

RESTY GONZALES GARCIA

# The impact of digitalization on Property Operations & Maintenance (O&M).

Oslo, June 2017

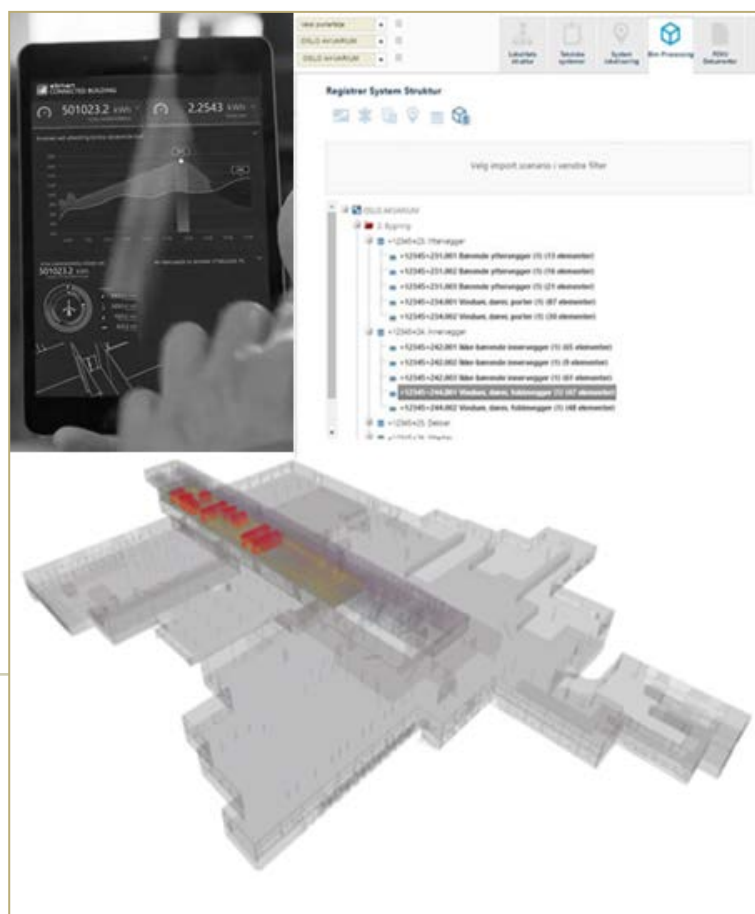


Photo: Statsbygg





Oppgavens tittel: The impact of digitalization on Property Operations and Maintenance (O&M) ( <i>Konsekvenser av digitalisering i eiendomdrift</i> )	Dato: 22. June, 2017		
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Ekstrakt:

This master thesis has investigated Statsbygg's Computer Aided Facilities Management (CAFM) system, "SESAM". It is developed and modified to support a more effective FM process in the line management, from strategic to operative level.

The four important aspects in information systems management (Atkins, 2009) were used as a theoretical framework for this research study. The activity theory (Engerström, 1999) was used in this research study to support the investigation on how Statsbygg O&M organization adapt to the development of its CAFM-system.

SESAM aims to provide better data quality, effective information management of all relevant legal requirements, regulations and directives. It has separate modules for O&M planning tailored to support the property and operations management in Statsbygg. The use of building information model (BIM) and mobile applications in SESAM are expected to simplify a more effective and efficient management of O&M tasks.

Digitalization help increase productivity in O&M. An overview of all interrelated processes is significant in specifying the requirements for CAFM-systems. The benefits of utilizing CAFM-systems to support O&M process and increase production are realized when utilized optimally. Access to information affects the O&M workflow. Information systems management is important to make all necessary information available across the organization. The digital strategy which affects the FM process including O&M must be understood from the strategic, tactical and operative levels of the organization. The involvement of O&M personnel from the development to implementation and use of CAFM-system to support the O&M process is vital, to the development of digital culture.

This master thesis suggest further to undertake cost analysis and evaluation on return of investments (ROI) in utilizing ICT tools. Other relevant further research is the study of BIM aided O&M process on how relevant O&M information are collected, delivered and exchanged in a life-cycle perspective.

Stikkord:

1. Digitalization
2. Operations and Maintenance (O&M)
3. CAFM System
4. O&M Productivity

  
(sign.)





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### Formål

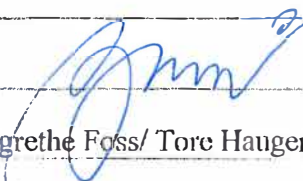
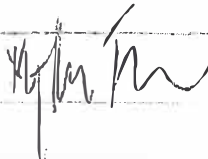
The main research question for this thesis is:

How can digitization help increase the productivity of property operations?

The thesis aims to gain new knowledge and understanding in facing the challenges of finding the best practice and concept for digitization of property operations.

### Følgende hovedpunkter skal behandles:

1. What is the current status of available methods and solutions relevant to digitization of property operations?
2. What role does organizational structure have in the digitization of property operations?
3. What are the success factors for use of digital tools that contributes to the productivity of property operations?

Underskrifter	Dato
Student: Resty Garcia 	01 September 2016
Veileder/faglærer: Margrethe Foss/ Tore Haugen 	01 September 2016
Leder for studieprogrammet: Geir Hansen	01 September 2016



## PREFACE

This master thesis is a final examination during my third and last year in the experience-based masterprogramme for Real Estate and Facilities Management at the Norwegian University of Science and Technology (NTNU). The masterprogramme is cooperation between the Faculty of Architecture and Fine Arts and the Faculty of Engineering Science and Technology, which constitutes 30 credits.

Statsbygg aims to take the lead in simplification and digitalization, as an efficient and modern property management firm. The implementation of its Computer Aided Facility Management system (CAFM-system), SESAM and the use of building information model for facility management (FM-BIM) are two of the most significant projects to achieve this goal. These projects have motivated me to carry out this thesis, investigate further, the status of property operation management in Norway, and highlight the implications of digitalization. This research study has rewarded me with significant insights from my colleagues working in the O&M organization. Technology development is accelerating. Digitalization is already becoming an inevitable part of business development, which could lead to the disruption of traditional business processes. Peter Drucker quoted that *“the best way to predict the future is to create it”* (Zhu, 2014). This research project aims to contribute into understanding the new digital paradigm and the impact of the digitalization on property operations and maintenance in Norway. This is an independent work for a master thesis, carried out in the period from September 2016 to June 2017.

Oslo, 22 June. 2017



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Resty Gonzales Garcia

## **ACKNOWLEDGEMENTS**

My gratitude goes to my employer Statsbygg, for the financial support and my manager Mai Anh, for giving me the opportunity to take a master's degree in Real Estate and Facilities Management. I sincerely thank my colleagues in Statsbygg for their support, especially in the property management and R&D department.

I would like to thank my supervisor Margrethe Foss for her assistance and professional advice in writing this master thesis. I acknowledge my fellow students and our professors in NTNU for the academic journey that we have shared together in the past three years.

Finally, thank you Maricel for your patience and support.



## SUMMARY

The research topic of this master thesis is;

*“How can digitalization help increase productivity in property Operations and Maintenance (O&M)?”*

The research topic focuses on the challenges and opportunities in utilizing Computer Aided Facilities Management (CAFM) system regarding the operative function in Operations and Maintenance (O&M). The purpose of this research work is to analyze relevant literature and empirical data on how digitalization affects the O&M process and how the O&M personnel adapt towards a digital organization.

Three research questions (RQ) were asked to answer the research topic;

**RQ1 - How does organization develop CAFM-system to support O&M process?**

**RQ2 - How does organization adapt to the development and implementation of CAFM-system to support O&M?**

**RQ3 - How can digitalization contribute to best practice in O&M?**

The hypothesis for this research is;

Digitalization increase productivity in property Operations and Maintenance (O&M). Right ICT tool, organization and best practice are the keys to successful digitalization of O&M process.
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This master thesis has six chapters divided into four main parts. The three research questions is the framework of the entire research work.

A triangulated research method was carried out for this master thesis. Theory and literature study was used to answer the first research question (RQ1). Both qualitative (interview) and quantitative approach (survey) were used to answer research questions 2 and 3.

The investigation is limited to Statsbygg east regional office. The empirical study focuses on the use of CAFM-system. Statsbygg is currently utilizing “SESAM” as a comprehensive CAFM-system, modified to support its FM process including O&M. To test the hypothesis in finding the right ICT tool, it was necessary to investigate briefly how BIM and mobile “app” solutions influenced the development and implementation of CAFM-system. CAFM-system may include Building Information Models (BIM) to provide object-oriented building

information. Mobile “app” solution was developed to support SESAM, to effectively and efficiently access work orders and accomplish tasks.

### **The development of CAFM-system to support O&M process**

The examination and investigation of relevant internal documents in Statsbygg have provided this research work, theory and concept on the development of its CAFM-system. A large organization like Statsbygg was representative to answer the research questions in this research study. The results of the investigation shows that correct development of ICT tools depends on business strategy and objectives. Providing the best ICT solution alone does not ensure the success of O&M process. There are important aspects on the development and implementation of CAFM-system as a tool to support and increase production in O&M process.

- Appropriate process architecture with overview of interrelated processes
- Effective management of legal requirements and standards
- Overview of relevant technological solutions
- Resources planning
- Open and neutral interface

### **Adapting to the digital O&M process and tools**

The qualitative and quantitative investigation have produced different results that are both useful in providing empirical data. The interview results showed optimism and positive feedback about the development and use of CAFM-system in Statsbygg O&M organization. The respondents in the survey investigation were skeptical. The research study has revealed some important aspects to successfully adapt to the digital process;

- Access to O&M information
- Transparency in business plans and objectives
- Maintaining the quality of policy and standards
- Involvement and support
- Continuous training and skills development
- Intuitiveness of digital solutions

A total overview of FM process and sufficient skills of human resources are essential to the digital transformation of O&M organization and increase productivity.

### **Digitalization of O&M process and best practice**

The context of this research study has given a clearer perspective and understanding about the impact of digitalization on O&M. Digitalization of O&M process contributes to best practice by;

- Supporting a standardized process and activity workflow
- Better cooperation on all level of responsibilities
- Improved client and customer relationship
- Maintaining the quality of policy and standards
- Continuous technology advancement
- Development of the digital culture

### **Recommendations on further research**

There are three recommended topics for further research that are relevant to this master thesis.

- It would be interesting to study the economic benefits of digital tools to FM. The analysis of the return of investments (ROI) on use of digital tools. There are theories and methods on how to manage the life-cycle of ICT tools for FM.
- The study on how FM can benefit from Internet of Things (IOT) is an interesting topic for further research.
- There are new opportunities on BIM aided O&M process. The utilization of BIM with product data templates (PDT) is developing the way FM documents are collected, delivered and exchanged. It is compelling to investigate how O&M benefit from this technological development.

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## **LIST OF ABBREVIATIONS**

AEC – Architecture, Engineering and Construction

API – Application programming interface

BIM – Building information model or building information modeling

BAS – Building Automation System

BMS – Building Management System

bSa – Building smart alliance

CAD – Computer-aided design (software application)

CAFM – Computer aided facility management system

CMMS – Computerized maintenance management system

FM - Facilities management

FM-BIM – Facilities Management – Building Information Model

GIS – Geographic information system

ICT – Information and communications technology

IFC – Industry foundation classes (data format)

IWMS – Integrated Workplace Management System

O&M – Operations and management

PC – Personal computer

PDA – Personal digital assistant

PPM - Planned preventive maintenance

RFID – Radio Frequency Identification

STS – Sociotechnical Systems

SSB – Statistisk sentralbyrå/ Statistics Norway

TFM - Statsbyggs Tverrfaglig Merkesystem (Multidisciplinary identification system)



# 1. INTRODUCTION

The selected topic for this master's thesis aims to answer the question, "*How can digitalization help increase productivity in property Operations and Maintenance (O&M)?*"

This chapter presents the background, purpose of the study, general overview of the research problem and structure of the report.

The official Norwegian report NOU-2015-1 (2015) suggest, "*Increased use of digital tools will save both industry and municipalities for time and cost*". Norway is ranked number 2 among the most digital countries in Europe, based on a report by the European Commission (DESI, 2017). With this status, it would mean that Norway could benefit most from the range of opportunities in digitalization (Koss, 2012). Digital infrastructure and practices could contribute to an increase of 50% in business productivity.

While there are organizations that do not agree on the benefits of digitalization to improve business processes, there are also organizations that will implement it without a proper strategy. Operations and Maintenance (O&M) organization must be prepared to meet the different implications of digitalization. It is crucial to determine how to develop a correct digitalization strategy for O&M process and align it to its digital future. The digital shift will have a great impact on facility operations and maintenance. O&M are included in the Facilities Management (F M) process which represents the greatest expense for owners in operating a facility over its life cycle (NIBS, 2017).

## 1.1. Background and purpose of the research study

Digitalization of O&M process can be an intricate process. O&M personnel will need to adjust in utilizing tools and learning the new process in order to successfully achieve the organizational objectives and successfully propose the new requirements and standards for their clients and customers (Teichholz, 2012). Some technological solutions fail probably due to lack of strategic analysis or because of misalignment to the business core objective. FM organizations may possess the necessary disciplinary expertise in O&M, but have limited knowledge and experience on the development of new process in utilizing technology. It is important to create a balance between digital technology and people.

Statsbygg has currently implemented the use of Computer-Aided Facilities Management (CAFM) system as a tool to support its O&M activities. This implementation is a part of Statsbygg's digital transformation. "CAFM supports both operations and strategic facility

management” (NIBS, 2017). Today, CAFM-system may include Building Information Models (BIM) to provide object-oriented building information. Most of the CAFM-systems has interface to Computerized Maintenance Management System (CMMS) or other systems related to O&M (NIBS, 2017).

Research studies have shown positive results on the utilization of CAFM-systems regarding the strategic functions in FM. The purpose of this study is to examine and better understand the challenges and opportunities in utilizing CAFM-system regarding the operative function in O&M. It aims to highlight the different implications regarding the impact of digitalization on O&M. Previous research studies on implementation of CAFM-systems have focused mainly on the technical issues. This research work will look both on *hard* and *soft* characteristics regarding the implementation and use of CAFM-system that may affect business productivity.

Best practice is significant in O&M services to increase customer satisfaction and enhance the value of the facility . “*Digitalization is about using technology to innovate, improve and simplify*” (NOU-2015-1, 2015). The traditional tools, practices and organizational structure in O&M need to engage, benefit and adapt towards the future digital organization. This is a very young subject today. To understand it demands relevant empirical studies.

The result of this research study should provide relevant literature study and empirical data on how digitalization affects O&M process and how the O&M personnel adapt towards a digital organization. The target audiences of this report are FM advisors and O&M organization that are planning to digitalize the O&M process in their organization.

## 1.2. Research questions

Research topic:

**How can digitalization help increase productivity in property Operations and Maintenance (O&M)?**

The research topic for this master thesis is an extensive and challenging task. There are several methods and tools for digitalization of O&M process. This master thesis focuses on the use of CAFM-system to support O&M process. The research questions answers the research topic.

Research questions:

- 1. How does organization develop CAFM-system to support O&M process?**
- 2. How does organization adapt to the development and implementation of CAFM-system to support O&M?**
- 3. How can digitalization contribute to best practice in O&M?**

### **1.3. Hypothesis**

The hypothesis for this research study will be the focus for this master thesis (Fellows, 2015).

Digitalization increase productivity in property Operations and Maintenance (O&M). Right ICT tool, organization and best practice are the keys to successful digitalization of O&M process.

### **1.4. Scope and limitations**

This master thesis investigates the impact of digitalization on O&M with focus on the O&M organization and process.

The first significant research question is “*How does organization develop CAFM-system to support O&M process?*” It will investigate the important aspects needed, to optimally manage and support the O&M process. It aims to provide an overview of significant requirements and not the detailed specifications for CAFM-system.

The second research question is “*How does organization adapt to the development and implementation of CAFM-system to support O&M*” The question is related to investigating how the O&M organization adjust and prepare to digitalization regarding the development and implementation of CAFM-system to support O&M process.

The third research question is “*How can digitalization contribute to best practice?*” Digitalization of O&M is a new paradigm. Best practice is about finding new and better methods. The research question aims to suggest best practice based on the result of the theoretical and empirical investigation in this master thesis.

CAFM-system “typically combines the use of Computer-Aided Design (CAD)” (Watson, 2016). CAD systems are also developing regarding the use of building information model (BIM) and mobile solutions. It is necessary to examine briefly how BIM and mobile solutions affect the development and implementation of CAFM-system.

The O&M personnel are the main subjects of the research study. The investigation is limited to Statsbygg east regional office. Statsbygg property management includes management, operations, maintenance, development of existing buildings and service. It is also necessary to understand the views of the property manager and FM professional in the organization with focus on the O&M process.

**1.5. Document structure**

This report has six chapters divided into four main parts. The four main parts are the definition of the research work, theory and literature, the collection of empirical data, and the data analysis (Figure 1). The research questions (RQ) will be the framework of the entire research work (Olsson, 2011).

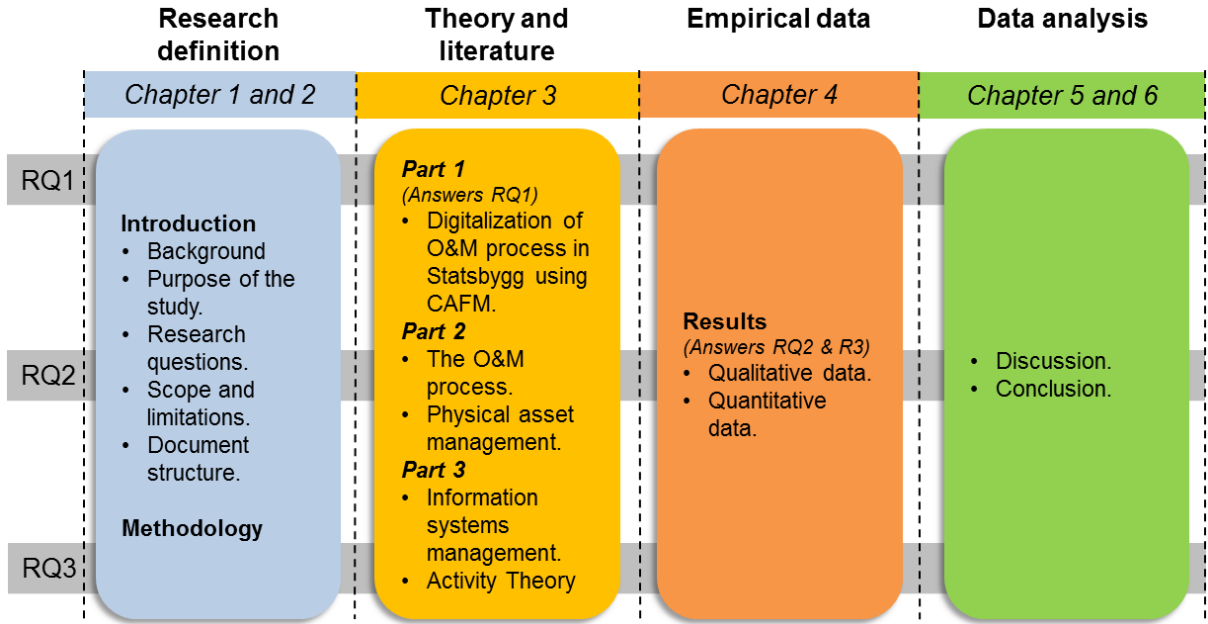


Figure 1 - Document structure for this master thesis.

The literature references used in this research work are presented in the references section at the end of this report. The appendix section is also provided.

## 2. METHODOLOGY

The purpose of this chapter is to present the research approach and the methods utilized for this master's thesis. A correct method for collecting empirical data, theory and literature is essential for this thesis. "*Method*" is a tool for providing a description of reality (Jacobsen, 2015a). The empirical test for this master thesis is to "*evaluate or assess*" the formulated hypothesis (Fellows, 2015).

### 2.1. Research methods

This section presents the relevant research methods. The last section of this chapter explains the validity and reliability of methods used in this research study.

#### 2.1.1. Triangulated research method

A triangulated research method uses a combination of two or more research methods to investigate the same topic of research (Olsson, 2011). According to Liu (2015), the use of both qualitative and quantitative approaches can help "*reduce or eliminate disadvantages of each individual approach while gaining the advantages of each.*"

A *qualitative* or *quantitative* research method are two basic research approaches (Kothari, 2004). It answers research questions depending on the topic of the research study. Qualitative and quantitative analysis are not principally different from each other. Both methods can be used for collecting empirical data that are suitable in different contexts (Jacobsen, 2015b).

Theory and literature review, qualitative and quantitative research methods were used in this research. Fellows & Liu (2015) suggests that careful and thorough planning is essential especially when large amounts of data will be collected. The purpose, type of data, format, result and type of analysis for each of the three different research methods are presented in **Table 1**. This overview is a very useful reference, to identify the advantages and disadvantages between the different approaches.

Purpose - explains briefly why the research approach is significant to the research study.

Data - is the data to be collected using the relevant research method.

Format – explains what and how data are gathered. It is important related to the analysis of the result.

Result - explains how the results are presented.

Analysis - explains how the results will be analyzed.

	<b>Qualitative</b> New theoretical data	<b>Quantitative</b> New statistical data	<b>Theory and literature</b> Theoretical and statistical (previous and existing)
Purpose	To describe the phenomenon, gain insight related to O&M practice, implementation and use of CAFM system in Statsbygg.	To measure the degree of effect of digitalization using CAFM System in Statsbygg.	To gather and collect relevant, existing theory and literature about the O&M process and the development and implementation of CAFM system, both in general and in Statsbygg.
Data	In-depth interviews of a total of 6 people regarding the implementation and use of Statsbygg's CAFM system.	Represents a larger regional office in Statsbygg.	Comprehensive data (previous and existing)
Format	Structured interviews using interview guide.	Categorized and standard measure on productivity (effective and efficient).	Books, articles, reports, standards, journals, websites.
Result	Illustrations and individual responses from the interviews.	Summarized percentage aggregation from questback survey result. (tables and graphs)	Categorized data on existing concepts and empirical data.
Analysis	Categorized data on concept and personal insights.	Descriptive. Test hypothesis, uses data to support conclusion.	Investigation of theory and concept

**Table 1 - Triangulated method in this research study(Garcia, 2017).**

The triangulated method was sequential. “Sequential implementation” means that qualitative and quantitative data were collected in phases. The qualitative method was carried out before the quantitative method. Both qualitative and quantitative approaches collected new empirical data. Theory and literature review was carried out to support the research approaches. Although a preliminary theory and literature review was carried out in the early stage of research, a more comprehensive review was necessary (Olsson, 2011). The following sections will explain how the different research methods were used.

### **2.1.2. Qualitative research method**

A qualitative research method is relevant for this master thesis to get a complete and detailed description of the research study. Most of the earlier research work and thesis related to the study of change in working environment, tools or process has been using qualitative research as a method. Qualitative research is a tool for social change. Digitalization is a new paradigm in property operations. In qualitative research, “*the beliefs, understandings, opinions, and views of people are investigated*” (Fellows, 2015). Qualitative method helps the researcher reveal how people explain and understand a phenomenon (Jacobsen, 2015b). It focuses on the personal perceptions of a phenomenon and the experiences of the people as they create the reality of how they work (Fellows, 2015). This method is used when “*investigating the*

*reasons for human behavior*” (Kothari, 2004). The use of the method is best suited when the researcher have good prior knowledge of the topic to be investigated and when the problem is relatively clear.

### Interview as a method

Qualitative method can gather data using structured, semi-structured or unstructured interviews. The levels of structuring the interview is as illustrated below (Jacobsen, 2015a).

