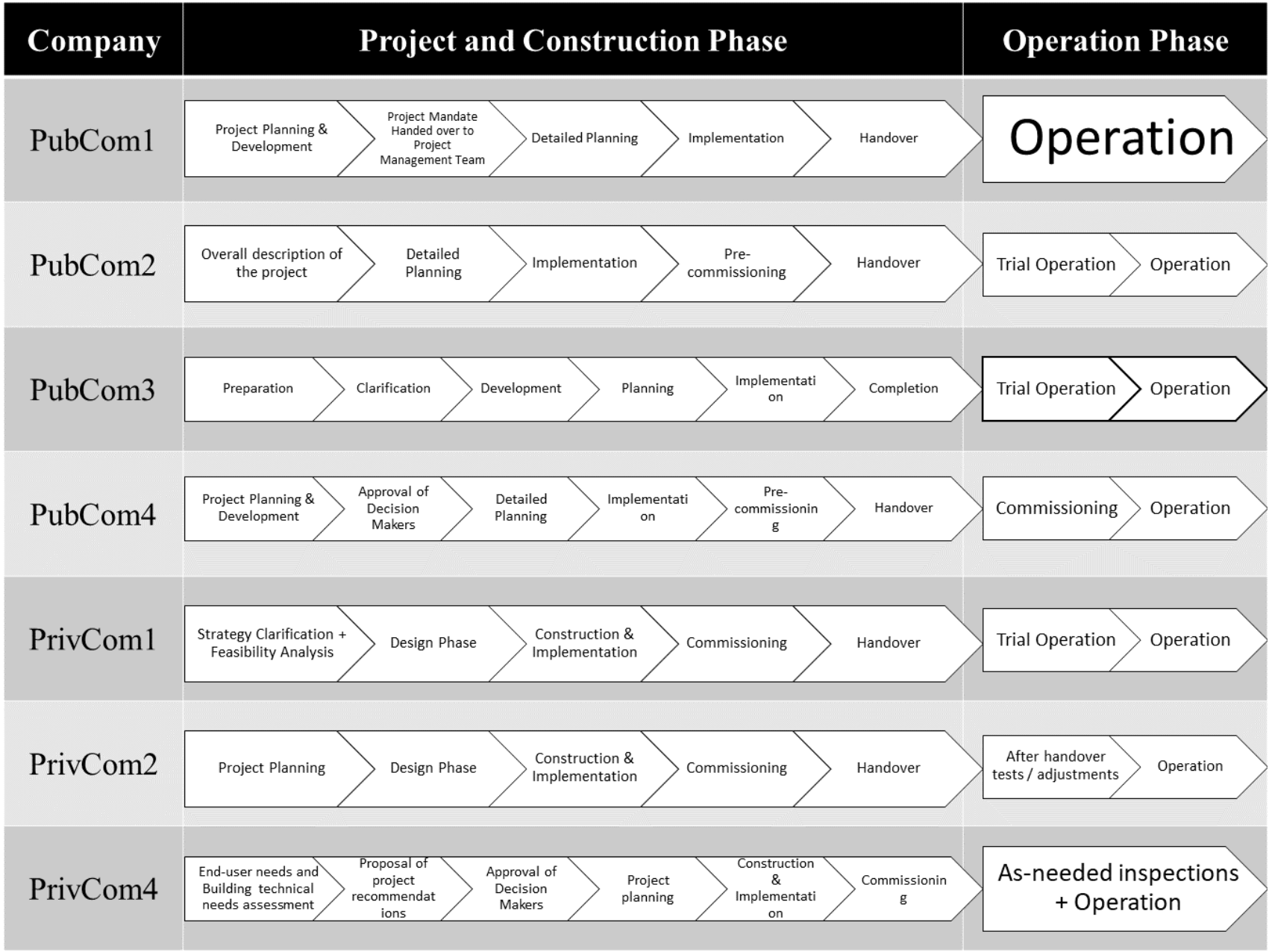


Figure 12: Project models from the different interview objects *(Own production)*

"What output do you want from the project? What is the value of this project for you? Is it to refurbish it and then sell it to highest price then I have to refurbish it for the lowest price possible or are you going to rent it out long-term?" - PrivCom3.Con

Right after identification of strategy, PrivCom3.Con stated that he will conduct adaptability analysis - checking the level of adaptability of the area / building; and condition analysis which follows the Norwegian standard NS 3424.E:2012 (2013). As seen in the previous section, NS 3424.E:2012 (2013) states the different level of condition analysis in order to fulfill different goals. He relates this to an analogy with the doctor looking for the problem in a patient:

"I can compare it when you go to the doctor, they conduct simple tests like blood pressure and other simple measurements and they can tell you that you have to take these medicines. But if the doctor cannot find the problem, he has to call for a specialist, which is the same with the next level (of condition analysis)."

The results from the adaptability analysis and condition analysis form as a part of the requirements for tender document for the contractors. In addition to this; the other companies i.e. PrivCom1, PubCom4 and PubCom1; conduct detailed designing. PubCom 3 and PrivCom1 together with their designers invite their own O&M team during some of the meetings. This depends on the agenda of the meeting or when they think they need the input from the O&M team. Furthermore, PrivCom1 invite their O&M team and clients into workshops outside the design meetings. The reason behind the workshops are two-folds: (1) their O&M team cannot attend all the meetings that they were invited to because they have to prioritize other scope of works, and (2) their goal is to present, review and verify the concepts of the design with the O&M Team and client. For PubCom1.PM, they use the expertise of 3rd-party consultants during their detailed design to help them with the design and confirm the documentations needed to be delivered by the contractors during the handover phase. When asked if they also invite their O&M team, he answered that they do not invite their O&M that much in the design phase because they already use their internal building standards which contains all the requirements of their O&M Team. O&M team are only invited for bigger projects.

When the contracts are finalized and awarded, the companies proceed with the construction period. During the construction period, especially in the end phase, the O&M teams of the different companies interviewed join the testing of the technical installations and training. This was evident in the interview with PubCom4, wherein they invite their O&M team in kick-off meetings before the handover. In their kick-off meetings, they decide on the schedule of the remaining activities such as testing, trainings, inspections and handover. Part of these remaining activities is the submission of the required O&M documents as well as checking and approval.

Because the handover phase is the focus of this master's thesis, the next subsection is dedicated in showing the results of the interview about the said subject. The different processes and key points from the different interview objects are presented below.

4.2.1.2 Handover Phase

For PubCom3.OM, the handover phase is not just the delivery of the project output and documentations to the facility managers / O&M, but is a continuous phase that starts early in their project model.

"It is normal to think that handover itself is at the end of the project phase, but handover planning starts early in the project model and would deliver the building to FM at the end of the project." - PubCom3.OM

It starts with properly planning the trainings and deliverables for the O&M team just like what PrivCom3.Con stated in his interview.

"...you have to prepare for the handover. I think there are two things that are important. The first is, to define what kind of documentation you want to have for the operation and maintenance of the building ... The next thing is to have training program for the people who will conduct the operation and maintenance of the building..." - PrivCom3.Con

There are two types of handover for PrivCom1. The first one is the handover from the contractor to their company while the second is the handover from them to their tenants. The first handover is the one relevant to this master's thesis thus it was the one discussed during the interview. It mainly consists of three elements; namely, testing of installations with the O&M team, physical audit / checking of installations with the PM Team, and verification of all documents. Their handover starts from the commissioning phase where their O&M are included in the technical testing done by the contractor. The goal is to learn how the systems work plus what are the failures that may happen during the operation. In a sense, the handover as a phase continues until the first year after the handover as a process. This means that for them, they collaborate with the contractors even after that handover as a process in order to test and adjust the building with the contractors. The contractors are not in-house, but joins them in a monthly meeting wherein issues and concerns both from the O&M team and their clients are raised.

For PrivCom2.PM, the handover phase depends on the physical completion of the installations / project. After the completion are the tests and depending on the project, they can conduct the tests per zone / gradually. Formally, the handover phase is the date when they conduct the handover inspection and the operations manager confirms that the system installed is working. In addition to these, they continue with the testing after the formal handover and the moving in of the end-users / tenants. The goal is to adjust the operations of the new system to the operation of the end-user e.g. adjusting of ventilation. This testing after the moving in of tenants lasts from a few weeks until a year depending on the size of the project.

PubCom1.PM describes their handover as the date wherein the handover documents are signed and the date of warranty starts. The responsibility to contact the contractors if there are problems with the system / project output is also transferred to the O&M. PubCom1.PM further states that their handover is somewhat a silent agreement between

their department and the O&M department on when the project output are taken care of by the O&M department. This is because they do not have a formal agreement as to which point in the project completion should the O&M take over. This forms one challenge that is shown in the latter part of this chapter.

"It's sort of a silent agreement. Sometimes we just hand it over to them and hope for the best. This is something to be solved in the management level not us the project managers or the people in the OM Team." - PubCom1.PM

PubCom4 conducts two handovers. The first one is the handover from the contractor to the project management team and the second is the handover from the project management team to the O&M team. This happens on the same day according to PubCom4.PM. In addition, PubCom4.PM mentioned two other main activities done before and after the handover that are relevant to this master's thesis. The activity before the handover is the pre-commissioning wherein individual tests of the systems installed. It starts usually 6 months before the planned handover and with a kick-off meeting with the contractors, O&M team, and the end-users. The kick-off meeting is done in order to plan the activities like tests and inspections before the handover. The other activity is the commissioning which is done after the handover. Commissioning according to him is the whole systems test.

4.2.2 Roles and Responsibilities in Building Adaptation Projects

This section takes note of the different roles and responsibilities of both the Project team and the Operation and Maintenance team. By taking a look at the tasks of the focused actors in this thesis, it may be possible to search for the gaps that may be causing the challenges experienced in the handover phase. The following paragraphs states the different roles, tasks, and responsibilities that appeared from the interviews.

4.2.2.1 Project Team

The interview objects from the project management side identified their teams' task is to be the coordinator of the project. They are the ones who serve as the "middle man" to everyone i.e. designers' ideas vs. the O&M team's wants or O&M Team's requirements vs. the contractor's offer. They are also the one in charge of controlling the legal and economic part of the project i.e. contract and budget. In addition, their team checks the progress of the project based on the created progress plan during the initial phase of the project.

Based on the statements of PrivCom1.PM shown below, some of them serve as a consultant to the owners wherein they conduct market analysis and feasibility studies in order to offer the best alternative that can give the best return on investment to the owner. This includes identifying both the investment cost for the project and value that the project will provide to the owner as well as the end-users. The proposal is then presented to the owner for their approval.

"In the start, I am the advisor to the building owner, because they are not sure what to do with the building. Should we demolish it and build residential houses? Or continue with the way of how the building is? Or should we do a large investment so that the building is in good shape for the next 20-25 years? So we were considering all these possibilities and looked after the different economic consequences." - PrivCom1.PM

While to some, like in PubCom1, there is a different department that conducts the project development and give them an general description of the project called the *"project mandate"*. This document consists the overall goals of the project together with the allotted budget. The statement below was the answer from PubCom1.PM when asked about their rehabilitation project model.

