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Internet of Things (IoT) in real estate

Designing guideline for employee-oriented IoT implementation in office real estate

Master thesis
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Colophon

Document information

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List of abbreviations

BMS	Building Management System
CREM	Corporate Real Estate Management
Flex	Flexible office (space characteristics)
FM	Facility Management
FMIS	Facility Management Information System
GDPR	General Data Protection Regulations
HR	Human Resources (department)
IoT	Internet of Things
IT	Information Technology (department)
MBE	Management in the Built Environment (MSc track)
RE	Real Estate
REM	Real Estate Management
SRE	Smart Real Estate
SRET	Smart Real Estate Tools (graduation laboratory)
SS	Smart Solutions (CBRE)
ST	Smart Tool(s)
TM	Technical Management
WSP	Workplace Strategies (CBRE)

Preface

The following document presents the master thesis research on which I had been working since September 2018. The research falls under the Graduation Laboratory called 'Smart Real Estate Tools' organized in line with the Master Studies 'Management in the Built Environment' at Delft University of Technology.

Motivation

I have joined Delft University of Technology (TU Delft) in September 2017. Previously I have accomplished Engineering Studies related to Spatial Planning on a city and regional level. Already during my bachelor, I have realized that in order to have a real impact on the Built Environment development I have to focus on a different scale. After I have graduated, I have joined the master track Management in the Built Environment (MBE). Ever since then I have been developing my knowledge, skills and most importantly my passion related to the field of real estate management.

Vision

Ever since the beginning I have aimed at developing a practice-oriented master thesis which can have wide applicability in our challenging and constantly developing Built Environment. The goal was to create a framework which can enable CREM to acknowledge end users in the IoT implementation process in office real estate and add value to various stakeholders.

The research development had been strongly steered by focusing on the end users of office real estate. In fact, in the last 5 months I could luckily experience being one of them (office employee) at the CORE (CBRE), while at the same time I was a member of the team responsible for further smart office development. The 'double glasses' that I could wear in the last 5 months had given me valuable insight into CREM's and end user's perspectives. These days I can conclude that the development of SRE is a multidisciplinary team challenge which have to be properly managed in order to provide most value to the bigger group of stakeholders.

Personal Study Targets

While living in The Netherlands I have become strongly interested in the concept of digitalization and opportunities related to it. I believe it is incredible to observe how fast new technologies are invented and implemented in our surroundings. Within Smart Real Estate Tools studio I saw a great opportunity to develop in-depth knowledge about implementation of smart technologies in offices and learn more about the CREM's role(s) within this initiative.

Today I see that I have learned a lot, however I also see that there is still a lot to be discovered. Not only by me or other researchers, but also by organizations and CREM. This year had been a great learning experience filled with many satisfactory moments. I am sure that I am going to further continue the learning process in the upcoming future.

Hanna Maria Majchrzak

June 2019

Abstract

The purpose of this research is to extend knowledge on adding value to office employees (end users) due to smart technology implementation. The focus of this research document is given to end users since the problem statement emphasises a need of a strategic change in CREM's activities related to smart technology implementation. The problem statement explains the recognized paradox. On the one hand smart technologies are the components of Smart Office Real Estate which should serve its end users – office employees. On the other hand , it seems that smart technology implementation initiative is a top-down process which causes issues such as peoples' fear or privacy concerns. The proposed in this research strategic change implies focusing on employee-oriented IoT implementation initiative. The research main question is 'how can Corporate Real Estate Managers (CREM) shape Internet of Things (IoT) initiative which adds value to office employees?'. The research methodology combines systematic literature review and case study methods. The case study method consists of two parts: in-depth interviewees (incl. appendage) and desk research. The research have an explorative character. The appointed mixed methodology allows to gather information from practice and at the same time ensure its reliability. The research analysis presents a comprehensive process design. The process design framework visualises actors, steps and phases of IoT implementation initiative. Additionally the research addresses implemented within investigated case studies smart technology and its explains its added value. Both findings guide CREM on how to shape an IoT initiative due to: (1) clarifying their role in the comprehensive IoT implementation process and (2) indicating application functionalities and data which CREM should pay attention to in order to add value to office employees. The research findings are highly relevant to the multiple actors, primarily CREM's practices in current changing RE market.

Key words: CREM, IoT implementation, process design, adding value to office employee.

Management summary

Introduction: research basis

The concept of smart real estate is constantly developing and does not have a fixed definition (Ullah, Wang, & Sepasgozar, 2018) Neither does the smart office. The goal of a smart (office) real estate vary largely in the literature. For the sake of this master thesis an umbrella definition of a smart office had been created. The smart office is further understood as *'an office space which is equipped with multiple connected IoT devices which monitor, control and manage indoor working environment and support office workers activities due to communicating with them the real-time information as well as provide CREM with data which can influence managerial decisions'.*

Very often investments in smart real estate are made because the technology enabled building promises substantial organizational savings. Not only the performance of the building can be improved but also its management (Verhoeven, Maaijen, & Brink, 2015). The information gathered via multiple sensing technology and other smart tools can provide CREM with historical and real-time data related to their asset which can bring benefits to REM and an organization (Riratanaphon & van der Voordt, 2015) (Arata III & Hale, 2018).

Despite the benefits which CREM can gain due to smart technology implementation, end users of the buildings tend to raise up objectives related to privacy issues. The initiatives are questioned and discarded by the end users. (Bersin, Mariani, & Monahan, 2016) Factors which contribute to this situation from the end user perspective are: fear from unknown, privacy concerns, lack of awareness and not seeing personal benefits related to the initiative. (Bersin, Mariani, & Monahan, 2016) Factors which contribute to this situation from managerial (CREM) perspective can be linked to: poor understanding of the IoT value to end users, lack of strategic objectives related to end users, no involvement of end users in the process, neglecting the importance of rising up the awareness of the end users about the implemented systems (Thomas, Devan, & Khan, 2018).

The challenge is therefore to design smart technology/IoT solutions (for a workplace) which offer employees obvious positive value (Bersin, Mariani, & Monahan, 2016). Additionally what has to be overcome is the people's fear of the unknown which shows the necessity of acknowledging the end user in the smart technology implementation process (Ratcliffe, Saurin, & Puybaraud, 2008). It is also important to raise up CREM's and organization's awareness and understanding of the IoT value preposition in order to clarify its benefits to office employees.

Research objective

The goal of this master thesis research was to create a guideline which presents a strategic approach towards IoT implementation that focuses on adding value to office employees. The guideline had been defined by the researcher as *'information intended to advise CRE managers on how do shape smart technology implementation initiative which benefits office employees. The guideline consist of: (1) sketch of a smart technology implementation process which acknowledges end users and includes barriers which have to be overcome, and (2) list of smart technologies which can add value to end users (and CREM)'*. The research objectives have direct link to the research output (see figure 1).

Main research question

The main research question is:

How can Corporate Real Estate Managers (CREM) shape Internet of Things (IoT) implementation initiative which adds value to office employees?

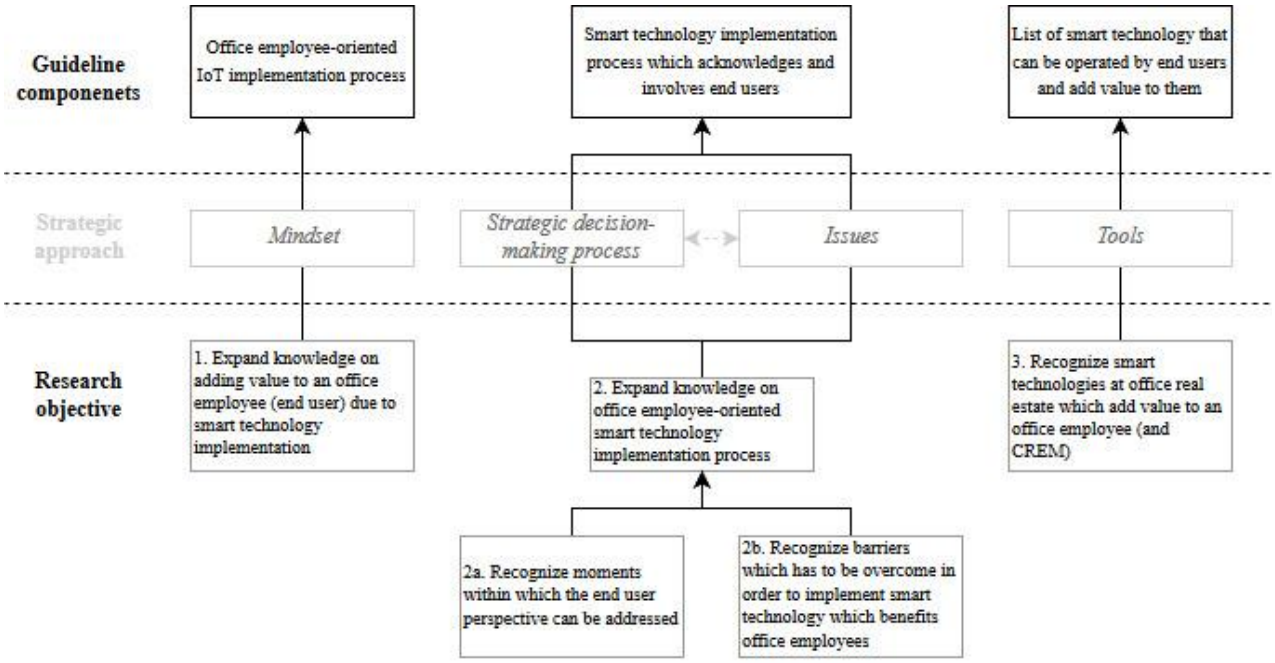


Figure 1 Research objective and output; source: author

Research relevance

People fear that collected via smart technology data on their behavior at an office can be used against them (Bersin, Mariani, & Monahan, 2016) (EY, 2016). In order to minimize public objections towards smart technology and data gathering, concerned parties should be made aware of possible private and corporate benefits (Bersin, Mariani, & Monahan, 2016). The implementation of IoT and data analyses represent new concepts which keep on growing in strategic importance. It should be kept in mind that data itself does not add value to the real estate portfolio and/or management if the user is unsatisfied with the way the data is gathered or proceeded. (Ratcliffe, Saurin, & Puybaraud, 2008) The changed perspective (from top-down IoT implementation process to an IoT initiative which involves end users and focuses on adding value to them) can enable real estate managers to successfully handover the implemented smart technologies to the end user, present benefits of IoT to office employees and improve the IoT implementation and adaptation process.

Some research has been done about application of the technologies in the built environment, but they tend to focus on architecture, engineering and construction, while the real estate services sector and managerial approach have been left behind. This can be observed in spite of *'the high dependency of the real-estate services sector on the availability and accuracy of information on properties'* (Mahbjoubu, Moobela, & Laing, 2013). The number of publications on technologies related to IoT in office real estate is very limited and it does not always recognize a link between the smart tools and office end users. (Ullah, Wang, & Sepasgozar, 2018)

The need for building up a knowledge within this field was also recognized by Valks, Arkesteijn, & den Heijer (2018) in relation to smart tools (an element of a broader concept called an Internet of Things) in a publication '*Smart Campus Tools 2.0'.* The theme *'Planning transformation: To further expand the knowledge on how to implement smart tools by studying the relation of smart tools within organisational processes'.* The researcher recognizes it as an encouraging topic which has been mentioned in the publication as theme recommended for further research.