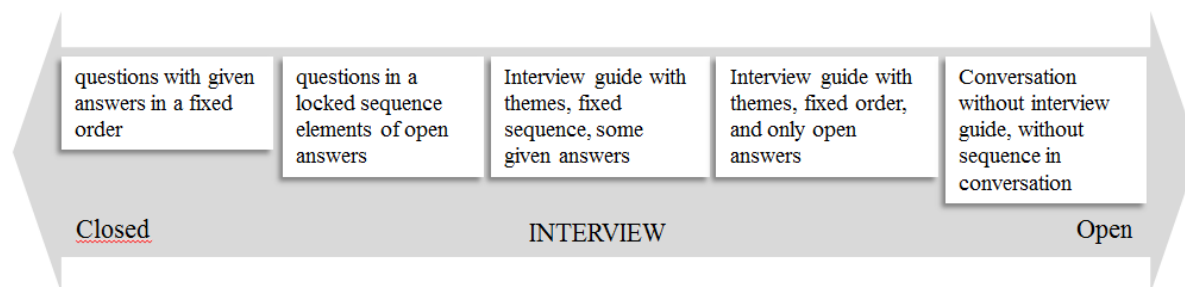


Figure 2 - Levels of structuring an interview (Jacobsen, 2015a)

This research study carried out in-depth interviews. It involves individual interviews with a small number of respondents (Boyce, 2006). This research study has interviewed six people. The interviewees provided detailed information about the implementation and use of CAFM-system related to O&M in Statsbygg.

Roles	No. of interviewees	Roles ( <i>Norwegian</i> )
O&M manager	1	<i>Driftssjef</i>
O&M supervisors	2	<i>Driftsleder</i>
Property manager	1	<i>Forvalter</i>
Advisor	1	<i>Rådgiver</i>
CAFM Program manager	1	<i>Programleder</i>
<i>Total no. of interviewees</i>	<b>6</b>	

Table 2 – Interviewed persons for this research study (Garcia, 2017).

The interviewees have central roles, and are associated with the development and implementation of CAFM-system in Statsbygg. The property manager, O&M manager and supervisor perform the responsibilities and tasks regarding the operations and maintenance of properties in Statsbygg. They represent the *end-users* of the CAFM-system. The advisor will give significant academic and interdisciplinary views and opinions about the development and implementation of Statsbygg’s CAFM-system. The program manager for SESAM project was

interviewed. He is responsible for the project development and implementation of Statsbygg's CAFM-system. The result of the interviews often help refine the questions for the survey (Boyce, 2006). Each in-depth interview was carried out in one hour using an interview guide with 14 questions. A voice recorder *mobile app* on a smartphone was used to collect all information taken during the interview, with the approval of the interviewees. The interviews will be kept anonymous.

### **2.1.3. Quantitative research method**

By using a quantitative method means that factual numerical data will be gathered for this research study. The work using this method is unaffected by the beliefs and values of the researcher because it is objective (Fellows and Liu, 2015).

Quantitative research method was carried out for this research study to collect sufficient data that will strengthen the validity and reliability of this research. A survey using quest back software was utilized as a tool for collecting data. The aim is to get a representative statistical overview of the user's experiences and opinions in utilizing CAFM-system and other relevant digital tools in Statsbygg related to the digitalization of O&M process. This method is essential to answer the research questions. The survey structure and categories are as listed below.

Survey structure and categories:

- Demographic data (in the organization)
  - roles
  - age
  - length of employment
- Views and opinions
  - Introduction to the hypothesis (ICT tool, organization and best practice).
  - Standardization, simplification and more effective O&M
  - organization and digitalization
  - digitalization and best practice
- Comments

Statsbygg property management department has over 400 employees. There are different users of the CAFM-system divided into strategic, tactical and operative roles and responsibilities. To get a representative sampling of the O&M organization to be investigated,



the survey was carried out in Statsbygg region east office. Region east office is the largest region office in Statsbygg with 159 O&M personnel. This is more than half of the total number of O&M personnel in Statsbygg. The survey was sent to all 159 O&M personnel in the region east office. The survey was simplified by providing multiple choices for answers and giving scores from 1 to 6, where 1 is the lowest and 6 is the highest score. The respondents were given the opportunity to give comments after each category. The survey was carried out in Norwegian. A total of 96 respondents or 61% of the O&M personnel in Statsbygg region east office has completed the survey. Some respondents were not able to answer the survey because of their current work load. The interpretation and analysis of result will be based on the 96 respondents who completed the survey. The survey questions are attached in the appendix of this report. The survey will be kept anonymous.

#### 2.1.4. Theory and literature review

The relevant internal documents in Statsbygg regarding the use of CAFM-system is an essential data for this research study. This is an issue that needs careful assessment from the author of this master thesis and approval from Statsbygg, the organization to be studied.

To search and examine potentially relevant theory and literature is an essential early stage of this thesis (Fellows and Liu 2015). The potential sources of theory and literature have different qualities which needs to be evaluated (Olsson, 2011).

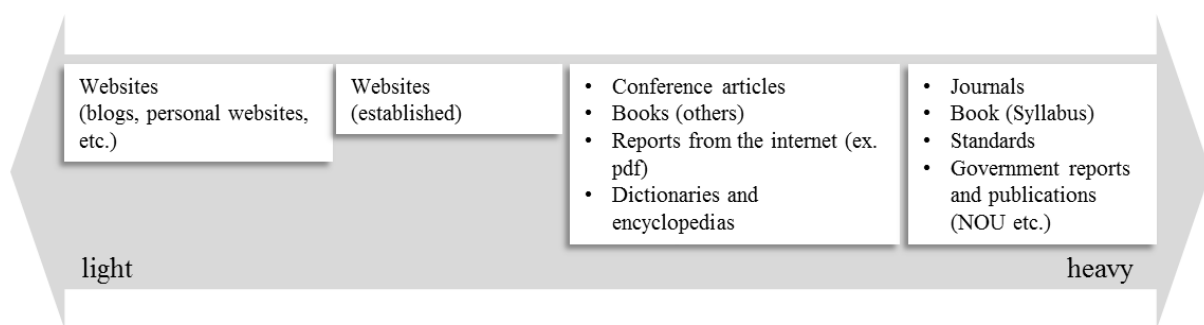


Figure 3 - Example evaluation on qualities of theory and literature (Olsson, 2011).

The books and syllabus from the previous courses in NTNU's experience-based masterprogramme were a relevant source of theory and literature. Oria was used as a search motor to find relevant articles, books and reports. The Norwegian standard (NS), government reports and journals on their websites also provided reliable information for this master thesis.

The relevant theories and literature are presented in chapter 3.

### 2.1.5. Validity and reliability

Validity means to evaluate the right things. Reliability means to evaluate things correctly. In qualitative research, validity relates to whether the findings of a research study are “*true and certain*” (Guion L., 2002). The reliability of the results of this research study was achieved by choosing the right subject and object of the research study. The people that were interviewed and investigated in this research study are representative roles who were directly involved in the implementation and use of Statsbygg CAFM-system and the O&M process.

The author of this report is currently employed in Statsbygg when this research was carried out. The author’s own perception and belief may affect the results of this research work. Jacobsen (2015) points out some advantages and disadvantages about studying own organization. The greatest advantage is having the “*first-hand knowledge*” about the topic of research study (Jacobsen, 2015b). According to Liu (2015), the validity and reliability of a research study also relies on how the author understood the phenomenon. Another advantage is that it was easier to collect both existing and new empirical data. But to prevent the disadvantages of having a less valuable result for this research study, the author has carried out a neutral approach by using a triangulated research method. Guion (2002) explains about establishing the validity of qualitative studies regarding triangulated method. “*The weight of evidence suggests that if every stakeholder who is looking at the issue from different points of view sees an outcome, then it is more likely to be a true outcome*”. The use of triangulated method will strengthen the validity of results in this master thesis.

#### **Qualitative and quantitative data analysis**

Both qualitative and quantitative research methods were used. I have considered utilizing quantitative technique together with qualitative method, to create a balance regarding the results of the interview and my own perception of the phenomenon. It will strengthen the reliability of the research study because the results were also measured according to the degree of effect.

Qualitative methods are often carried out to understand the statistical results of quantitative data (Olsson, 2011). Otherwise, the result of quantitative method may support or disagree on the result of the qualitative method. Compared to quantitative data, qualitative data can be difficult to analyze (Fellows, 2015). Categorization has been very useful to systematically analyze the collected data for this research. Early analysis of the results have developed and

suggested new questions to ask and what to focus on during the interview. It has also contributed to the construction of the research structure.

Case study method was originally planned in the early stage of this master thesis. It can also be a relevant qualitative method to answer the research questions in this master thesis. However, the availability of existing reports and internal documents in Statsbygg have provided sufficient data to understand the development and implementation of CAFM-system to the organization. This will be supported by the results of the interviews and survey data from the end-users of the system to produce valid and reliable theoretical and empirical data for this research work.

### **Measuring productivity**

Productivity in this research study is analyzed as an *effective* and *efficient* process for O&M by digitalization. “*Effective*” means doing the right things and “*efficient*” is doing things right (Sæbøe, 2014). The *effect* or the results of an effective and efficient O&M are improved quality and client satisfaction. The Norwegian term “*effektivisering*” means both being effective and efficient.

### 3. THEORY AND LITERATURE

This chapter is divided into 3 parts.

**Part 1** presents the result of the collected internal documents from Statsbygg. The guidelines, process and management documents about the development of CAFM-system in Statsbygg answers the first research question.

**Part 2** presents the general theory and literature on the O&M process and physical asset management. Olsson (2011) suggest that discussing the general theory and literature with the internal documents is helpful when internal documents from a large organization are relevant to the research question.

**Part 3** presents the theoretical framework for this master thesis.

### 3.1. (RQ1) How does organization develop CAFM-system to support O&M process?

I have examined and investigated relevant internal documents in Statsbygg regarding the development and implementation of its CAFM-system. The guidelines, process and management documents are relevant source of literature data, that are helpful in investigating the first research question.

#### 3.1.1. About Statsbygg

It is necessary to start with a brief introduction about Statsbygg organization and its core business, to fully understand the relationship of its strategic objectives to O&M activities regarding digitalization. NS-EN 15221-1 describes the importance of organization to its primary processes in order to achieve its strategic objectives. It explains further that “*changes shall be managed and structured in strategic, tactical and operational levels, in order to remain viable and compliant to changing demands.*”(NS-EN 15221-1, 2007).

Statsbygg is the Norwegian government’s key advisor in construction and property affairs, building commissioner, property manager and property developer (Statsbygg, 2016a).

Statsbygg is a public sector administration company responsible to the Ministry of Local Government and Modernization (KMD) (Statsbygg, 2016a). The organization is one of the leaders in utilizing new technologies in the AEC industry, both in Norway and abroad. Today, the organization is paving its way again for digitalization and the new working methods.

Statsbygg is cooperating globally in solving the challenges and discovering the opportunities in using technology for building construction and property management. Statsbygg provides appropriate, functional premises to public sector enterprises, as well as realizing prevailing *sociopolitical* objectives in relation to architecture, governmental planning interests, preservation of heritage sites and the environment. The official Norwegian report Meld. St. 27 (2015-2016) has proposed a guideline to prioritize digitalization. Every year, Statsbygg receives a mandative letter from KMD regarding the business budget allocation for the organization based on Prop 1S (Tildelingsbrev, 2017). The letter determines the requirements of KMD for Statsbygg. It is an authorization letter for Statsbygg, regarding the disposal of expenses and income allowances with reference to the regulations for financial management in Norway. Statsbygg is responsible for its own business plans to achieve its goals based on

the requirements from KMD, within the budget framework granted to Statsbygg. The conditions and requirements from KMD in 2017 regarding efficiency and productivity improvement for Statsbygg in 2017 is that *“Statsbygg will work systematically to better utilize the allocated resources and increase productivity. Digitization of work processes and services (digitalt førstevalg) is a key instrument to this work, together with, for example, re-organization, process improvement and other use of technology.”*(KMD, 2017).

### **Statsbygg organization**

Statsbygg owns 2,270 buildings distributed among 550 property complexes in Norway and abroad (Statsbygg, 2017). The organization has regional offices in Oslo, Porsgrunn, Bergen, Trondheim and Tromsø. Statsbygg’s head office is situated in Oslo. Statsbygg has 908 employees, about one half of them are personnel working with property management. A total of 254, 4 personnel works in property operations and maintenance (O&M).

#### **3.1.2. Statsbygg’s CAFM-system, SESAM**

“SESAM” is Statsbygg’s CAFM-system. SESAM is a modified solution of a comprehensive CAFM-system from Main Manager, tailored to support Statsbygg’s FM activities including O&M. SESAM provides an overview of Statsbygg portfolio. All properties that Statsbygg owns , manage, operates and maintains are registered in SESAM. It was developed to support a more effective work process in the line management, from strategic to operative level (Statsbygg, 2016e). It aims to provide better data quality, effective information management of all relevant legal requirements, regulations and directives. It assists the O&M personnel on the daily monitoring of its property assets, both the building and outdoor areas. O&M personnel uses SESAM as an administrative tool, with the ability to track and plan O&M and property development activities. It provides an overview of the daily tasks and routines, who will do it, when and where it should be done, and the costs.

#### **SESAM master data**

To ensure the quality of information in CAFM-system, a systematic and standardized data management is needed. All master data in SESAM are established based on the Norwegian Standard, NS 3451- Table of building elements (*Bygningsdelstabelen*) and Multidisciplinary marking system (*Tverrfagligmerkesystem*) TFM. In SESAM, Statsbygg has created two directories for building parts and tasks. For the property managers, these act as a library where Statsbygg standard data is retrieved and adopted to each property when modeled in the property layout. The professional responsibility for the administration of master data is

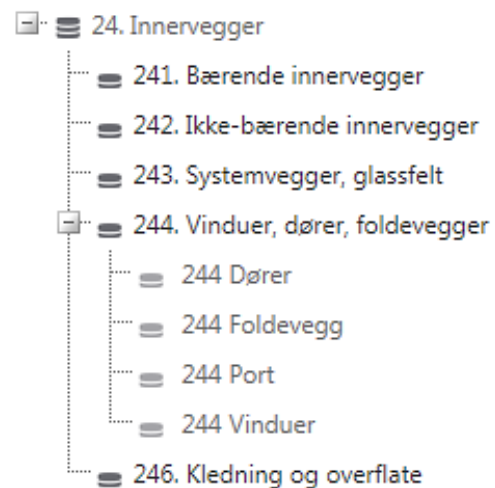
allocated in Statsbygg's property management section for operations and maintenance, ED (*Drift og vedlikeholdsseksjon*). All multidisciplinary technical changes in master data are updated in individual building's construction and operating plans according to specific rules.

### Masterbygg

SESAM has predefined proposed operational tasks for building components for construction, electricity, plumbing, telecommunications/ automation, other installations and site. These contexts of operation are specified in SESAM module "Masterbygg", which is also built up and maintained by the O&M staff in Statsbygg's operations and maintenance section (ED).

In "Masterbygg", all tasks are identified using TFM (Tverrfagligmerkesystem) or *multidisciplinary identification system* (A more detailed description of TFM is explained later in section 3.1.7). TFM is a standardized identification system to track systems and components in the operations and maintenance phase. The building systems and components will have predefined schedule intervals regarding periodic O&M tasks, where it is applicable.

**Figure 4** illustrates an example. 24. Interior walls include all related wall system types including interior windows and doors. The system specification uses 3-digit codes 244 for windows, doors and folding walls. Each actual TFM system will be chosen from the "Masterbygg" list and will be placed on its actual location to an actual



**Figure 4 - TFM system in SESAM**

building or site. It is also possible to locate the building system to the actual building level or floor, room or zone. SESAM "Masterbygg" is the basis for registration of existing properties in Statsbygg in its CAFM-system, SESAM. Statsbygg has developed and used TFM as a standard identification system for over a decade now. The integration and use of TFM in SESAM has been a challenge because of its hierarchical structure.

### Work order management

Work orders and check lists are administered in "Masterdrift". The standard work order will be automatically generated when building systems along with its components are registered in SESAM. The actual systems and components may be operated and maintained with regards to safeguarding other disciplinary and legal requirements. These can be managed by *tagging*

them with the required additional information. It may be related to the correct maintenance of systems and components for protected buildings. O&M personnels who will carry out operations and maintenance tasks in a protected building will be notified, that the building is subject to protection. The notification includes the requirements and recommendations that O&M personnel must follow regarding the operation and maintenance of protected cultural heritage buildings. Other disciplinary requirements that are administered in SESAM are management and control of fire and electrical legal requirements, universal design, health, environmental and safety requirements.

### Document management

The access to updated relevant O&M documents is a challenge to all O&M organizations. SESAM has document management functionalities. It can archive and hyperlink PDF and picture documents in its system. It also offers interactive 2D plans and elevations functionalities. The functionalities of the traditional interactive 2D drawing is not utilized in Statsbygg. To access 2D drawing documents, Statsbygg utilizes the web based drawing archive *Hyperdoc*. Hyperdoc is a digital drawing archive for as-built drawings needed for O&M activities.

### Mobile technology

SESAM also offers a *mobile app* solution to access and administer work orders. It is designed to provide flexibility and mobility for SESAM. This allows SESAM users to administer their O&M activities wherever they are, even outside the office.

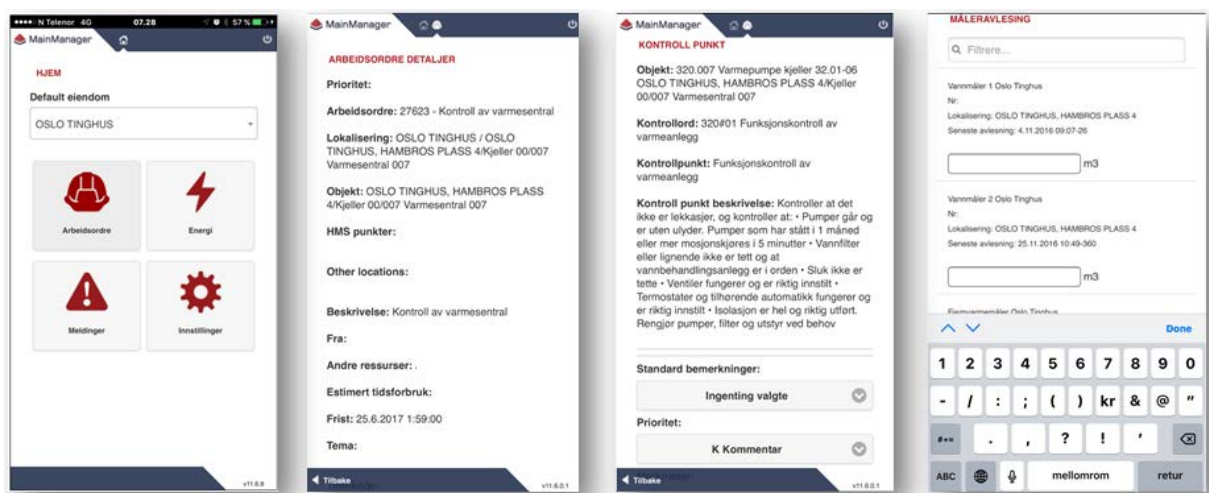
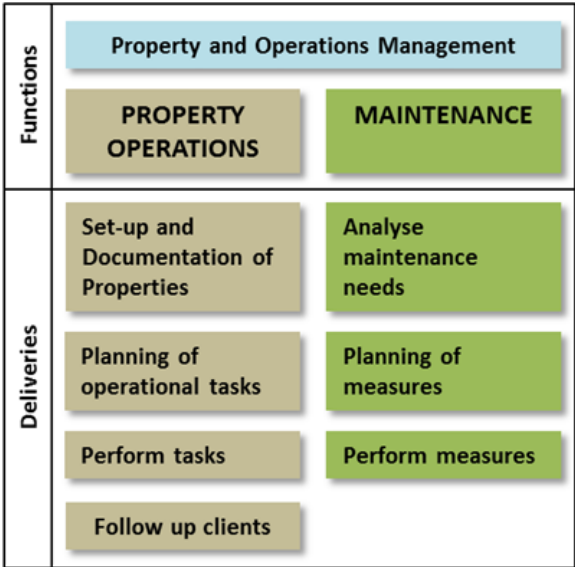


Figure 5 – SESAM mobile application in Statsbygg (Statsbygg, 2017).



Other important features in SESAM mobile app solution today are time-tracking, energy metering registration and notifications. **Figure 5** shows the work order, check lists and electricity metering in SESAM mobile application. It enables the O&M personnel to register and track, “when and how long” a task from a work order is carried out. It allows the O&M personnel to divide the registration of operations and maintenance activities . The mobile application can take photos and has easy to use redlining functionalities.

**3.1.3. Property operations and maintenance process in Statsbygg**



**Figure 6 - Functions and deliveries in Statsbygg.**

The property and operations management in Statsbygg has two divided functions that work together (**Figure 6**). The properties that Statsbygg owns, managed, operated and maintained are registered in the CAFM-system. Statsbygg maintains the owner’s responsibility to ensure that O&M documentations are secured and up to date during the life-cycle of the building, as described in the Norwegian building regulation TEK 10. “*All documentations needed for the operations and maintenance will be handed over and retained by the owner*” (TEK 10, 2016).

With or without the use of CAFM-system, O&M tasks are performed on the basis of work orders and regular observations using checklists. O&M activity data are important source of information for condition survey. Statsbygg performs technical condition survey of its asset as a prerequisite for maintenance planning and execution of maintenance measures. SESAM is not an instrument that makes decisions, but it provides a basis for decision on the execution of the technical condition assessment (NS-EN 16646, 2014). The information contained in the operation and maintenance plan is administered in SESAM. When preparing a maintenance

plan, it must be related to the property operation plan and status remarks on each system or component.

Statsbygg (2016) defines maintenance as the combination of all technical, administrative and property management related measures through the whole life cycle of a building system and parts, which intends to “*preserve or put it back to its original condition*” where it can perform the necessary functional requirements. Statsbygg maintenance practice supports a long-term operations and maintenance plan. Preventive measures planned for the building systems and components will be maintained within the lifetime expectancies, based normally on condition survey (NS 3424, 2012). Allocation of responsibilities between the owner and the tenant for the maintenance of the building is specified in Statsbygg standard agreement on *lease contract*. Statsbygg’s goal regarding maintenance aims at sustaining the property’s performance. With basis in “*quality level as built*”, the quality level “*maintenance as planned*” is determined (Jensen, 2008).

### 3.1.4. Roles and responsibilities in O&M and SESAM

The development structure is located in several areas of strategic, tactical and operational levels of the organization. The O&M staff, ED (Eiendomsdrift og vedlikeholdsseksjon) belongs to operations and maintenance section in Statsbygg property management department. The O&M staff represents the strategic and tactical activities and responsibilities in property management. ED is responsible for ensuring that all operations and maintenance of Statsbygg’s properties complies with all relevant regulations and directives.

Nr.	Conditions	Responsibilities
1	Building information, storeys, rooms including building systems and components registered and approved in SESAM.	O&M manager/supervisor (planner) Facility manager (FM)
2	Standard tasks are specified in «Masterdrift».	O&M staff
3	Responsible staff (resources) are specified in property administration module.	O&M manager/supervisor (planner) Facility manager (FM)
4	Standard tasks and notifications are transmitted to approved work orders in operations module.	O&M manager/supervisor (planner) Facility manager (FM)

Table 3 - Four conditions for carrying-out O&M using SESAM (Garcia, 2017).

There are four conditions for carrying-out operations and maintenance on properties using SESAM in Statsbygg (**Table 3**). The end-users of SESAM are the O&M personnel. O&M personnel are O&M manager, supervisor and technician that performs the operative activities and responsibilities in Statsbygg's O&M process. The standard tasks in a work order are prepared and specified in "Masterdrift" by Statsbygg's O&M staff (ED). O&M supervisors are responsible for registering all the necessary building information to be approved by the property manager or the O&M manager. When all registered building data are approved, the O&M manager and supervisor can start allocating resources. They are also responsible for ensuring that the standard tasks are transmitted to approve work orders in operations module

### **3.1.5. The importance of lease contract to Statsbygg's O&M process**

Lease contract is the basis for tenant and owner agreement. It covers and explains the principle and organization for property management, operations and maintenance, development and services that will be included during tenancy. It is an important agreement between the tenant and the owner. Lease contract is essential for the owner's vision, strategic goal, and requirements (Statsbygg, 2016b).