"At PubCom1, you have this section where the projects are developed which is called Seksjon for plan og utvikling and then they handover to the project section the mandate – where they have written down what we should do and the costs and agreements... " - PubCom1.PM

PubCom2 uses NS8405:Norsk bygge- og anleggskontrakt wherein the responsibility for the drawings, descriptions, and calculations are carried by them, the client.

PubCom4.PM's team is the one responsible in following up the punchlist items found before and after the handover. This responsibility is handled until the first year after the

handover. They ensure that most of the punchlist items are closed before this period ends.

For PrivCom4.PM, because they do not own the building, they conduct inspections during the first few years after the handover. This can span from 1 year to 5 years depending on the contract. The inspections are not set periodically, but they are done as needed by the clients.

4.2.2.2 Operations and Maintenance Team

In PubCom4, the O&M team joins the PM team and their designers in the planning and initial phase of the project. In here their knowledge and experience from the previous projects are tried to be incorporated. Before the handover, specifically during the pre-commissioning phase, documents checking and approval is done by the O&M team. These documents are sent to them by the project team from the contractors. They also join the tests and training conducted on this phase. This aims for them to gain knowledge about the technical installations as well as trouble-shooting skills when problems happen. In addition to this, the O&M team checks and audits the installations based on the approved contract. During the handover, the team / a representative from the team joins the activity wherein documents are passed on to them from the project management team. After this, they input this into their strategic maintenance plan.

For PubCom2.OM, they are the source of the idea of the rehabilitation projects. They describe an overall need for a project i.e. something that needs to be done. If this need is small they themselves manage the projects, but if it is bigger than their capacity, then they turn the responsibility over to the project team. Both the interviews from PubCom2.PM and PubCom2.OM confirms this with their statements below:

"... We describe an overall description of what needs to be done ... some small rehabilitation requirements, we do those under our department. If it's a huge total-rehabilitation, we do those under the project department.." - PubCom2.OM

"... det starter jo gjerne med at drift meldinger et avvik ... mindre sånn vedlikeholds prosjekt utfører drift på egen hånd. (English translation: It usually starts with the operations reporting problems ... the small-scale maintenance projects are performed by the operations on their own.)" - PubCom2.PM

In addition to this, PubCom2.OM's team is involved during the project planning and supports their project team in finding good solutions and checking the plans that are proposed by their consultants or architects. Their team is also involved in the project meetings during the construction phase. Their aim is to ensure quality in the installed units, but PubCom2.OM mentioned that they do not have executive roles in these meetings. In the last part of the project, their team members are invited to conduct inspections and final inspection of the installed systems.

The O&M team of PrivCom1 is involved during the project design phase. They help in the decision making about which technical solutions is perfect for the project. They attend some of

the design meetings wherein they input their knowledge that can help achieve the project goal.

PrivCom4 the O&M team of their clients are invited in the project design phase.

"We have a start-up meeting wherein the people who do the maintenance are informed so they can come with their notes about what to actually expect..." - PrivCom4.PM

4.2.3 Challenges in the Handover Phase

This subsection answers the first and second research questions of this master's thesis based from the results received from the qualitative interviews. Different challenges experienced during the handover phase were gathered from the interview objects. The challenges are arranged based on the number of times it appeared in the interview answers. The first being the mostly answered challenge and the last being the least. These are written below while a table was created at the last part of this subsection to summarize all the gathered information. The research questions are:

RQ1: What are the main challenges encountered in the project handover phase in the eyes of the PM team and the OM team?

and

RQ2: What are the causes of these challenges?

4.2.3.1 Project Defects

Project defects are a challenge during handover according to PubCom3.OM, PubCom1.PM, PubCom4.PM, PubCom2.PM, PubCom2.OM, PrivCom1.PM, and PrivCom4.PM. For PubCom1.PM, they encounter project defects prior to handover and after handover pointing the cause to contractor's competency. For PubCom3.OM, these defects normally happen when some project components needs to be changed due to difficulty in production in the project phase which in turn affects the other parts of the project. These affect the functionality, performance and aesthetics of the project.

PubCom1.PM admits that the standards for quality here in Norway is high and sometimes contractors sub-optimize their profits - focusing on earning more rather than delivering the quality they should have delivered. When asked further how can it be possible for PubCom1 to engage with these type of contractors, PubCom1.PM answered that them being a state-owned organization makes it harder to filter the "good" contractors from the "bad" ones.

"First of all, Norwegian Standards are very high and some of the contractors are thinking more about the profit instead of thinking about delivering the contract or the design or the quality they should." - PubCom1.PM

In addition, PubCom4.PM answered that the first thing that comes to mind when asked about challenges is having the knowledge and competence of all the actors who participates in the handover.

He also mentioned that project defects prior to handover are being experienced in their projects due to suppliers or contractors being delayed in delivery, but stated that project defects prior the handover are not as huge challenge as the project defects after the handover. They monitor these defects using their punchlist system. Punchlists are list of project defects found, reported, and needed to be fixed during the period of the project. In their punchlist system, they have punchlist A - project defects that are top-priority / critical and should be fixed before the handover or else the handover will not proceed e.g. defects in the fire alarm system; and punchlist B - project defects that are minor and can be fixed after the handover. Too much punchlist B before the handover can also cause delay of the activity according to PubCom4.PM. He also referred to their punchlist as a living list because while they have already solved some defects, some others appears and are being added onto it.

On the other hand, PubCom4.OM sees a defects on the handover due to economic factors. He stated that some of the contractors choose the cheaper and inferior alternative which sometimes gives them equipment with lower than expected quality.

The project defects that PubCom2.PM experiences during their pre-handover phase points to the reason that their properties are old. As mentioned in the previous subsection, PubCom2 follows the Norwegian Standard NS8405:Norsk bygge- og anleggskontrakt wherein they are the ones producing the design and computations for their different contractors. Because their properties are old, PubCom2.PM stated that they need to be really careful with all the designs and computations, but still there are things that they make mistakes. Old buildings have different phases where different construction workers have completed different projects causes the deviations in dimensions from what PubCom2.PM has created in their designs.

Project defects during the pre-handover also lingers in PrivCom1. There are situations when they are conducting testing of the installed systems and something fails. When this happens, their different contractors and subcontractors point fingers as to who caused the problem. Therefore, these defects causes the handover to be delayed. In addition to this, there are also times when defects i.e. equipment installed does not comply with the contract, are discovered during the testing. This leaves PrivCom1.PM to decide whether to continue with the already installed unit so that the handover will happen as scheduled or require the contractor to replace the unit with what was agreed from the start and risk the handover being delayed.

When asked what can he say about defects and delays on these types of projects, PrivCom3.Con mentioned that some project planners underestimates the complexity of the projects. Sometimes, other undefined tasks will appear suddenly during the project phase.

4.2.3.2 Misalignment between PM and O&M

A challenge for PubCom1.PM is that they have misalignment with their O&M team. This means that the transfer of responsibilities during handover is unclear which causes discussion between the two teams. The reason for this is because they do not have a formal agreement with each other about the handover process. Both their project and their O&M team belongs to one organization but different departments. PubCom1.PM discussed this challenge during the interview even when only asked about their project model.

"After we have done the project we hand it over to OM Team. OM Team is a total different division... and I think that today we don't have a good agreement on when you should deliver the project to them and what kind of documentation should be there and also when should the hand over take place..." - PubCom1.PM

4.2.3.3 Change in end-user's requirements

In the interview with PrivCom2.PM, he mentioned that a problem after the handover are when their end-users change the function of the rooms in their rehabilitated area. The examples he have given are when meeting rooms suddenly are being used as an office area or vice versa. This affects the design of ventilation which are usually based on the number of people that is expected to use the rooms. Even though that this is a problem caused by their end-users, being the owner of the building, they are expected to fix it for their clients.

"...if the tenants are changing like putting in more people or using a meeting room as an office area, or office as a meeting room ... the ventilation system is sized after the people and if you're changing that, then we can have some problem." - PrivCom2.PM

4.2.3.4 Unclear scope of works to the end-users

For PrivCom4.PM, a challenge they have experienced in some of their rehabilitation projects is that end-users being non-technical choose to drop some of the project scopes needed for the project to be successful after handover. An example is given below wherein they are being called by the end-users after the handover due to a problem caused by an unclear scope of works to the end-user.

"...if we are doing some ventilation works, if we're making a building airtight and they don't want balanced ventilation for example, they just want some (holes?) on the wall, but when it gets cold, they tighten this and no air comes in, then they call us and complain "Hey we got these moisture inside our apartment."" -PrivCom4.PM

One of the main cause of this is that their clients or end-users are not technically knowledgeable, which makes it hard to explain the project when it comes to technicalities.

Another interview object that mentioned about having unclear scope of works before the handover phase was PubCom4.OM. What happens to them is that their tenants expects something from the building adaptation project, but they do not know if that should be included in the scope or not. This was visible in the presentation he made for the project

team wherein he evaluated the project after the handover. At the summary part, he wrote the following:

Tydeliggjøring av innholdet i kontrakter før overtakelse (eierskapsenheten)

English translation: Clarification of the content of contracts before takeover (ownership unit)

4.2.3.5 Capacity of their O&M team

For PubCom4.PM, the challenge concerning the capacity of their O&M team are two-folds. The first one deals with the capacity to adapt to new solutions and technologies that are used in their building adaptation projects. In here he is mainly concerned on the members of their O&M team who have more than 10 years in experience.

"In this method of how to incorporate the innovative solutions - much more are focused on the computer, you may control everything, we can see that young people with some 5-10 years of experience are very much clever in learning new things and learn very fast, but those with 30-40 years maybe slower." - PubCom4.PM

The next challenge in capacity deals with the manpower capacity. Their O&M team needs to almost always be on site when one project is at the pre-commissioning phase to witness tests and attend trainings, but they are also involved in other projects and tasks which makes it hard for them to fulfill all these tasks. Below is an excerpt from the interview transcription with PubCom4.PM.

"... have time to participate during the handover. That maybe a problem to get the people involved in accordance to my schedule." - PubCom4.PM

".. so are you only referring to the O&M personnel?" - Author

"Yes and the reason is that for instance, the maintenance people are also involved in other projects and the operation personnel are involved in other project. And you see the operation personnel has its main role of operating another building not this new one because this will be an extra job for him. It could be a challenge to schedule these audits for the operation and maintenance department." - PubCom4.PM

4.2.3.6 Inconsistency in the collaborative processes between O&M and PM

When asked about their involvement in the building adaptation projects, PubCom4.OM mentioned that they are experiencing a challenge with this which causes problems in the handover phase. The competency of both colleagues from the project team and the O&M team is the main cause of this challenge according to him. A project manager can perform poorly with their collaboration skills i.e. inviting their O&M in their meetings in the design phase, or an O&M personnel can be invited to the meetings but lacks information on what

he will input into the meeting or scared to speak up in the meetings.