The following master thesis aims at filling the literature gap and responding to the recognized issue, by expanding knowledge on adding value to an office employee (end user) due to smart technology implementation, learning about the process, barriers, involvement strategies and available technological solutions.

Research question(s) and methodology

The main research question is: 'How can Corporate Real Estate Managers (CREM) shape Internet of Things (IoT) implementation initiative which adds value to office employees?'.

The table 1 presents the research sub-questions and selected research methods which had helped the researcher to formulate answers to them.

Research objective	Component of the guideline (strategic approach)	Research sub-question	Selected research methods		
			Literature study	Desk research	In-dept interviews (incl. appendage)
1. Expand knowledge on adding value to an office employee (end user) due to smart technology implementation	*mindset*	1. How can Corporate Real Estate Management (CREM) add value to office employees?	•		•
2. Expand the knowledge on office employee-oriented smart technology implementation	*strategic decision-making process issues*	2. How is the IoT implementation process organized?	•	•	•
2a. Recognize moments within which end user perspective can be addressed		2a. How, when and by who can the perspective of end users be acknowledged?		•	•
2b. Recognize barriers which has to be overcome in order to implement smart technology which benefits office employees		2b. What are the barriers that have to be overcome in order to implement smart technology which benefits office employees?	•		•
3. Recognize smart technologies at office real estate which add value to an office employee (end user)	*tools*	3. What are the existing smart technologies implemented within (investigated) offices that add value to office employees?		•	•

Table 1 Research questions and methods; source: author

The research strategy combines literature study & web search, case studies (based on information gathered via in-depth interviews incl. appendage, and desk research). The approach represents a descriptive type of study which aims at integrating qualitative information into a research output - guideline. Proposed research techniques reflect the critical reality, that the information which is needed in order to define IoT implementation strategic approach is not widely researched and there is very little qualitative information presented about it in scientific literature.

Theoretical framework: knowledge basis

The development of theoretical framework had shaped knowledge basis for the further case studies research. The literature review findings (part III) had been combined with the case studies findings (part IV) and are described in part V 'analysis'. Those three parts formulated the answer to the research questions which are answered in part IV.

Findings: Employee-oriented IoT implementation process

Following section summarizes the analysis by placing the recognized steps and actors within the holistic employee-oriented IoT implementation process. The text describes the figures 2 and 3. The process design is 'holistic' since it brings into light important actors, link them to their responsibilities and includes steps which have to be taken in order to overcome barriers recognized in this research paper. Furthermore the figures present missing elements which had been discussed and added by the researcher within the framework. The process design is a part of the guideline for CREM which explains how to shape/conduct smart technology implantation process. Figures 2 and 3 present two inseparable parts of the process (they had been divided only due to the page size therefore they should be read together as one figure).

For more details (the process full description) the reader should take a look on sections: '2.3. Employee-oriented IoT implementation process design' p. 80-84 & '3.2. Process design: comprehensive employee-oriented IoT implementation process – missing elements' p. 92-95.

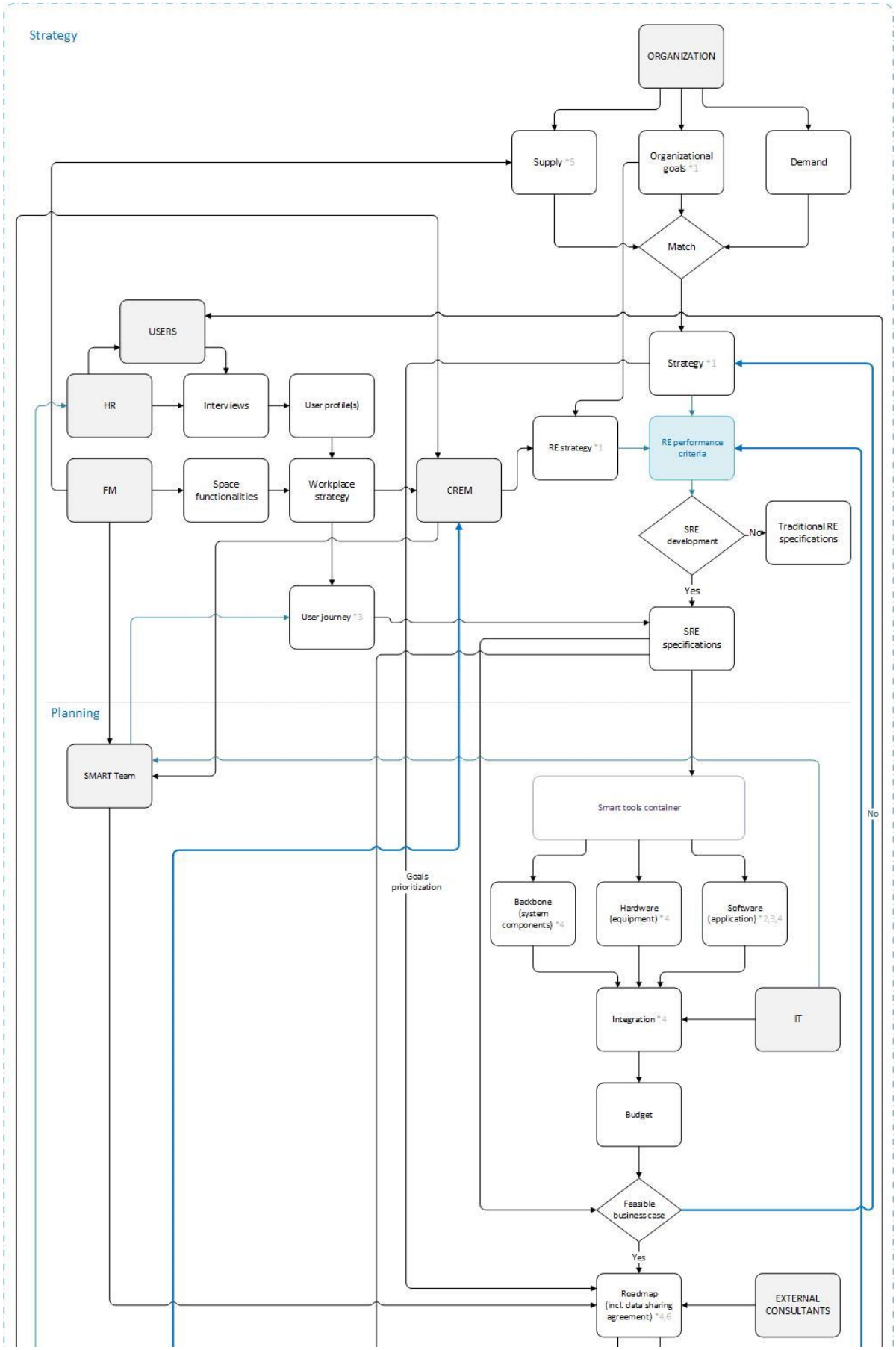


Figure 2 Holistic employee-oriented IoT implementation process, part I; source: author

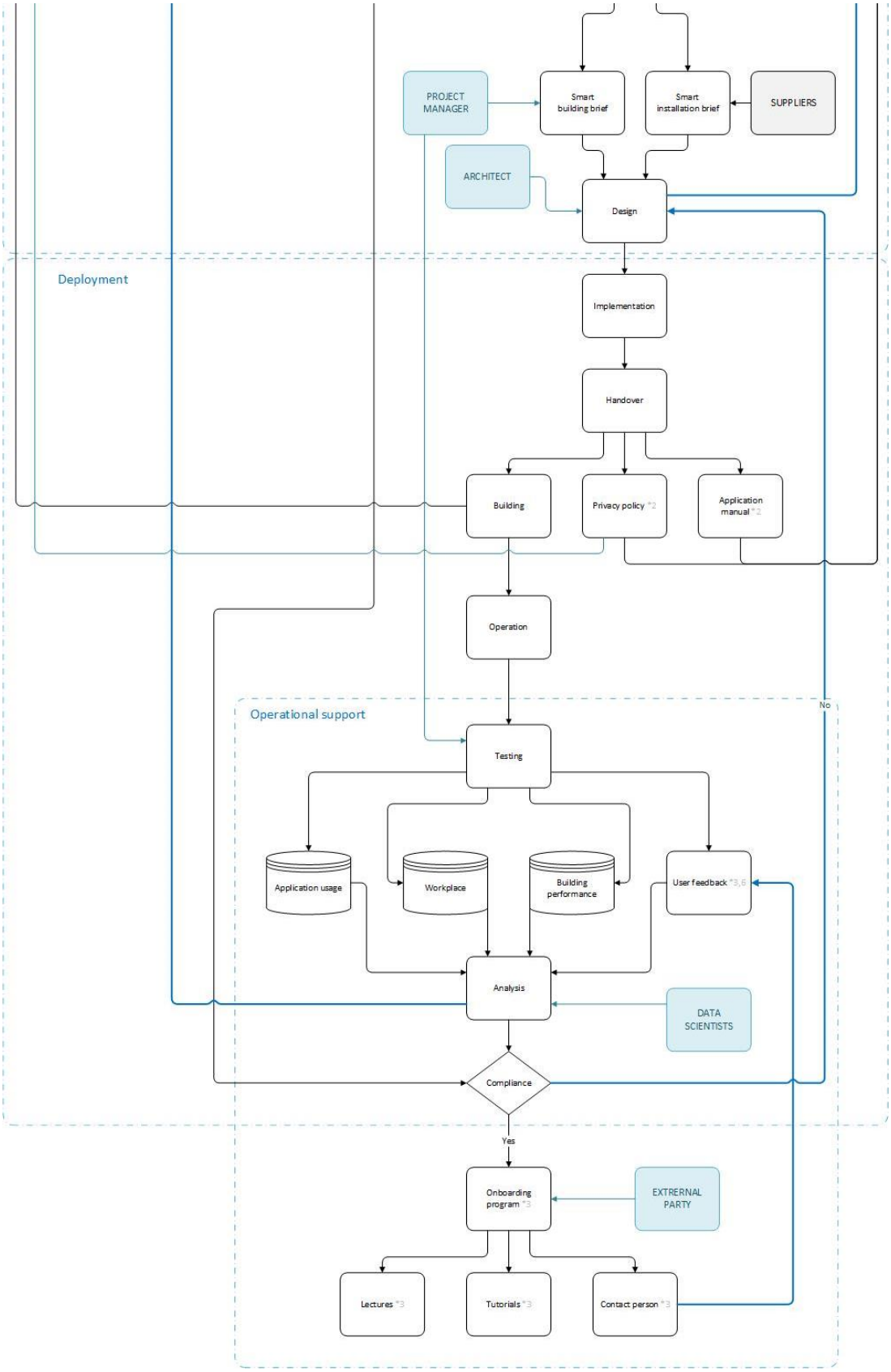


Figure 3 Holistic employee-oriented IoT implementation process, part II; source: author

Findings: smart technology and its added value

The existing smart technologies implemented within offices can be divided into display devices for end users (mobile application's functionalities, interactive screens) and those for CREM (servers which gather historical data, automatized BMS, FMIS). Mobile applications and informative screens in an office space add value to office employees, whereas various dashboards are intended to add value to CREM by giving CREM an insight into data related to the building performance and its usage and/or exploitation.