The principle on how the leasing cost is calculated is significant, to know how responsibilities and costs are divided between the tenant and the owner during tenancy or lease. The tenant lease computation should cover the whole tenancy expenses during the tenancy period. The property manager who is familiar with both the tenant and the property must be active in preparing the lease contract. A good and comprehensive lease contract provides a better owner and customer relationship (Statsbygg, 2016b).

Lease contract is a tool, which defines and describes the distinction between operations and maintenance. It clarifies how the tasks and responsibilities are divided between the tenant and the owner of the property. Having a uniform and correct accounting help achieve budget visibility and the objective requirements. An example for this is the agreed maximum operational cost per square meter. It gives financial security and provides reference for future clarifications.

Normally, the requirements of a CAFM software program includes property lease and contract management. Statsbygg has acquired *ISY Eiendom* to manage its property leasing and contract. ISY is an information system from Norconsult, that will also give Statsbygg overview of all its asset related to lease contract management.

### 3.1.6. Internal control system in Statsbygg

Even before the implementation of the CAFM-system, “SESAM” in Statsbygg, the internal control system was obligatory (Statsbygg, 2016). “*Internal control is a systematic measure to ensure that business plans, organizes, executes and maintains its activities in accordance with applicable regulatory requirements*” (Regelhjelp, 2016). The system is relevant in finding the best practice for property operations. “*Businesses should have internal controls and work systematically to ensure that the regulations are followed*” (Regelhjelp, 2016). Statsbygg divides the use of internal control systems of its properties, “IK Eiendom” and “IK DV”.

#### **Internal control of properties (IK Eiendom)**

Statsbygg has developed their own internal control system called “IK Eiendom” or the internal control system for its properties. IK Eiendom was used on all Statsbygg properties. It is a management tool where all procedures, requirements and important information that apply to the actual property and the tasks to be performed are documented. While it is important to meet the requirements in carrying out the operations and maintenance tasks, the procedures given in IK Eiendom follows the laws and regulations. IK Eiendom contributes to the achievement of Statsbygg strategic goal. The system is divided into 10 chapters which includes the internal control for operations and maintenance “IK DV”. Although IK Eiendom and IK DV should be understood related to the whole system, IK DV is the most relevant subject for this master thesis.

#### **Internal control on property operations and maintenance (IK DV)**

IK DV (Internkontroll drift og vedlikehold) is the internal control system for property operations and maintenance (O&M) in Statsbygg. All periodic operations and maintenance tasks on a property is systemized in IK DV. All tasks that were carried out in the property shall be documented for future reference. IK DV ensures that periodic operation and maintenance tasks are performed at the right time and with appropriate scheduled intervals. The operations and maintenance system shall document the control of building parts and equipment that were carried out. All planned and performed corrective measures and defects are also documented.

IK DV safeguards Statsbygg for liability on operations and maintenance tasks as stated in the *lease contract* or eventually any other agreements. The system also covers requirements for control and documentation of maintenance tasks related to legal requirements on internal control for electrical installations and fire (IK Brann).

IK DV uses standard color coding. Work orders related to fire uses red color. Green code is used for tasks related to health, environment and safety. Yellow code signifies information on all electrical components and installations, and was used to prevent danger to life, health or material assets. All work orders and tasks were easily identified and differentiated according to their discipline by color coding.

### **3.1.7. Multidisciplinary identification system (Tverrfagligmerkesystem, TFM)**

I did not find any equivalent english translation for *Tverrfagligmerkesystem* (TFM). I will therefore use the term “multidisciplinary identification system” for the purpose of this master thesis. Statsbygg uses TFM as a standard multidisciplinary identification system of all building systems and components. TFM will make it easy to track down and refer to the objects in the drawings, specifications, budget, accounting, internal control and documentation for operations and maintenance.

TFM is composed of the location code, system code and the component code. The location code tells where the system or component is located in the building. The location code starts with a plus sign. For example **+133** for building no.133. TFM standard will help systematically identify and locate an interior door in building 133. The system code is based on the Norwegian standard, NS 3451- Table of building elements. An interior door is a component in an interior wall and is identified with system numbers **244** in NS 3451. The component code identifies the type of component and its use, for example **DI** which is an interior door. Both the system code and the component code are followed by a serial number. The TFM identification system for the interior door in an interior wall located in building 133 will be **+133=244.001-DI001**.

Finally, a unique interior door does not need to have different TFM identification number and there is no need to distinguish the various components apart. It means that if there are many other interior doors of the same type in the building, the code **T** will be used. A unique interior door in building 133 will be identified as **+133=244.001-DI001T**. All the physical components in the building are marked with TFM identifications. The same TFM identifications will be registered in the CAFM-system, SESAM.

### 3.1.8. BIM in Statsbygg

CAFM-system “typically combines the use of Computer-Aided Design (CAD)” (Watson, 2016). CAFM-system today may include Building Information Models (BIM) to provide object-oriented building information.

BIM stands for “Building Information Model” when referring to the product (Statsbygg, 2016d). BIM is a digital representation of a building. It is based on objects with properties. “Building Information Modeling” refers to the process of developing BIM models. The use of BIM from planning to construction will continuously enrich the model with new information which requires good “Building Information Management”. BIM can be utilized and presented in 2D, 3D, 4D, 5D and 6D. BIM helps secure updated 2D plans that can also be extracted in other formats like dwg and pdf. 3D BIM is the visualization of the BIM model in 3D. It provides an intuitive representation of the building to view the BIM model as a whole building, partial views or its components as objects with properties. 3D BIM contributes to better quality of building construction documents by automatic coordination to the different views (Graphisoft, 2017). Quality, time and cost are important factors in project management. 4D BIM is utilized in project management planning to simulate and track planned schedules during construction. Quantity lists can also be extracted from a BIM model, for example door and window schedules. 5D BIM provides cost data which is utilized to get an overview and calculate building construction costs.

The development of CAD systems to BIM and other new technology and methods will affect the development and use of CAFM-system in Statsbygg. BIM is a requirement to all new building projects in Statsbygg since 2010. The ongoing building projects in Statsbygg will deliver its as-built documents in BIM format. Statsbygg’s BIM strategy suggest that a link between BIM and SESAM must be developed, to utilize O&M information. (Statsbygg, 2016c). In 2011, Statsbygg has carried out a research and development (R&D) project in cooperation with Jotne. The project “TilDa” is a “BIM server technology” utilized for managing leased properties and its space areas. It can also be used as a repository for BIM models with possible interface to the CAFM and CMMS system. Statsbygg will also acquire a BIM model server as a repository of all of its *as-built* BIM models in open format.

#### **Open BIM**

Open data is significant when using ICT solutions to effectively and efficiently make information accessible and easily available. To adopt the open data practice as an

organizational policy, both technical and legal issues should be taken into account. This would require the AEC and FM to collaborate and work together to create necessary standards and requirements. In 1995, buildingSMART has evolved to meet the demands of the building and infrastructure sectors (buildingSMART, 2017). The open BIM format IFC (Industry Foundation Classes), the standardized dictionary IFD (International Framework for Dictionaries) and standardized process IDM (Information Delivery Manual) were introduced to the AEC and FM industry regarding the use of BIM. Open BIM as a requirement is significant in providing an open and standardized utilization of BIM in the AEC and FM industry. In a press release on the 28<sup>th</sup> of November 2013, the joint statement on open BIM were signed by four large public building clients and owners in Norway including Statsbygg (buildingSMART, 2013). The joint statement defines “*requirements for all parties involved in their projects to use software based on open standards by 1 July 2016*” (buildingSMART, 2017). Statsbygg requires open BIM format IFC in the deliveries of as-built BIM models. IFC will be used as a standard BIM format in the CAFM-system.

#### **FM BIM in Statsbygg’s CAFM-system, SESAM**

The last phase of a building project is the delivery of as-built BIM. All relevant FM information collected from the early stage of a building project until the operations and maintenance phase will be delivered using a BIM model. The datasets of the build-assets are delivered in a graphical and non-graphical information in a shared digital space called the “*common data environment*” (BSI, 2013). The 6D BIM will be delivered to the owner. It is used to support facilities management. The value of 6D is to utilize BIM in the operations and maintenance of the property.

Statsbygg’s CAFM-system, SESAM is now also capable of BIM integration. The system developer of SESAM, Main Manager, has demonstrated how BIM can be used in its CAFM-system. The registration of the actual systems and components of a building is a prerequisite to administer work orders in SESAM and carry-out tasks in O&M. Using BIM in SESAM can automatically populate the systems and components from the IFC BIM. This will save time for the users of the CAFM-system from manually registering all actual systems and components of the building that they need to register in SESAM. Work orders are shown in the BIM model which helps the user track the locations of the tasks easily by navigating in the BIM model. **Figure 7** shows how BIM is integrated into the CAFM-system, SESAM.



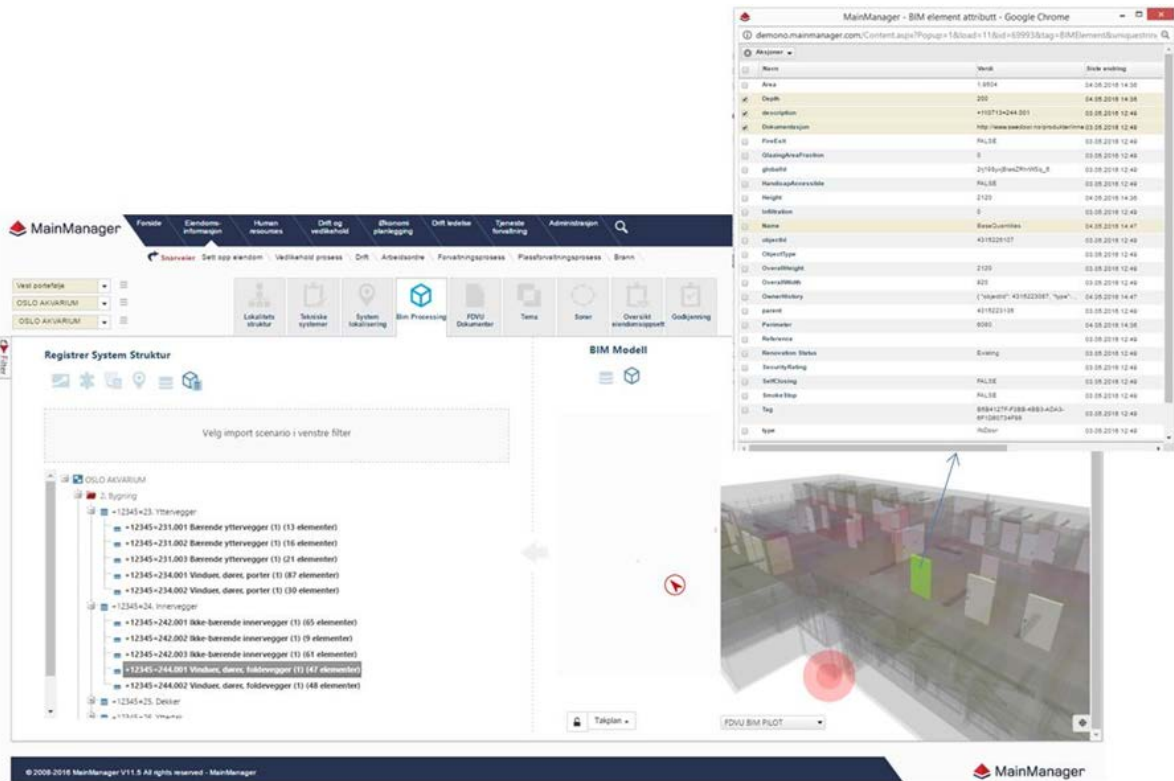


Figure 7 – FM BIM in Statsbygg’s CAFM-system, SESAM (MainManager, 2017).

Another option for using BIM in O&M process in Statsbygg is by making it available from a mobile device. **Figure 7** shows the proof of concept for Statsbygg on using the BIM solution from Dalux. Dalux is a Danish company that aims to provide an intuitive BIM solution to its customers.



Figure 8 –Using mobile device with BIM (Dalux, 2017).



A mobile phone is utilized to access work orders and view the BIM model both in 2D and 3D. The 2D plan of the BIM shows the location of the work orders and their status. The user can easily view the interior of the BIM model in 3D by simply choosing a location in the 2D plan as illustrated on the left side of **Figure 8**. O&M personnel can also access necessary documents that are needed to carry out their tasks. Dalux has also developed and implemented Artificial Reality (AR) functionalities in its mobile BIM viewer. It enables the user to view and compare BIM models with the physical building. The mobile solution from Dalux can also be integrated to SESAM. The BIM module in SESAM and mobile solution from Dalux are still under evaluation and testing in Statsbygg. This master thesis focuses mainly on investigating CAFM-system. This section has presented briefly some of the potentials on the development of CAFM-system, in utilizing BIM to increase productivity in O&M process.

#### **SUMMARY OF PART 1**

Part 1 answers the first research question, “*How does organization develop CAFM-system to support O&M process?*” It is summarized as part the results of the investigations for research question 2 and 3 in chapter 4.

### 3.2. The Operations and Maintenance (O&M) process in FM

Property operations and maintenance (O&M) process includes the primary activities and facility services in FM. This master thesis focuses mainly on the O&M process in FM. In FM, “processes have to set up for the specific circumstances and requirements of an organization”(NS-EN 15221-5, 2011). The key principle of the FM process is to satisfy the demands of the primary processes (NS-EN 15221-5, 2011).The requirements including resources are specified during the process *input*. The *output* or the result of the process should satisfy the specified requirements. This principle is relevant for the development and implementation of CAFM-system to support the O&M process.

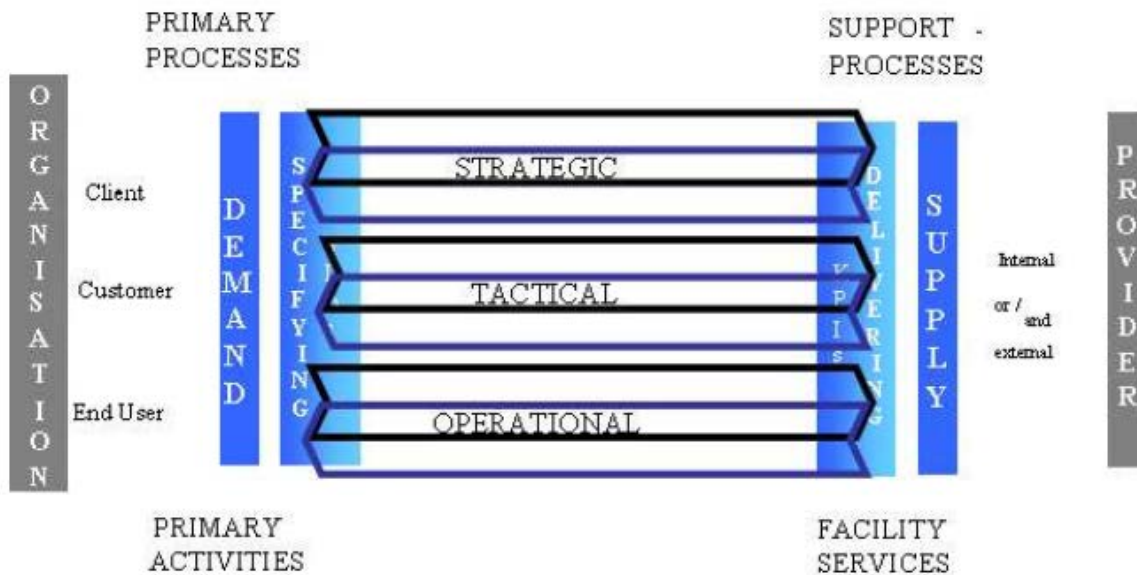
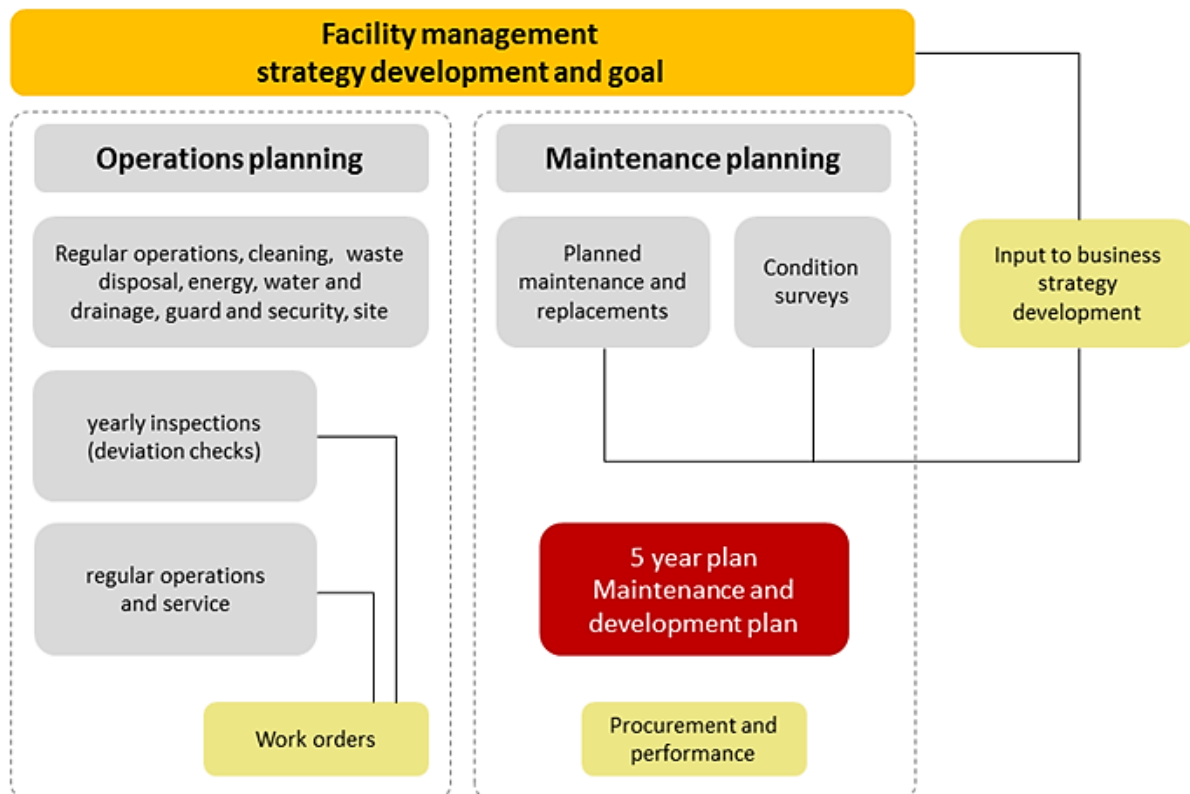


Figure 9 – Relationship of FM processes to the Facility Management model (NS-EN 15221-5, 2011).

FM is defined as “the integration of processes within an organization to maintain and develop the agreed services which support and improve the effectiveness of its primary activities” (NS-EN 15221-1, 2007). The Norwegian Standard NS-EN 15221-1:2007 further explains that technology influences the primary activities in FM. It is important to look at where property operations and maintenance activities are placed in the whole FM perspective and the different levels of responsibilities (**Figure 9**). “Connectivity and coordination is required at 3 levels – the strategic, tactical and operational level” (NS-EN 15221-5, 2011). The roles in an organization as client customer and end user refers to the people or organizations that are using the building or property to perform their primary activities.

### 3.2.1. Operations and maintenance management

It is important to understand the fundamental differences between operations and maintenance to manage it successfully. “*The relationship between the organization’s overall goals and strategies, operations and maintenance planning and action*” (Valen, 2011) is illustrated in **Figure 10**. The differences and important elements of operations and maintenance planning will be explained in this section.



**Figure 10 - Relationship between the organisation's overall goals and strategies, operations and maintenance planning and action (Valen, 2011) translated to english.**

#### Operations planning

Operation planning consists of regular operations, cleaning, waste disposal, energy, water and drainage, guard and security and site operations. Planned yearly inspections to carry-out deviation checks, regular operations and service are tasks that are performed and administered using work orders (**Figure 10**). Operations planning also includes *risk and vulnerability analysis*, and the result will be the combination of calculated values from the Building Management System (BMS) (Valen, 2011). Building Management System (BMS) is an important tool in building operations. BMS helps secure the operational performance of the building. It gives an overview and control of heating, ventilation, and air-conditioning

(HVAC) status. BMS also helps ensure the satisfaction and safety of the building users. The continuous monitoring of building status produces important information in operations planning.

### **Maintenance planning**

A maintenance plan gives an overview of the actual maintenance measures needed for a building within a perennial perspective (Valen, 2011).

Valen et.al. (2011 p.35) refers to maintenance plan as an active document that;

- *Gives overview of the building condition and needs for measures both short and long term.*
- *Helps ensure that the right maintenance measure is carried out at a right time.*
- *Allows planning of larger replacements.*
- *Forms the basis for the preparation of realistic budgets.*
- *Allocates funds to meet future need.*
- *Provides better opportunity for follow-up.*

Valen et.al, (2011) concluded that the conditions for performing good property management depend on the availability of necessary information, namely:

- ***Good overview** of all building and properties with key data on area, condition, the extent to which the buildings work for the user, data regarding adaptability and suitability for use.*
- ***Strategy and goal** for all property portfolios that supports the core business purpose.*
- ***Action plans** in the short and long term one year and four to five-year maintenance plans in order to develop the building in line with the strategy.*

Jensen (2008) explains that property operations «include all services, which are a precondition that a property can function satisfactory during use”. The maintenance of a building and its parts is an important task in property operations. To make O&M work together, a system is needed. Haugen (2008, p.9) explains the purpose of establishing a system for operations and maintenance planning :

- *Better overview of condition and need for measures*
- *Better financial overview and monitoring*
- *More predictability for owner and user*

### **Three approaches in maintenance planning**

The book “*A guide to achieving operational efficiency*” by Sullivan et.al. (2010) mentioned three different maintenance approaches. These approaches are reactive, preventive and predictive maintenance (Sullivan, 2010).

***Reactive maintenance:*** Reactive maintenance means that interval checks and necessarily replacements of parts of an equipment or a building is not planned and performed. It will save time and costs at the early stage of the equipment or building part life cycle. But until the equipment fails to function or the building parts start to deteriorate shorter than its expected longevity, it can suddenly become a costly problem for the owner. Unplanned maintenance affects the longevity of an equipment or building parts.

***Preventive maintenance:*** Sullivan et.al. (2010) defines preventive maintenance as “*Actions performed on a time- or machine-run-based schedule that detect, preclude, or mitigate degradation of a component or system with the aim of sustaining or extending its useful life through controlling degradation to an acceptable level.*” Sullivan et.al. (2010) explained further that compared to reactive maintenance, preventive maintenance have several advantages over a purely reactive program.

Maintenance is one of the five main fields in property operations (Jensen, 2008). Planned preventive maintenance (PPM) is “*a schedule of actions aimed at avoiding breakdowns and failures*” (Atkins, 2009). Tasks include “*inspections, equipment checks, diagnostics, adjustments and overhauls at specific intervals*” (Atkins, 2009). The schedule of activities in property operations such as PPM is significant in managing information and in evaluating which information system to adopt.

***Predictive maintenance:*** This approach carries-out condition surveys to detect evidence that an equipment or parts of the building is deteriorating (Sullivan, 2010). For example, the walls of a building requires to be painted every 2 years. This is a preventive maintenance approach because the activity is scheduled. Predictive maintenance performs condition surveys of the wall and finding alternatives for the longevity of the wall. The alternative could be to use paint that are better than what is often used. If the paint is better than the previous paint, the walls of the building will only need to be painted every 4 years. This should also be based on the result of the condition survey. It will save time and costs looking at a longer life-cycle perspective and planning.

## Building life-cycle

The building in its original as-built condition will be delivered to the owner at the end of the construction project. The quality of the building will degrade as the building gets older. It needs to be maintained to function satisfactory during use and according to the standard requirements. Bjørberg (2015) explained that the requirement on maintenance or development of a building can be related to the organization standard requirement or political requirements. Periodic maintenance and replacements are needed throughout the building life-cycle to maintain its as-built condition. The standard requirements are based on the condition degree (Guion L.). The concept of the building life cycle (Bjørberg, 2015) is illustrated in **Figure 11**.