"... I heard that the project management team requests for your participation during the different phases of the project, for example planning and development..." - Author

"...Yeah, but it is very different. It can be that you are good and he wants input from operations, but it is not the same with the other colleague. They do not look at it the same way, so they are very different. Some people think it is very okay that we join. Other ones, it's not good. So this is where we have challenges – we have colleagues who lacks information, lacks being inclusive and collaborative." - PubCom4.OM

4.2.3.7 Little influence of the O&M Team

PubCom4.OM understood that personally, he experienced a lot of involvement from different projects, but at the same time acknowledged that their influence to the project still needs to be improved. He thinks that this is a challenge specifically after the handover of the building adaptation projects since they will be the ones who will be taking over the project.

"... we want little more influence to them to get the right equipment in the right place. We have influence, but there has been a little bit of it, so we want more influence because we know operations and what challenges the operations have." - PubCom4.OM

Sometimes, their small amount of influence decreases further when the architects and designers overlook their input because of their own designs.

"I also want to add that yes, I have influence for some change, but there are architects that are determined about what they want and that makes it difficult." - PubCom4.OM

Table 7: Challenges in the handover phase from the interview *(Own production)*

Project Management	O&M
➢ Misalignment between the PM and O&M as to when the O&M team will takeover. ➢ Project defects pre-handover and post-handover ➢ Capacity of their own O&M team to participate in the handover tests and inspections. ➢ Small challenge is the innovative changes in the practice. Some from the O&M are faster to adapt than others. ➢ Defects on the post-handover phase ➢ Project defects during the handover ➢ Delay-causing project defects ➢ Tenants changing their office set-up after the handover ➢ Misalignment between what the end-user wants and what the project delivers ➢ Project delays	➢ Wrong O&M resources are involved early in the project meetings or have insufficient knowledge and understanding about the project. ➢ Project defects: Difficult to coordinate with the contractor because of disconnect between O&M and Contractor ➢ Project defects: Contractors have prioritized the other phases of the projects, therefore it is hard for O&M to request for help in fixing defects in the initial handed over phase.

4.2.4 Strategies

This subsection presents the solutions or strategies that are being used by the different interview objects or they think will work in order to address the challenges they experience in the handover phase. The purpose of learning about their current solutions is to identify the gaps and improvements that can enhance the handover phase of building adaptation projects. Lastly, the structure of this subsection is per company. These will be grouped based on themes in the next chapter.

PubCom1

PubCom1.PM uses their own building standard during the design phase. This helps them to be more efficient in this phase by not relying too much on their O&M team. The purpose of these documents is to specify the requirements in line with the installed system e.g. piping, electrical or building automation. These building standards contain information such as required placement of equipment and documents need to be submitted by the contractor. This is shown in Figure 13.

Their challenge with project defects are being managed through the employment of a construction manager. This construction manager is an employee of their consultants. He/she is also based on-site in order to give comments on the contractors' work, verify the project's actual progress versus the planned progress, and control the project output all through out the implementation phase.

Tekniske krav:

All belysning skal leveres med høy kvalitet og skal minimum tilfredsstille følgende krav ved Ta=25°C:

- Levetid lyskilder: L90B50 minimum 50.000 timer
- Levetid elektronikk/driver: maks 10% utfall etter 100.000 timer.
- Lysfarve, spredning: MacAdam 3 SDCM eller bedre.
- Fargegjengivelse: CRI80
- Effektivitet: 100lm/w for armaturer inkludert forkobling
- På utsatte steder skal det tas hensyn til vandalsikkerhet samtidig som tilgjengelighet for drift og vedlikehold ikke skal forringes.
- Ved eventuelt vanskelig tilgjengelige armaturer skal tilgang i forbindelse med vedlikehold vurderes i samråd med Campusservice, Fagområde elektro.

Dokumentasjon fra entreprenør/leverandør:

Som minimum må følgende teknisk dokumentasjon av belysningsutstyret foreligge:

- IP – klassifisering
- Ra – indeks
- EMC – merking
- Lysarmaturens virkningsgrad
- TA-merking (temperaturklasse)
- Lysberegning for typiske rom basert på valgte lysarmaturer.
- Effektforbruket til belysning for rom og soner i W/m2.
- Armaturliste.

Original text from PubCom2's Building Standard

Technical requirements:

All lighting must be delivered with high quality and must at least satisfy the following requirements at Ta = 25 ° C:

- Lifetime light sources: L90B50 minimum 50,000 hours
- Lifetime electronics / driver: maximum 10% outcome after 100,000 hours.
- Light color, scatter: MacAdam 3 SDCM or better.
- Color rendering: CRI80
- Efficiency: 100lm / w for luminaires including ballast
- In exposed places, vandal safety must be taken into account at the same time as accessibility for operation and maintenance should not be impaired.
- In the event of difficult-to-access luminaires, access must be in connection with maintenance assessed in consultation with Campus Service, Electrical subject area.

Documentation from contractor / supplier:

As a minimum, the following technical documentation of the lighting equipment must be available:

- IP classification
- Ra - index
- EMC marking
- Efficiency of the luminaire
- TA marking (temperature class)
- Light calculation for typical rooms based on selected light fixtures.
- Power consumption for lighting for rooms and zones in W / m2.
- Luminaire list.

English translation

Figure 13: Extract from PubCom1's Electrical Building Standard: Lighting

PubCom2

For PubCom2.PM, one important thing in order to prevent defects and delays in the project handover is to have the same group of people working in the same project. This includes laborers from the contractors as well as the site managers. By having the same group of people working on the project, they will learn from the problems encountered the first time i.e. wrong dimensions in the drawings versus the actual site, and will most probably prevent worse problems from happening again.

"... og det er viktig for at de beholder å ha det samme håndverkerne på stedet...(English translation: ... it is important that we keep the same workers in place)" - PubCom2.PM

Another strategy that PubCom2.PM mentioned is to set aside more time in the planning phase, specially in the first part of the project when doing a different part projects. This is in anticipation that there will be things that are not foreseen in the project plan. He added that everyone in the project team should also be informed about this.

PubCom2.OM identified their good collaboration and communication with their project team as very helpful in preventing problems in the project. An example he gave is communicating about details such as transporting furnitures out of the rehabilitated area at the start of the project in order to prevent creating problems to their tenants or end-users. At the final phase of the construction, they collaborate with their project team in checking and doing inspection. He also acknowledges that they, the O&M team, needs to support the project team in order to decrease the problems experienced during the handover.

In order to easily provide the required specifications by their O&M team, PubCom2 has their internal document wherein these specifications are written. At the moment of the interview, PubCom2 is in the process of developing this and importing it into an internal software that they can use to define the functions they need in a room and the software will create a list of items needed for that room based on their required specifications.

PubCom3

According to PubCom3.OM, they are now using a "Quality system" internal to their organization wherein they can access necessary documents and information about their project model. This system is distributed to all their departments for better realization of strategy and goals. Another strategy that they are doing is the implementation of educational and learning programmes.

PubCom3.PM, on the other hand, mentioned that he/she believes that they need more trainings about the handover process. She also mentioned that their O&M team should have someone who has the responsibility to help in their rehabilitation project. This O&M personnel should always be available when needed to assist in the projects.

PubCom4

Both the interviewed objects from PubCom4 believes that the collaboration between the project team and O&M team is important. Not only in the initial phase of the project, but also in the testing and inspection activities during the construction phase and pre-commissioning phase. PubCom4.PM acknowledges the experience and competence of their O&M team and tries to incorporate their input to the projects specially in the design phase. Furthermore, PubCom4.OM emphasizes the importance of the collaboration between all actors i.e. project managers, architects and O&M, during the planning and design phase.

PrivCom1

By creating alignment between all the actors in the project, PrivCom1.PM most of the time does not have any problem with the completeness and fidelity of the documents needed by their O&M team. This is done during the planning and design phase wheerein these needed documents are already identified plus how should they be made and delivered.

In addition to the mentioned above, PrivCom1.PM stated that working with good designers and contractors helps address the risk of having incorrect or insufficient documents. They choose the partners they want to work with. Being a private company makes it easier for them to separate the companies that they do not want to work with and those who they want to work with. Companies are separated based from the experiences PrivCom1 had with these companies. If they were not satisfied with the work of the contractor, it is most likely that they will not invite them again for the bidding of their other projects.

Lastly, by involving the right group of people at the right time helps PrivCom1.PM identify the items needed in the project. During meetings in the design phase wherein the agenda is about items that will affect or needs the comments from their O&M team, PrivCom1.PM ensures that they are invited and their suggestions are considered.

PrivCom2

Putting more time in the design and planning phase makes the handover phase in PrivCom2 simpler according to PrivCom2.PM. This includes involving their O&M team in the initial phase to help them identify the items that are needed when doing building adaptation projects. They are involved even before the consultants and designers come into the picture. In addition to this, their O&M team also joins them in the tests and inspections before the handover phase. These give their O&M team the sense of ownership in the projects where afterwards they will operate.

"... we put in time for that (design and planning phase) because that makes our handover phase simpler. When the operations team join with the design of the system / solutions they gain ownership with these things that they will operate. It is an important pre-requisite that is good to note that we conduct." - PrivCom2.PM

PrivCom2 also focuses on the lifecycle cost of their projects as this is what is expected from them by their owner. This creates a culture within the company where they are always open to looking for better solutions. They understand the benefits of having a lower operational cost even with a higher investment cost. This helps them ensure in choosing the best solutions for the company, their O&M team, and their end-users. Below is an answer from PrivCom2.PM when asked what are the things that he thinks they are doing correctly in order to minimize or prevent challenges in the handover phase:

"There is something that I said in the start where we have an owner who has a long-term perspective and that means value lies when the property is well like the equipment functions and the biggest value is the everyone of us in the company do what we think is right for the properties." - PrivCom2.PM

Another important factor in order to minimize the challenges during the handover is by increasing the competence of their team, according to PrivCom2.PM. This is done by "learning from experience." They do this by asking questions such as "What went well" and "What did not go well?." With learning by experience, this also includes experiences with previous contractors wherein they learn to separate contractors who perform as expected versus those who do not. Them being a private company plays a part in this factor. As PrivCom2.PM mentioned:

"..we are a private company and we are not under public procurement process. We expose the projects for bidding competition, but we can also be clearer about who we want to have. We can go to an electrical company and tell them that we want this guy to be the electricians in the project." - PrivCom2.PM

Lastly, PrivCom2 uses a single software for both their project team and O&M team. The project team input all their documentations in this software while their O&M team uses this to follow up service reports and review important documents.