The smart technology implemented within investigated offices has a form of a mobile application. The mobile application can consist of various, unique functionalities. Those are:

- Ambient control: adjusting temperature, adjusting lightening
- Real time occupancy data: desk status (free/occupied/booked), room status (free/occupied/booked), no-show communicates
- Booking workspaces: book a room, book a desk
- Collaboration features: localizing employees/colleague finding, communicate (chats/vide calls)
- Additional services: elevator synchronization (with end user location, after request), parking overview (plots occupancy and wayfinding), smart lockers (lockers occupancy and wayfinding)

Technologies which support user activities aim at making the time spent at a smart office easier and more comfortable (CBRE, 2018b). Provision of an IoT concepts which helps an office employee to easily book and/or find a desired space, see the overview of meeting rooms and/or booking opportunities, locate team members in order to collaborate, find a way to certain service (e.g. printer) or quickly communicate in various ways with a colleague to great extend support office workers activities (Acoba, Charaya, James, & Rahalkar, 2018) Technologies which increase user satisfaction are characterised by the fact that they enable end users to modify their working conditions in line with their preferences (Borghero, 2018). In practice it means for instance adjusting air quality, having control over the temperature around them or being able to have control over the light intensity. (Brugmans, Appel-Meulenbroek, Kemperman, & Dinnissen, 2017) (Nehchiri, Vahedprast, & Esfahani, 2018). Additionally some functionalities add remaining values from the 'adding value framework': stimulating collaboration, supporting culture and image of flex office spaces, increasing flexibility, reducing costs, reducing footprint and controlling risks (see part V analysis and appendix D).

The smart technology which allows CREM to collect and analyse data are servers which store data, various Building Information System (BMS) and Facility Management Information System (FMIS). The data is gathered via various ST when a RE is occupied by office employees. The technologies gives CREM an opportunity to gain data insight, which can steer further their actions which can add value in various manners. Last but not least, the case studies research indicate an implementation of the smart technology adds value due to stimulating innovation and increasing RE value (van der Ven W. , 2019) (La Grouw , 2019) (Stam, 2019), however the findings cannot be quantified.

For broader overview of the smart technology added value the reader should follow the discussion section included in part Vi of this research paper.

Main conclusion

CREM can shape the IoT implementation initiative by imposing (on other actors) and following the 'comprehensive employee-oriented IoT implementation process design' framework. CREM should follow the framework presented in figure 33 & 34 (on page 93 and 94), which supplement the results of the research due to taking a critical look on the research findings (process design). Finally, CREM should ensure implementation of a mobile application. All recognized within this research application functionalities add value to office employees due to supporting their activities and increasing their satisfaction. The finding confirms that the mobile application adds value to office

employees. The mobile application functionalities should however respond to the RE and the organizational strategy. The RE strategy should be strongly based on the end users' input.

While shaping the IoT implementation initiative, CREM can ensure a successful smart technology implementation by making sure that the office employees are involved in the IoT implementation process. The office end users can be acknowledged in various moments throughout the process:

- Strategy and planning phase: the office employees' needs and preferences related to the working environment should highly steer a workplace strategy concept developed by FM. The insight should be further translated by CREM into RE strategy and SRE specifications.
- Strategy and planning phase: the selection of smart technology (application functionalities) should respond to the SRE specifications created on the basis of CREM's RE strategy, organizational strategy and users' input (user journey).
- Strategy and planning phase: SRE specifications document is a basis for the roadmap document and the design document. The SRE specifications document takes into account the perspective of office employees (through user journey).
- Deployment phase: the end user perspective can be acknowledged while directly communicating privacy policy and application manual with office employees (done by HR).
- Deployment phase: gathering a direct end users' feedback after the building is handed over ensures that the users' feedback contributed to the analysis results handed over to CREM.
- Operational support phase: continuously gathering the end users' feedback for data analysis.
- Operational support phase: establishing an onboarding programme and appointing a contact person for office employees, who they can approach if they have any comments related to developed smart office.

Additionally, CREM should form an interdisciplinary team – SMART team – while shaping the IoT implementation initiative, in order to maintain an important position within the process and further steer the IoT implementation initiative. Within the process, the SMART team creates a roadmap document which includes data sharing agreement. Defining the data sharing agreement is a crucial step for CREM because such an agreement can give CRE managers an insight into data, which gives CREM an opportunity to add more values related to CREM.

Opportunities for further research

Further research on the smart technology implementation within office RE should fully focus on scientifically defining the added value of specific data bases to 4 different CREM perspectives. The goal would be to adopt the basic framework created within this research and collecting more empirical research which will provide more reliable and generic research findings. The challenge for a researcher which would continue further study on the smart technology added value would be to define the direct impact of an application functionalities and/or data on the appointed 'adding value' framework elements.

The IoT implementation process design could also be recommended for further research. The goal of the further research should lay down in applying and testing the framework in relation to specific corporate objectives and organizational performance outcomes. The process design should be investigated further by more case studies research. While looking at more case studies, it is possible that further research can provide valuable process actions/elements therefore improve the created framework.

Contents

Readers guide

The following report presents the final version of the master thesis paper. The report consists of finalized part I (introduction), II (research methodology), III (knowledge basis), IV (cases analyses main findings), V (analysis) and VI (research findings, conclusion & discussion). The document is preceded by the preface note and management summary.

Part I

The 1st part of this master thesis consists of multiple elements which sketch the starting point of the further research. The introduction is intended to present the thematic fields relevant to the research, sketch their connections and present shortcomings of the current situation recognized due to literature study. The introduction is followed by the problem statement which is later translated into research scope. Research scope explains in more details the research objectives, research output, research questions and research definitions. Additionally the 1st part addresses overview of the research methods, research relevance and dissemination.

Part II

The 2nd part of this master thesis consists of a comprehensive research methodology description. The section starts with explaining the methodological framework which has been build up on the basis of interpretivism approach. The framework consist of research strategy explanation. The research strategy consists of multiple research methodologies which are appointed in line with research objectives and research questions. Research design and data analysis approach present the research process diagram and specify in more details the output of this master thesis (guideline). Respectively the 2nd part explains in more details appointed research methods: literature review, case study approach (in-depth interview) and desk research. Last but not least, ethical considerations are addressed in the following part.

Part III

The 3rd part of this master thesis consists of literature review which steers further case studies approach and helps to sketch answers to research sub-questions. The knowledge basis includes: (0) explanation of guideline form, (1) description of CREM, its objectives and its relation to office end users, (2) explanation of the smart office concept and technology which can add value to end users and (3) description of actors, barriers and elements relevant to the IoT implementation process. The 3rd part is finished with a summary and short discussion which indicates the direction of further case studies research.

Part IV

Part IV presents case studies main findings. The case studies main findings are introduce in a systematized manner in order to give a reader an overview of the main findings which are later on analysed in the next part of this document.

Part V

The 5th part of this research paper consists of extensive analysis related to the 2nd and 3rd research objectives. The analysis are divided into two parts: (1) smart technology analysis and (2) process analysis. The 1st part focuses on defining smart technology which is implemented within investigated offices and defining its added value to office employees and CREM. The information are spited into application functionalities added value and data added value. The process analysis first discuss steps recognized in processes learned through case studies research, next it presents recognized (by practice and theory) barriers which can be encountered in the process and proposes steps which ensure overcoming those barriers. The full process is visualised in two figures and described in words so that the reader can follow the process.

Part VI

Formulating the analysis and defining research findings enable the author to proceed with the 5th part. The part VI combined research findings, gives an answer to the main research question and presents further discussion on the research outcomes. First the researcher gives direct answer to all the research sub-questions, which helps to formulate the answer to the main research question. The conclusion section answers the main research question by explaining how can CREM shape IoT implementation initiative which adds value to office employees. In the discussion part, author further elaborates on the research findings and strive for its improvement. The last paragraphs indicate defined opportunities for further research.

Part VII

The 7th part of the master thesis consists of author personal reflection. The reflection touches upon multiple aspects related to the process of conducting the research. The reflection discusses elements related to the research process and research design.

Remaining parts

The document is closed with bibliography, tables & figures list and relevant appendixes. The appendix D is mentioned in the section since it summarizes case studies findings which are analysed in part IV.

Appendix D

The part addresses the case studies analysis. The case studies are presented in a predefined format so that the results can be clearly presented and analysed in part IV. Part IV presents analysis which links the findings of 5 cases: The CORE, The Outlook, The EDGE, EDGE Olympic and ECORYS office with the literature study (called within this paper 'knowledge basis').

PART I
Research basis

1. Introduction

Since *'technology is revolutionizing life, and its development is not slowing down'* (Arata III & Hale, 2018) it is interesting to observe changes, related to its development. It is clear that technologies bring complexity to the working environment in relation to both spatial solutions and social acceptance (Verhoeven, Maaijen, & Brink, 2015). Digital technologies appear to be vital for the real estate industry's growth and the industry's ongoing transformation nevertheless its usage and adaptation are challenged (Ullah, Wang, & Sepasgozar, 2018).

In the 21st century the majority of real estate (RE) is being transformed from traditional into Smart Real Estate (SRE). That means into a property which '*uses various electronic sensors to collect and supply data to consumers, agents and real estate managers, which can be used to manage asset and resources efficiently'* (Ullah, Wang, & Sepasgozar, 2018). The following document is going to further emphasize on the mentioned 'customers' which represent inner alia the end users of the smart technology and smart real estate.

Smart Office Real Estate Management

The most important foundation for any real estate management is the relationship between real estate and its performance. In the end this relationship has a significant impact on the organizational performance. Organizations aim at managing mentioned relation in order create a positive added value and avoid negative effects related to their goals. (den Heijer, 2011) Efficient and effective management of real estate, facilities and human resources requires conscious decision-making which helps to align facilities and services management to the core business and organizational performance (Riratanaphon & van der Voordt, 2015). Evidence-based decision-making needs valid and reliable data. These days, it is possible to proactively manage real estate and make well-thought managerial decisions based on data collected via smart technology (for example sensors, Wi-Fi etc.) (Verhoeven, Maaijen, & Brink, 2015).