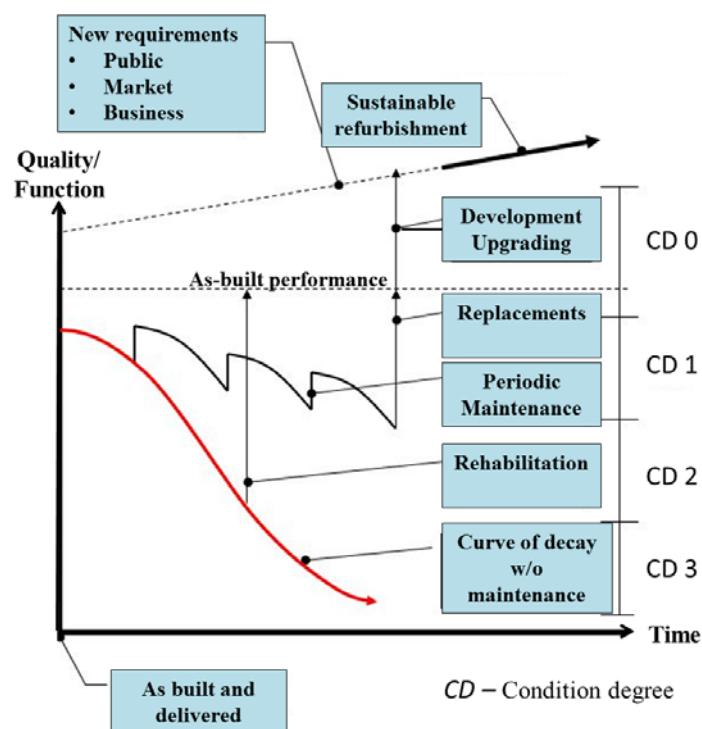


Figure 11 – The concept of building life cycle (Bjørberg, 2015). Author's translation.

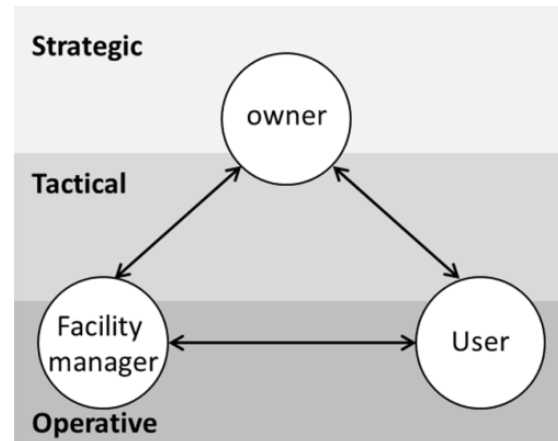
### 3.2.2. Roles and responsibilities in FM

#### Roles in FM

The roles and responsibilities in FM are owner, facility/property manager and user (**Figure 12**).

**Owner** – The owner is a private or public organization with property rights to a building or facility. The owner makes the political and economic decisions in a strategic level (Haugen, 2008). The owner performs the strategic functions in creating value to its property and give economic gains to its business.

**Facility manager** – is a person or organization who maintains the owner’s interest and responsibilities related to property management, operation and maintenance process of a building or property (Haugen, 2008). The property manager makes the strategic and technical decisions regarding tactical and operative process and activities.

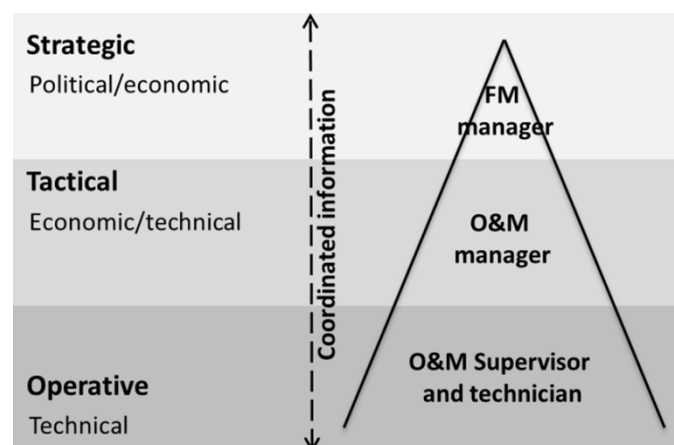


**Figure 12 - Roles and responsibilities in FM (NOU 2004:22, 2004) author’s translation.**

**The user role** – is a person or business organization who uses the building or property, to carry out or and perform its core business processes (Haugen, 2008).

*“The roles as owner, property manager and user are defined through their relationship with the building, but are influenced and shaped through their interrelationships, relationships with the environment, and the actors performing the roles.” (NOU 2004:22, 2004)*

### Responsibilities in FM



**Figure 13 – Roles and areas of responsibilities in FM (Haugen, 2008) Author’s translation.**

**Figure 13** Illustrates how the different areas of responsibilities and tasks regarding planning and control in FM are divided in the strategic, tactical and operative level of an FM organization (Haugen, 2008).

### **Strategic function**

FM strategy is a central task in the strategic function (NOU 2004:22, 2004). FM strategy includes the political and economic responsibilities in determining the purpose of owning a

certain property or a facility, its potential, use and procedures for acquiring, managing, development or disposal, goals and framework conditions for tactical level (Haugen, 2008).

### ***Tactical, administrative functions***

The tactical level is responsible to follow up and carry out the goals and perform the activities within the framework conditions that are decided from the strategic level (NOU 2004:22, 2004). The tactical, administrative function relates to the daily activities and planning in property management. The primary activities in the tactical function includes the organization and management of O&M process. The overall financial management in FM is a central function in the tactical function (NOU 2004:22, 2004).

### ***Operative functions***

The execution of operations and maintenance activities that were planned and determined on the tactical level is a central part of facilities management on operative level (NOU 2004:22, 2004). The operative tasks will have something to do with the daily operations of a facility. This task aims to maintain both the technical and aesthetic quality of a building to provide the needs of the client and user. The tasks will be divided between the owner's O&M staff and the client. The tasks and responsibilities between the owner and the client will be specified in a lease contract. This was also explained earlier in this chapter regarding the importance of lease contract in Statsbygg.

### **O&M organizational structure**

The business digital transformation and the use of CAFM-system will have an impact to the organizational structure. The choice of organizational structure depends on the property extent, technical complexity and orientation, geographical location, building age and status, customer requirements, quality requirements, etc. (Lindblom, 2004).

### **Measuring the quality of O&M program**

Sullivan et.al, (2010) suggest a number of metrics that can be used to measure quality or effectiveness of O&M program. Sullivan et.al (2010) explains further that these metrics are “*useful in cost justification, of equipment purchases, program modifications, and staff hiring.*” The evaluation metrics (Sullivan, 2010) are listed below.

- *Capacity factor*
- *Work orders generated/closed out*
- *Backlog of corrective maintenance*
- *Safety record*



- *Energy use*
- *Inventory control*
- *Overtime worked*
- *Environmental record*
- *Absentee rate*
- *Staff turnover*

### **3.3. Physical asset management**

May and Williams (2012 p.73) suggest that asset management should be considered as one of the core requirements of a CAFM software program. An effective and efficient management of maintenance activities are *key success factors* for the O&M organization. The European standard on maintenance within physical asset management NS-EN 16646:2014 has introduced “*physical asset management as a framework for maintenance activities*”(NS-EN 16646, 2014). Physical asset is defined, “*item that has potential or actual value to an organization*” and physical asset management as “*coordinated activities of an organization to realize value from physical assets*”(NS-EN 16646, 2014). A building is a physical asset that has economic value. Like all other physical assets, buildings and its parts must be managed from its conception to its disposal or in a life cycle perspective.

**Figure 14** illustrates “*the interrelationships between maintenance process and other processes of the physical asset management system*”(NS-EN 16646, 2014). It focuses on the relationships between maintenance and other processes in physical asset management system, but all core processes including operation of asset also has the same relationship to the processes in physical asset management system. Support processes are necessary in physical asset management because it provides resources (NS-EN 16646, 2014). Resources are for example, human, information and material. All processes in physical asset management are organized to satisfy organization’s needs (NS-EN 16646, 2014).

The core processes that are directly dedicated to the objectives are;

- a) *The acquisition of appropriate physical assets;*
- b) *The operation of assets;*
- c) *The maintenance of assets;*
- d) *The modernization or upgrade of the assets;*
- e) *The decommissioning and/or disposal of assets;*

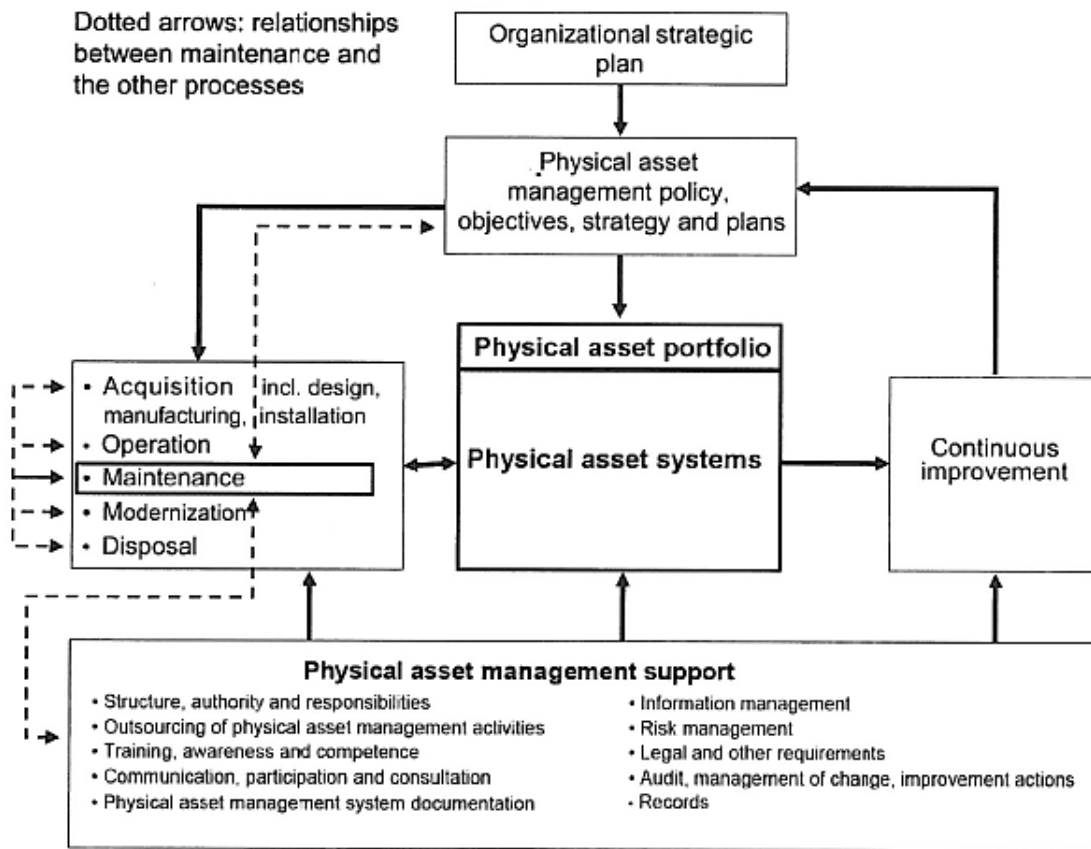


Figure 14 – The interrelationships between maintenance process and other processes of the physical asset management system (NS-EN 16646, 2014).

“Requirements for information system, are expressed and published in order to get an efficient and updated Computerized Maintenance Management System (CMMS)” (NS-EN 16646, 2014). CMMS are often integrated with the CAFM-system. SESAM provides system modules for operations and maintenance process in Statsbygg. An overview of operations and maintenance process is also significantly relevant when specifying the requirements for a CAFM-system.

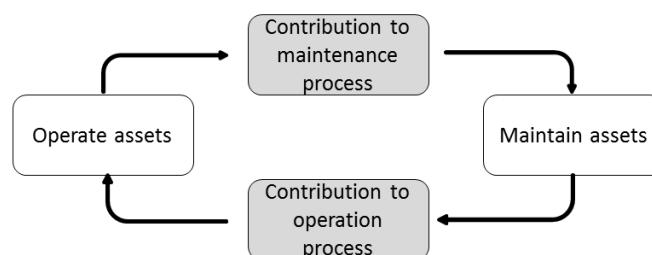


Figure 15 - Relationship between maintenance and operation. (NS-EN 16646, 2014)

The CAFM-system in Statsbygg has separate modules for operations and maintenance management that works together as a whole system. The operation of assets provides inputs to the maintenance process (**Figure 15**).

## **SUMMARY OF PART 2**

Generally, property operations and maintenance includes the *primary activities* in FM which is located in the operative level. The *primary processes* is located in the strategic level of the organization (NS-EN 15221-1, 2007).

The purpose of establishing a system for operations and maintenance planning are better financial overview, better conditions overview and more predictability (Haugen, 2008).

The conditions for performing good property management regarding maintenance are good overview of all building and properties, strategy and goal and action plans (Valen, 2011).

The roles in FM are owner, facility manager and user. The different areas of responsibilities for this roles are divided into strategic, tactical and operative functions. These roles are also relevant to O&M process.

A building is a physical asset that has economic value. Like all other physical assets, buildings and its parts must be managed from its conception to its disposal or in a life cycle perspective.

All processes in physical asset management are organized to satisfy organizations' needs. Support processes are necessary in physical asset management because it provides resources (NS-EN 16646, 2014).

A clear understanding of the fundamental differences and relationship between maintenance and operation planning is significant on the development of CAFM-systems.

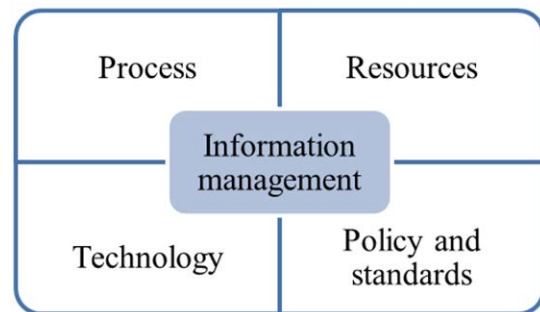
### 3.4. Information systems management

The essence of utilizing ICT tools in O&M is to make all necessary information available across the organization to save both time and money. *“Information is the lifeblood of FM, without which the organization will fail to deliver its promise to customers. Too little information and the FM function will starve, too much and it will be overwhelmed”* (Atkins, 2009). O&M is one of the important tasks in FM.

The evolution of ICT started from using email (Aziz, 2016). Providing information to the different levels of an organization requires standardization that complies with its own requirements and stakeholders. Producing and providing complete and accurate information at a right time for the right person. *“Information management is more than document management; it is a means to inform, influence, and implement actions in the workplace and unlike document management, is dynamic”*(Atkins, 2009).

Atkins and Brooks (2009) named *“four aspects of information management that deserves attention.”* These are namely process, resources, technology, policy and standards (**Figure 16**).

These four aspects are significant to the study on the development and utilization of CAFM-system.



**Figure 16 – Four aspects of information management (Atkins, 2009).**

Organizations must recognize that different personnel are needed to provide the service and to support it in use. Employees in the organization must be able to perform their work *“efficiently and effectively”*. As a factor for success, *“organizations need to ensure that information is accurate, reliable, up to date, complete and consistent”* (Atkins, 2009). Information is categorized as *“structured data”* or digitized information, held digitally in databases used to support operations and *“unstructured data”* or non-digital information (Atkins, 2009).

*“A key factor in realizing productivity gains is that the organization must be structured to take advantage of the technology and to optimize the contribution of those who use it”* (Atkins, 2009).

## **FM documents and O&M**

Other source of important O&M information are found in FM documents. FM documents can be delivered as paper and/or electronic documents. The official Norwegian standard on FM documentation is based on the interaction between the building construction life cycle and FM documentations (NS 3456, 2010). FM Documents includes the documentation of all delivery requirements, construction, installation, function, and instructions on operation and maintenance of building components. FM documentations are used as a basis for property management, operation and maintenance (O&M) consists of several main parts (DIBK, 2017). It is prepared for the management organization, operating and maintenance staff and users of the building (DIBK, 2017).

## **CAFM-system**

Computer-Aided Facility Management (CAFM) System “*provides the facility manager with the administrative tools and the ability to track, manage, report, and plan facilities operations*”(Watson, 2016). “*CAFM-systems are only associated to the administrative function and not a technical activity*” (NIBS, 2017). CAFM-systems are traditionally utilized differently from Computerized Maintenance Management System (CMMS). A computerized maintenance management system (CMMS) is a type of management software that performs functions in support of management and tracking of O&M activities (Sullivan, 2010). These two systems have begun to continue to merge into Integrated Work Order Management Systems (IWOMS) (NIBS, 2017). CAFM-systems also “*includes the creation and utilization of Information Technology (IT)-based systems in the built environment*” (Watson, 2016). CMMS and IWOMS is not covered by this research work.

CAFM-system is defined as the complete solution to support FM including the CAFM software (May & Williams, 2012 p. 72). It’s complexity includes the *concept, software and data* as pillars of the whole *CAFM-system* (May & Williams, 2012 p. 73). The concept relates to the initial survey, requirements and functional specifications. It should be related to the goals and benefits of the organization. The additional software components and interface for building automation systems (BAS) are some elements of the CAFM-system. These softwares should work together with the *CAFM software*. The third important structure in the CAFM-system is the data. CAFM data includes the inventory and process data that are recorded from different activities in FM including O&M. The FM organizational structure will be the stable base that CAFM-systems need (May & Williams, 2012 p.73).

### 3.5. Generation gaps

In 2025, the workforce will constitute of people from the *Generation C*. This will affect the future O&M workforce on how they are accustomed to produce and get information, administer activities and perform actions (Mohan, 2015). *Generation C* or the *digital natives* are people who were born in 1990's or younger. These are the generation of people who are always online (Friedrich, 2010). *Generation X* or people that were born between 1960-1979 will gradually decrease and get dominated by the *Generation C*. **Figure 17** illustrates how the workforce constitution is likely to become by 2025 (Mohan, 2015).

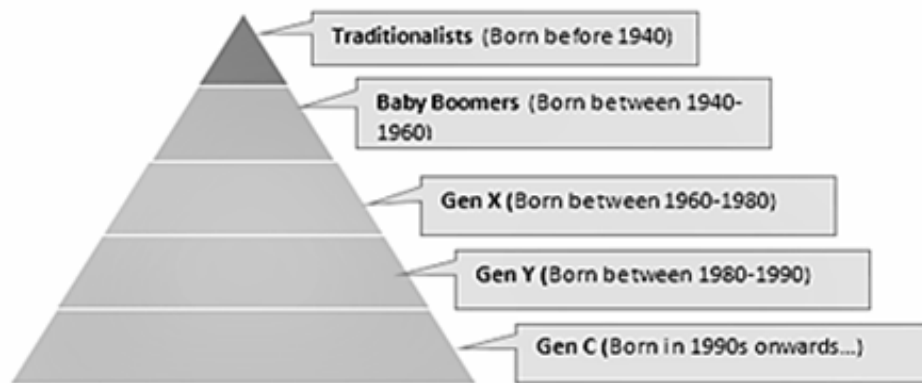


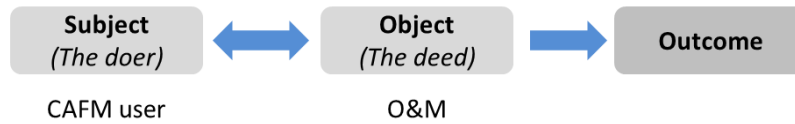
Figure 17 – The workforce constitution by 2025 (Mohan, 2015).

### 3.6. Activity Theory

The activity theory will be a helpful tool in discussing the results of this master thesis. Activity theory or sometimes referred to as Cultural-Historical Activity Theory (CHAT) is a descriptive meta-theory (Hasan, 2013). It was pioneered by Lev Vygotsky, Alexei Leontiev and Sergei Rubenstein in 1920s (Hasan, 2013). In 1987, a paper by Yrjö Engeström started the reformulation and development of Activity Theory in Scandinavia (Engeström, 1999).

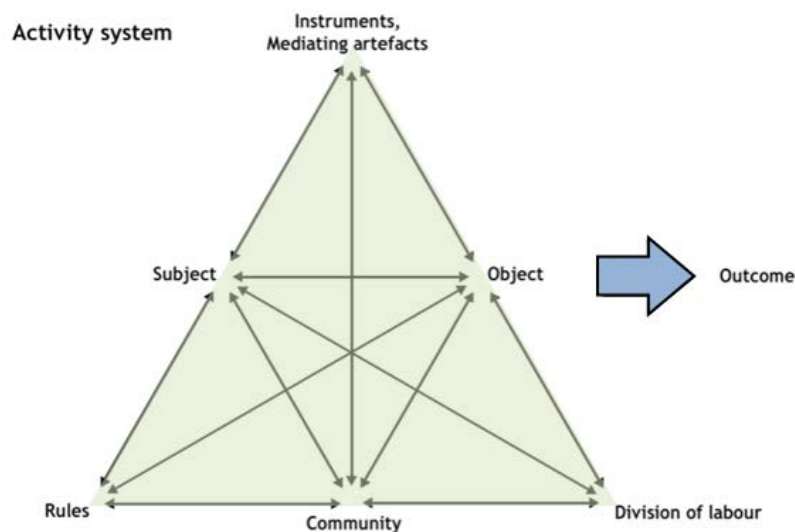
The term *activities* are mentioned many times in this research study. NS-EN 15221-5 defines *activities* as “tasks that are needed to complete deliverables.” “Activity” in activity theory is a system on which a human being works for a *purpose* to achieve a desired *outcome*. Activity theory is about “*who is doing what, why and how*” (Hasan, 2013). The activity theory is often used to better understand the human activity and as a theoretical framework for research on information systems (Crawford, 2006). This master thesis will investigate the use of CAFM-system to support the O&M process in Statsbygg. CAFM is an information system. O&M is performed by people with different roles and responsibilities e.g. O&M managers,

technicians and engineering staff. Engeström (1999) suggests that “context” is necessary for a successful implementation of information system. The context includes “*the people and their relations*” (Engeström, 1999). Hasan (2013) explains that in activity theory, “*the relationship between subject (human doer) and object (the thing being done) forms the core of an activity*” as illustrated in **Figure 18**.



**Figure 18 - The core of an activity (Hasan, 2013).**

Activity theory is often used to describe actions in a “*socio-technical system*”. It studies the total work activity system through six related elements to achieve a desired result or the outcome. The elements of an activity system is illustrated in **Figure 19** (Engeström, 1999).



**Figure 19 - The elements of Activity System (Engeström, 1999)**

To explain **Figure 19**, the *instrument* are mediating artifacts or *tool* which is essential to support the *object* or the deed, to achieve its goal or a desired *outcome*. The *object* and the *tool* must comply with *rules* such as policies, requirements and standards. The *subject* is the user of the *tool*. The *subject* belongs to the *community* where the activity is carried out and the *division of labor* are distributed. The *activity system* is an essential theoretical framework for discussing these issues. Although it is not the purpose of this research study to test the *activity theory*, it will help both for the reader and the author in developing a logical context for analysis and discussion on how the organization adapt to the development of CAFM-system, later in this report.

### **SUMMARY OF PART 3**

CAFM is an information system. A “context” is necessary for a successful implementation of information management system. It includes “*the people and their relations*” which “*forms the core of an activity*”(Engeström, 1999). The activity theory is useful to understand human activity and the utilization of information systems (Crawford, 2006).

Based on the research questions, the elements of the *central activity system* for this research are identified. The CAFM users are the doers. The object or the “deed” is the O&M process. The goal of the CAFM user is to provide a good facility for the satisfaction of their clients and users of the building.