"We are dependent in that the input to (our software) to be good so that the operations manager can only use one platform and relax from using different systems." - PrivCom2.PM

PrivCom3

In order to deliver what is needed by the end-user or client at the handover phase, PrivCom3.Con clarifies the strategy of the project. This is done by asking the clients questions such as:

"What output do you want from the project? What is the value of this project for you? Is it to refurbish it and then sell it to highest price then I have to refurbish it for the lowest price possible or are you going to rent it out long-term?" - PrivCom3.Con

PrivCom3.Con experienced challenges wherein the cost estimated at the start of the

project caused delays in the handover. In addition to this, there are unanticipated events that happened during the project implementation phase. In order to address this, improvement in the condition survey should be conducted at the start of the project, before the requesting for tender from the contractors. The survey should be done whenever possible. This will lower the risk of surprises during the project phase.

"I think the most important thing is to improve the condition survey upfront ... because if you know as much as possible about the building and the condition of the building, then you will lower the risk and the surprises." - PrivCom3.Con

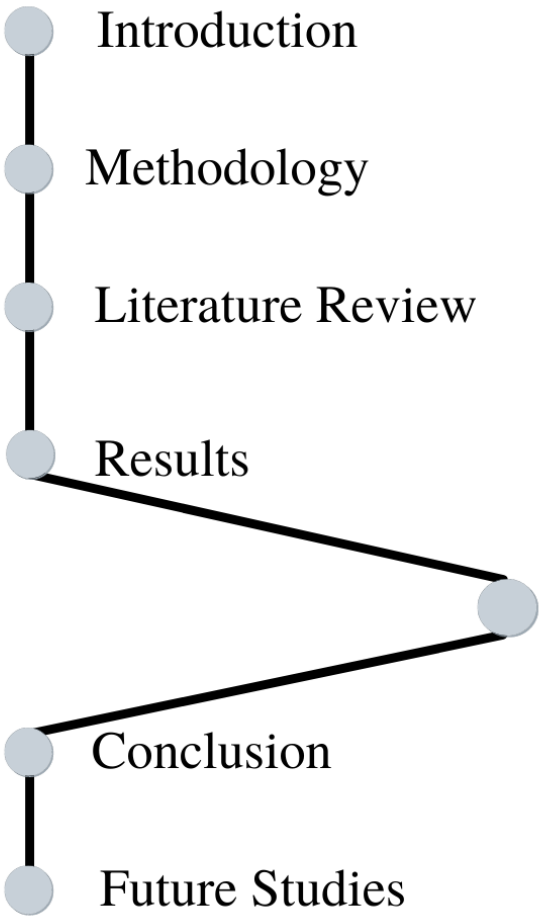
Another strategy that PrivCom3.Con mentioned is by adding additional clause in the request for tender documents from the contractor. In this additional clause, supplementary works should be included. Supplementary works means items or scope of works that are not expected to be done but there is still a possibility to happen. Another set of clause that should be included in the tender document and contract is the trainings and documentations needed by the O&M team. Anticipating what the supplementary works is a challenging task. In this, the competency of the project team plays a part. PrivCom3.Con said that the project team needs to have experience.

Lastly, PrivCom3.Con explained that the output of the building adaptation projects cannot be fully assessed during the guarantee period of the contractor i.e. within 1 year after the handover. From his point of view, there should be an improvement in checking the project output after the handover and guarantee period. To explain further, PrivCom3.Con discussed that sometimes that contractors failed to follow completely what the solution in the project description states. These little details can cause problems not on the first year but maybe after a few years of operations.

PrivCom4

For PrivCom4.PM, improving their team's competence both technically and socially is one of the most important things to avoid challenges in the handover phase. They first have to understand what their clients / end-users want and need. They use meetings with the end-users and condition analysis of the site as their tools to gather these details. After gathering these details, they have to propose the scope of projects to their end-users. With better explanation, the clients / end-users will be able to understand what the project scope includes, what the effects of the projects to them, and what should be included in the project.

"To work with this kind of refurbishment project, you have to be good with technicalities and you also have to be a people-knowing. You need to have people skills. Almost a psychologist. It is important to understand the needs, you have to be good in explaining..." - PrivCom4.PM



Discussion

- Challenges in the Handover Phase
- Strategies for Improvement

5 Discussion

This master's thesis aims to identify different strategies in order to improve the handover phase of building adaptation projects. This was done by conducting literature review to have a deeper knowledge about the subject of handover phase and building adaptation projects. The process resulted to a better understanding about facility management and project management processes, clearer definition of what building adaptation projects are, and four main challenges experienced in the handover phase. The next step conducted was document review wherein the different Norwegian standards and public documents that are applied in the different building adaptation projects were understood to grasp the different proposed strategies in order to have a better handover phase. Lastly, interviews were conducted on people from both the project teams and O&M teams to understand and find out what are the challenges they experience in practice and how do they address these challenges.

In the first section of this chapter, the challenges found from the research methods were summarized and categorized into themes. Challenges that were found in the literature but were not discussed or rejected by the interview objects were taken out of the list. The reason for this is that as mentioned in the literature review chapter, there is a lack of study about the handover of building adaptation projects, thus some of the challenges in the said chapter only applies to new building projects.

The second section presents and discusses the sets of strategies in order to address the discovered challenges. This was done by synthesizing the ideas and processes used by the interview object supported by the literature and documents reviewed. At the last part of the chapter, the limitations of this master's thesis were acknowledged and recommendations for further studies were proposed.

5.1 Challenges in the Handover Phase

The interpretation of the results indicates that there are four (4) main categories of challenges experienced by the project team and the O&M team during the handover phase. These are ***project output related, information and communication related, management related, and competency related challenges***. In addition, some of the challenges are also causes why the other challenges appear in the handover phase.

The goal of this section is to discuss the challenges and their causes by interpreting and synthesizing the results part. To create a primer, Table 8 states the challenges found from the research methods within their respective categories. The numbers on the right side shows how many of the interview objects mentioned these challenges.

Table 8: Main challenges in the handover phase *(Own production)*

Category	Challenge	Found in literature?	Project Team	O&M Team	Total
Project output related challenges	Project Defect	Y	4	2	**6**
	Change in end-user's requirements	N	2	-	**2**
Information and Communication related challenges	Lack of influence of O&M team	N	-	1	**1**
	Inconsistent collaboration between PM and O&M	N	-	1	**1**
	Gap between project scope and tenant needs	N	2	-	**2**
	O&M lacks information after handover	Y	-	2	**2**
Management related challenges	Misalignment between PM and O&M	N	1	-	**1**
	Manpower capacity	N	1	-	**1**
Competency related challenges	Competency of contractors	Y	4	-	**4**
	Competency of O&M team	Y	1	2	**3**
	Competency of Project team	Y	2	1	**3**

5.1.1 Project output related challenges

In totality, this is the second-most discussed category by the interview objects. This category refers to the challenges that are related to the physical project output i.e. refurbished area, renovated building, retrofittted system, etc. The challenges include project defects and change in end-user's requirements.

Project defects

Project defects appeared six (6) times during the interview - four (4) of them came from the project team while the other two (2) were from the O&M team. It is also the most stated challenge by the interview objects. This adds to the findings of Zhu et al. (2019) that project defects are one of the main challenges experienced in the handover phase both in new constructions and building adaptation projects.

Based from the interviews, one of the largest reasons why defects happen during the handover is because of the contractors. Contractors may install systems or products that are below the set quality due to cost saving measures. They want to win the bidding competition in order to get the projects thus they offer cheaper solutions which affects the quality of the system. Competency of the project team comes to play on this part as they should be able to verify the contractor's systems before the installation phase.

Change in the end-user's requirements

Both of the interview objects who discussed this challenge - PrivCom3.PM and PrivCom2.PM, are from the project team. Based from their experience, it is usual that the end-users would like to add something else from the scope of works during project implementation until after the handover phase. This affects the project output specially how it functions and its efficiency. Imagine if the design of an office space is only for ten (10) employees and after the handover phase, fifteen(15) employees work in that area, the performance of the heating system as well as its ventilation system will surely be affected.

This challenge found in the interview can be argued that it is related to the challenge found in the literature - insufficient consideration of end-users or occupants (Zhu et al., 2019), but both PrivCom3.PM and PrivCom2.PM mentioned that they involve their end-users and O&M team during the their planning and design phase. In fact, PrivCom3.PM presents the project scopes to their clients prior to project implementation while PrivCom4.PM creates an office plan for their clients before implementation. Therefore, this is different from the challenge found in the literature as they consider their end-users during the project phase. This shows that end-user behavior can cause challenges at the handover phase. It is a factor that should be managed by the project team during the project phase.

5.1.2 Information and communication related challenges

This category refers to challenges that are related to information management, communications and collaboration between the actors in a building adaptation project. Most of the interview objects who stated this challenge came from the O&M team which indicates that these are experienced after the handover, during the trial operation or even the operation phase.

Lack of influence of O&M Team

Out of the three (3) interview objects from the operations and maintenance department, only one (1) mentioned this challenge. This is partially related with the challenges found in the literature - insufficient consideration of end-users / occupants (Zhu et al., 2019) and the challenge in knowledge transfer (Jensen et al., 2019). The data agrees with the literature in which the latter is caused by lack of knowledge push and human resource from O&M team. These were visible in the interview with PubCom4.PM wherein he acknowledged the challenge in manpower capacity specially from their O&M team. In another interview, PubCom4.OM mentioned that not everyone from his team speaks up in the meetings when they are invited which promotes lack of knowledge push. This means that competency of the O&M team is another factor that affects their lack of influence.

Inconsistent collaboration between PM and O&M Team

This challenge was discussed by only one interview object - PubCom4.OM, but it somewhat relates to the challenge found in the literature which is the insufficient consideration

of end-user / occupants. During the times wherein they are not engaged in the project phases, the effect to PubCom4.OM is more project defects as seen in his project evaluation presentation sent to the project team. This is aligned with the findings of Forcada et al. (2012) wherein the lack of consideration of the end-users creates perception of low project quality.

Gap between project scope and tenant wants

Only one of the interview objects mentioned this challenge - PrivCom4.PM. The reason for this is that a lot of their clients are non-technical people wherein they do not understand the technical consequences if they skip the other proposed projects due to cost savings. Even though this challenge is related to the project output, it is put in the category of the information and communication related challenge. The reason for this is because the real challenge is how can the project team explain the necessary scope of works to the non-technical clients.

O&M lacks information after handover

Based from the literature, gathering the correct information was one major challenge encountered in the handover phase of new building construction (Zhu et al., 2019). The data gathered from the interview suggest otherwise. Even though it was directly asked to some of the interview objects, all of them answered that it was not a challenge they experienced. This may suggest two things: (1) the documents needed in building adaptation projects are fewer and less complex than the new building projects which makes it easier for project teams to ensure the correctness of FM documents, and/or (2) the interviewed objects have an effective process for verifying and checking the documents submitted by the contractors.