The term Internet of Things (IoT) was first defined by Asthon in 1999. These days it is perceived to be a growing technological trend which influences many professions, including CREM. In practice, Internet of Things refers to a network which interconnects indoor objects and devices (things) with their virtual representation (Ryu, Jun, & Yun, 2015). IoT connects objects (so called 'things') which are detected via sensors, monitors and radio-frequency identification (RFID) devices. IoT represents an umbrella term which expresses a variety of more specific developments like sensor networks and (M2M) Machine-to-machine communication (machine learning). (Dutton, 2014) Many organizations use the Internet of Things (IoT) in order to collect data and get a new operational insight into their organizational performance, grow revenues, reduce costs and increase productivity and well-being of office workers. (Arata III & Hale, 2018)

The smart office concept does not have a fixed definition. In general the word 'smart' stands for buildings with network connectivity, the ability to communicate and if applicable interpret data about the object, its status and performance (Wellener, Manolian, Michalik, & James, 2019), however the definition can be easily challenged. Multiple smart office definitions do not acknowledge end users. The definition therefore should not only focus on the physical characteristic of the smart building but also its purpose – adding value to various stakeholders. For the sake of this master thesis an umbrella definition of a smart office have to be sketched. The smart office is understood as '*an office space which is equipped with multiple connected IoT devices which monitor, control and manage indoor working environment and support office workers activities due to communicating with them the real-time information as well as provide CREM with data which can influence managerial decisions'*.

Data value

Data continues to grow in terms of its value as well as its strategic importance (Deloitte, 2018b). Data analyses are perceived to be crucial for addressing future real estate portfolios and employees'

performance. Despite that trend, recently usage and adaptation of digital technologies is being questioned (Ullah, Wang, & Sepasgozar, 2018).

The technological solutions (systems) are often designed for an area, room or simply to gather specific data (Verhoeven, Maaijen, & Brink, 2015). That results in good climatization of the space, but not necessary always in what is best for the end user. (Verhoeven, Maaijen, & Brink, 2015) Furthermore the top-down approach raises up multiple concerns of office workers. They worry that the corporate managers may use the collected data for personal monitoring and then use it against them. People are becoming concerned about their privacy and data protection. (Bersin, Mariani, & Monahan, 2016) Soon all of them will have to justify their practice: explain what they do with such a wealthy database and/or what exactly do they want to measure and mange with use of the gathered data. (CBRE, 2018f) (Kejriwal & Mahajan, 2016) (EY, 2016) (Verhoeven, Maaijen, & Brink, 2015)

Conclusion: Paradox & Strategic Change

Despite the benefits which CREM can gain due to smart technology implementation, end users of the buildings tend to raise up objectives related to privacy issues. The initiatives are questioned and discarded by the end users. Ultimately '*there are always employees who will refuse to accept the fact that social and cultural makeup of their workplace is changing. The 'we have always done it this way' mentality hinders new ideas and inhibits progress'* (Ratcliffe, Saurin, Paybaraud, & Kristensen, 2009). Because Internet of Things (IoT) can offer substantial benefits to real estate management and organizational performance there is a need for a strategic change in smart real estate management. The change should strongly focus on end users and changing an approach related to IoT implementation from top-down to bottom-up.

In fact, what has to be overcome is the people's fear of the unknown which shows the necessity of acknowledging the end user in the smart technology implementation process (Anderson, 2018). It is also important to raise up CREM's and organization's awareness and understanding of the IoT value preposition and implementation process in order to clarify its benefits to office employees. Finally the challenge lies down in designing and implementing smart technology/IoT solutions (for a workplace) which offer employees obvious positive value.

In short, it is essential to focus on IoT initiatives which creates value – '*not just connecting staff for the sake of connecting stuff*' (Thomas, Devan, & Khan, 2018).

Prepositions ← Reflect on them in the discussion

Based on the introduction the following prepositions are formed:

- Proposition 1: Implementation of Internet of Things (IoT) within office is going to widespread.
- Preposition 2: The main focus of smart office is going to be aligned with the CREM objectives related to end user: adding value to office employees due to supporting their activities and enhancing their satisfaction.
- Preposition 3: Acknowledging and involving the end user in the process of smart technology implementation can bring benefits to the CREM and an organization.

The propositions set up the direction for further discussion based on reviewed empirical and theoretical material. The nature of this master thesis is strongly explorative which is justified by lack of existing knowledge within the theme.

2. Problem statement

Literature presents a paradox. An intelligent/smart workplace environment should support individual social, psychological and intellectual needs in order to enhance performance and empower employees' productiveness (Shabha, 2006). Ultimately the end users (office workers) determines overall efficiency of an organization and matters the most. Employees satisfaction and higher level of their performance positively impact business performance. (Verhoeven, Maaijen, & Brink, 2015) Unfortunately, most of the time smart technologies implementation is a top-down approach which omits users' opinion (Verhoeven, Maaijen, & Brink, 2015).

Well-thought real estate management strategy enables an organization to profit from experiences and transform a business unit into a learning organization (Krumm, Dewulf, & de Jonge, 1998). An employee participation in a creation of their workplace is becoming widely recognized as an essential input for decision-making. Involving office employees in the smart technology implementation initiative is important since formal and informal communication channels with various stakeholders enlarges CREM's ability to provide a 'tailor-made' products and services. (Krumm, Dewulf, & de Jonge, 1998)

When it comes to IoT implementation what has to be overcome is the people's fear of the unknown (Bersin, Mariani, & Monahan, 2016). Office employees participation in decision-making can help to minimize or even avoid problems related to indoor working environment conditions. Due to the proactive approach and feedback received from office workers, CREM and FM can support office workers' health and wellbeing (Ratcliffe, Saurin, & Puybaraud, 2008) and add value to them while implementing smart technology at the office. Last but not least, *'involving employees in decision-making process not only empowers them to contribute to the success of an organization, but also saves the company time and money'* (Anderson, 2018).

However he problem is that when an employee does not see any real benefits of using the smart technology, he/she is very likely to avoid it or even undercut its adoption (Bersin, Mariani, & Monahan, 2016). A mismatch between user demand and smart technology implementation is very often caused by a poor understanding and lack of awareness of benefits which smart technology can bring to multiple actors (de Vries, Allameh, & Heidari Jozam). It is important to recognize and communicate possible benefits of IoT with office employees and provide them with an infrastructure which in practice fulfil the aim of a smart workplace: '*empowers employees through self-regulation, engages employees through collaboration and communication, promotes a strong environmental ethic and sustains organizational agility'* (Ratcliffe, Saurin, Paybaraud, & Kristensen, 2009). The challenge is therefore to design smart technology/IoT solutions (for a workplace) which offer employees obvious positive value (Bersin, Mariani, & Monahan, 2016).

The proposed strategic change strongly focus on end users and proposes change in an approach related to IoT implementation (from top-down to bottom-up). The research is going to cover the strategic change holistically. The change has to be reflected not only in the form of the final output (technology and its functionalities which add value to end users) but also is going to present the stages of smart technology implementation process within which end user can be involved.

The section 'research relevance & dissemination' (see section 5, p. 27) addresses further the importance of the research within its substantive field (see: societal relive) and the contribution it makes to the literature on that field (see: scientific relevance). The arguments presented there not only support the problem statement but also explain how developing this research can bring benefits to end users, CREM practitioners and academia.

3. Research scope

The presented paradox shows the need for further research which elaborates upon implementation of smart technologies (in particular IoT) in office real estate which adds value to office employees. This master thesis focus on approach that can help to solve the paradox, in other words on approach which acknowledges and brings benefits the office employees (end users) and raise up the awareness to the CREM of the process and benefits related to IoT implementation.

The paragraphs below address research objectives, research output, research questions, overview of the research methodology overview (discussed in details in part III), relevant thematic fields and defines how various definitions are understood within the research paper.

3.1. Research objectives

The goal of this master thesis it to create a guideline which presents a strategic approach towards IoT implementation that focus on adding value to office employees. The main research objective is to:

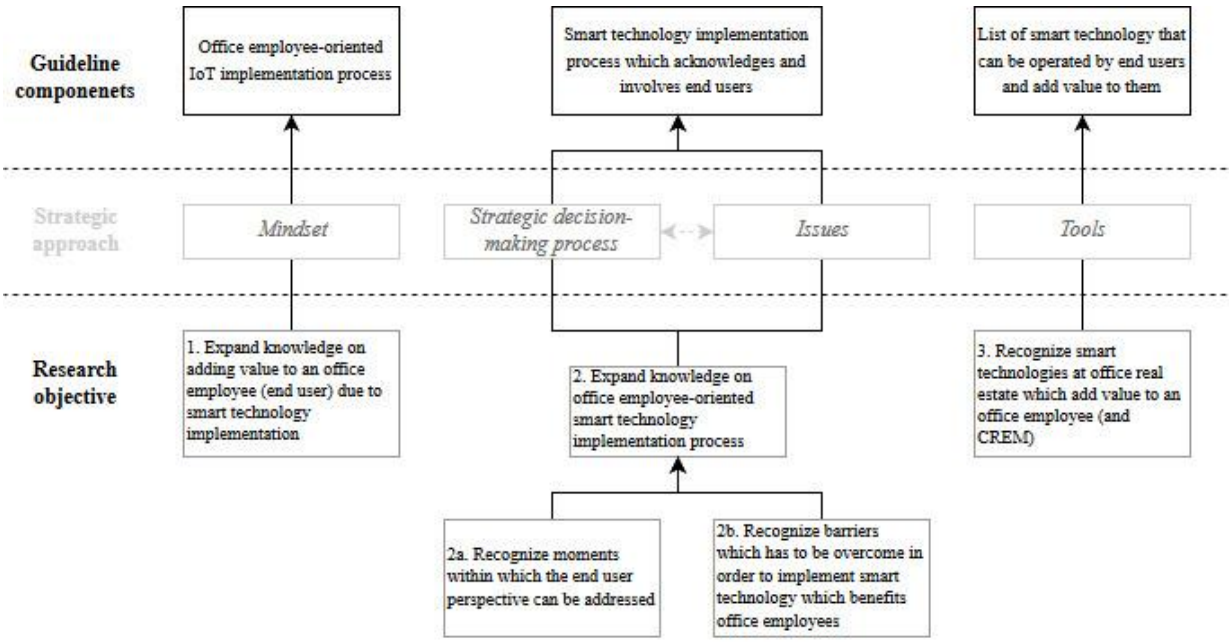
1. Expand knowledge on adding value to office employees (end users) due to smart technology implementation.

In order to shape the strategic approach which will be addressed in a form of a guideline and fulfil the main research goal, the supplementary research objectives had been set up:

2. Expand knowledge on the office employee-oriented smart technology implementation process:
    a. recognize moments within which the end user perspective can be addressed,
    b. recognize barriers which has to be overcome in order to implement smart technology which benefits office employees,
3. Recognize smart technologies/tools at office real estate which add value to an office employee (and CREM).

3.2. Research output

Each of the research objectives had been translated into a research question which are addressed in the section 3.3. (research questions). Answering the research questions allows to shape the



guideline which consists of information intended to advise CRE managers on how to shape smart technology implementation initiative which benefits office employees. The guideline consists of: (1) smart technology implementation process which acknowledges end users and includes barriers which have to be overcome, (2) list of smart technologies which can add value to end users (see figure 4). The research additionally adopts the broader CREM perspective by acknowledging other benefits (added value) of the available technologies. In order to answer research questions multiple research methods are used (for more details see: 4. Overview or research methods and/or part II Research methodology).