Statsbygg utilizes CAFM-system as a *tool*. The main purpose of the *central activity* is to carry out a more effective and efficient O&M to enhance the value of a facility and increase client and customer satisfaction by utilizing the CAFM-system. The relationship between the CAFM user and O&M forms the core of the central activity in this research study.

The four aspects of information management that deserves attention are *process, resources, technology, policies and standards* (Atkins, 2009). These four aspects are also given important consideration as representative elements in the central activity system.



## 4. RESULTS

### 4.1. Introduction

The objective and significant requirements on the development of CAFM- system in Statsbygg was investigated . It has revealed that the important aspects in developing Statsbygg's CAFM-system are access to information, total overview of interrelated processes and technology, resources planning, legal requirements and standards. The development structure of Statsbygg's CAFM-system is located on several areas of strategic, tactical and operational levels of the organization. The three important roles in FM that are relevant to O&M process in Statsbygg are the owner, the facility/property manager and the user of the building.

This chapter presents the results of the qualitative (interview) and quantitative (survey) investigation to answer the research questions.

- How does organization adapt to the development and implementation of CAFM-system to support O&M?
- How can digitalization contribute to best practice in O&M?

#### **Interviews**

A total of six people with central roles in the implementation and use of Statsbygg CAFM-system were interviewed using the interview guide. The interview guide is found in the appendix section of this report. The interview results were based on *process, resources, technology, policies and standard*. Atkins & Brooks (2009) suggest that these are four aspects that deserves attention related to information management.

#### **Survey**

A survey was carried-out after the interview method. The aim is to collect the views and opinions from a larger number of users of the CAFM-system in Statsbygg. A total of 96 respondents or 61% of the O&M personnel in Statsbygg region east office has completed the survey. The survey was provided with multiple choices to answer the questions. The scores were rated from 1 to 6, where 1 is the lowest and 6 is the highest score.

The summary of results for all three research questions will be presented at the end of this chapter. A more detailed discussion is presented in Chapter 5.

## **4.2. (RQ2) How does organization adapt to the development and implementation of CAFM-system to support O&M?**

### **4.2.1. Adapting to the digitalized process**

#### **INTERVIEW RESULTS**

Statsbygg O&M organization utilizes different ICT systems or tools to accomplish their tasks. Not all of these ICT tools are necessarily integrated with each other. It was pointed out that the important thing about property management is not about the number of systems, but that all systems work together to cover the whole process. The O&M personnel recognizes it as a goal, to carry-out a more effective and efficient operations and maintenance of their properties. They suggested that a full description of the actual work process is important to see the whole picture. They indicated that the description of the O&M process and its relationship with other interrelated processes does not have a clear digitalization strategy.

The comparison and differences between the development and use of CAFM-system and Computerized Maintenance Management System (CMMS) were discussed to learn about SESAM interface with other systems in Statsbygg. Seen from the user's point of view, it is not about where the system belongs to and what it is called that is important, but how they spend their time in the system to administer the tasks that they are assigned to accomplish. There are differences in managing operations and maintenance in Statsbygg. These differences are often not seen isolated from each other. The separate modules for O&M in SESAM have contributed in identifying these differences.

Understanding the benefits and barriers in utilizing SESAM is important to understand the digitalized process. The two important benefits are access to information and transparency. The O&M manager and supervisor explained that information is important to achieve a more effective process in utilizing the CAFM-system, SESAM. They explained further that everyone work efficiently by getting access to the same data. A transparent O&M workflow is achieved by implementing SESAM in the O&M organization. Transparency is important specially regarding maintenance planning. It contributed to the receptiveness of employees from all levels of the organization.

The property manager in Statsbygg stressed that the greatest challenge when working in a large organization like Statsbygg is knowing who to ask for help regarding disciplinary and technical assistance needed. Now that information and data are kept in SESAM, digitalization

helped simplify changes that are made in a process, but adding complete and correct data to the system is an important task for the users of the CAFM-system.

All interviewees mentioned two common barriers in utilizing SESAM. The O&M manager and supervisor both explained that SESAM is already making a positive impact to the organization, but there are still some issues that needs to be solved. Speed performance negatively affects the administration of O&M tasks in SESAM. The system design must be intuitive as it affects the process workflow.

An effective collaboration and cooperation in organization is important to the O&M process. By collaborating with other parts of the organization, the O&M personnel have surpassed long steps towards something that is much better than purely manual system. The availability of information has improved, but it was too early for the interviewees to conclude if information is better. They explained that there is still a long way to go to get good data foundation regarding history and data registration. SESAM is already starting to make all information available across the organization, but its quality still needs improvement.

All of the interviewed O&M supervisors and manager confirmed that they are very satisfied with the maintenance system module (*vedlikeholdsmodul*) in SESAM. The O&M managers, supervisors and the property manager mentioned it many times as the most favored module. The fire and safety module and the operations module are also being utilized. The interviewees were asked if they would go back to the traditional process. They all agree that it is not an option to go back to the previous and pure manual system. They believe that SESAM is a good basis to communicate different decisions across the whole organization. They also added that the O&M personnel should be able to contribute with their knowledge and expertise. The digitalization strategy must be clearly understood to solve the right problem.

## **SURVEY RESULTS**

### **Effective O&M using ICT tools (CAFM-system, BIM and mobile solutions).**

The respondents answered the survey question about effectivity. The question aims to collect the views and opinions of the users regarding how SESAM, BIM and mobile solutions contributes to a more effective O&M process. The result shown in **Figure 20** indicated that 59.6% of the respondents believes that all three ICT tools, namely; CAFM-system, SESAM, BIM and mobile solutions will contribute to a more effective O&M process and increase productivity. The result shows an approximately equal percentage score regarding effectivity

and the implementation of SESAM, BIM and mobile solutions to the O&M organization. The combination of all three ICT tools gets the highest *mean* percentage score of 4.35% followed by BIM with 4.21%, mobile solution with 4.13%. CAFM-system got the lowest with 3.96%.

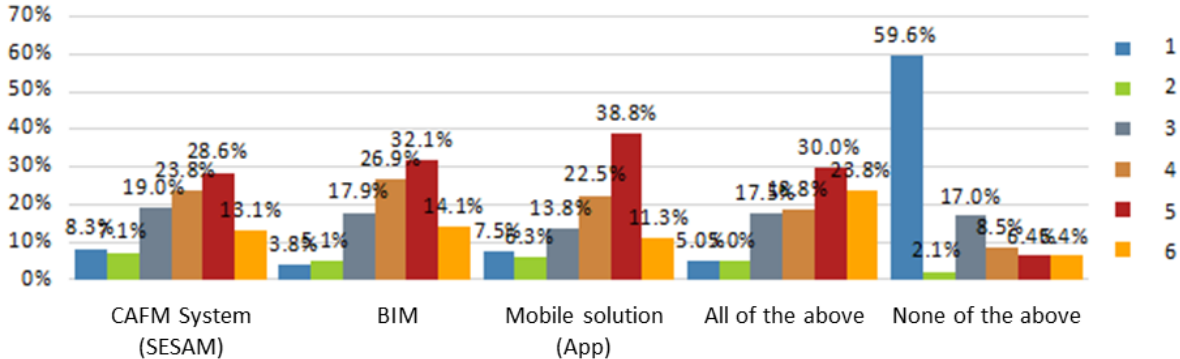


Figure 20 - O&M personnel opinions on how ICT tools contributes to a more effective O&M process.

A respondent suggested that ICT tools must not be too comprehensive. It will be very academic which is not practical. The respondents also emphasized in the comments given for this question, that although ICT tools are important, the building technical knowledge which O&M personnel possess must never be ignored. They recommended more skills training. The respondents explained that there are huge amounts of knowledge held by operating staff around the different properties in Statsbygg. They added that sharing experiences through establishing network collaborations and providing experience data bank will help achieve a more effective O&M organization.

**Simplification and use of ICT tools (CAFM-system, BIM and mobile solutions).**

The respondents answered the survey question about simplification. The question aims to collect the views and opinions of the users regarding how SESAM, BIM, and mobile solutions contribute to the simplification of O&M process. The result shown in **Figure 21** indicated that 52.3% of the respondents believe that all three ICT tools, namely: CAFM-system, SESAM, BIM and mobile solutions will contribute to the simplification of O&M process and increase productivity. Only 9.1% believe that any of these tools does not contribute to simplification.

The combination of all three ICT tools gets the highest *mean* percentage score of 4.16% followed by BIM with 4.01%, mobile solutions by 3.99% then lastly by CAFM-system with 3.79% regarding simplification.

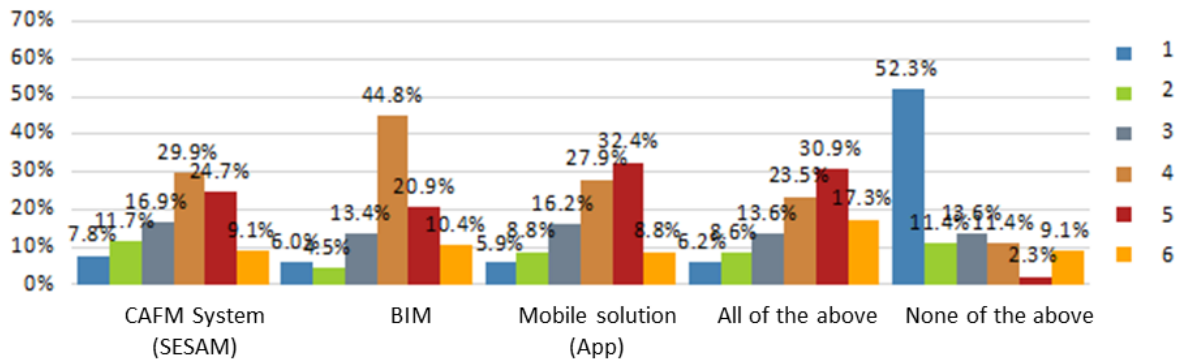


Figure 21 - O&M personnel opinions on how ICT tools contribute to simplification of O&M process.

#### 4.2.2. Roles and responsibilities

##### INTERVIEW RESULTS

To gain an actual description of the different roles in Statsbygg's O&M organization, the interviewees were asked to describe and define their roles and responsibilities in Statsbygg organization. It is an essential primary information when investigating how the organizations adapt to the implementation of CAFM-system to support O&M. There are 6 different roles that were mentioned in the interview.

The property manager has been working for Statsbygg for almost 2 years. The O&M manager has been working for Statsbygg for almost 5 years. The O&M supervisor and advisor has been working for Statsbygg for more than 10 years.

The O&M engineer and technician were not interviewed in this research. The roles and responsibilities of the O&M engineer and technician were described and defined by the O&M manager and supervisor. The CAFM-system program manager role was important to collect views and opinions regarding the implementation of the project. But it is connected only to the project activities regarding the development and implementation of SESAM. The program manager is therefore not included in the list related to O&M process.

- **Property manager (Forvalter)** – responsible for overall property management activities including lease contracting and client relationship. The property manager is also responsible for other owner and client agreement like the promoting the “green lease agreement” (*Grønne avtale*).
- **Advisor (Rådgiver)** – belongs to O&M staff (ED) that is responsible for maintaining the disciplinary expertise in FM including O&M. Coordinates and follows-up the maintenance strategy with other Statsbygg FM professionals. An FM advisor helps

develop skills and competence within the FM and O&M organization in Statsbygg. In order to see a complete picture and status of FM in the organization, an advisor contributes to the strategic management organization on administrative fields, correlation between processes in property management related to leasing, O&M estimates and budget accounting.

- **O&M manager (Driftssjef)** - ensures that the daily operations functions on all the properties and responsible for all other O&M personnel.
- **O&M supervisor (Driftsleder)** – responsible for daily operations, customer-related task, and supervising external operating technicians.
- **O&M engineer (Driftsingeniør)** – responsible for engineering and technical operations in the property. Typical disciplinary expertise in building, HVAC, energy management, electrical and automation.
- **O&M technician (Driftstekniker)** – is also responsible for daily operations, customer-related task, and coordination with external operating technicians.

The interviewees managed to describe and define the different roles and responsibilities in their organization. They indicated that they are aware of the O&M activities and tasks that they need to perform and the *division of labor* within and outside the organization.

## **SURVEY RESULTS**

### **Demographic data in Statsbygg Region east**

Different roles, status on length of employment and age group in the O&M organization will be an important variable in analyzing how the organization affect productivity in O&M regarding digitalization. There are 159 O&M personnel in Statsbygg region east office where 96 responded to the survey. Sixty-three people did not respond to the survey. Sixty-one percent of the total numbers of O&M personnel will be sufficient for this research study to create an overview of how many O&M personnel belongs to different categories of roles, age, and employment.

### **Roles**

The O&M organization in Statsbygg, Region east office includes four main different roles and responsibilities (**Figure 22**). All four utilizes Statsbygg's CAFM-system, SESAM. The role O&M supervisor (Driftsleder) represents 60% of the majority O&M organization O&M manager (Driftssjef) represents 17% of the O&M organization. The role O&M technician

(driftsteknikker) represents 15% of the O&M organization. Eight percent of the organization are O&M engineers.

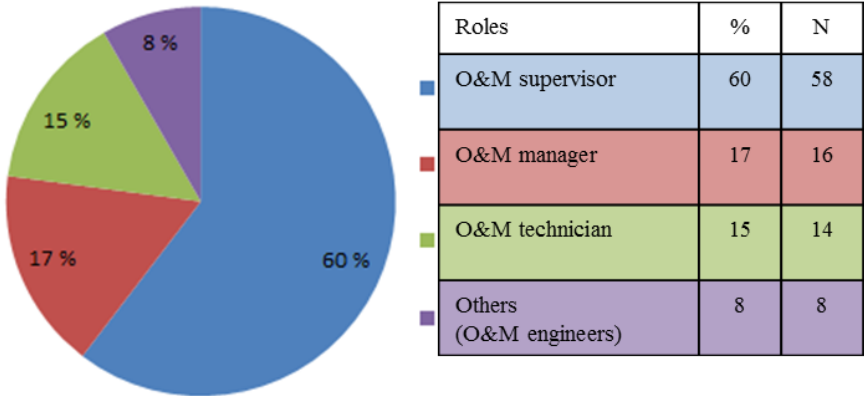


Figure 22 - Roles in Statsbygg O&M organization, Region east office.

**Length of employment**

The length of employment of O&M personnel in Statsbygg were collected in the survey (Figure 23). The length of employment in an organization contributes to the practical competency of the personnel and staff. Sixty-five percent of the respondents are working in Statsbygg for more than 5 years. This is followed by 19% of the respondents who are working in Statsbygg for 4-5 years. Only 7% of the respondents are working in Statsbygg for 2.3 years. 9% of the respondents are working in Statsbygg for less than a year.

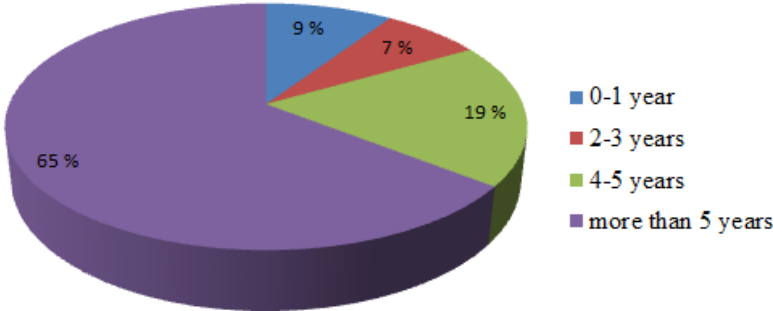


Figure 23 – Length of employment of O&M personnels in Statsbygg, Region east office.

**Age group**

Around 60% of O&M personnels working in Statsbygg region east were born between 1960 and 1979. These are followed 30% of O&M personnels who were born between 1940-1959. 8% of the O&M organization are people born between 1980-1989. 2% represents the youngest age group in the O&M organization.

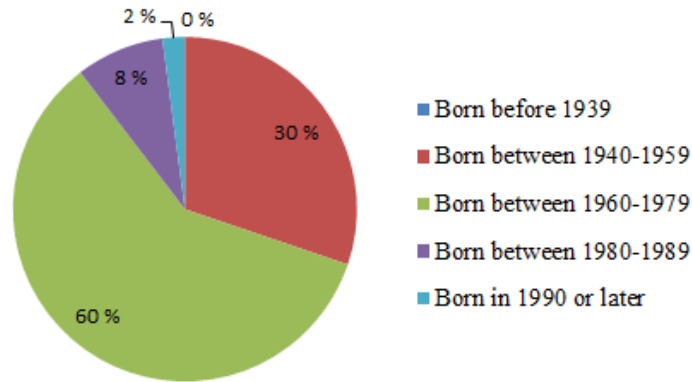


Figure 24 - Age groups in Statsbygg O&M organization, Region east office.

### Correct O&M organizational structure regarding the use of ICT tools.

The O&M organizational structure need to change regarding the use of ICT tools. The respondents answered the survey question regarding how the existing organizational structure affects the use of ICT tools. The respondents gave an approximately equal percentage score regarding organization and use of CAFM system, BIM and mobile solutions (Figure 25). A respondent commented that more skills training is needed regarding the use of the digital tools in the O&M organization and the properties in their portfolio before they can say that they have the right organizational structure. Another respondent also pointed out that BIM is not available for existing buildings for the meantime. The basic idea about the use BIM to support O&M process is good. But there is a doubt about how BIM will be maintained and followed-up if implemented. Generally, the result indicated a need to increase resources or manpower on the implementation of ICT tools in the O&M organization.

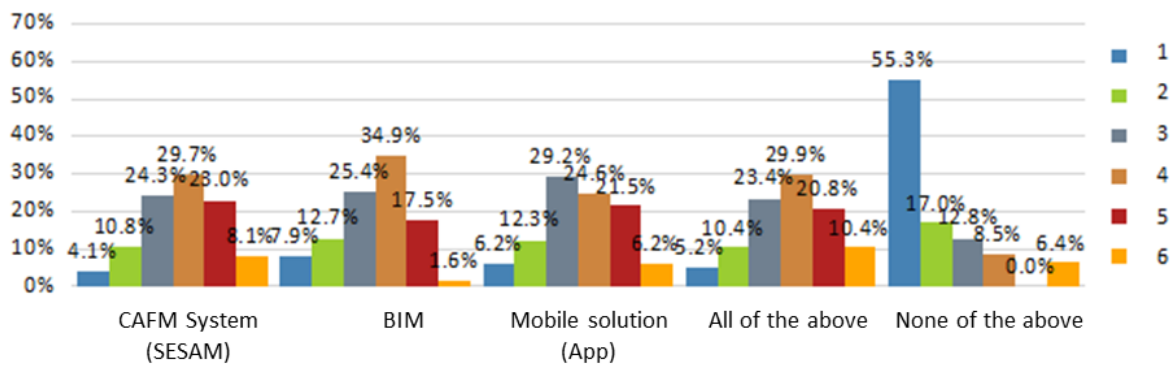


Figure 25 – Survey result regarding organization and ICT tools.



### 4.2.3. Client and user impact

#### INTERVIEW RESULTS

The interviewees were asked how their CAFM-system SESAM affects their clients. The O&M manager explained his opinion about the effect of digitalization to their clients using CAFM-system, SESAM. He claims that in utilizing SESAM, the client will always get a better facility. He asserted that Statsbygg's O&M organization is now clear and evident about maintaining their facility. They will get faster response through SESAM if tasks are registered and done correctly. The tasks that were collected and administered in SESAM contributed to solving some of the challenges in handling work orders compared to the old manual system. Statsbygg O&M organization have very good O&M personnel, but not all of them are good in following up the work order. There are some personnels that would sometimes miss the tasks that were assigned to them. SESAM and the digitalization of O&M process provides better overview and control in managing work orders which improved the quality of their work activities.

The advisor in Statsbygg property management department indicated that utilizing SESAM for maintenance planning is a way to share information that makes tenants able to plan for their own business in a better way. Statsbygg's maintenance plan is much more easily produced ahead of time and then harmonize it with the tenant's own plan.

The property manager have identified the challenges before the implementation of SESAM. As a new employee in Statsbygg, it was not easy to administer invoices allocated by previous property managers. A good overview of budget allocations has become more effective with SESAM. It contributes to the property manager's responsibilities regarding budget management which also affects its clients. The property manager additionally explained that one of Statsbygg's core businesses is property management and that the implementation of CAFM-system is important with regards to client and owner perspective. A good system that helps effectively and efficiently maintain properties and assets is important in property management.

CAFM-system, SESAM has provided the O&M manager and supervisor with a tool to effectively follow-up daily O&M tasks on their properties. It ensures a uniform and systematic execution and reporting of the operational, maintenance and property development tasks. An effective and efficient property operations and maintenance is the most important prerequisite to achieve client and customer satisfaction in Statsbygg.

#### 4.2.4. User involvement and training

##### INTERVIEW RESULTS

The advisor's involvement on the development of Statsbygg CAFM-system started since the identification of the need for a digital solution in 2009 and until today. A group of maintenance professionals was currently established in Statsbygg. The group is working primarily with the academic content regarding maintenance and advises the property management regarding the proper improvement and development of necessary functionalities in SESAM. It was also pointed out that technical support is available for the users of SESAM, but lacks an adequate FM and O&M professional support. The CAFM implementation project was managed by small project teams. The extent to which the individual groups have worked together is varied. The biggest weakness that were identified was the lack of coordination on academic delivery. The academic disciplinary knowledge in FM is very important. A poor general knowledge in FM may affect the development and implementation of the digital solution.

Training and skills development throughout the O&M organization is crucial to the success of SESAM. Two of the interviewed O&M supervisors are SESAM instructors (SI) and carries out training courses about the use of SESAM. They are also available for support to help their colleagues in the region east office when needed. During the interview, the O&M manager was assisting other O&M personnel in using SESAM.

The property manager explained that when the system is used often, the more they become familiar and better users. The challenge about digitalization is not the technology but the digital culture. They also believe that the challenges on motivating the personnel in using SESAM may also have something to do with geographical issues of the organization.

##### SURVEY RESULTS

###### **Status on implementation of CAFM-system in Statsbygg O&M organization (Region East office).**

Coordination, technical support, user involvement and culture development are some of the aspects that were named in the interview. The survey result in **Figure 26** show that the respondents gave an approximately equal percentage score regarding how these aspects were given attention in their organization. Technical support is important especially during the early stage of implementation. The involvement of the interviewees on the development of

SESAM was evident, but these is unlikely to the rest of the organization. The comments from the respondents informs that more training activities are needed.

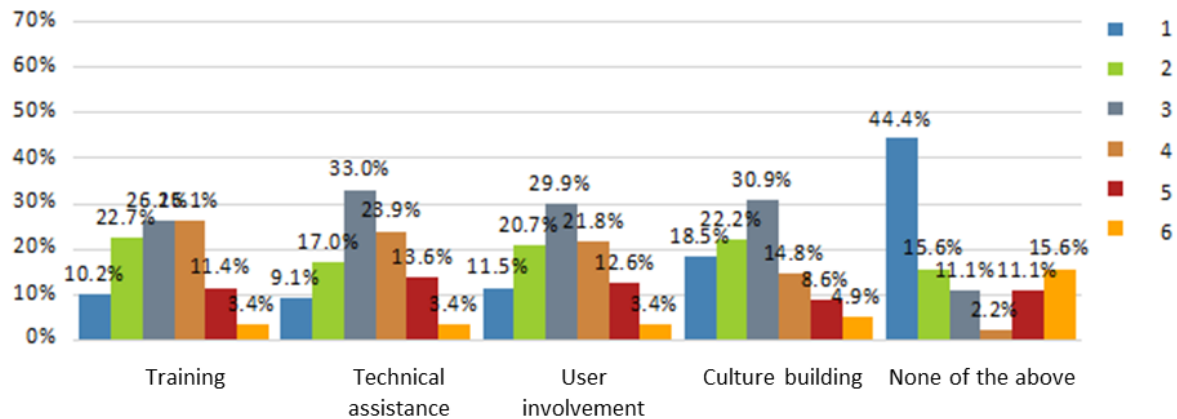


Figure 26 – O&M personnel involvement and support regarding the implementation of CAFM-system in Statsbygg.