On the other hand, O&M team identified that they experienced challenges regarding missing information after a few months or years after the handover. This information mainly concerns the project contract scopes. The two (2) interview objects who noted this challenge came from the O&M team. It makes sense because they are the ones who take over the project output after the handover and operation. No reason were discussed about this challenge during the interview, but some causes can be assumed: (1) there are no proper guidelines about the process of handing over the project scope from project team to O&M; (2) if there is, the documents / information given to the O&M are not easy to understand; or (3) the O&M team was not involved during the project phases.

The project managers are also aware about this problem because they are usually contacted by the O&M team to request for the copies of these documents, but they do not see it as a huge challenge as how the O&M team perceives it to be. A reason for this is the project managers jump to another project right after the handover which shifts their focus totally.

5.1.3 Management related challenges

This category refers to challenges that are related to management processes and structure.

Misalignment between PM and O&M

A surprising result from the interview was the misalignment between PM and O&M teams in a company. This means that there is no clear line when the O&M team will takeover the project output. It is surprising in a way because both the PM and O&M team are internal to PubCom1 - they belong in the same organization. In these organizations, the project processes beginning from the starting up of process until the closing of a project (Bennett et al., 2017*b*; Project Management Institute, 2008), should already be in place in order to achieve project success. In addition, this challenge may cause a larger problem specially after the handover when the maintenance should be ongoing in order to ensure that the project output is performing to its designed level.

This challenge is considered as management related as this should be addressed by the top management of organizations. The strategic level should spearhead the solution to this challenge as this level steers the organization to the right direction and ensures that the goals are achieved i.e. project output are delivered, operated and maintained efficiently.

Manpower capacity

Challenge in manpower capacity was experienced by two (2) project managers. Both of them experienced or are experiencing this challenge during the pre-handover phase wherein tests, trainings and verification of FM documents are done. This challenge and at the same time cause of other challenges was found in the literature such as the article written by Jensen et al. (2019). Similar to Jensen's case study, both of the interview objects who mentioned this challenge comes from state-owned companies which may suggest that this challenge are special to this type of companies. A reason for this is because of the economics involved wherein deployment of budget for manpower is more stringent than those of private companies.

Lastly, this challenge is also considered as management related because it entails proper planning of manpower deployment. The management / strategic level have the power to hire more people if needed.

5.1.4 Competency related challenges

This category refers to challenges that are related to competency of actors in the building adaptation projects. This category captured the mostly mentioned challenges in the handover phase. The results show that this is a challenge as well as a cause of other challenges i.e. project defects, inconsistent collaboration between PM and O&M, and gap between project scope and tenant needs. This reason makes it a very important challenge that needs to be addressed during the lifecycle of the project, not just the handover phase.

Competency of contractors

Out of the three (3) challenges in this category, competency of the contractors were mentioned mostly compared to the other two. The four (4) interview objects who mentioned

this challenge came from the project management side as they are the ones who mainly coordinate with the contractors. They also know what the details of the projects are, thus they can compare the actual design to the as-planned design.

As mentioned in the project output defect, competency of contractors is one of its main cause. Therefore it is an important part of the strategy moving forward to ensure that the contractors invited in the project implementation should have the right tools and skills in order to decrease challenges in the handover phase such as project output defect. Having the right competency by the contractor can also help solve problems that can cause project delay in the handover phase.

Competency of O&M team

This challenge was stated by one (1) project manager - PubCom4.PM and two (2) from the operations and maintenance side - PubCom3.OM and PubCom4.OM. The data shows that there is a difference in the priorities of the Project team and O&M team. Both PubCom3.OM and PubCom4.OM identifies this challenge during the project design and planning phase while on the other hand, PubCom4.PM connects it with the pre-handover phase. The O&M team both discussed which competencies are needed from them during the design phase: knowledge about their needs during the operation phase plus the competency to speak up and discuss these during the meetings with the project team. Rightfully so, these are what is needed from them as identified in the interviews. Some project managers invite them to gather information and knowledge on what are the important things to note in the project. On the other hand, PubCom4.PM did not identify which competencies was referred during the interview, but based on the roles and responsibilities of O&M in the company, competencies such as technical knowledge about the installations and adoption to technology is needed in order to achieve a good handover phase.

Competency of project team

Competency of the project team was also stated by the interview objects - PubCom1.PM, PubCom1.OM, and PrivCom3.Con. The data from the interview matches the result from the literature review. The first competency is the competency of project planning as stated by PrivCom3.Con where he mentioned that some project manager underestimate the complexity of some projects. The second competency is the ability of the project manager to be collaborative and facilitate good communication between the different actors. These are supported by the quantitative analysis done by Schultz et al. (2015).

5.2 Strategies for improvement

As mentioned in the start of the literature review, there are three (3) management levels in FM, which are: The strategic level which is responsible in creating long-term goals and ensuring that all the resources to achieve these goals are available, the tactical level which creates a more detailed plan based on the goals set at the strategic level, and operational level which conducts the daily operation and maintenance of the facility (Atkin and Brooks, 2015).

In this part of the discussion, the different strategies gathered from the interviews were matched against past studies i.e. literature, resulting to a proposed set of potential solutions. Figure 14 shows the different strategies. These solutions are positioned to the project lifecycle phase which they have the possibility to be utilized. In addition, the FM management levels serve as the basis of discussion of the different strategies to discuss the different tasks and responsibilities of the project team and O&M team in the implementation of these solutions. It has to be noted that these strategies are not a one-size-fits-all solutions, therefore organizations need to tailor-fit these into their organizations as some of the challenges may not be applicable to them or some of the solutions are not feasible.

5.2.1 Entire project lifecycle

There are strategies that should be ensured that are implemented across the whole project life-cycle. The first one is ***creating a culture of collaboration***. The importance of this is shown by almost all interview objects by showing that the project team are involving the O&M team in the different phases of the project. By ensuring a culture of collaboration, it will (1) increase the efficiency and effectiveness of knowledge transfer between the actors and (2) address problems with lack of influence of O&M in the design phase.

The strategic level can organize interaction and collaboration between PM and O&M that aims to build good relationship. Some of the examples of these are team building, social events, and moving both teams in the same office (Jensen et al., 2019). For project managers in the tactical level, they should create a balanced approach where they invite the O&M when needed and note their input. They have to understand that they will hand the responsibility of taking care of the project output over to their counterparts. On the other hand, the O&M team should be prepared to input their ideas and thoughts whenever invited in the project design and planning meetings. They need to be active whenever in these meetings at the same time knowledgeable of what is needed from them. Same with the O&M in the tactical level, the operational level should be prepared, active, and knowledgeable about the things or input needed from them whenever they are invited in the design and planning phase of the projects.

Even though the challenge of misalignment between the project and O&M team was discussed only once in the interview, this should not be disregarded as this will cause serious challenges not just at the handover but also the operation phase. As mentioned by PubCom4.PM, they just hope for the best after the handover. With this, organizations should

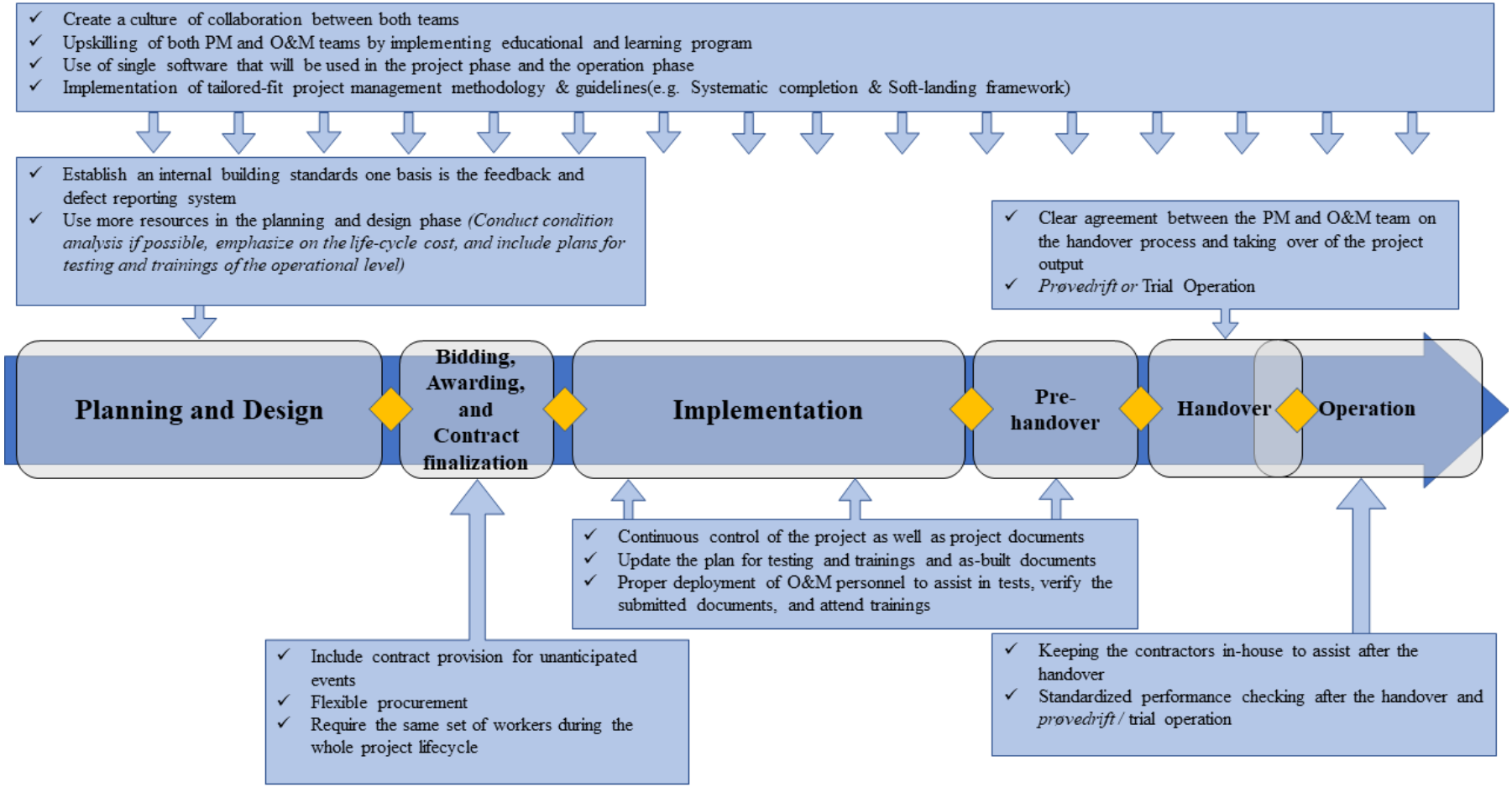


Figure 14: Strategies to address the handover challenges *(Own production)*

establish standard project management procedures such as *systematic completion* and *soft-landing framework* that will guide the whole project lifecycle. The strategic level should tailor-fit their project management procedures depending on the level of rigidity and flexibility of the projects (Wells, 2012) including the tasks and responsibilities of each department or actor - following the recommendation of Cavka et al. (2015) in her alignment framework. As a result, the project managers and O&M managers on the tactical level should be guided by these procedures ensuring a smooth transition from one phase to another. Lastly, the operational level should be informed about the scope of works that they will be taking over and the schedule when they will be taking over. For example, as gathered from the interviews, usually the guaranteed period in Norway spans from 1 year to 5 years. During this period, the responsibility of the operational level is to just check the system and report to the contractors if there are problems. The contractors are the ones responsible in fixing the problem.