It is important to understand that the focus of this master thesis is not to develop a strategy for IoT implementation but to describe a strategic approach which can lead to a successful IoT implementation which aims at adding value to office employees (office real estate end users). The difference between those two is significant. A strategy describes one way to approach the problem which can be used to solve any similar issue. The strategic approach describes *'a mindset, a strategic decision-making process some important issues and tools that might be useful for different situations and projects'*. (Hunnes Blakstad, 2001) This choice is made due to the fact that the results of this master thesis should not serve one particular case, since it does not present the only possible solution. Instead, the master thesis outcome should serve as starting point for any organization which aims at developing smart technology within their office portfolio. The output of this thesis provides a guideline which can and should be revised in line with exiting circumstances and CREM's strategic goals.

3.3. Research questions

Derived from the problem statement and research objectives the research paper addresses the following main research question:

How can Corporate Real Estate Managers (CREM) shape Internet of Things (IoT) implementation initiative which adds value to office employees?

Sub-questions:

1) How can Corporate Real Estate Management (CREM) add value to office employees?
2) How is the IoT implementation process organized?
    a. How, when and by who can the perspective of end users be acknowledged?
    b. What are the barriers that have to be overcome in order to implement smart technology which benefits office employees?
3) What are the existing smart technologies implemented within (investigated) offices that add value to office employees (and CREM)?

3.4. Research definitions

There are multiple definitions which help to narrow down the focus and make the scope of this master thesis manageable. Those are: the type of real estate that is being studied, the characteristics of office employees, the characteristic of the workplace and the managerial perspective towards IoT. The paragraphs below describes these characteristics in more detail.

Corporate Real Estate Management

The abbreviation CREM expresses Corporate Real Estate Management. CREM is one of various specializations related to real estate management. It refers to a '*real estate management by parties that are both owners and occupiers of their real estate*' (den Heijer, 2011). While looking at CREM activities, CREM is defined as '*the range of activities undertaken to optimally attune the institution's accommodation to organizational performance*'. In other words, the CREM concerns managing a RE which intend to support the core business of an occupier/tenant – further called an organization. (de Jonge H. , 2018) CREM is characterized by the fact that the real estate managers focus on matching supply with the demand (of RE) in order to improve organizational performance and bring internal benefits. The demand is derived from institutional goals and primary processes. (den Heijer, 2011) The primary processes are performed by real estate occupants (den Heijer, 2011), therefore CREM's activities strongly relate to end users' goals.

For the purpose of this thesis corporate real estate (CRE) is understood as the property held or used by a business enterprise or organization for its own operational purposes. The REM is strongly related to the facility management and property management, however the concept discussed in this thesis is usually broader and represents multiple CREM's disciplines. Furthermore, CRE focuses on commercial properties – mainly offices, but also retail and industrial properties.

Office buildings represent the largest part (in floor area) of the built environment (Labeodan, Zeiler, Boxem i Zhao, 2015). The corporate real estate, office in particular had been selected for further research due to observed by the researcher trend of smart offices development. The researcher is going to look at properties located in the Netherlands since those are accessible and they are in line with the recognized trend.

Smart Office Real Estate

Smart Real Estate (SRE) is understood as a property which '*uses various electronic sensors to collect and supply data to consumers, agents and real estate managers, which can be used to manage asset and resources efficiently*' (Ullah, Wang, & Sepasgozar, 2018).

The smart office concept does not have a fixed definition. In general the word 'smart' stands for buildings with network connectivity, the ability to communicate and if applicable interpret data about the object, its status and performance (Wellener, Manolian, Michalik, & James, 2019), however the definition can be easily challenged. In most developed countries the building services within smart office spaces aim at satisfying occupants' comfort needs. (Labeodan, Zeiler, Boxem i Zhao, 2015) The definition should therefore not only focus on the physical characteristic of a smart building but also on its purpose. For the sake of this master thesis an umbrella definition of a smart office had been created. The smart office is further understood as *'an office space which is equipped with multiple connected IoT devices which monitor, control and manage indoor working environment and support office workers activities due to communicating with them the real-time information as well as provide CREM with data which can influence managerial decisions'.*

The smart office properties which are managed internally by owner-occupiers had been selected for further research. The ongoing trend observed in The Netherlands in combination with the proposed strategic change can be enabled significantly by CREM at offices where CREM has an impact on property management.

Employee (office worker/employee)

The thesis addresses an office worker/employee. The term office worker/employee stands for '*an employee who works in an office, (…) carrying out professional, managerial, clerical or administrative work for an organization'* (definition is based on Collins, 2018).

Office

An office is understood as *'a room, set of rooms, or building used as a place of business for non-manual work'* (Cambridge Dictionary, 2019a). The place where an office worker/employee is performing his work is going to be called a workplace.

Indoor working environment

An indoor working environment conditions refer to conditions in an office, such like lighting and temperature. Those two elements can be steered these days by an office employee via a smart tool and smart application.

Adding value due to IoT implementation process in real estate

The research express why a process of smart technology (IoT) implementation within an office has to involve office employees. The main focus is therefore given to office employees - end users - and facility management domain within CREM. Subsequently the research elaborates in more details upon the selected approaches which add value to an end user (and are relevant during the discussion about IoT implementation process): supporting user activities and increasing user satisfaction. The remaining approaches and CREM's domains will also be discussed, nevertheless the paper emphasizes mentioned before two elements.

Real Estate Smart Tools and IoT

The presented research is conducted within a graduation studio called Smart Real Estate Tools. In this research paper the smart tool is understood as *'a service or product that collects information on space use real-time to improve space use in an office on the one hand, and to improve decision-making on the future of an office on the other hand'* (definition based on: Valks, Arkesteijn, & den Heijer, 2018). A smart tool is therefore only an electronic device which collects data but do not communicate it to office workers. That is why the broader perspective is appointed for further research: Internet of Things (IoT). The broader perspective of IoT also implies that information collected via sensors can address multiple purposes (for instance not only collection of data about space use but also about employees behavior and building performance) as well as enables office employees to make use of the smart technology via a mobile application.

4. Overview of research methods

The research methodology combines (1) literature study & web search and (2) case studies analyses (based on information gathered via in-depth interviews and desk research).

Research objective	Component of the guideline (strategic approach)	Research sub-question	Selected research methods		
			Literature study	Desk research	In-dept interviews (incl. appendage)
1. Expand knowledge on adding value to an office employee (end user) due to smart technology implementation	*mindset*	1. How can Corporate Real Estate Management (CREM) add value to office employees?	•		•
2. Expand the knowledge on office employee-oriented smart technology implementation	*strategic decision-making process; issues*	2. How is the IoT implementation process organized?	•	•	•
2a. Recognize moments within which end user perspective can be addressed		2a. How, when and by who can the perspective of end users be acknowledged?		•	•
2b. Recognize barriers which has to be overcome in order to implement smart technology which benefits office employees		2b. What are the barriers that have to be overcome in order to implement smart technology which benefits office employees?	•		•
3. Recognize smart technologies at office real estate which add value to an office employee (and CREM)	*tools*	3. What are the existing smart technologies implemented within (investigated) offices that add value to office employees (and CREM)?		•	•

Table 2 Research questions and methods; source author

The approach represents a descriptive type of study which aims at integrating qualitative information into a research output - guideline. The proposed research methods reflect the critical reality that the information which is needed in order to define IoT implementation strategic approach is not widely researched and there is very little relevant qualitative information presented in the scientific literature.

The table 2 presents the research sub-questions and selected research methods which will help to formulate appropriate answers, formulate research output and conclusions. Philosophical underpinning called interpretivism, developed by Merriam has been selected by the researcher. The approach fits best to this research due to the fact that not much information can be simply learned from the scientific literature. It is essential therefore to supplement the knowledge via learning from case studies and further explore the research theme.

The part II (research methodology) covers in details: interpretivism approach, research strategy (process diagram; see table 6, p.34), research design and data analyses, research techniques' explanation and ethical considerations relevant to the research.

5. Research relevance & dissemination

Societal relevance

Current trends show that the further digitalization of real estate is not going to slow down. On the contrary, more and more data are going to be gathered and utilized in order to manage real estate. (Dutton, 2014) Concepts such as Internet of Things (IoT) - which includes smart tool and sensing technology - have a significant link to social and economic development therefore it is important to examine legal, ethical and social concerns that are relevant to the technological solutions. (Dutton, 2014) That is why it is also important to constantly *'explore the impact of technology on future global workplace solutions'* (Ratcliffe, Saurin, & Puybaraud, 2008) and zoom into the added value which can be gained by end users.

It should be kept in mind that data itself does not add value to the real estate portfolio and/or management if the user is unsatisfied with the way the data is gathered or proceeded. (Ratcliffe, Saurin, & Puybaraud, 2008) Furthermore multiple concerns (such as privacy issues, smart tools utility, added value to end user etc.) have to be addressed and overcome when it comes to smart technology implementation. The changed strategic approach (which involves end users in the IoT implementation process) can enable real estate managers to successfully handover the implemented smart technologies to the end user, present benefits of IoT to office employees and improve the IoT implementation and adaptation process.

People fear that collected via smart technology data on their behavior at an office can be used against them (Bersin, Mariani, & Monahan, 2016) (EY, 2016). In order to minimize public objections towards smart technology and data gathering, concerned parties should be made aware of possible private and corporate benefits (Bersin, Mariani, & Monahan, 2016). The implementation of IoT and data analyses represent new concepts which keep on growing in strategic importance. Performing smooth implementation process of smart technology can help to overcome barriers (such as peoples' passiveness), which will provide multiple stakeholders with rich database and in the end bring benefits to the organization.

Nowadays it is essential to shape a strategic approach for IoT implementation which involves end users. The following research can help office employees to better understand the opportunities related to the new technology and present to CREM their possible involvement in the IoT implementation process which contributes to ensuring successful IoT implementation at office RE.

Scientific relevance

The need for building up a knowledge within this field was also recognized by Valks, Arkesteijn, & den Heijer (2018) in relation to smart tools (an element of a broader concept called an Internet of

Things) in a publication '*Smart Campus Tools 2.0'*. The theme *'Planning transformation: To further expand the knowledge on how to implement smart tools by studying the relation of smart tools within organisational processes'.* The researcher recognizes it as an encouraging topic which has been mentioned in the publication as theme recommended for further research.

Until now some research has been done about application of the technologies in the built environment, but they tend to focus on architecture, engineering and construction, while the real estate services sector and managerial approach have been left behind. This can be observed in spite of *'the high dependency of the real-estate services sector on the availability and accuracy of information on properties'* (Mahbjoubu, Moobela, & Laing, 2013).

The literature review findings ensure that the office workers can and should be involved in the process of IoT implementation. Nevertheless for now none literature has presented an office employee-oriented IoT implementation initiative. The number of publications on technologies related to IoT in office real estate is very limited and it does not always recognize a link between the smart tools and office end users. (Ullah, Wang, & Sepasgozar, 2018)

The following master thesis aims at filling the gap in existing literature, by expanding knowledge on adding value to an office employee (end user) due to smart technology implementation, learning about the process, barriers, involvement strategies and available technological solutions.