**Status on implementation of BIM in Statsbygg O&M organization (Region East office).**

BIM is assumed to contribute to a more simplified and effective O&M process in SESAM. The same survey investigation was also carried regarding BIM. The result show that technical assistance is needed in the O&M organization if BIM will be implemented in SESAM. A total of 11 respondents commented that they have no knowledge and experience about using BIM. “As O&M supervisor, BIM is something that i have heard about , but has not personally had any experience in using it related to my O&M daily tasks.” The users should be involved on the development of BIM in SESAM to help identify the relevant requirements.

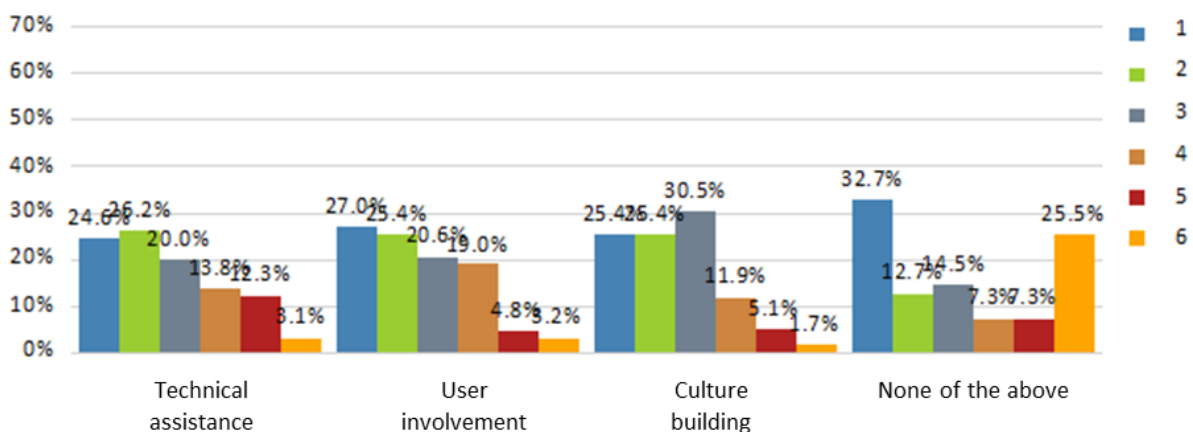


Figure 27 - O&M personnel involvement and support regarding the implementation of BIM in Statsbygg.

The percentage score regarding culture development indicated a motivation to utilize BIM to support O&M process in SESAM. There is one respondent who commented that BIM models will soon be delivered to O&M. “We do not have BIM on our property yet. But some new

*buildings and projects are starting to deliver BIM to O&M. We are still waiting about what will happen in about a few months.”* 2 respondents has tried using BIM, although their properties does not have a BIM model yet.

#### **4.2.5. Technology**

### **INTERVIEW RESULTS**

#### **System performance**

The interview about the process, collaboration, and client and customer impact has revealed some positive results regarding the development and implementation of SESAM in Statsbygg. System performance is one of the most important criteria for the successful implementation of ICT tools in Statsbygg. The negative issues that were mentioned many times in the interview are speed performance of the system, poor reporting capabilities, poor graphic and visual solution and poor intuitiveness.

Speed performance issues related to the solution was the biggest weakness in Statsbygg's CAFM-system. It was also one of the biggest challenges during the implementation that has negatively affected the solution in terms of flexibility. SESAM can be accessed within Statsbygg's secure network. To access SESAM outside Statsbygg's office premises, the users will have to log on to Statsbygg's virtual desktop application, Citrix.

The O&M organization utilizes SESAM for taking out reports and information about the maintenance plan. There are some issues about SESAM's reporting capabilities. As a result, there is a tendency for users to go to other programs like Cognos to take out reports instead of using the CAFM-system. This happens especially in maintenance accounting because users are already familiar with Cognos. It gives relevant information regarding maintenance expenses. The advisor believes that SESAM should be the main system that maintains that quality of information. Frustrations as a result of poor system performance and capabilities makes its users go back to older solutions or look for other digital solutions that work better.

#### **BIM**

O&M staff and personnel indicated that drawing documents are important O&M documents. It provides them with necessary information needed on their daily tasks. It is also utilized to locate and find the areas or parts of the building. Accessing updated drawing documents is a challenging task in Statsbygg O&M. There were proposals on how BIM could improve it.

*“BIM can help solve the challenges regarding the availability of updated drawing documents. We can use one BIM model instead of producing and using hundreds of drawing files. BIM model server can be used when collaborating with external consultants. The model server will make it easier to manage model versions and track activity”* (Statsbygg O&M manager).

The O&M manager also suggests that utilizing BIM in SESAM will help enhance a better overview of work orders and locate it easily. O&M organization can benefit from BIM if information is placed on the right level. Information in BIM need not to be too much or too little.

The overall response confirmed that interviewees are familiar with BIM but lacks the general theoretical knowledge and practical training.

### **Mobile solution in SESAM**

Mobile solutions are now becoming the most common and necessary supporting tool for CAFM-systems. The mobile solution in SESAM is important to O&M personnel to be able to sit anywhere and work, then provide good customer service by always being available. The *users* can easily notify them about their needs.

The O&M manager and supervisors are among the few personnel to test the mobile solution in SESAM. Experiences about the use of SESAM mobile *app* solution shows that it helps put things in a system and structure tasks. An example is the routine check of fire extinguisher every 3 months. The app automatically gives notifications to the O&M personnel about this task within a sufficient amount of time and before deadline. However, O&M personnel will also have to think and use their professional intuition while using this technology. All relevant information about building properties that are registered in SESAM will also be available in the mobile solution. The mobile app solution also helps collect useful information that can be used for analysis.

The O&M manager and supervisor described what works well about SESAM mobile app solution. The O&M manager indicated that communicating status information has become much more easier and intuitive by taking pictures and writing comments on it. The O&M supervisor explained that he prefers the use of iPad or a tablet computer compared to the mobile phone because of its larger screen. The interviewees stressed that the *app* solution in SESAM is still under development and testing. There was also an ongoing project in Statsbygg regarding the use of mobile application with BIM visualization capabilities. The

project aims to deliver a “proof of concept” with interface to a BIM module. The focus of the research question is to answer how the organization adapts to the implementation and development of CAFM-system, SESAM. BIM in SESAM is currently not operative in Statsbygg O&M organization. It was therefore irrelevant to investigate and examine further, how the O&M personnel to support CAFM-system and the O&M process utilize BIM.

**4.2.6. Policies and standards**

**INTERVIEW RESULT**

SESAM also contains system modules that deals with the legal disciplinary requirements for property owners. The second most favored module in SESAM is the fire and safety portal (*brannportal*). The O&M manager and supervisors indicated that the legal requirement such as fire and safety supervision is a good and very useful module in SESAM. The O&M manager suggested the same system module for electrical installations. Digitalization of documents and processes related to this type of requirements helps improve communication between O&M managers and clients. Furthermore, clients should also have access to SESAM to effectively and efficiently work together in keeping an updated status and record of documentations on fire or electrical routine supervisions. Updated status and necessary documents will be easily available in case the authorities will visit or check the facility. This is very important for owner and client relationship.

**SURVEY RESULT**

**Standardization**

Digitalization demands the development of new requirements and standards. The respondents were asked about their views and opinions about how digitalization can contribute to a more standardized O&M process and when.

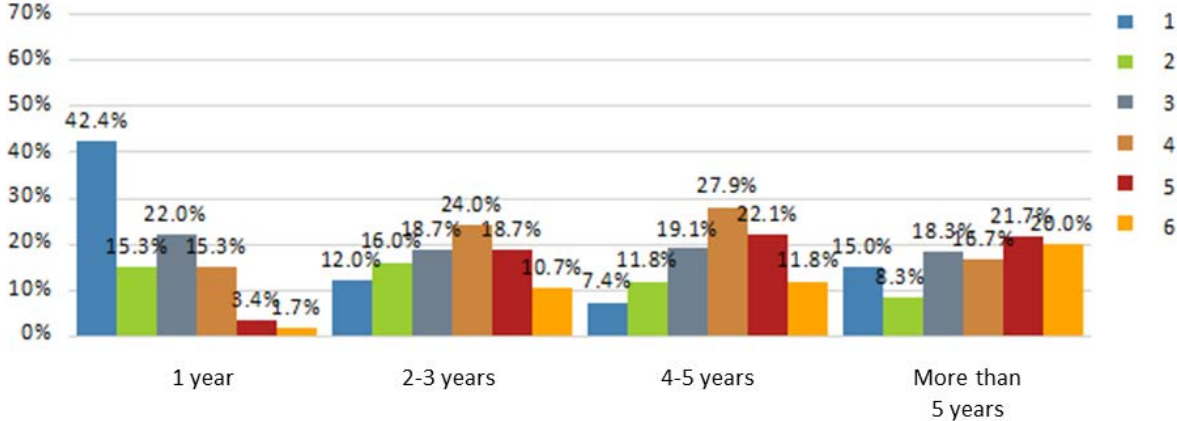


Figure 28 - Expectations regarding standardization and digitalization.

The purpose of this survey question is to describe how digitalization contributes to a standardized process. The result show that it could take 4-5 years or more before the digital O&M process contribute to a more standardized O&M process (**Figure 28**).

One comment is that there are many tasks in property operations that are not standard and varies from day to day. Another comment additionally argues that although standardization in property operations is good, they also wish that human and data interaction and interface should be much easier. It should be easier that it will not need too much training. It should be intuitive and innovative. SESAM is not used as a full-pledged CAFM-system yet. The respondents believe that SESAM is used to keep track of employees' working hours.

### **4.3. (RQ3) How can digitalization contribute to best practice in O&M?**

#### **INTERVIEW RESULTS**

The interviewees indicated some aspects that can contribute to best practice in O&M regarding the implementation of SESAM in Statsbygg.

One of the most important aspect that relates to best practices in utilizing SESAM to support the whole FM process including O&M is transparency. Transparency help maintain better ways of working and improve those that are not. A more transparent leadership management processes and responsibilities are important to Statsbygg's multidisciplinary tasks.

Statsbygg's CAFM-system was implemented to support a more effective work process from strategic to operative level. The O&M activities and work flow are tracked and managed in SESAM. It provides the management level an overview of the activities and its status. The operative personnel indicated familiarity about how the activities are approved and distributed to them to accomplish different tasks.

Statsbygg focuses on proper and efficient time management. The O&M personnel registers daily O&M activities in SESAM. The property manager usually finds it difficult to track activity history and invoices. This has now become better in a digitalized process and in utilizing SESAM as a tool. The property manager can now keep track of what was done by looking at invoices. The interviewees explained that it is important to have overview and control of the O&M budget, and prioritized tasks. They believe that this relates to professionalism.

A group of O&M personnel have participated in the pilot case study. It is an which is an advantage to the continuous learning process in SESAM. The coordination with other pilot groups can share their positive experiences and the challenges met in utilizing SESAM. It helps motivate the users and gives satisfactory training process and method.

### **Best practices on the implementation of SESAM in Statsbygg**

The program manager is responsible for the project implementation of SESAM in Statsbygg. SESAM is integrated to other systems in Statsbygg. I asked him about the implications of developing a unique system for Statsbygg. He explained, *“There are a lot of good CAFM-systems in the market today. But during the development of the project, the market was not yet mature, and it was difficult to find the most appropriate solution for Statsbygg. Statsbygg has a unique way of carrying out and managing its FM process including O&M.”* The concept study for the implementation of CAFM-system in Statsbygg started in 2009. The development stage started in 2012. The development of SESAM is more than just developing an ICT solution. It is a part of Statsbygg’s digital transformation particularly in O&M.

A list of success factors regarding the project was mentioned.

### **Success factors**

- *Clear link to business strategy.*
- *Full involvement from the line organization during the project.*
- *Good cooperation across all relevant disciplinary areas.*
- *Knowledge and skills improvement while working in the project.*
- *Gradual and goal oriented development and implementation.*
- *Focus on benefits throughout the project period.*

There were also challenges during the development and implementation of the project. Some important learning points were explained.

### **Important learning points**

- *Engage an experienced and professional project manager from the first phase of the project.*
- *Increase focus on communication as a strategic tool in the project activities.*
- *Enough manpower with good project execution skills.*
- *Focus on the link between the management model, work processes and product deliveries.*

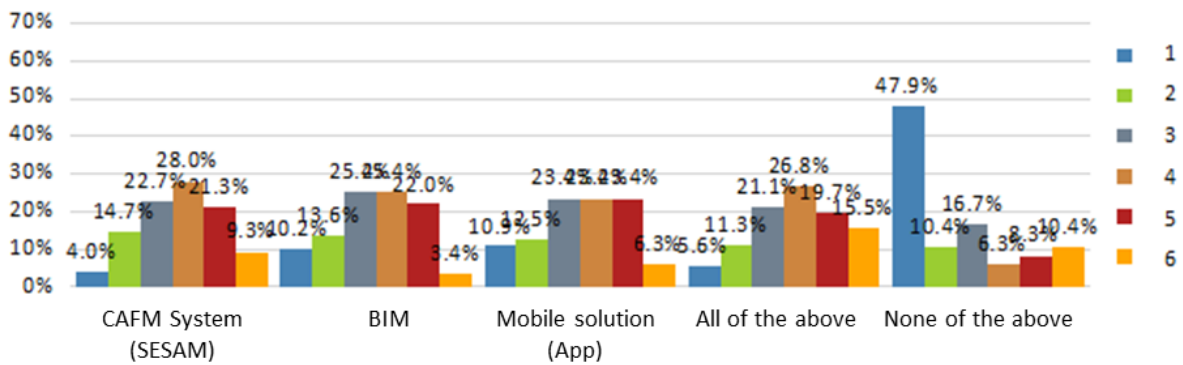


- *Interdisciplinary focus on system performance from the start of the project.*

## SURVEY RESULT

### *How the use of ICT tools contributes to best practice in O&M.*

The survey result show an almost equivalent result regarding the respondents views and opinions on how SESAM, BIM and mobile solutions contribute to best practice. Although SESAM got the least total standard deviation score compared to BIM and mobile solution. A combination of all three digital solutions is expected to contribute to best practice in O&M.



**Figure 29 – O&M personnel’s opinions on how ICT tools contributes to best practice.**

A comment from the survey suggests that “*sharing of experiences and knowledge should also be considered best practice.*”

#### 4.4. Summary of results

This section presents the summary of results for all three research questions. The summary is illustrated in **Figure 30**. The results are categorized according to process, resources, technology, policy and standards (Atkins, 2009). It also points out the status of achievements on the development and implementation of CAFM-system, SESAM in Statsbygg and a few that has improvement potentials.

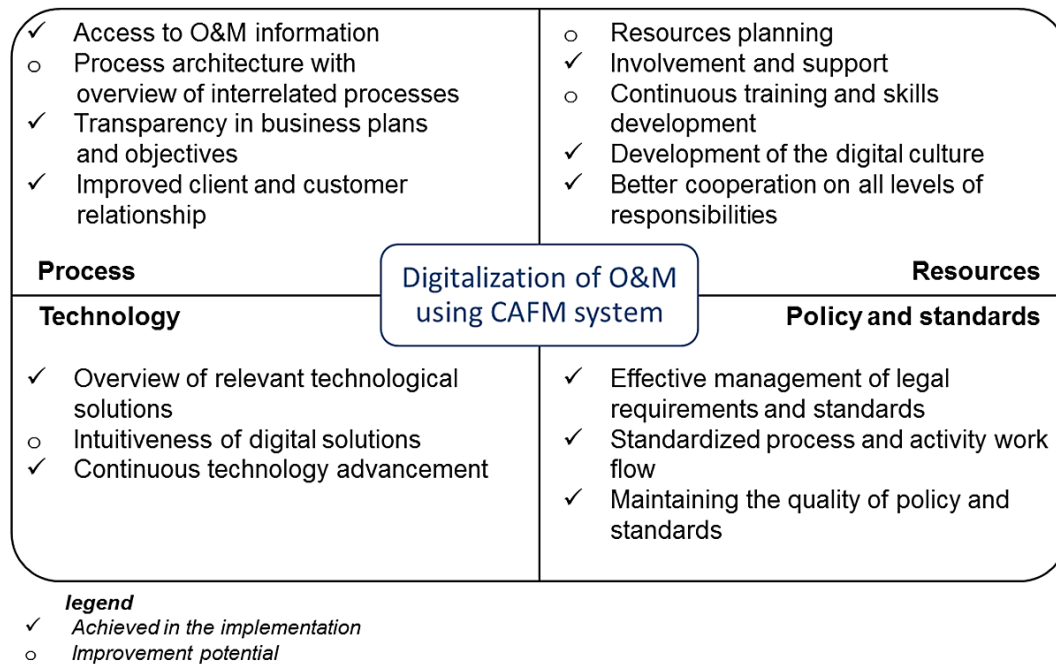


Figure 30 – Summary of results (Garcia, 2017).

#### How does organization develop CAFM-system to support O&M process?

- “Masterbygg” is the master data of Statsbygg’s CAFM-system, SESAM. It is based on the Norwegian standard NS 3451 – Table of building elements (*Bygningsdelstabellen*) and Statsbygg’s TFM system.
- TFM system or multidisciplinary identification system is utilized as a standard multidisciplinary identification system for all building systems and components in Statsbygg properties.
- IK DV is an obligatory internal control system. It safeguards Statsbygg for liability on operations and maintenance tasks. The system also covers requirements for control and documentation of maintenance tasks related to legal requirements.
- Lease contract is essential for the owner’s vision, strategic goal, and requirements (Eljarbø, 2016). Lease contract is an important tool, which defines and describes the distinction between operations and maintenance. It clarifies how the tasks and responsibilities are divided between the tenant and the owner of the property.

- BIM is a requirement for all new building projects in Statsbygg. O&M information will be delivered and exchanged in open BIM format.
- SESAM offers a mobile app solution, designed to provide flexibility and mobility to access and administer work orders.

***How does organization adapt to the implementation of CAFM-system to support O&M?***

The research investigation using qualitative and quantitative methods revealed the challenges and opportunities on how Statsbygg O&M organization adapt to the development and implementation of SESAM. These are summarized as listed below.

- O&M personnel suggested a full description of the actual work process relationship with other interrelated processes.
- The two important benefits are access to information and transparency.
- Speed performance negatively affects the administration of O&M tasks in SESAM. The system design must be intuitive as it affects the process workflow.
- Maintenance and fire and safety are the two most favored modules in SESAM.
- The O&M personnel expects that CAFM-system combined with BIM and mobile application will contribute to a more effective and simplified O&M process.
- Clear roles and responsibilities is significant to successfully adapt to the digital O&M process.
- The involvement of O&M personnel on the development and implementation of CAFM-system is important to the development of digital culture and transformation.
- The legal requirements and standards must be maintained and coordinated to all levels of organization.

***How does digitalization contribute to best practice in O&M?***

The results of the interviews, survey and literature review has revealed several aspects about how digitalization can contribute to best practice in O&M regarding the use of CAFM-system.

- Supporting a standardized process and activity work flow
- Better cooperation on all levels of responsibilities
- Improved client and customer relationship
- Continuous technology advancement
- Development of the digital culture

## 5. DISCUSSION

The topic for this master thesis is “*How can digitalization help increase productivity in property Operations and Maintenance (O&M)?*”.

There three research questions (RQ) discussed in this chapter are;

**1. (RQ1) *How does organization develop CAFM-system to support O&M process?***

The important aspects needed to optimally manage and support O&M process were investigated. The result have provided an overview of the significant overall requirements regarding the development of CAFM-system in Statsbygg.

**2. (RQ2) *How does organization adapt to the development and implementation of CAFM-system to support O&M?***

Based on the result of the investigation in RQ1, the O&M organization in Statsbygg has been investigated regarding how they adapted to it. The results of the empirical investigation are discussed with the existing theory and literature.

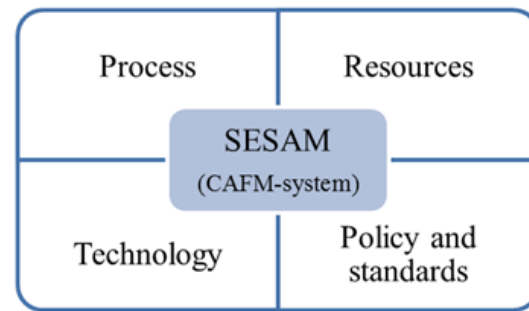
**3. (RQ3) *How can digitalization contribute to best practice in O&M?***

The discussion is based on the results of the theoretical and empirical investigation in RQ1 and RQ2 in this master thesis.

The hypothesis for this research study is “*Digitalization increase productivity in property Operations and Maintenance (O&M). Right ICT tool, organization and best practice are the keys to successful digitalization of O&M process.*” The study is limited to the investigation of CAFM-system as the primary ICT tool supported by BIM and mobile solutions.

## 5.1. The development of CAFM-system to support O&M organization

Atkins (2009) suggests that information systems should give attention to the four aspects of information management. The four aspects are process, resources, technology, policy and standards (Atkins, 2009). It will be used to discuss the results of the theory and literature investigation to answer the first research question (**Figure 31**). The investigation and study of internal documents in Statsbygg has provided this research study with information about the development of its CAFM-system, SESAM.



**Figure 31 - Four aspects of information management (Atkins, 2009) and CAFM system.**

### Developing the digital process

*“SESAM was developed to support a more effective work process in the line management, from strategic to operative level.”*

The study of internal documents in Statsbygg showed that the need to develop and implement its CAFM-system is to provide a tool that will improve the management of its FM process including operations and maintenance (O&M). Statsbygg’s concept of having two separated O&M functions in its property operations management reflects the relationship between the organization’s overall goals and strategies related to O&M planning and actions (Valen, 2011). An effective property management system is an important prerequisite to the development of CAFM system. NS-EN 16646:2014 explained the importance of having an overview of operations and maintenance (O&M) process when specifying the requirements for information systems. The strategies and overall goals of the organization must be clearly communicated. It is an essential approach to achieve a more effective process from strategic to operative levels of the organization. Atkins and Brooks (2009 p. 197) suggest that process model provides transparency. It helps understand what is needed and how the activities in the processes can accomplish tasks. It is conclusive that the overview of the whole business process should be the basis for specifying the process requirements and system architecture. Without it, the CAFM system will not be successful.

After examining the principles of managing O&M, I am convinced that having two separate modules for property operations and maintenance in SESAM is the proper solution. It is

essential to Statsbygg's property management process to effectively separate planning and performance of tasks between O&M. Using two separate modules will help the O&M personnel recognize the fundamental differences between operations and maintenance. Invoice and resources data are separate, but systematically administered in each process. However, it is advisable that O&M modules in SESAM share the same data and documentations. It would also require careful and correct registration of data.

### **Maintenance and development of policy and standards**

The result of the investigation shows that Statsbygg's sociopolitical responsibilities influences Statsbygg's digitalization strategy. These are driving factors for digitalization of Statsbygg's business processes including the implementation of CAFM-system SESAM. However, Statsbygg should also be able to propose and recommend the most appropriate methods and solutions to its organization. The requirements of the Norwegian government for Statsbygg should create a balanced and realistic goal that is achievable.

There must be general and internal conditions for Statsbygg business and its O&M process. The general condition for Statsbygg business must be related to the organization's role and political responsibilities to the Norwegian government and the society. To deliver its service and accomplish the right goals, the internal conditions of Statsbygg's own business strategy and goals must be related to the general conditions. Statsbygg plays an important role for the success of Norway's digitalization strategy especially for the (Architecture, Engineering and Construction) AEC and FM industry. Its CAFM-system, SESAM is a preceding step to the digital transformation of its organization including O&M.

*“SESAM will provide better data quality, effective information management of all relevant legal requirements, regulations and directives.”*

The literature study has identified important policies and standards in Statsbygg regarding the development and implementation of its CAFM-system, SESAM. The organization will need to adjust and update the guidelines and procedures for O&M process, which complies with all relevant standards and codes. The three important standards and requirements in Statsbygg are IK Eiendom, IK DV and TFM.