It was noted that the different companies are using their own systems in order to manage their projects and buildings. ***Using a single software*** for both the project team and O&M team can create a simpler system for an organization. This may help ensure that problems with information management and interoperability are decreased as project managers will be fully aware of the format needed by the O&M team during operations or they can easily check different files / data if the O&M team raised some concerns. The strategic level should be open to investing in these technological interventions. They should also lead the implementation of these programs by identifying an overview of data needed while collaborating with the tactical level.

As seen in the challenges section, problems regarding competency was huge for the interview objects. This category of challenges causes several more challenges to be experienced during the handover such as project output defects and information related challenges. This data calls for the strategy of ***implementation of upskilling programs***. This program applies to both the project team and O&M team. It should be designed based on what is needed by the teams i.e. technology familiarization, project planning skills, etc.. The strategic level should be tasked to create this program and ensure that it is sustainable and effective. The tactical level defines the needed skills, while both them and the operational level should actively participate in these programs.

5.2.2 Planning and Design Phase

The ***use of an internal building standard*** helps the project team identify the needed specifications and quality of the items needed in their project. This is helpful specially when there is insufficient manpower capacity from the O&M team which is the case of PubCom1.PM. The strategic level should lead the creation of this standards by including this in their organizational documents. They should also ensure that the projects developed and implemented follows the created building standards. This level should also ensure that resources are placed to match the competency of everyone using the standards by planning for learning program just like what PubCom3 is doing. The tactical level in collaboration with the operational level should be responsible in the using and updating the building standards. If properly implemented, this can address challenges in project defects, manpower capacity,

and competencies of the project and O&M team.

These building standards should base their details from the different national standards or guidelines like NS6450:2016 Idriftsetting og prøvedrift av tekniske bygnings installasjoner *(English translation: commissioning and test operation of technical installations* and NS3424.E:2012- Condition survey of construction works content and execution. In addition, ***technological interventions*** can be used to update and improve these building standards. An example of this is the automatic feedback and defect reporting system proposed by Zhu et al. (2019) and the program being developed by PubCom2. They are developing a software which the project team can use to identify the needed specifications and items of a part of a facility or a whole facility. As mentioned in the previous section, the strategic level is the one that is responsible in providing the resources to properly implement these interventions. The tactical level, on the other hand, ensures that the functionality of the software are the functions they need and the files format are standardized to prevent inter-operability challenges in the future which was found in the literature (Zhu et al., 2019). Lastly, the operational level should ensure that the defect reporting system is used in all the projects after the handover phase or during the operation phase and ensure that all the guidelines regarding the proper way of usage and format of reporting will be followed. This will help in the knowledge push from the O&M team to the project team.

As Zhu et al. (2019) noted, automatic feedback reporting systems are more feasible than requiring the attendance of the end-users during the design phase, but the study of Jensen et al. (2019) contradicts this by stating that even though there are building standards at the design phase, these are overpowered by the decisions of the architects. Personally, the automatic feedback reporting system can work if the receiver and collector of the report is fully knowledgeable about the project, but still they need resources from the end-user or O&M to clarify what was reported in order to prevent miscommunication. In addition, PubCom4 uses both of these systems - using an internal building standards and collaborating with O&M at the design phase, which suggests that there should be a balance between using the building standards and collaborating with the O&M team.

The planning phase is another phase that is vitally important to the project. Organizations should ***set more time*** in this phase. One idea is to focus on the life-cycle cost of the project output not just the project investment cost. This is easier for organizations who own their properties such as PrivCom2. For them, by looking at the life-cycle cost gives them better understanding which products or projects have the better quality. It also includes investing to more expensive and competent designers and contractors. With this, organizations may be able to prevent different challenges in the handover such as incorrect documentations, project defects and delays. In addition, planning of the tests and trainings should also be included in the planning phase. This is supported by the Systematic Completion (Beste, 2020). This can create alignment between all actors as early as the planning phase.

5.2.3 Bidding, Awarding and Contract Finalization

As mentioned by PubCom2.PM and found in the study of Firing et al. (2016), unanticipated events can cause delays and defects in the project handover. A possible solution to this was mentioned by PrivCom3.Con. ***Inclusion of a lump sum cost in the tender which allotted for unanticipated circumstances*** can help minimize their consequences. If an unforeseen task needs to be accomplished, for example; additional reinforcement should be installed to an old wall along the middle of project implementation, the organization can easily release cash too proceed with the additional work; they will be well prepared to release financial resources rather than go through a longer process of having the additional cost approved by the strategic level. This part is the task of the project managers in the tactical level as they are the ones who implement the project.

In the bidding process, organizations should ***have a proper system to filter the contractors*** that are best fit for the project. In this filtration process, the strategic level should ensure that the criteria should not just be the cost but also the quality and competence of the contractor *(Focus on the lifecycle cost rather than investment cost as mentioned earlier)*. These criteria should be complied by the project managers on the tactical level. Based from the interview, this process is easier for private companies than the public ones as they follow a more stringent procedure overlooked by the government.

With regards to the contract, the tactical level can add a provision that states that the ***same set of team should be working in the project***. One reason for this is that the project team can encounter recurring challenges in the different zones of the project e.g. difficulty of installation of motors in equipment room A due to space constraint, and it will make these easier to be solved using the lessons learned from the first time the problems occurred and solved. One solution mentioned earlier is the automatic feedback system, but it may take time for the other laborers to absorb the knowledge. By having the same set of employees on site, they already have the tacit knowledge which will help them solve the other recurring problems easier. Another reason is that the employees can build a good relationship with the project team from other organization such as the client's which is a foundation of good knowledge transfer according to McBeath and Ball (2012). Lastly, information on the scope of the contract should also be handed over to the operational level as it is an important information during the operations as mentioned by PubCom4.OM and PubCom2.OM.

5.2.4 Implementation Phase

During the implementation phase, a strategy found in the literature as well as the interview is the ***continuous control of the project***. This can be done by the project manager or even employing a third party company who will act as a construction manager just like what PubCom1 is doing. Continuous control includes quality assurance (Firing et al., 2016), but it has to be noted that this process should be conducted early in the implementation phase as identified by (Schultz et al., 2015) and consistent. Depending on the severity of the deviation from the plan, project managers or the construction manager should bring up the issues to the periodic project meetings or as soon as it was discovered. Again,

the strategic level should be well informed of the advantages this strategy brings therefore they should allot resources in order to implement it. They can also delegate the responsibility to both the tactical and operational level, but they have to balance out the tasks as this can cause burden to their lower levels and result to the challenge of manpower capacity.

Planning of the tests and trainings should be done at the planning and design phase according to the PA0701: Systematisk Ferdigstillelse (Statsbygg, 2018), but these ***plans should be updated during the implementation phase***. When planned, updated and scheduled ahead of time, this ensures that everyone needed in the activities, specially the O&M team will be able to attend. The strategic level should plan for the manpower deployment and include these tasks on the job descriptions of the tactical and operational level. The tactical level should ensure that this strategy is accomplished while the operational level should be active in attending the tests and trainings.

It is not just the plans for the tests and trainings that are needed to be updated; according to the literature and document reviewed, ***as-built documents should also be updated and verified during project implementation*** (Zhu et al., 2019; Whyte et al., 2016). Verification of the design should be conducted by the project managers in collaboration with the O&M team in the tactical level if possible. This ensures that the documents that will be handed over to the O&M team are correct and complete.

5.2.5 Handover Phase

As mentioned earlier, there should be a ***clear agreement of tasks and responsibilities between all actors***. This also applies during the handover phase where the O&M team should be informed what their roles will be. This calls for an action from the strategic level wherein they fix their organizational structure. Agreement between all actors also implies that there is an open communication between all of them which is one of the success factors of a good handover phase (Szentes, 2010).

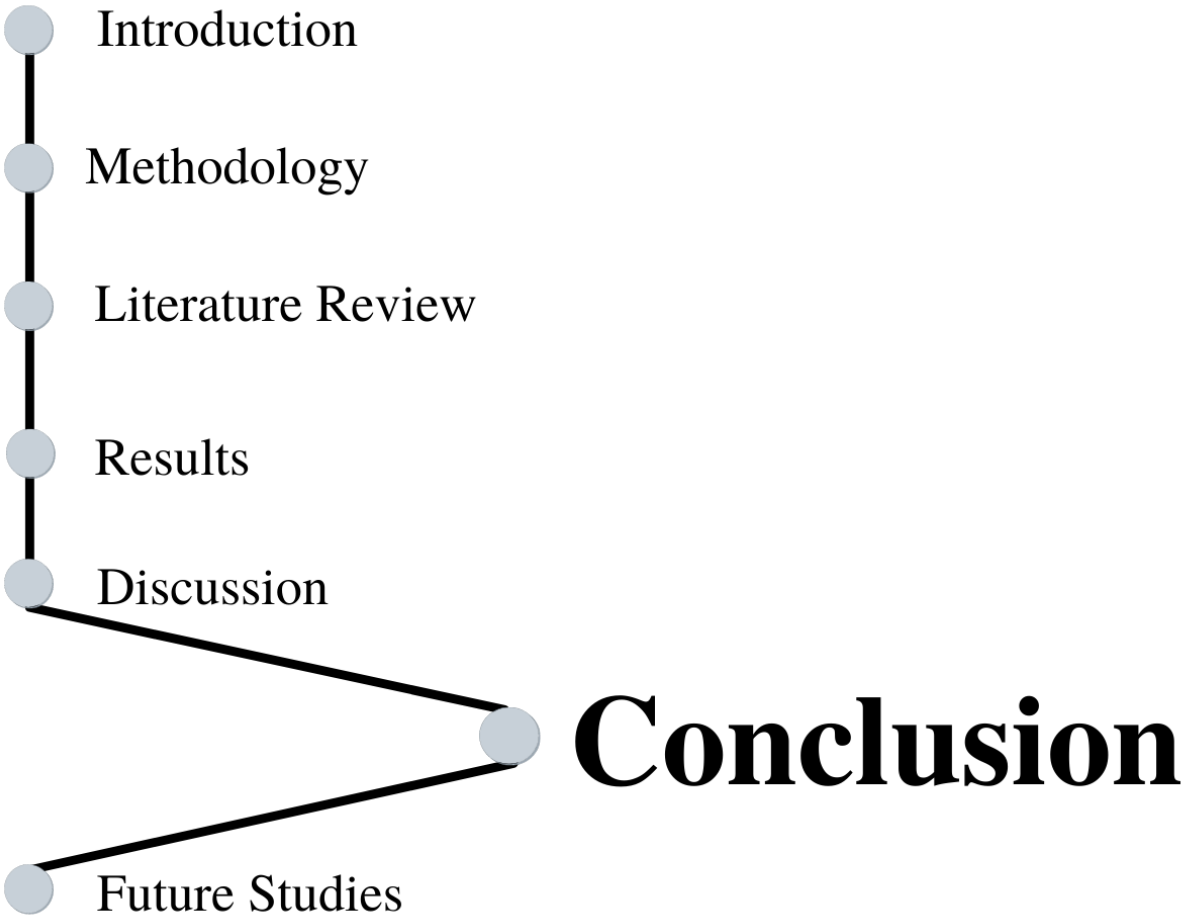
Part of the handover phase is the ***trial operation or*** **prøvedrift** as how they call it in Norway. This is a huge help to the O&M teams specially within countries with four (4) season as some projects can be finished during summer, and heating equipment will not be fully tested until the cold season or winter comes, or vice versa. The difference between the trial operation and commissioning should be clear. All the tests including the whole systems test and integrated tests should be accomplished during the commissioning phase. The trial operation is conducted after the handover process. It is accomplished to monitor the operation of the project output and to optimize the system after the end-users have moved in.