Research dissemination

The research is addressed to professionals who contribute to the process of IoT implementation. Due to the strong focus on office workers the pinpointed persona is a facility manager who aims at adding value to end users of RE. The research indirectly also address remining CREM stakeholders. Practice shows that there can be a specific (unique) position created within organizations, which is appointed to manage the initiative. In that case, this professionals can also benefit from learning the outcome of this study.

PART II
Research methodology

1. Research methodological framework

The 2nd part of this research paper explains in detail appointed research methodology. The chapter discusses how the research had been intended to be conducted and justifies the research methods selection. First the philosophical underpinning of the research methodology is explained. Later the overall research strategy is discussed. Next the selected research techniques are explained in more detail. The research techniques' section compromises literature review & web search as well as case study approach. The case study method, is explained in more detail in sections which elaborate upon desk research, in-dept interviewing approach and data processing plan. The part II (research methodology) concludes with a section which addresses ethical considerations relevant to the research approach.

1.1. Philosophical underpinning

The master thesis paper follows the structure of a qualitative research paper. The document starts with recognizing a problem and formulating research questions. There are multiple possibilities how the researcher can develop further research that is why it is important to specify the main philosophical underpinning which gives a direction to the research approach. Philosophical underpinning called interpretivism, developed by Merriam has been selected by the researcher as an approach which serves best to this research and explored themes.

The interpretivism is also called as social constructionism, the paradigm is mainly exploited in theory building. Within interpretivism human interests are recognized as main drivers of science. Following interpretivism epistemological commitments the primary interest of the qualitative researcher is to '*understand the meaning or knowledge constructed by people'* (Yazan, 2015). The case study of qualitative information is therefore defined as *'a study of the particularity and complexity of a single case, coming to understand its activity within important circumstances'* (Yazan, 2015). The data analysis is therefore a matter of giving a meaning to the content of the interview and desk research related to appointed case studies in the broader context. It matches the research aim, since the goal is to learn the processes and outcomes of smart technology implementation at various office real estate. This information can be later interpreted and translated into the guideline (research output).

In line with Merriam philosophy the case study should be proceed by conducted literature review about the topic, then theoretical framework/conceptual model should be build up, so that the research problem can be identified and the researcher can formulate research questions and select a purposive sampling. The purposive sampling and case study design should take place before the data collection and analysis (after literature study). (Yazan, 2015)

The approach fits best this research paper due to the fact that there is not much information which can be learned from the scientific literature. It is essential therefore to supplement the knowledge by learning from case studies. The data collection procedure is based on conducting in-depth interviews and carefully selecting data from relevant documents (desk research). In line with the interpretivist approach the data collection can be performed simultaneously with the data analysis. (Yazan, 2015) This plays a big role, since the researcher can analyse each case study while simultaneously collect new information related to remining appointed cases.

Listed above characteristics of interpretivism are reflected in the structure and purpose of this master thesis document.

1.2. Research strategy

In order to solve presented in the introduction paradox the researcher proposes to create a guideline for employee-oriented IoT implementation initiative in office real estate. (The paradox: On the one hand smart technologies appear to be a component of Smart Office Real Estate which should serve its end users - office workers. On the other hand, is seems that smart technologies implementation

is a top-down process which raises up issues such as peoples' fear or privacy concerns and focuses on buildings performance instead of people. Multiple actors have to gain an understanding in benefits of smart technology, its added value to office employees and learn how to acknowledge end users within the process of IoT implementation.)

The research strategy combines literature study & web search, case studies (based on information gathered via in-depth interviews and desk research). The approach represents a descriptive type of study which aims at integrating qualitative information into a research output - guideline. Proposed research techniques reflect the critical reality, that the information which is needed in order to define IoT implementation strategic approach is not widely researched and there is very little qualitative information presented about it in scientific literature.

As stated before, the main research question is:

> How can Corporate Real Estate Managers (CREM) shape Internet of Things (IoT) implementation initiative which adds value to office employees?

The table 3 presents the research sub-questions and selected research methods which will help to formulate answers to them.

Research objective	Component of the guideline (strategic approach)	Research sub-question	Selected research methods		
			Literature study	Desk research	In-dept interviews (incl. appendage)
1. Expand knowledge on adding value to an office employee (end user) due to smart technology implementation	*mindset*	1. How can Corporate Real Estate Management (CREM) add value to office employees?	•		•
2. Expand the knowledge on office employee-oriented smart technology implementation	*strategic decision-making process issues*	2. How is the IoT implementation process organized?	•	•	•
2a. Recognize moments within which end user perspective can be addressed		2a. How, when and by who can the perspective of end users be acknowledged?		•	•
2b. Recognize barriers which has to be overcome in order to implement smart technology which benefits office employees		2b. What are the barriers that have to be overcome in order to implement smart technology which benefits office employees?	•		•
3. Recognize smart technologies at office real estate which add value to an office employee (and CREM)	*tools*	3. What are the existing smart technologies implemented within (investigated) offices that add value to office employees?		•	•

Table 3 Research questions and methods; source author

1.3. Research design & data analyses

Further in this paper the research outcome – guideline - should be understood as *'information intended to advise CRE managers on how to shape smart technology implementation initiative which benefits office employees. The guideline consist of: (1) sketch of a smart technology implementation process which acknowledges end users and includes barriers which have to be overcome, (2) list of*

smart technologies which can add value to end users'. The guideline indirectly addresses broader CREM perspectives and benefits which can be gained due to smart technology implementation.

Prior to case studies, the research paper formulates 'knowledge basis'. The knowledge basis presents relevant for the research themes: CREM, IoT implementation process and the concept of adding value to office employees due to smart technology (IoT) implementation. The goal of creating the knowledge basis is to define relationships between the research themes and later on test and supplement them with the knowledge gathered via case studies. Those two section (knowledge basis and case studies findings) are combined in analysis and later on placed in the content of the guideline for the office employee-oriented IoT implementation initiative.

The researcher is going to analyze per each case: (1) project info, (2) end user involvement strategy, (3) barriers, (4) process overview (with highlighted moments when the end user perspective had been acknowledged), (5) technology overview, (6) access to data and (7) additional lessons learned. Components 1 & 7 indicates background information which are informative and will not be included in the guideline. Those are adopted so that the researcher can learn the broader perspective about extra added value of the smart technology to the organization (not only to the end user). Aspect 2, 3 & 4 are strongly linked to the 2nd objective of this master thesis and aim at answering 2nd research sub-question. Finally the 5th and 6th component of case studies analyses provides the answer to the 3rd research sub-question, which is strongly linked to the 3rd research objective. The findings combined are going to shape the guideline which gives the answer to the main research question.

The research output presents the office employee-oriented IoT implementation process which describes (1) smart technology implementation process that acknowledges end users and (2) lists smart technology which adds value to end users and CREM. The research output directly corresponds to the research objectives (see figure 5).

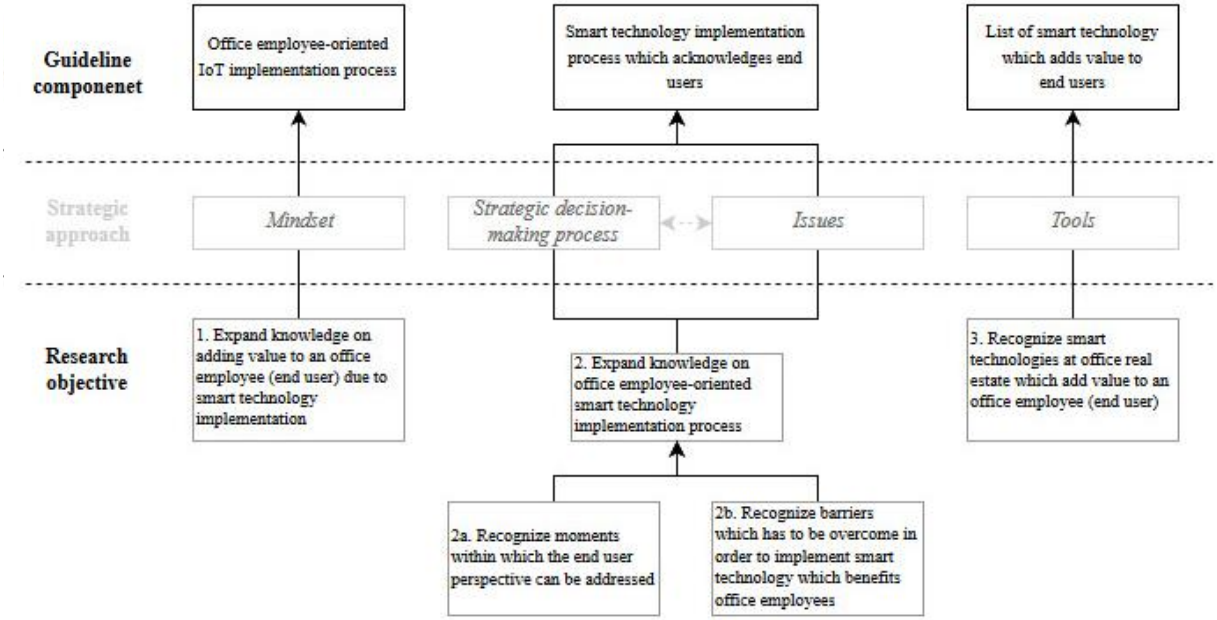


Figure 5 Relation between research output and research objectives; source: author

The questions asked in the interview can be found in appendix C. Section '2.3. In-depth interview' explains in more details the process of the interview creation and its procedure. The mentioned section also indicates how different parts of the interview can provide the researcher with the information which will shape the answer to research sub-questions. In order to answer the main research question, the researcher is going to combine the literature and case study findings.

Figure 6 indicates research process and research design. The research has started by indicating the research field. It was followed by defining research goal and research objectives, building up 'knowledge basis' for the guideline (and further study). In the end the guideline is going to be created as a summary of the research after performing analysis of gathered information.