Statsbygg internal control system IK DV is a very important system for the operations and maintenance of its properties, to comply with all relevant legal requirements and standards. But Statsbygg IK Eiendom and IK DV can only work optimally when conceived together as a

whole system. IK DV is a systematic approach but was not necessarily digitalized. SESAM aims to provide a digital tool with the ability to track, manage, report and plan the O&M activities in Statsbygg. After analyzing the content and overview of the significant requirements in SESAM, I can acknowledge that it should be the appropriate system for the digitalization of Statsbygg's internal control system for O&M. All documents and data that are recorded in SESAM including the management policies and requirements for cultural heritage buildings, fire and safety, universal design, health, environment and safety will help provide necessary information that the government authorities need during control. This will have a positive impact on the client and owner relationship.

The Norwegian standard NS 3451 is one of the important standards in FM (Haugen, 2008). Statsbygg has been using TFM (Multidisciplinary marking system) for over a decade. It is based on NS 3451. The development of CAFM-system in Statsbygg has identified some challenges about the use of TFM codes in the system. It has been a very useful identification system for building systems and components, but it needs to be updated and revised. The digitalization of O&M process using SESAM helped identify deviations in standards that cannot be easily discovered in the previous manual process.

The registration of all the properties that Statsbygg owns, manages, operates and maintains was obligatory during the implementation of SESAM. It delivers a complete overview of all its assets. The categorization of its properties according to portfolio and building type, facilitates easy access to information, that are significant for the development of policies, requirements and standards. These attributes are useful regarding administration and collection of information that the strategic and tactical staff need. Categorization also limits access to unrelated information. Operative levels will only have access to the properties within their portfolio. Better overview and control of information is significant to a more effective and efficient activity workflow.

### **Physical asset management and digitalization**

The Norwegian standard NS-EN 16646 (2014, p. 8) on maintenance within physical asset management explains that physical asset management focuses on the “*value that the asset can provide to the organization*” (NS-EN 16646, 2014). But how is value creation relevant to the development of and implementation of CAFM-system to support O&M? According to Statsbygg's project report, SESAM was developed and implemented to support a more effective work process in the line management, from strategic to operative level. SESAM will

also assist the O&M personnel on the daily monitoring of its property assets, both the building and outdoor areas. Physical asset management is about the “*coordination of activities of an organization to realize value from physical assets.*” (NS-EN 16646, 2014)

The internal documents in Statsbygg showed that SESAM aims to provide an overview of the daily tasks and routines, who will do it, when, where and the cost, which is maintained both in the operation and maintenance module in Statsbygg. NS-EN 16646 (2014: 8) explains that realization of value normally involve balancing of costs, risks, opportunities and benefits. If the concept of how Statsbygg has digitalized and put together the different O&M activities and work flow in SESAM are correct, the use of CAFM-system to support the O&M process contribute to value creation.

Statsbygg’s CAFM-system, SESAM supports life cycle management and operations. Haugen (2008) explains that the key elements in the building owner's life-cycle perspective while focusing on creating value for its business are the use and management of buildings and facilities with associated services, operations and maintenance and property development. The implementation of CAFM-system in an O&M organization must look at a building life cycle perspective including its development and upgrade. The investigation shows that Statsbygg’s goal regarding maintenance aims at sustaining the property’s performance. Performing technical condition analysis of its assets is significant to its maintenance plans. O&M plans in SESAM will provide essential data for planning the development and upgrade of its buildings or assets.

## **Resources**

Resources are important to perform the activities in a process and accomplish tasks. The resources that will be discussed are human, information and material.

Humans are important resources. They should be able to perform the activities in the CAFM-system. Statsbygg has identified the conditions and responsibilities for carrying out O&M in SESAM. The conditions and responsibilities are distributed to all different levels of the FM organization in Statsbygg. Identifying the different responsibilities of strategic, tactic and operative roles in O&M help indicate its importance in Statsbygg’s business process. Atkins (2009) suggest that a process model can be used as a basis for identifying the necessary competencies that the organization need to continuously improve or develop. As digitalization and the utilization of its CAFM-system changes Statsbygg’s O&M process, its organizational structure changes with it. New knowledge and competency requirements will be necessary.



The O&M personnel must understand the relevant academic background for O&M. They also need to learn how to use the CAFM-system related to the interrelated processes.

Atkins (2009) pointed out that “*information is the lifeblood of FM.*” Information is important to accomplish tasks. Correct and updated information is much more important. Utilizing the CAFM-system as an ICT tool to support O&M, requires good information systems management. Atkins (2009) explained, “*information systems management is more than just document management.*” The information related to the interacting activities of the O&M process in Statsbygg that are registered and collected in SESAM are systematically grouped and categorized. A systematic information process is important in a CAFM-system. The challenge would be to ensure that the end-users of SESAM registers all necessary data and that it is done correctly.

Statsbygg has already provided tablet computers for the users of SESAM. All of the employees in Statsbygg uses smart mobile phones. The availability of materials or tools are the third most important resources on the development of CAFM-system. The users of the CAFM system needs correct tools to effectively and efficiently *capture, process and exchange information* (Atkins, 2009) and accomplish tasks. Tools are for example, computers, TV screens, tablet computers or mobile phones. An overview and specifications on which tools are needed must meet the requirements of the CAFM system and other technologies that will be used. This is an important information that needs to be included in planning the development of CAFM systems.

After discussing the importance of resources to the development of SESAM, it is safe to acknowledge that the availability of skilled human resources and the right materials or tools needed to use and exchange information are essential, to achieve a more effective and efficient management of resources. It will be a relevant variable when investigating further the return on investment (ROI) on implementation of ICT tools.

### **Technology**

The result of the investigation on Statsbygg’s organization shows that being one of the leaders regarding the use of technology and digitalization is not always an advantage. The availability of the right ICT solution to support its unique process was a challenge for leading organizations like Statsbygg. The common mistake that some of organizations do today regarding digitalization is the integration of obsolete process to new technology. Choosing a modifiable solution was regarded as the best solution in Statsbygg with focus on process. A

modifiable system gave the organization the flexibility to choose the most important functionalities it needs, to be more effective and efficient. But too much flexibility is not always beneficial. Full flexibility without full control of the system architecture affects the system performance and the reliability of information. The system architecture must be developed logically according to the process and activities without negatively affecting the corresponding information that will be registered and made available in the whole system.

There are advantages and disadvantages in acquiring different systems from different vendors. Statsbygg will have the advantage to utilize and improve systems that works well and discontinue the systems that do not work appropriately. O&M organizations must prevent vendor lock-in when acquiring ICT tools. The disadvantages will affect the end users. They will have to learn to use different solutions from different vendors. This will have a negative effect to their productivity. This topic will be discussed later related to the second research question (RQ2) about how organization adapt to the development and implementation of CAFM-system in Statsbygg.

The investigation has identified the importance of lease contract to Statsbygg's O&M process. The responsibilities and costs between the tenant and the owner must be divided systematically during tenancy or lease. I believe that CAFM-systems that includes both lease contract management and work orders management system is beneficial for the O&M process and activity work flow. The property data will be registered and administered using only one single system. The result of literature review of Statsbygg's internal documents showed that Statsbygg uses separate vendors and systems processes for lease contract management and work orders management. If the use of different systems from different vendors are necessary and inevitable, open data formats and the use of application programming interface (API) should be possible. It is also important to identify which appropriate system provides the *master data* to maintain the validity of information.

The utilization of mobile app in SESAM will contribute to provide an intuitive and more systematic overview of necessary information needed in O&M. Haugen (2012) explained that one of the purpose of establishing a system for operations and maintenance planning are; better financial overview, better conditions overview and more predictability. Today, the mobile app solution in SESAM delivers access to work orders, energy meter registration and notifications. These features will contribute to a more efficient O&M process in Statsbygg.

The investigation reveals that although SESAM has yet to prove its usability in Statsbygg, there are already recommendations on how to improve it. Statsbygg's BIM strategy describe how the challenges on collecting and sharing O&M information can be resolved. The importance of drawing documents in O&M is a discerning fact. To clear-up the common confusion, it is important to remember that CAFM-system is not a drawing archive. The availability of updated drawing documents that O&M personnel need is a problem for O&M organizations. CAD system should be an important functional requirement in a CAFM-system. Work orders are easier to track when visualized in 2D plan drawings or even better in a BIM model. BIM functionalities was only an open option in SESAM during its project development that started in 2009. The development of BIM to support O&M was in its maturity stage during those years. The lack of focus on BIM in the early stage of the project may have affected the development of SESAM with regards to its BIM capability. This solution is already available in the market today and is developing very fast. Main Manager has already demonstrated their own mobile solution with BIM capability. The solution from Dalux already provides a modern and intuitive BIM solution using a mobile device. The result of the investigation showed that BIM is expected to contribute to a more effective and simplification of O&M process. The result will be discussed further in section 5.2.

Energy reporting is a significant module for property operations in SESAM. This can be both a legal requirement and a measure that will improve O&M productivity and predictability. It is interesting to assume that Automatic Meter Reading (AMR) may soon be implemented in Statsbygg. As soon as this becomes available on all of Statsbygg properties, it will not be necessary to carry-out manual reading of energy meters. Energy reports in SESAM can be registered using mobile applications. The mobile solution will make the O&M personnel available around the clock. The convergence or the combination of two or more different technologies using a mobile phone or a tablet will contribute to a more efficient O&M process. Sensor technology and the Internet of Things (IoT) are also disrupting the way we provide and collect information. Statsbygg has already utilized sensor technology and IoT on one of its properties. This is also supported by a mobile app solution, developed by the students themselves, who are also users of the building to provide information about indoor climate. By using the mobile app, clients and users can interact better with the O&M personnel.

O&M activities will soon turn in a connected and automated process. Real-time information will be provided using a mobile device with the convergence of SESAM mobile app solution,

IoT and BIM. As a result of digitalization of property operations and the fast developing technology, businesses are continuously developing new concepts for a more effective and efficient process for property operation and maintenance.

Producing modern and sustainable buildings contribute to value creation. Modern and sustainable buildings includes modern equipment that can only be operated using advanced technologies. Digitalization is a key success factor to get it done. Organization may need to develop and implement CAFM-system to support O&M of modern and sustainable buildings, but it may not be the only solution. The development and implementation of CAFM-system combined with BIM and mobile solution is necessary to effectively manage modern and sustainable buildings. BIM is already a requirement in Statsbygg and many other large public sector organizations in Norway and abroad. An appropriate CAFM-system is significant to operate and maintain these buildings. CAFM-system with BIM and mobile application capabilities is essential to save time and improve the quality of O&M information that O&M personnel need to accomplish their tasks.

SESAM supports the operation and maintenance management of Statsbygg's properties that are distributed to different geographical locations and property extent. Lindblom (2004) explains that these are two of the important aspects when choosing the right organizational structure for O&M. Another technological solution that could also help improve SESAM in Statsbygg is the use of "Geographical Information System" or GIS. This will enable the users to navigate and better locate all of its assets in Norway and abroad. The review of Statsbygg's internal documents showed that GIS technology has been tested in SESAM, but is not yet available for the end-users. Most of the CAFM-systems uses map to navigate into the different properties in different portfolios. It gives the O&M personnels or end-users a summarized overview of information about the property that they responsible for without unnecessarily having to go deep into the CAFM-system.

## 5.2. How does organization adapt to the development and implementation of CAFM-system to support O&M?

The activity theory is used to identify the elements that influences the core of an activity. The users of SESAM and O&M forms the core of the central activity in this research topic. The activity theory will be used to discuss the research question while giving attention to process, resources, technology, policy and standards (Atkins, 2009).

*“Who is doing what, why and how? (Hasan, 2013)”*

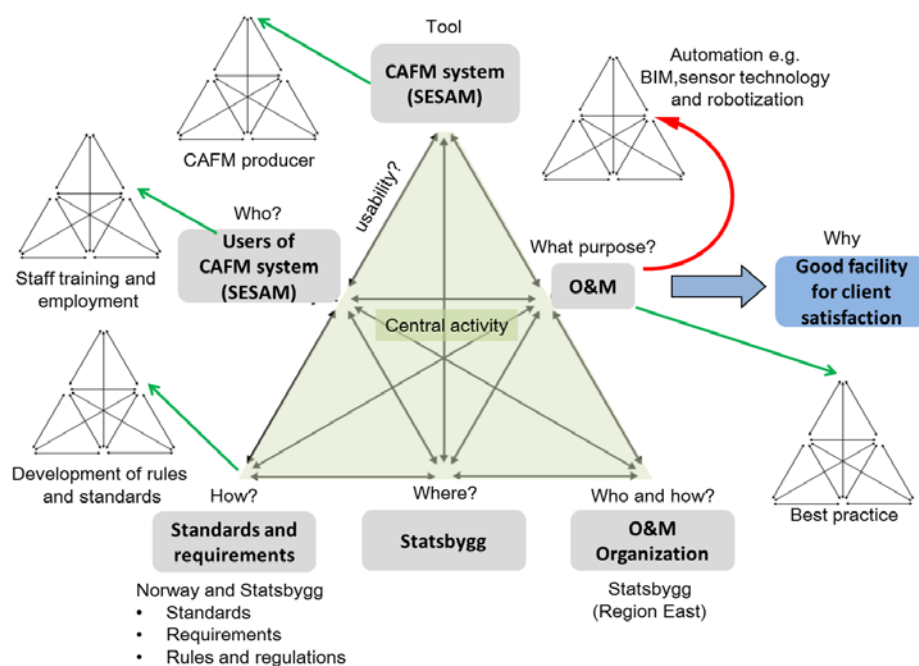


Figure 32 - Application of the elements of the activity system (Engeström, 1999).

### Adapting to the digitalized process

The interview result revealed that SESAM includes different modules to support the most important processes in Statsbygg's property management. It is a challenge for large organizations to make systems work together and support the whole process. Section 5.1 discussed the importance of having an overview of the O&M process on specifying the requirements for information systems. The organizational strategic plan should lead to the development and implementation of CAFM system, or any other digital tools and not the other way around. A clear overview of how the O&M activities relates to the whole FM process makes it easier to coordinate the significance of all activities that the O&M personnel need to accomplish.

*“Statsbygg O&M personnel will use SESAM as an administrative tool, with the ability to track and plan O&M and property development activities.”*

An important issue that was mentioned in the qualitative investigation was about access to O&M information. Getting access to updated information is a challenge in O&M. Utilizing SESAM as a *tool* to collect and access relevant information will make Statsbygg’s O&M personnel work efficiently. But the quality of information depends on its consistency and *usability*. Process quality is also important to achieve relevant information. Poor system design and infrastructure of CAFM-system will affect its performance and usability. Appropriate process architecture will define how the tasks should be administered and accomplished. The overview of functions and deliveries in Statsbygg and the separated modules for O&M in SESAM develops a manageable workflow.

The interviewees suggest that transparency plays a significant role to improve communication and collaboration in a process. Continuous improvement is always needed for all physical assets and the digital tools that are utilized to manage it. The Norwegian standard NS-EN 16646 (2014) explain that communicating the challenges from the operative level are important contributions to the organizations strategy and plans. Strategy and plans must be collaborated from strategic, tactic and operative levels of the FM organization. The solution to challenges must be a result of cooperation from the whole organization including O&M. It is an appropriate assumption that SESAM will be a good basis to communicate why and how different decisions are made across the whole organization. The system was developed and are utilized by all levels of the organization. The users will easily recognize and be informed of the different decisions and actions in the O&M process across the FM organization.

One of the most important aspect in developing a more effective process is its impact to the client and user of the building. The investigation result showed that Statsbygg prioritizes its clients and users of the building. The digitalization of O&M process in Statsbygg using CAFM-system is a result of its goal to provide good facility to its clients and customers. SESAM provides an overview of its buildings and properties, goal and action plan. Valen (2011) concluded that performing good property management depends on the availability of these necessary information.

### **Effective and efficient management of resources**

The activity theory suggest that it is important to understand the tasks, roles and responsibilities (who) and purpose of O&M (what). Statsbygg O&M staff is the *subject* for

the *central activity* system in this research study. Statsbygg utilizes CAFM-system as a *tool*. The main purpose of the *central activity* is to carry out a more effective and efficient O&M to enhance the value of a facility and increase client and customer satisfaction. The result of the interview indicated how the O&M personnel managed to define and explain their roles and responsibilities in their organization. A clearer understanding of roles and responsibilities in O&M is significant, to successfully achieve the goals of each activities in O&M process. The conditions on carrying out O&M activities in SESAM requires that the different roles and responsibilities are clearly understood by those using it. The development work and implementation of CAFM-system in Statsbygg helped the O&M personnel and staff identify more clearly their roles in the organization.

***“A key factor in realizing productivity gains is that the organization must be structured to take advantage of the technology and to optimize the contribution of those who use it” (Atkins, 2009).***

The implementation of the FM System in Statsbygg is an organizational transformation. Engeström (1999) defines transformation as “*changing an object internally, making evident its essence and altering it*”. It implies the importance of education and involvement of all levels responsibilities in an organization. The hypothesis for this research study is that organization is one of the keys to successful digitalization of O&M process. The result of the survey investigation showed an equal percentage score about how end-users experience the use of CAFM-system, mobile solution and BIM with regards to Statsbygg’s organizational structure. The digitalization of process and information eliminates silos. It means that digitalization will affect the hierarchy model of an organization structure. Organizations are now adopting a more horizontal and flatter organization. This change will affect the development of new standards and policy in the O&M organization. The advantage of a flat organization is that information will be easily communicated to all levels of the organization. But a flatter organizational structure would mean more flexibility and lesser quality control of information put in the system. To avoid this, it is important to provide guidelines and procedures in line with necessary requirements and standards.

Skills and training on how to use SESAM is not enough to understand and evaluate the right organizational structure. The operative level must have the basic knowledge and understanding about the FM organization and responsibilities including O&M management. A group of experts were established as a result of development of maintenance module in

Statsbygg's CAFM-system. A respondent in the survey also suggested that sharing experiences by establishing network collaborations and providing experience data-bank will help achieve a more effective O&M organization.

The survey on how the existing organizational structure affects the use of ICT tools in Statsbygg did not provide sufficient results. The respondents indicated that skills training is needed and that solutions must exist to evaluate the right organizational structure. Lindblom (2004), explained that choosing the right organizational structure depends on the property extent, technical complexity and orientation, geographical location, building age and status, customer and quality requirements. The tactical and administrative function is responsible for the organization and management of O&M process (NOU 2004:22, 2004). This survey question is most relevant for the tactical level than the operative level. However, the opinions of the operative personnel are important when making organizational decisions.

With digitalization, real-time information is possible. It will also support an effective and easier decision-making process for the strategic, tactic and operative level. Creating *champions* and effective cooperation throughout organization is significant to the success of business transformation. The activity theory illustrates that training and employment will affect the *subject* in the central activity system. The survey result indicated that user involvement, technical assistance, and training need to be improved regarding the implementation and use of CAFM-system in Statsbygg. The views and opinions of the respondents are different from the interviewees. It was tempting to carry-out new interviews after getting the survey result, because it represented a larger population in Statsbygg. A new investigation will be essential in evaluating how the implementation of ICT tools affect the organization. It can be used as a basis for continuous development.

Mohan (2015) believes that the workforce in 2025 will be dominated by people from *Generation C*. Today, about 60% of O&M personnel working in Statsbygg region east represents the *Generation X* and only 2.1% represents the *Generation C*. It indicates that around 30-40% of Statsbygg workforce will still be represented by the *Generation X* before 2025. Focusing on increasing the digital culture in organization will help improve the cooperation between these two generations. Sixty five percent of O&M personnel have been working in Statsbygg for more than 5 years. The length of employment in an organization depicts the employees' familiarity with the processes and existing digital tools in their



organization. Familiarity is useful on the development of new processes and tools. But, it may also make them loyal to the traditional process.

The implementation of SESAM in Statsbygg requires the O&M personnel to register backlogs and inventory control of all activities in the CAFM-system including the record of time spent in performing their tasks. Sullivan (2010) suggested a list of evaluation metrics to measure the quality or effectiveness of O&M program. The relevant requirements that were mentioned are also included in the evaluation metrics. These are namely; overtime work, absentee rate and staff turnover. This recognizes that these metrics are necessary to improve the quality and effectiveness of O&M in Statsbygg.

### **The maintenance and development of policy and standards**

The activity theory as illustrated in **Figure 32** shows the relationship of standards, requirements, rules and regulations to Statsbygg, O&M and the users of SESAM. IK-Eiendom, IK-DV and TFM are three important standards and requirements in Statsbygg that were discussed earlier. The result of the investigation on how end-users adapt to maintain these standards and requirements by utilizing SESAM will be discussed in this section.

An effective information management of all relevant legal requirements, regulations and directives requires that all this data are registered and is accessible in SESAM. But it will take time before these become completely available. According to the survey result, the respondents expect that it could probably take about 4-5 years or more before the digitalized process can contribute to a more standardized O&M process. Our experiences indicates that technology development is faster now than ever before. Standardization is significant to effectively and efficiently manage technological solutions. If it would take more than 5 years before digitalization contributes to a more standardized O&M process, it will be a challenge to keep up with the fast developing technology. The result of the survey is limited to the views and opinions of O&M personnel in Statsbygg region east office. The tactical and administrative level of FM organization is responsible for the organization management of the operative level (Haugen, 2008). A survey result from the tactical level of organization is necessary to get a reliable data for this analysis.

The fire and safety portal in SESAM was mentioned in the interview result. It is one of the most important legal requirements in O&M. The literature review on Statsbygg's internal control system and the result of the interview indicated that Statsbygg has successfully achieved its goal to provide "*a more effective information management of all relevant legal*

*requirements, regulations and directives.*” The suggestions and proposals from the interviewed O&M personnel on how to improve the system further indicates their motivation to utilize SESAM. However, it is also important take the result of the survey into account. The results of the two research method approaches showed knowledge gap, about these types of information found in the CAFM-system, between those who are involved in its development compared to the end-users in general.

### **Technology**

An effective and efficient digitalization of O&M process varies depending on the organizational ambitions and objectives. Statsbygg strategic goal towards digitalization indicated that the organization belongs to the innovators in AEC and FM industry.

*“Right ICT tool is the key to successful digitalization of O&M process.”*

The result of the survey investigation shows that CAFM-system got the lowest with percentage score regarding how ICT tools contribute to a more effective O&M process. The feedback from the respondents may have been influenced by their experiences in utilizing SESAM. System speed performance was a critical issue for the end-users of SESAM. It has affected their motivation to use the system. This issue may have something to do with scale. The increase of data means that available information also increases but affects the speed. The design and intuitiveness of the CAFM-system is also important. It should also be given attention because it affects the productivity of the end-users of CAFM-system. There should be a balance between the administrative and the technical capabilities of CAFM-system. The result of the investigations may vary if other CAFM-system and O&M organizations were also investigated. Although this was the result for Statsbygg’s CAFM-system SESAM, the respondents expects that supporting the system with BIM and mobile solution may improve it.

The use of CAFM-system, SESAM also got the lowest score in the survey investigation regarding simplification in Statsbygg. Followed by the use of mobile app solution, it is expected that BIM will help simplify the O&M process. Drawing documentations are important to the O&M process. SESAM does not currently have a full integrated solution for drawing documents. Only a limited set of drawing documents are available from the existing drawing archive “Hyperdoc” in Statsbygg. The lack of access to drawing documents in SESAM may have contributed to the positive result of the survey investigation on BIM. The research investigation revealed that Statsbygg is already using BIM on all of its new building

projects. It indicates that BIM will soon become a requirement on operations and maintenance of Statsbygg's properties. Furthermore, although BIM is not yet utilized in O&M, the survey result showed that the respondents acknowledges its potentials. BIM is already showing benefits in the design and construction phase. This could be the reason why the respondents expects that BIM will contribute better to the simplification of O&M process. The combination of BIM and mobile devices will be a powerful tool that will help simplify the way SESAM users can collect, exchange and use information.