5.2.6 Operation Phase

At the start of the handover, ***a contractor representative can be required to be stationed in-house*** according to the soft-landing framework. This ensures that someone who is knowledgeable about the system is available to assist the O&M team. Different tasks such

as trouble-shooting and guidance in the operation can also be done by in-house contractor. This enables the organic O&M team to learn about the project output as fast as possible. The question here is does it have to be the general contractor or the subcontractors that should be in-house? If the general contractor is the one who is in-house, there is a chance that they will also contact their subcontractors will defeats the purpose of having someone who can guide the O&M team.

After a certain period after the trial operation, ***a standardized performance assessment of the project output should be agreed by all actors and conducted*** as suggested by PrivCom3.Con. This supports the findings in the literature wherein different authors propose the use of performance evaluations to compare the actual performance of the building and the designed performance (Zhu et al., 2019). By conducting this evaluation during the operation phase, the actors i.e. contractors, project team, and O&M team, will be able to learn from the project and identify key actions that need to be done to prevent the challenges and minimize the gap between the actual and designed performance.


Introduction
Methodology
Literature Review
Results
Discussion
Conclusion
Future Studies

6 Conclusion

The number of literature that focuses on the handover phase of building adaptation projects are scarce even though this is one of the most important phases of the project not only for the project managers but also for the operation and maintenance team who will take care of the project output all through out its life. Therefore the goal of this master's thesis was to contribute to the existing literature and search for improvements that can be implemented to the mentioned phase.

Data were gathered using three (3) method: Literature review, document review and qualitative interviews. Using these methods, data were collected and analyzed to propose potential improvements. The next part states the major findings of the research in line with the research questions.

RQ1: What are the main challenges encountered in the project handover phase in the eyes of the PM and the O&M team?

There are four main categories of challenges in the handover phase. These are challenges that are related to project output, information and communication, management practice, and competency. Project related challenges are those that are associated to the physical output of the project. This includes the mostly seen challenge in the handover - project defects. Information and communication related challenges are considered one of the most important challenge in the handover phase. This is because information is the lifeblood of operations. It makes operation and maintenance of a facility more efficient and sustainable. Under this category are challenges such as lack of influence of O&M team, inconsistent collaboration between the teams, gap between project scope and tenant needs, and lack of information of O&M team after the handover. The third category is management related challenges. These are the challenges that mostly concern the strategic level. Under this are misalignment between project team and O&M about the handover process and challenge with manpower capacity. Lastly, the competency related challenges which is also considered as a major cause of the other challenges. This consists of challenges in competency of the project team, the O&M team, and the contractors.

In comparison with the literature, the fourth challenge identified by Zhu et al. (2019) which the inter-operability problem between BIM and FM systems were not a challenge for building adaptation projects. This might be because BIM is not widely used for building adaptation projects due to its cost effectiveness. It is more expensive to draw digitally a structure that is already built with wires and pipes in areas which cannot be inspected.

RQ2: What are the causes of these challenges?

By identifying what causes the challenges gave a deeper understanding about the challenges. This process helped identify applicable strategies in solving them. This master's thesis found out that there are different causes that lead to the challenges in the handover. One of

the major causes is related to competency. The first one is the competency of the contractor to provide good solutions in the design phase and solve problems before the handover phase. Another is the competency of the project team to plan for the unanticipated events, to gather input from the different stakeholders specially the O&M team, and to explain the scope of the project to their end-users specially the non-technical ones. Lastly, the competency of the O&M team to speak up during the design meetings where they should be knowledgeable about the things that is needed from them. Other causes are end-users behaviour, unclear management process, lack of manpower capacity, and strict awarding procedures.

RQ3: How can we improve the handover phase?

Different strategies were identified through this master's thesis. All level of management have their share of tasks and responsibilities in implementing these strategies. These strategies can be implemented throughout the project lifecycle or to separate phases of the project. Lastly, these strategies should be tailored fit to the structure of the organization.

During the whole project lifecycle, creating a culture of collaboration can improve knowledge transfer between the teams which minimizes the challenges experienced in the handover like lack of information after the handover. Using technological interventions also helps minimize or eliminate challenges found in the handover phase. These interventions include automatic defect or feedback system and internal building standards software. End-users' needs should be taken into consideration and careful planning and implementation of the technology should be ensured. They should be easy to be adapted by everyone, the data format across the different programs should be aligned, and if possible, few programs should be used as possible. Different project management procedures should be studied and implemented in order to have a clear definition of everyone's roles and responsibilities. This is important specially at the end part of the handover phase. Improving the competency of the internal team and working with competent contractors decreases the chances of having project defects as well as delays,

At the planning and design phase, project teams can use an internal building standards to easily identify what is needed by their O&M team. In addition, the project team should balance using the standards with inviting their O&M team in meetings for verification and confirmation of the project output as well as O&M documents that will be submitted by the contractors. Lastly, more time should placed in this phase and ensure that everything is covered e.g. training and testing plans, required documentations, etc.

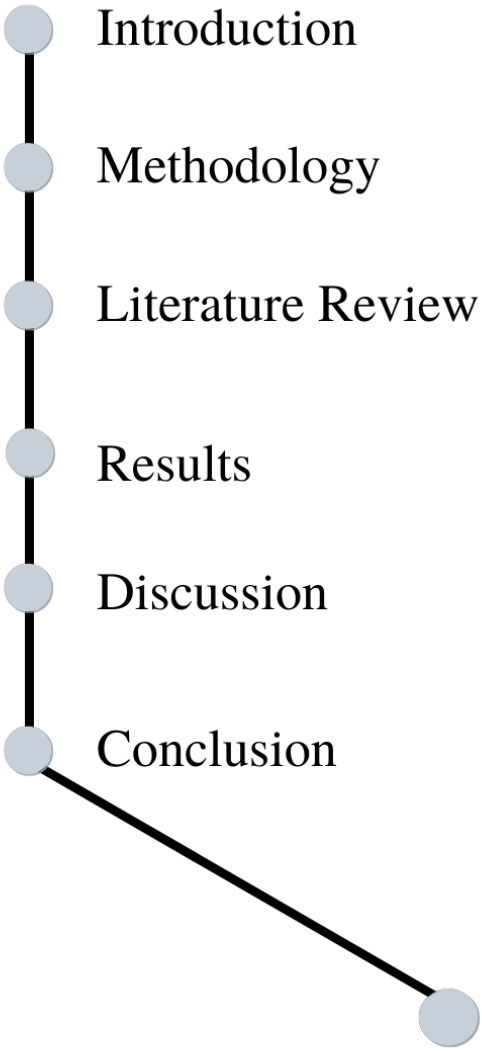
Strategies found during the bidding, awarding and contract formalization processes are: having a flexible procurement to easily separate the better fit contractors from the others, including a lump sum cost for unanticipated events in the contract cost for faster release of budget, and requirement of contractors to have the same set of team working in the project. These three (3) addresses challenges like project defects and change in end-user's requirements.

Moving forward to the implementation phase, teams should update the plans created in the planning and design phase as it is possible that there are changes after the awarding to

contractor. They should also implement continuous control of project delivery all throughout the project in order to ensure quality assurance. O&M should also join the testing, trainings and verification of the deliverable of the contractors. This increase their familiarity to the project output which can help them during the operation phase.

At the end of implementation is the handover phase where teams should already have a clear agreement of the roles. This process in itself is more of a formal transfer of responsibilities from the project team to the O&M team, but one strategy to ensure the challenges are solved is to continue the handover phase with the period called *trial operation*. This ensures that contractors are still in close contact with the project and they can be easily contacted when problems arise during this period.

During operation, organizations can also extend having the contractors in-house depending on the complexity of the project. As part of this, the organizations together with the contractors can develop performance evaluation or measurement of the project output to learn from it and identify the gap between as-designed and as-built. This way, both the organization and the contractor will gain valuable insights that can be used to minimize defects of their future building adaptation projects.



Future Studies

7 Recommendation for Future Studies

- Due to the limitation of only having the project management and operations and maintenance side, it is recommended to conduct a same type of study to research the challenges experienced by the contractors as well as identify strategies to solve them. This will give an addition to the bigger picture started in this master's thesis.

- Organizations need to filter the "good" contractors from the "bad" in order to minimize the challenges encountered during the handover and other project phases. This is easier for the private companies than the public companies. It is recommended to analyze and create a process to help public companies conduct a better procurement system to be able to work only with contractors that are best fit for the projects.

- Digitalization is another path of future research. The technical intervention like what PubCom4 are developing can be a central part of a study where one can verify and validate the effect of this technical intervention to building adaptation projects.

- One of the most important strategy is the implementation of upskilling programs. Researchers can study what are the most important skills that the project managers and O&M personnel need in order to improve the project handover phase which in turn ensure that the project output operates as expected. There were some skills identified in this master's thesis, but it is important to focus on the subject by using a wider set of research objects.

- As mentioned in the conclusion, the usage of BIM in building adaptation projects are not prominent as compared to new constructions, but technology is changing fast and there will come a time wherein the cost will be cheaper. Organizations may choose to embrace the implementation of BIM and integrate it with their FM systems. Therefore, it is a subject for future research to study the requirements of smooth integration of these systems when used in building adaptation projects.

- We can see that using a standardized performance evaluation system during the operation phase is one of the strategies found in this master's thesis. In order for this to work, organizations need to ensure that the knowledge gathered from this system is properly transferred to the project team so that they will learn from it and use it when they are designing and implementing a new one. With this regard, researchers can study and theorize frameworks that will ensure proper knowledge transfer and effective utilization of the lessons learned.