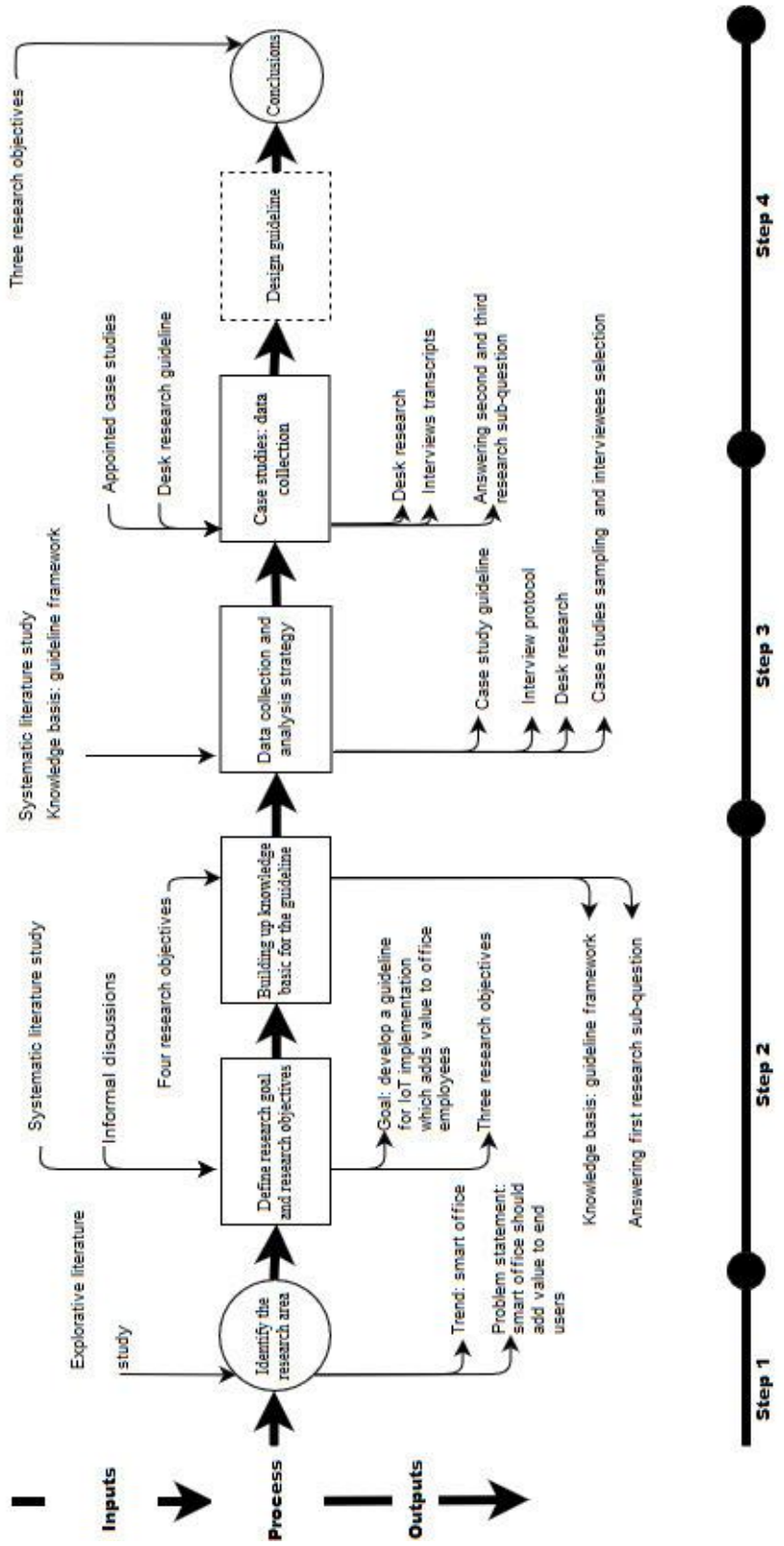


Figure 7 Research process; source: author

2. Research techniques

The research design presented before (see figure 5 and table 3) appoints three research techniques: literature review, desk research (case study) and in-dept interviewing (case study). Each of them is explained in more details in the paragraphs below.

2.1. Literature review

The first step of this research is an explorative literature study and internet/web search. At first, around 60 scientific papers had been revised. It has enabled the researcher to formulate the research problem and further systematic literature approach. In the later stages additional scientific had been revised which gas gradually strengthen the research problem and research objectives.

Systematic literature study

The main purpose of the systematic literature study was to develop a theoretical framework which will serve as a basis for the guideline. Simultaneously the goal of the literature study was to learn already researched concepts and define elements which have to learn via case study method.

Scientific literature had been searched online on Scopus database (publications in journals) and Google Scholar (publications in journals and grey literature). Due to the innovative character of the theme multiple publications and reports were revised and included within the part III of this research document (knowledge basis). Within this systematic literature study number of steps were followed:

1. In order to gather the publications from Scopus and Google Scholar a search criteria were developed. The searched for themes were 'corporate real estate management', 'smart technology', 'office real estate management', 'adding value to office employees', 'internet of things', 'smart technology implementation process'.

2. Later on, the researcher has selected relevant publications on the basis of their content. The abstract of first 25 publications (per theme) had been analysed and allowed to select appropriate literature for further study.

3. Finally, the list of relevant publications had been created. The list indicates an author, data, main findings, relevant definitions and quotations.

The literature study was based on background questions, which the researcher had asked herself in order to answer research sub-questions. The part III reports literature study results and form the theoretical framework (called knowledge basis).

2.2. Case study approach

Due to the fact that the literature do not extensively cover the research field, the researcher decides to supplement the research methodology with case study approach. The case study method had been appointed as a data source of the information which will partially answer the research sub-questions. The term 'case study method' is defined as *'a strategy for doing research which involves an empirical investigation of a particular contemporary phenomena within its real life context using multiple sources of evidence'* (Robson, 1993). Following Robson (1993) *'a case is a situation, individual, group, organization or whatever it is that we are interested in'*. Finally, the case study is *'both, the process of learning about the case and the product of our learning'.*

The nature of this master thesis research is explorative. The approach corresponds well with the research philosophy. It has been appointed due to the fact that there is little knowledge developed within the research field by scientists. As mentioned before, the main purpose of the case studies is explorative, that means that the purpose of conducting the case studies is to supplement the information gathered during the literature review. In principle the explorative studies look for

patterns, ideas or hypotheses which appear in practice. The purpose is therefore not to test a hypothesis, but to learn new research input. (Manewa, 2012)

Case studies selection criteria

The case studies had been selected in line with the following criteria:

- Selected buildings host office employees,
- Selected offices are enabled by Smart Tools and/or Internet of Things,
- Selected projects were implemented by internal actors from an organization,
- Selected cases are of similar scale: advisory office, located in The Netherlands.

Following the criteria 5 cases had been selected. The researcher contacted various actors within those organizations and managed to schedule an interview with at least one relevant stakeholder within 5 cases.

2.3. In-dept interview

As mentioned before, the research approach includes in-depth interviews with professionals who were/are responsible for IoT implementation at offices. The in-depth interviews aim at gathering descriptions of processes and events that took place in practice (Opdenakker, 2006).

The qualitative empirical research distinguishes between multiple interview styles, inter alia: standardized open-end interview and general interview guide approach. The open-end interview aims at developing a structured interview with standardised questions which are addressed in exactly the same manner to every participant. The advantage of this approach is that the researcher can ensure information consistency, however it limits an opportunity of addressing additional questions which could deepen the understanding of given answers or mentioned (not addressed in the interview form) concept. In contrary, the general interview guide presents an approach where an interviewer prepares a set of standard questions which will be asked to every interviewee, however the interviewer is also able to formulate additional questions during the conversation. (Turner III, 2010)

The general interview guide approach has been selected as the appropriate method for further research. The approach is also called by Bryman (2016) a ‘semi-structured interview’ which is a type of an ‘in-depth interview’. The general interview guide is further called an interview protocol and it is designed for the in-depth interviewing approach.

Interview guide/protocol

The interview guide is further interchangeably named as interview protocol or questionnaire. As mentioned before, the interview is addressed to a person who is/was responsible for leading the smart technology implementation process within an office. The interview protocol is enclosed to this research paper in appendix C.

The purpose of the interview is to gather and analyse information related to the process of smart technology (Internet of Things/Smart Tools) implementation at office real estate. The implementation process is understood as a sequence of events, which take place from the initiative phase, throughout decision-making moments, placing the solution on site up until the operational phase. Additionally the interview aims at learning about the barriers faced throughput the process and added value of the smart technology to end users (office employees/workers). The outcome of the interview clarifies aspects which help the researcher to answer the man research question. Paragraphs below explain in more detail the interview structure and researched aspects.

The interview consists of 4 thematic areas which have to be linked in order to learn fully about the smart technology implementation process. Those are: (1) Smart Real Estate Management (incl. data analyses), (2) IoT/ST implementation process, (3) adding value to office workers in an office enabled by smart technology, (4) involvement of end users in IoT/ST implementation process. The interview

closes with question which asks about challenges and barriers faced during the process (broader perspective). Each of the sections addresses one of the three research sub-questions.

1st section (Smart Real Estate Management) addresses background questions such as: how and why was the project started (strategic objectives)?; Did the project run in a straight way or with lots of twists? And why?; How does the implemented technology impact RE management and office workers?; What data/information are available and to who?. The 1st part of the interview is strongly linked to the background information about the implementation process and strategic objectives for smart technology implementation.

2nd and 4th section of the interview aims at answering the 2nd(a) research sub-question: 'How, when and by who is the perspective of end users acknowledged during the process of smart technology implementation in office real estate?'. In that sense it aims at learning the process of smart technology implementation and recognizing possible approaches due to which the end user can be involved in the process. It implies learning about the process phases, key steps and deliverables. The 2nd section also addresses various actor's roles, their responsibilities and questions about the involvement of end users in the process. Last but not least, the involvement and input given by office employees within the process is investigated. If applicable the interviewee is asked to pinpoint moments during which the end user had been involved (explain why and how) and explain how did it affect the process outcome. Additionally 4th section, (if applicable) touches upon evaluation methods which were applied in order to monitor smart technology impact on office workers.

The 3rd part aims at learning the ways in which the smart technology has added value to office workers/employees in an office enabled by smart technology. Questions address two ways of adding value: supporting office worker's activities and increasing their satisfaction. Together, section number 1 and 3 answer the first research sub-question: 'how can Corporate Real Estate Management (CREM) add value to office workers in an office enabled by smart technology?'.

Additionally the 3rd section of the interview aims at recognizing technology which adds value to office employees. It addresses further questions related to the relevant measurement methods related to supporting office worker's activities and increasing their satisfaction. This section provides answers to the 3rd research sub-question 'what are the existing smart technologies implemented within (investigated) office real estate portfolio that add value to an office employee?'.

Finally the interview closes with question related to corporate real estate management in general. The goal is to recognize barriers and challenges faced throughout the process by multiple actors who represent different CREM perspectives. This brief information will help to shape the answer to the 2nd(b) research sub-question 'What are the barriers and obstacles that have to be overcome in order to implement smart technology which benefits office employees?'. For the whole interview protocol see appendix C.

The set of interview questions combined enables the researcher to answer the main research question: 'How can Corporate Real Estate Managers (CREM) shape Internet of Things (IoT) implementation initiative which adds value to office employees?'. This can be done due to learning about practices of selected organizations and relating it to the literature findings.

Choice of interviewees

In the section (1.4.1.) of the part III (research methodology), the case study selection criteria had been listed. The researcher had established the list of cases which match indicated criteria. The researcher had applied multiple methods which had helped her to define appropriate interviewees. Those were: searching through LinkedIN, attending open days at various companies, networking through already established contacts, searching online, attending (and following online) events related to smart technology in real estate.

Table 4 presents interviewees assigned to cases, which had been selected in line with the case study selection criteria. The researcher was offered an opportunity of interviewing indicated actors,

therefore learning an insight of the smart technology implementation process within their office real estate.