BIM was only an option during its acquisition. It's system architecture was not necessarily based on BIM structure and topology. Although BIM is not the primary tool in this research study, it is important to look at how the O&M process and its activities may develop and require the development of tools. Engeström (1999) believes that when the *object* in the central activity develops and changes, it will also affect the *user* and the *tool*. This is also relevant and true on the development of SESAM and BIM in Statsbygg. Today, the connectivity of processes is disrupting the way businesses collect and use information. SESAM system structure is based on TFM. To utilize BIM in SESAM, it needs to use the TFM structure. Statsbygg has been using TFM for over a decade now. TFM is a standard identification system for building systems and components in Norway. Previous investigations about the development of FM-BIM experienced challenges, to optimally utilize BIM and CAFM-system using the TFM standard. Although this may only be a technical issue, it can also affect the flow of the digitalized O&M process using CAFM-system.

### 5.3. Digitalization and best practice in O&M

There are several aspects about how digitalization can contribute to best practice in O&M. These were identified as a result of the interviews, survey and literature study.

Effective and efficient information management is essential *“to inform, influence, and implement actions”* in property operations. The essence of information management system is to provide *“accurate, reliable, up to date, complete and consistent information”* (Atkins, 2009). SESAM is Statsbygg’s solution to utilize a modern, effective and efficient tool for operations and maintenance. This is also a part of its continuous technology advancement. But if all necessary information needed in Statsbygg’s property operations and maintenance is not digitalized, information will be difficult to share and risks of being lost (Atkins, 2009). It will result to an ineffective utilization of information system. Statsbygg utilizes several different systems to support its core business. The activities in property operations and maintenance that are managed in a day to day basis is an important part of FM strategy. Digitalization of O&M process in Statsbygg is therefore crucial. Digitalization of information is inevitable to benefit from the networked interconnection of objects. The *“digital convergence”* or the utilization of two or more different technology in a single device such as a mobile phone, is already a reality (Laudon, 2011). The survey result showed that the combination of all three digital tools (SESAM, BIM and mobile solution) in Statsbygg will contribute to best practice in O&M.

Best practice is about using new methods and standards. Standardized process affects the activity workflow. The Norwegian standard NS-EN 15221-3:2011 explains, *“best practice is about the improvement of quality of work»*. The quality of work can be identified by measuring the organizations performance using “key performance indicators” (KPI) or by benchmarking. When all relevant performance data are systemized and made easily available in the CAFM-system, benchmarking throughout the organization will be an easy task for the strategic level. It will be easier for the strategic and tactical management to identify both the strength and weaknesses that affects the O&M process. Maintaining the quality of policies and standards is a significant practice to business digital transformation.

***“Transparency helps maintain better ways of working and improve those that are not.”***

The interview indicated that utilizing SESAM on all levels of the organization contributes to a transparent and standardized workflow. Relevant O&M activities are recorded in a systematic

process with its corresponding attributes. SESAM can automatically track actions related to relevant O&M activities performed by O&M personnel. I believe that a systematic process will have an effect on planning and predictability of O&M activities. The size of an organization is an important variable in measuring its performance related to digitalization and the utilization of CAFM-system. This is also relevant for benchmarking of work processes within a large organization like Statsbygg.

Another significant aspect that was mentioned in the investigation is about transparency in leadership management process. This can be related to the Norwegian standard NS-EN 16646 (2014) about, "*The interrelationships between maintenance process and other processes of the physical asset management system.*" O&M and other processes of the physical asset management follows the organizational strategic plan. NS-EN 16646 (2014) explained that "support processes" are important to physical asset management because it creates resources. Resources are related to human, information and material. The information about these resources are available in SESAM regarding who does what, how and why.

NS-EN 16646 (2014) illustrates a list of types of physical asset management support. Continuous improvement suggest the change and development on the organizations' policy, objective, strategy and plans. It will influence the core processes including O&M. The decisions regarding the physical asset management support will also be affected by this development . A transparent leadership management process and responsibilities related to the core business objectives will be easily understood on all levels of the organization. The implementation of SESAM helped Statsbygg achieve a transparent work process, but the result of the investigation was not able to see a clear overview on how the O&M organizational structure relates to SESAM and the digitalization of the O&M process. Providing a clear overview on how the digitalization of O&M process relates to all other processes in an organization, will help the O&M personnel understand the new process. It will help them save time and resources to administer and accomplish tasks. Tasks that are delivered efficiently helps improve client and customer relationship.

### **Developing the digital culture**

Transformation and managing change are two important aspects on the development and implementation of CAFM-system. Atkins (2009, p.55) believes that change can stem from a variety of causes such as productivity demands, ICT and human skills and resources. The survey investigation indicated that the administrative activities in utilizing SESAM has been

overwhelming for some of its end-users. Self-service administration is one of the effects of digital disruption on traditional business processes. A gradual learning process can resolve this issue. Atkins (2009, p.56) suggest, “*change management should be seen in terms of process*”. One of the success factors regarding the CAFM-system project in Statsbygg is “*gradual and goal oriented development and implementation*”.

But how can an organization achieve a balance between disciplinary expertise and digital culture? The milestones of the project includes both technological and skills development. In Norway, FM discipline is historically a relatively young subject or discipline. The practical experiences working as a property operations manager within the field of FM will only be improved and developed through systematic training. It will be achieved when they have represented an image of the new learned knowledge. Special expertise is often a combination of parts of the overall competence. An example of this is the combined skills of a property operations manager and a facility manager in case of maintenance work. The measures are planned, carried out and documented. Knowledge of the process is distributed at different levels, which also applies within all technical areas. This is also why the internal control of O&M process in Statsbygg is significant in finding the best practice in O&M.

In Statsbygg, skills or the ability to apply knowledge to accomplish tasks and solve problems is by practice available at strategic, tactical and operational levels. A clear link to business strategy was one of the success factors during the project development and implementation of CAFM-system in Statsbygg. But the business strategy should also be communicated throughout the business organization. The O&M organization must know where they are going with the development and implementation of new tools and methods. If strategy and goal is not clearly understood, the process could lead to wrong results. This is significant to focus on realistic benefits. In some cases, the need to execute unnecessary tasks and effort from the involved personnel to correct it, will affect their motivations. Personnel and staff who are involved in the process should know their roles and responsibilities. Atkins (2009, p.60) suggested one of the important aspects about managing transformation and change in an organization. “*Ensuring the commitment of everyone increase the probability of success*” (Atkins, 2009). The development and implementation of CAFM-system in Statsbygg has involved the line organization and has achieved cooperation from all relevant disciplinary areas. This is important to continuously develop its digital culture and transformation across the organization.

#### **5.4. Discussion on research methodology**

This section discusses the advantages and disadvantages of the research methods used in this master thesis.

The qualitative investigation used interview method. It allowed the interviewees to ask for clarifications on questions not fully understood. The qualitative method successfully gathered significant data to answer the research problem in this master thesis. But broader source of insight were necessary to get a more valid results. The quantitative investigation using survey method were very useful in collecting data that represented a larger population. The quantitative data obtained in the opinion survey were presented in comparable graphs and was analyzed objectively.

The qualitative and quantitative investigation have produced different results that are both useful in providing empirical data. The interviewees showed optimism about the development and use of CAFM-system in their organization. Compared to the result of the interview, most of the respondents in the survey were skeptical. There were comments in the survey about SESAM that are not relevant to the topic of this master thesis. The quality of the survey results were revealed during the discussion. However, both qualitative and quantitative investigation are still conclusive to the general result of this master thesis.

The context of this research study has given a clearer perspective and understanding about the impact of digitalization on O&M. The examination and investigation of relevant internal documents in Statsbygg have provided this research work, theory and concept on the development of its CAFM-system. A large organization like Statsbygg was representative to answer the research questions in this research study. However, benchmarking or the investigation of several O&M organizations could justify the validity of the results of this research work.

## 6. CONCLUSION

This research study has investigated the use of CAFM-system to find out how digitalization help increase productivity in property operations and maintenance (O&M). The focus of the study is on Statsbygg's CAFM-system, SESAM. The investigation about BIM and mobile solutions were necessary because of its significance to the development of CAFM-system.

The four aspects in information systems management regarding process, resources, technology, policies and standards (Atkins, 2009), was an essential theoretical framework for the topic. The activity theory helped put the research topic in "context", which is necessary on the study of information system.

Digitalization increase productivity in property Operations and Maintenance (O&M). The O&M organization will greatly benefit from the global digitalization of information in the AEC and FM industry. The O&M organization must prepare for a digital future that requires capacity to handle large data. To integrate different processes and ICT tools successfully, the digital infrastructure must be open and neutral. A total overview of FM process and sufficient skills of human resources are essential to the digital transformation of O&M organization and increase productivity.

### **The development of CAFM-system to support O&M process**

Digital advancement is important to O&M organization to keep up and survive the fast accelerating global digital development. However, its success does not depend on the best digital solutions alone. The research study revealed factors that can lead to the success or failure on the development and implementation of CAFM-system as a tool to support and increase production in O&M process. The correct development of ICT tools depends on business strategy and objectives. The important aspects in developing CAFM-systems to support O&M process are;

- Appropriate process architecture with overview of interrelated processes
- Effective management of legal requirements and standards
- Overview of relevant technological solutions
- Resources planning
- Open and neutral interface



### **Adapting to the digital O&M process and tools**

Digital solutions or tools must be utilized optimally to increase productivity in O&M process. Digital transformation in large organizations requires effective change management, development of digital culture and communication throughout the organization as an important part of the digitalization strategy. The early involvement of the end-users is essential in choosing the right digital tool to support the O&M process. The O&M personnel should be involved and be able to participate in the whole process of development and implementation. Digitalization of O&M process suggests continuous development of skills. Creating champions and super-users from the different levels of responsibilities in the O&M organization is the key to the successful implementation of CAFM-system to support O&M process.

The development and implementation of CAFM-system in Statsbygg to support O&M process has an impact to the O&M organization skills, culture, structure and workflow. It creates a transparent process in the strategic, tactical and operative levels of the organization. CAFM-system, SESAM enhances the value of O&M information, by providing up to date O&M information across the organization. It helps carry out key activities systematically and provides information about decisions regarding O&M plans and measures. The research study has revealed and summarized aspects that are important, to successfully adapt to the digital process;

- Access to O&M information
- Transparency in business plans and objectives
- Maintaining the quality of policy and standards
- Involvement and support
- Continuous training and skills development
- Intuitiveness of digital solutions

### **Digitalization of O&M process and best practice**

The best practice in this research is based on the investigation of CAFM-system in Statsbygg supported by brief study of BIM and mobile solution. Best practice in O&M depends on the ability of the organization and its digital tool to adapt to the constant change and development of methods and standards. Digitalization help large organizations create a modern and standardized O&M process. The goal of O&M is to increase customer satisfaction and enhance the value of the facility. The value of digitalization of O&M process depends on its

positive impact to its clients and customers. Digitalization help improve communication between clients and owners.

O&M organizations must take care and retain the building technical knowledge that is very well rooted to O&M personnel. Providing *champions* and conducting skills development training in the organization must be considered as best practice in O&M. The knowledge gap between the strategic level and the operative level must be improved. The tactical level plays an important role in coordinating the challenges and opportunities between the strategic and operative level.

The capability of the CAFM-system, BIM and mobile solutions to support the O&M process in meeting the legal requirements and standards contributes to the best practices in O&M. The availability of updated O&M information and elimination of paperwork by digitalization enables the O&M staff to become more productive. Automated process will be possible and be much easier when activities are digitally structured and organized. A continuous technology advancement and development of the organizations' digital culture is necessary to survive the digital disruption.

### **Recommendations on further research**

There are three recommended topics for further research that are relevant to this master thesis.

This research study does not cover the analysis of the return of investments (ROI) on use of digital tools. There are theories and methods on how to manage the life-cycle of ICT tools for FM. It would be interesting to study the economic benefits of digital tools to FM.

The topic of this master thesis was limited to the investigation of CAFM-system and has included briefly the combination of BIM and mobile app solutions. Digitalization includes many other tools and methods that are not in the context of this master thesis. The utilization of a web-based CAFM-system opens up new possibilities. The study on how FM can benefit from Internet of Things (IOT) is an interesting topic for further research.

There are new opportunities on BIM aided O&M process. The utilization of BIM with product data templates (PDT) is developing the way FM documents are collected, delivered and exchanged. It is compelling to investigate how O&M benefit from this technological development.

## TERMS AND DEFINITIONS

**Activities** – tasks to complete deliverables (Norsk Standard, 2011)

**Best practice** – is the most effective and efficient way to complete a business task. Best practice is often measured by benchmarking (Atkins, 2009).

**Champion** - is a person in a business organization who advocates change. Change can be related to the implementation of new technology, process, methods or tools.

**Digitalization** – is the use of digital technology to take advantage of all digitized process and information.

**Facilities Management** - a profession that encompasses multiple disciplines to ensure functionality of the built environment by integrating people, places, processes and technology (IFMA, 2009).

**Generation C** – *generation of people who are fully tech-savvy, with an inherent understanding of digital technologies and the expectation of being connected to everyone and everything, anytime, anywhere* (Friedrich, 2010).

**Hard characteristic** – is objective and is related to physical, temporal, functional and financial characteristics (NS-EN 15221-3, 2011).

**Maintenance (M)** – *“combination of technical, administrative and managerial actions during the life cycle of an item intended to retain it, restore it to, a state in which it can perform the required function”* (NS 3456, 2010).

**Primary activities** - activities that constitute the distinctive and indispensable competencies of an organization in its value chain (NS-EN 15221-1, 2007).

**Process** – *“set of interrelated or interacting activities which transforms inputs into output”* (Norsk Standard, 2011).

**Operations (O)** – *“includes all services, which are a precondition that a property can function satisfactory during use. DFM-benchmarking divides property operation in the main fields: Maintenance, utilities, cleaning, general operations and fixed property expenses”* (Jensen, 2008).

**Soft characteristic** – *“Measurement of subjective characteristic e.g. client, customer and end user’s satisfaction, experience and perception are referred usually as “soft measures” and are usually a result of surveys”* (NS-EN 15221-3, 2011).

**Tagging** – is used to assign an information to a group or category. In Statsbygg’s CAFM SESAM, the term “tagging” is used to identify a building system or component (e.g. fire door, universal design door, etc.) that requires special O&M tasks.

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## **APPENDIX**

**A – Interview guide**

**B - Survey questions**

**C - Results**



## Appendix A – Interview guide

Date:

Dear Sir/Ma'am,

I am currently writing a master's thesis about the **Impact of digitalization on property operations and maintenance (O&M)**, which is the last part of a three year masterprogramme. In this regard, i would like to request your participation to an interview. The objective of this interview is to collect qualitative data that are important in answering the thesis's research questions. The interview will take approximately 1 hour and will be conducted in your best available time. The results of this interview will be analyzed together with the other results. A copy will be sent to you afterwards, which you may review at that time. Please inform if you wish anonymity in participating to this interview

Thank you in advance for your time and contribution to this research work.

Sincerely;

Resty Gonzales Garcia

## Research topic:

**How can digitalization help increase productivity in property Operations and Maintenance (O&M)?**

## Research questions:

1. **How does organization develop CAFM-system to support O&M process?**
2. **How does organization adopt to the development and implementation of CAFM-system to support O&M?**
3. **How can digitalization contribute to best practice in O&M?**

## Interview questions:

1. Is there a **strategy** for digitalization of facility management and property operations?
2. What are the digital **solutions and tools** used?
3. Does the organization have **skills and competency training plan**?
4. What are the key elements? Please explain.
5. Did you participate in the project implementation? To what extent?
6. How are you using the digital solution(s) and what worked well?
7. Would you go back to the traditional process? Please explain why.
8. Do you agree and how satisfied are you with your organization's strategy, training plan, solutions?
9. What are the barriers during the implementation/use of the solution/tools?
  - Availability of information?
  - Working hours?
  - Availability of technical assistance?
  - Resources management?
10. How did you overcome the barrier(s)?
11. How does the strategy and implementation of solutions and tools affect your work?
12. How does the strategy and implementation of solutions and tools affect your clients?
13. Do you have any suggestions about the digitalization strategy and its implementation in your organization?
14. Would you have comments and/or suggestions regarding this interview?

## Appendix B - Survey questions (Questback)



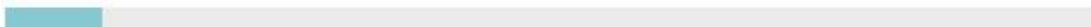
### Spørreundersøkelse: Digitalisering i eiendomsdrift

#### 1) Hva er din rolle i Statsbygg?

- Driftssjef
- Driftsleder
- Driftstekniker
- Annet:

Neste >>

9 % fullført



## Spørreundersøkelse: Digitalisering i eiendomsdrift

### 2) Hvor lenge har du jobbet i Statsbygg?

- 0-1 år
- 2-3 år
- 4-5 år
- Mer enn 5 år

Neste >>

18 % fullført

## Spørreundersøkelse: Digitalisering i eiendomsdrift

### 3) Din aldersgruppe?

- Født før 1939
- Født mellom 1940-1959
- Født mellom 1960-1979
- Født mellom 1980-1989
- Født i 1990 eller senere

Neste >>

27 % fullført



## Spørreundersøkelse: Digitalisering i eiendomsdrift

### 4) Produktiviteten i eiendomsdrift kan effektiviseres ved...

	Helt uenig					Helt enig
	1	2	3	4	5	6
Bruk av riktig IKT-verktøy	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Riktig organisasjonsstruktur	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Best practice	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ingen av disse	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

### 5) Kommentarer/evt innspill?

Neste >>

# Spørreundersøkelse: Digitalisering i eiendomsdrift

## Standardisering

Digitalisering i eiendomsdrift bidrar til mer standardiserte arbeidsprosesser.

**6) Ved implementering av FDVU-system (SESAM) og BIM i min organisasjon blir våre arbeidsplasser mer standardisert i løpet av**

	Helt uenig					Helt enig
	1	2	3	4	5	6
1 år	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
2-3 år	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
4-5 år	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Mer enn 5 år	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**7) Kommentarer/evt innspill?**

# Spørreundersøkelse: Digitalisering i eiendomsdrift

## Effektivisering

### 8) Digitalisering kan effektivisere driftsprosesser gjennom bruk av...

	Helt uenig					Helt enig
	1	2	3	4	5	6
FDVU-systemet (SESAM)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
BIM	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Mobile løsninger (App o.l.)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Både FDVU-system (SESAM), BIM og mobile løsninger (App)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ingen av disse	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

### 9) Kommentarer/evt innspill?



## Spørreundersøkelse: Digitalisering i eiendomsdrift

### Forenkling

#### 10) Digitalisering kan forenkle driftsprosesser gjennom bruk av...

	Helt uenig					Helt enig
	1	2	3	4	5	6
FDVU-systemet (SESAM)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
BIM	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Mobile løsninger (App o.l.)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Både FDVU-system (SESAM), BIM og mobile løsninger (App)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ingen av disse	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

#### 11) Kommentarer/innspill?

# Spørreundersøkelse: Digitalisering i eiendomsdrift

## Riktig organisasjonsstruktur ved bruk av digitale verktøy

12) Dagens organisering i min driftsorganisasjon er riktig med tanke på bruk av dette digitale verktøy:

	Helt uenig					Helt enig
	1	2	3	4	5	6
FDVU-systemet (SESAM)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
BIM	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Mobile løsninger (App o.l.)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Både FDVU-system (SESAM), BIM og mobile løsninger (App)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ingen av disse	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

## 13) Kommentarer/innspill?

## Spørreundersøkelse: Digitalisering i eiendomsdrift

### "Best practice"

Best practice er viktig for effektive drifts arbeidsprosesser. Bruk av IK DV, god samhandling mellom drift og leverandører samt bruker og standardiserte prosesser er eksempler på best practice.

#### 14) Bruk av digitalt verktøy i min organisasjon bidrar til best practice i drifts arbeidsprosesser

	Helt uenig					Helt enig
	1	2	3	4	5	6
FDVU-systemet (SESAM)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
BIM	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Mobile løsninger (App o.l.)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
FDVU-system (SESAM), BIM og mobile løsninger (App)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ingen av disse	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

#### 15) Kommentarer/innspill?

## Spørreundersøkelse: Digitalisering i eiendomsdrift

### "Best practice"

16) Ved implementering av BIM i min organisasjon har jeg fått tilstrekkelig...

	Helt uenig					Helt enig
	1	2	3	4	5	6
Teknisk støtte	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Brukerinvolvering	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Kulturoppbygging	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ingen av disse	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

17) Kommentarer?

Neste >>

## Spørreundersøkelse: Digitalisering i eiendomsdrift

### "Best practice"

Dette er siste side av spørreundersøkelsen. Du avslutter og sender inn ditt svar ved å klikke på "SEND"-knappen under.

#### 18) Ved implementering av FDVU system (SESAM) i min organisasjon har jeg fått tilstrekkelig...

	Helt uenig					Helt enig
	1	2	3	4	5	6
Opplæring	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Teknisk støtte	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Brukerinvolvering	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Kulturoppbygging	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ingen av disse	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

#### 19) Kommentarer?

## Appendix C– Summary of survey results

### RQ2 - How does organization adopt to the development and implementation

#### Effective O&M using ICT tools (CAFM-system, BIM and mobile solutions)

Question	N	Average	Standard deviation	Median
CAFM system (SESAM)	84	3,96	1,43	4,00
BIM	78	4,21	1,25	4,00
Mobile solution (App)	80	4,13	1,37	4,50
All of the above	80	4,35	1,40	5,00
None of the above	47	2,19	1,63	1,00

#### O&M personnel opinions on how ICT tools contributes to a more effective O&M process.

#### Simplification

Question	N	Average	Standard deviation	Median
CAFM system (SESAM)	77	3,79	1,38	4,00
BIM	67	4,01	1,22	4,00
Mobile solution (App)	68	3,99	1,31	4,00
All of the above	81	4,16	1,42	4,00
None of the above	44	2,27	1,64	1,00

#### O&M personnel opinions on how ICT tools contributes to simplification of O&M process.

#### Correct O&M organizational structure regarding the use of ICT tools.

Question	N	Average	Standard deviation	Median
CAFM system (SESAM)	74	3,81	1,25	4,00
BIM	63	3,46	1,19	4,00
Mobile solution (App)	65	3,62	1,29	4,00
All of the above	77	3,82	1,31	4,00
None of the above	47	2,00	1,43	1,00

#### Survey result regarding organization and ICT tools.

#### Status on implementation of CAFM-system in Statsbygg O&M organization (Region East office).

Question	N	Average	Standard deviation	Median
Training	88	3,16	1,28	3,00
Technical assistance	88	3,26	1,25	3,00
User involvement	87	3,14	1,30	3,00
Culture building	81	2,88	1,37	3,00
None of these	45	2,67	1,92	2,00

#### O&M personnel involvement and support regarding the implementation of CAFM-system in Statsbygg.

## Status on implementation of BIM in Statsbygg O&M organization (Region East office).

Question	N	Average	Standard deviation	Median
Technical assistance	65	2,72	1,44	2,00
User involvement	63	2,59	1,35	2,00
Culture building	59	2,51	1,23	2,00
None of these	55	3,20	2,01	3,00

## O&M personnel involvement and support regarding the implementation of BIM in Statsbygg.

### Standardization

Question	N	Average	Standard deviation	Median
1 year	59	2,27	1,33	2,00
2-3 years	75	3,53	1,52	4,00
4-5 years	68	3,81	1,41	4,00
More than 5 years	60	3,82	1,69	4,00

## Expectations regarding standardization and digitalization as foreseen by the O&M personnel in Statsbygg.

## RQ3 - How can digitalization contribute to best practice in O&M?

### How the use of ICT tools contributes to best practice in O&M.

Spørsmål	N	Average	Standard deviation	Median
CAFM system (SESAM)	75	3,76	1,30	4,00
BIM	59	3,46	1,33	4,00
Mobile solution (App o.l.)	64	3,55	1,41	4,00
All of the above	71	3,90	1,41	4,00
None of the above	48	2,48	1,76	2,00

## O&M personnel's opinions on how ICT tools contributes to best practice.





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