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Appendix A Interview Guide

Interview guide

"Improvement in the rehabilitation project handover from project team to operations and maintenance team"

Date & Time: _____ Location: _____
Role description and Department: _____
Education and Experience (years in organization): _____

Rehabilitation project discussed: _____

- We introduce each other and talk about the master's thesis and its goals.
- The role of the interview object with regards to the interview will be discussed
- The interviewee is free to ask questions during the interview.

Introduction	1. Could you describe your organization and what is your role and responsibilities in your organization? *(General roles and responsibilities)* 2. What is your role and responsibilities in the project? *(Project-specific roles and responsibilities)* 3. Could you describe a typical project, walk me through the phases from start until end and describe the role you have in this process and the department/roles you interact with?
Defining the Handover Phase	4. How do you define the handover phase? 5. What are the processes in the handover phase? 6. When does the handover phase start? 7. What is the basis for the start of the handover phase? 8. Who initiates the start of the handover phase?
Challenges and their causes and effects	9. What are the challenges you encounter during the handover phase of the project? 10. How do these challenges affect the project and the team? 11. What are the causes of these challenges?
Implemented solutions and effects	12. What are the strategies implemented to prevent the challenges from happening again? 13. Can you explain how does the strategy/s help? 14. What are the effects of these strategies to the project management team? O&M team? *(Interviewees can cite positive and negative effects)* 15. How can you improve these strategies based on the existing effects? 16. Which of these strategies do you think are the most effective?
Closing	17. Do you have anything else you want to add or something that I should have asked or know about? 18. Can you suggest someone who you think can help me answer the questions?

Intervjuguide

"Forbedring av rehabiliteringsprosjektsoverlevering fra prosjektgruppe til drifts- og vedlikeholdsteam"

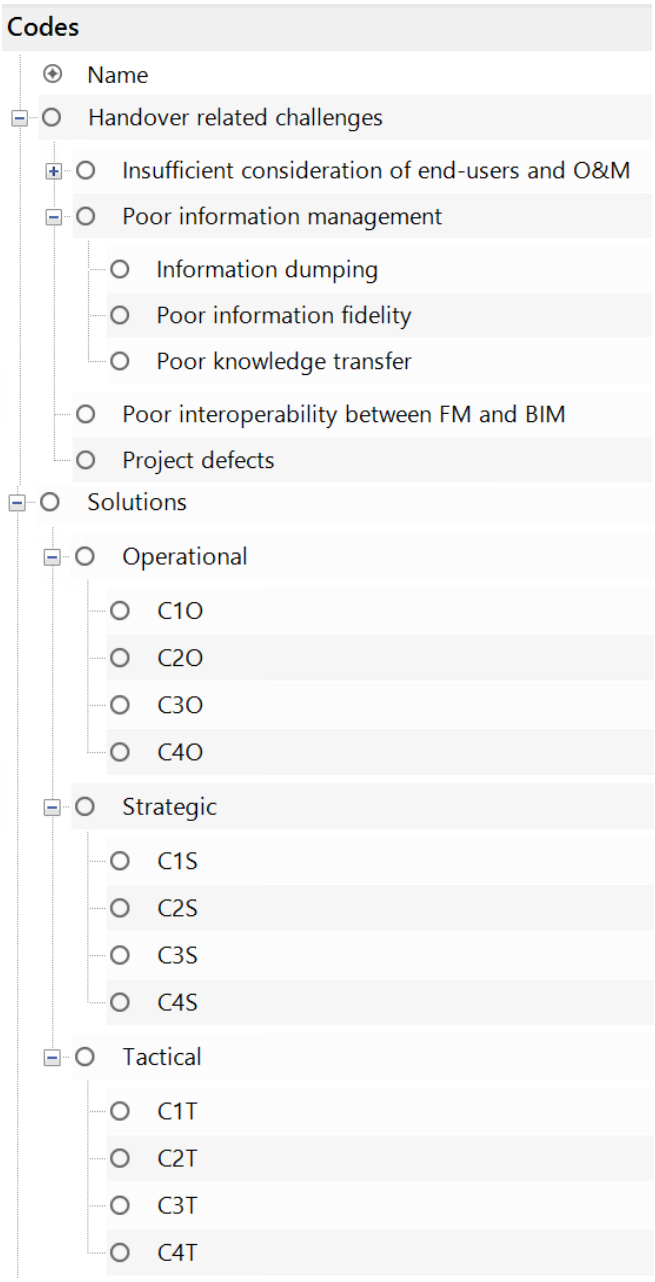
Dato og tid: _____ Sted: _____
Rolle beskrivelse og avdeling: _____
Utdanning og erfaring (år i organisasjonen): _____

Diskutert rehabiliteringsprosjekt: _____

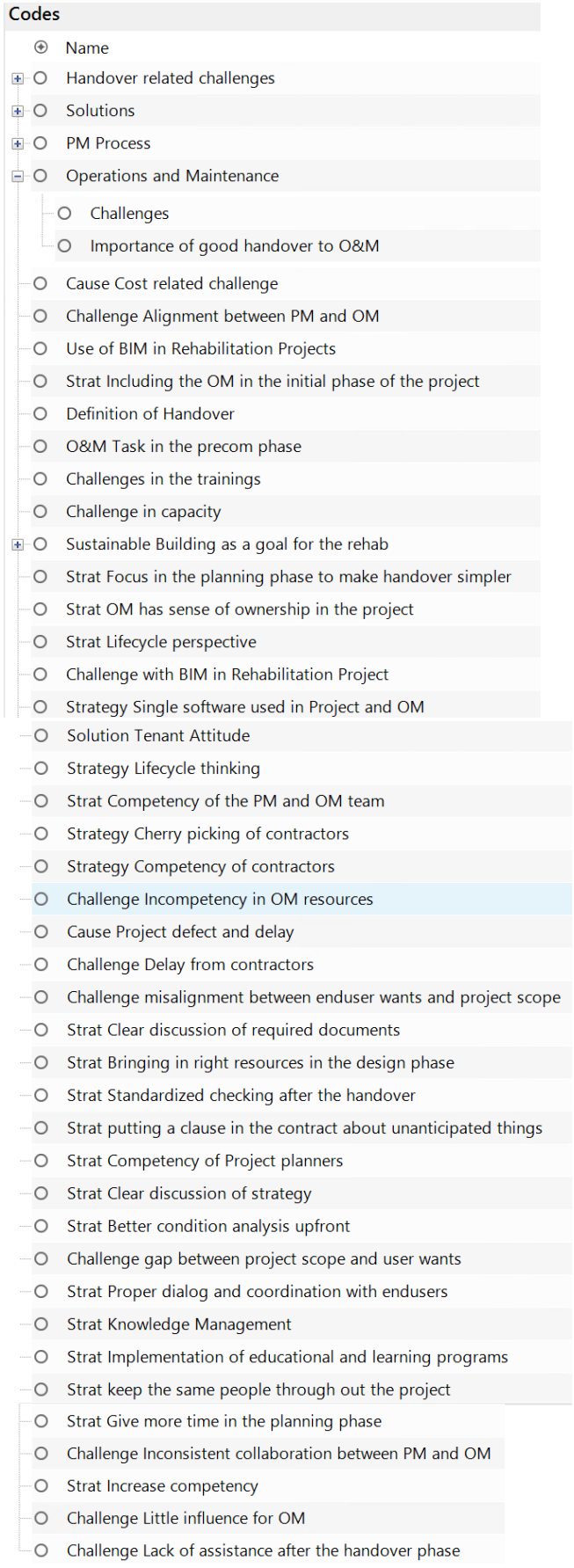
- Vi introduserer hverandre og snakker om masteroppgaven og mål
- Intervjuobjektets rolle i forhold til intervjuet vil bli diskutert
- Deltakere står fritt til å stille spørsmål under intervjuet.

Introduksjon	• Kan du beskrive organisasjonen din og rolle og ansvar i organisasjonen din? *(Generelle roller og ansvar)* • Hva er din rolle og ditt ansvar i prosjektet? *(Prosjektspesifikke roller og ansvar)* • Kan du beskrive et typisk prosjekt? Du kan gå gjennom fasene fra start til slutt og beskrive rollen du har i denne prosessen og avdelingen/rollene du samarbeide med.
Defineres av overleveringsfasen	• Hvordan definerer du overleveringsfasen? • Hva er prosessene i overleveringsfasen? • Når starter overleveringsfasene? • Hva er grunnlaget for starten på overleveringsfasen? • Hvem innleder starten på overleveringsfasen?
Utfordringe, aarsaker og virkninger	• Hva er utfordringene du møter i løpet av overleveringsfasen av prosjektet? • Hvordan påvirker disse utfordringene prosjektet og teamet? • Hva er årsaker av disse utfordringene?
Implementerte og løsninger og effekter	• Hva er strategiene implementer for å forhindre at utfordringene skjer igjen/gjentas? • Kan du forklare hvordan hjelper disse strategiene? • Hva er effekten av disse strategiene for prosjektledelsen? Drifts- og vedlikeholdsteam? (Deltaker kan sitere positive og negative effekter) • Hvordan kan du forbedre disse strategiene? • Hvilke av disse strategiene synes du er mest effektive?
Avslutning	• Har du noe annet du ønsker å legge til eller noe som jeg burde ha spurt om eller vet om? • Hvem tenker du kan hjelpe meg å svare disse spørsmålene?

Appendix B Codebook



Phase 1: Literature Review and Document Review



Phase 2: Interview Results

- Name
- Handover related challenges
  - Competency
    - Challenge Delay from contractors
    - Challenge Incompetency in OM resources
    - Challenges in the trainings
  - Information and Communication
    - Challenge gap between project scope and user wants
    - Challenge Inconsistent collaboration between PM and OM
    - Challenge Lack of assistance after the handover phase
    - Challenge Little influence for OM
    - Challenge misalignment between enduser wants and project scope
    - Poor information fidelity
    - Poor knowledge transfer
  - Management
    - Challenge Alignment between PM and OM
    - Challenge in capacity
  - Project Output
    - Different needs from different stakeholders
    - Project defects
- Strategies
  - Handover
  - Operation
    - Strat Standardized checking after the handover
  - Overall Project Phase
    - Strategy Competency of contractors
    - Strategy Single software used in Project and OM
    - Strat Proper dialog and coordination with endusers
    - Strat OM has sense of ownership in the project
    - Strat Knowledge Management
    - Strat Increase competency
    - Strat Implementation of educational and learning programs
    - Strat Competency of Project planners
    - Strat Competency of the PM and OM team
  - Planning and Design
    - Strategy Lifecycle thinking
    - Strat Lifecycle perspective
    - Strat Give more time in the planning phase
    - Strat Including the OM in the initial phase of the project
    - Strat Focus in the planning phase to make handover simpler
    - Strat Clear discussion of strategy
    - Strat Bringing in right resources in the design phase
    - Strat Clear discussion of required documents
    - Strat Better condition analysis upfront
  - Procurement
    - Strategy Cherry picking of contractors
    - Strat putting a clause in the contract about unanticipated things
  - Project Execution
    - Strat keep the same people through out the project

Phase 3: Finalized Codebook