Due to the strong focus on office workers the person which was intended to be interview was at first called as a facility manager. The practice shows that when it comes to an implementation of smart technology within an organization and its real estate, specific position are being created within organizations. In fact the personas can have various names (see 'function' in table 4).

Building	Location	Organization	Contact person / interviewee	Function	Case study: project
The EDGE	Amsterdam, The Netherlands	Deloitte – Advisory	Roy Halstead	Manager IoT Department	Coordination of multiple projects at The Edge: temperature, elevator, light, coffee machines and more.
The CORE	Amsterdam, The Netherlands	CBRE – Advisory	Geert Stam	Head of Smart Building Solutions	Lead Smart Implementation: Flowscape. Developing smart solutions.
ECORYS office	Rotterdam, The Netherlands	ECORYS - Advisory	Frank van der Ven	Facility manager	Coordination of sensing technology implementation in the office.
EDGE Olympic	Amsterdam, The Netherlands	The EDGE Technologies	Sandra Gritti	Product Excellance Director (ealier Concept Developer, Commericial Manager, Development Manager)	Developing and marketing smart technology designed by EDGE Technologies and implemented within their office space
Outlook	Amsterdam (Schiphol), The Netherlands	Microsoft	Casper La Grouw	Project manager.	Involved in the smart process of The Outlook, Microsoft building.
			Willem van der Ven	Development manager	Involved in the strategy of SMART.

Table 4 Interviewees; source: author

Interview processing: procedure, transcribing & coding

Prior to the interview the opening statement and consent form (see the appendix B) were communicated with the interviewee via email. During the scheduled appointment the interviewee had been asked to sign the consent form. Those are stored by the researcher. Due to following this procedure, the researcher could legally record the conversation. The interviews were recorded using a voice recorder. Each recording was later transcribed by the interviewer. After the Graduation Lab is finished, the recordings are going to destroyed. Only written transcripts will present the conducted interviews content. Those are going to be stored by the researcher. Appointed interviews (see table 4) took place in March 2019.

The researcher decides to transcribe only the audio material which is relevant for the master thesis content. Sections which do not add any important information to the case description and/or do not relate to the research questions are considered as not important, therefore those are not transcribed. The introduced approach is appropriate for the master thesis since it helps to efficiently manage limited time (between P2 and P4) and conduct the research in a consistent manner. The transcripts are further supplemented by notes taken during the interview. Finally the transcripts are being summarized. The transcripts and the interview summary/case study analysis are sent to the interviewee, so that he/she can reflect and correct their statement if necessary.

Finalized transcripts were later on coded. The coding strategy follows the thematic colour coding scheme introduced in figure 7. The coding variables represent the interview output, which is gathered in order to supplement the existing knowledge within the field. The interview protocol can be found in appendix C.

Codding an interview allows to group components of the research in line with the research sub-questions and draw consistent research conclusions. The colour coding scheme represents themes which the researcher is going to identify in order to conduct further analysis. The themes are grouped into 6 categories: reasons for smart (project info), end user involvement strategy, process (overall, acknowledging end user, barriers), technology, data access and extra insight. In short, the

categories are reflected in the structure of case studies' findings and supplemented by desk research performed for each case.

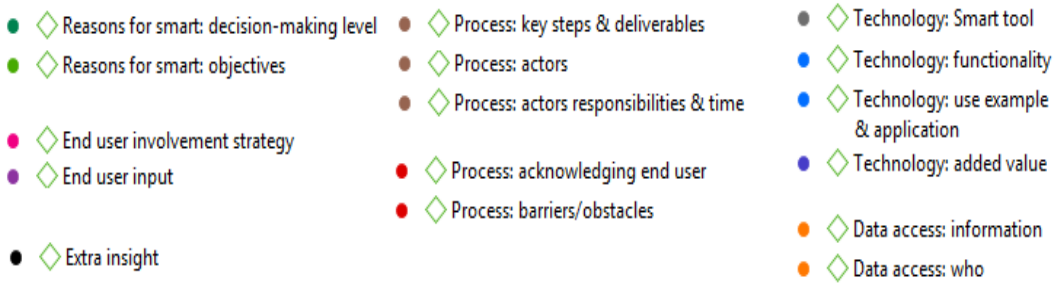


Figure 8 Thematic colour coding scheme; source: author

The coding procedure (data coding) was processed via the Atlas.TI software. Using the software enables the researcher to code multiple transcripts in the same manner and extract information linked to specified codes. The master student has an access to the student version of the software due to following the 'case studies' course at TU Delft.

2.4. In-dept interview appendage

The focus of this research had been given primarily to the end users, nevertheless while conducting further study the researcher had noticed that the smart technology can also add a great value to other stakeholders. In line with this finding, the research scope related to the 3rd research objective had been modified. As an result of fulfilling the updated 3rd research objective, the paper is going to present broader framework which links the smart technology with the elements form 'adding value framework' (see part IV analysis).

		Application functionality					Data collection and analysis	
Perspective	Perceived added value	Adjusting temperature	Desk status (free/occupied)	Room status (free/occupied)	Book a room	Localizing colleagues	Occupancy data (real-time)	Colleague location (real-time)
Strategic	Stimulating collaboration	☐	☐	☐	☐	☐	☐	☐
	Stimulating innovation	☐	☐	☐	☐	☐	☐	☐
	Supporting culture	☐	☐	☐	☐	☐	☐	☐
	Supporting image	☐	☐	☐	☐	☐	☐	☐
	Improving quality of space	☐	☐	☐	☐	☐	☐	☐
Functional	Supporting user activities	☐	☐	☐	☐	☐	☐	☐
	Increasing user satisfaction	☐	☐	☐	☐	☐	☐	☐
	Increasing flexibility	☐	☐	☐	☐	☐	☐	☐
Financial	Decreasing costs	☐	☐	☐	☐	☐	☐	☐
	Increasing real estate value	☐	☐	☐	☐	☐	☐	☐
	Controlling risks	☐	☐	☐	☐	☐	☐	☐
Technical	Reducing footprint (m2)	☐	☐	☐	☐	☐	☐	☐
	Reducing footpring (CO_2)	☐	☐	☐	☐	☐	☐	☐

Table 5 In-dept interview appendage example; source: author

The decision described above had been made after conducting the interviews. In those circumstances the interviewees had been asked to additionally fill in an in-debt interview appendage. The appendage combines information gathered via in-dept interview with the framework of 'adding value'. The table consists of two rows positioned on the horizontal and vertical rows. Elements on the horizontal row are: (1) recognized application functionalities and (2) data

which is being collected and analysed. The vertical line expresses ‘adding value’ framework (see the example below, table 5).

Input gathered in this form from the interviewees will help the researcher to define the added value of specific application functionalities and data analysis. The researcher is going combine the case studies findings with literature review. In that sense, the analysis will present findings which can be generalized.

2.5. Desk research

The third and final step of the research is a desk research. The desk research means that the researcher is going to review provided (mainly online) by the companies information about their RE portfolio and the smart concept developed at their offices.

The main research methods (primary) are the in-depth interviewing and literature study. Per each case the following elements are going to be presented: Project info, End user involvement strategy, Process overview, Technology overview, Access to data and Additional lessons learned. That implies information which is going to be revised per case via desk research.

The desk research is a supplementary research methodology which might be necessary in order to clarify case study findings and strengthen the case studies’ analysis. In case of CBRE office the researcher can perform internal desk research (organizational documents) due to following a graduate internship at the company. The remining desk research are performed outside of the organizational boundaries (external).

The idea behind performing desk research for cases presents extra insight, thanks to which the researcher can support the findings of the interview with the secondary research method as well as prepare well upfront for the in-depth interviews.

3. Ethical considerations

While conducting qualitative research, the researcher have to take into account the ethical considerations. First of all, the honest and unbiased presentation of information have to be ensured. As mentioned before, desk study of project documentations (desk research) ensures that the information gathered via in-depth interviews is validated. Second, the secondary sources cannot be copied – proper copyright procedures have to be incorporated. (Opdenakker, 2006)

Furthermore, data collected via in-depth interviews have a high degree of interpretability (Opdenakker, 2006). Personal perception cannot influence, in any way, the interviews’ outcomes. The interviewer cannot ask questions in a way that suggest a desired answer. The interview protocol is constructed in a way, that it does not guide an interviewee but allows him/her to freely formulate an answer to the question. In order to avoid research misinterpretation the desk research should also be analysed and reported within this paper. This approach is going to validate information recognized in the interview transcripts.

Last but not least, the data have to be systematically analysed so that there is no room for personal interpretation of findings. The outcomes of the research must be valid, therefore they cannot be influenced by the researcher’s perception. This can be ensured by incorporating findings from multiple interviewees. That can be achieved by conducting multiple case studies and not getting involved in only one pilot project. By all costs, the researcher has to remain unbiased. Personal interests and relations with interviewers form case studies cannot influence the research results.

In respect to the FAIR principles the research outcome (research paper with appendixes) will be Findable, Accessible, Interoperable and Reusable due to being published on the TU Delft Education Repository portal after completing the final research paper.

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PART III
Knowledge basis

Knowledge basis

The 3rd part of this research paper presents theoretical framework which formulates knowledge basis. This is later on translated into summary and discussion. The knowledge basis presents relevant for the research themes and provides answers to the research sub questions. The goal of creating the knowledge basis is to define relationships between the research themes and later on support and/or supplement them with the knowledge gathered via case studies. Those two section (knowledge basis and case studies findings) are combined in analysis and later on placed in the content of the guideline for the office employee-oriented IoT implementation initiative.

The text starts with a scientific explanation of a guideline which gives a reader an understanding of the research final outcome. After that the main research themes: CREM, IoT implementation process and the concept of adding value to office employees due to smart technology (IoT) implementation, are explained. Summary & discussion provides an overview of recognized knowledge and indicates further research steps - defines knowledge which has to be supplemented by case studies research.

0. Guideline

The following section defines what the author understands as a guideline. The guideline is an intended outcome of this thesis that is why it is essential to clearly specify what does the outcome consist of. The guideline form is explained below in more details. The research objectives, methods and the researcher goal are reflected in the content of the guideline. The content of the guideline strongly influences thematic fields which are developed within this chapter.

0.1. Strategic approach

As mentioned before the focus of this master thesis is not to develop a strategy for IoT implementation but to describe a strategic approach which can lead to a successful IoT implementation within office real estate which aims at adding value to end users. The difference between those two is significant. A strategy describes one way to approach the problem which can be used to solve any similar issue. The strategic approach describes *'a mindset, a strategic decision-making process, some important issues and tools that might be useful for different situations and projects'*. (Hunnes Blakstad, 2001)

The indicated strategic approach can be expressed in a form of a guideline. For the purpose of this master thesis, the researcher adopts definitions of a guideline retrieved from multiple sources. Cambridge Dictionary (2019b) understands the guideline as *'information intended to advise people on how something should be done or what something should be'.* The role of a guideline is to *'help to make a decision or form an opinion'* (Oxford Learner's Dictionaries, 2019), *'provide directions to action or behaviour'* while '*setting up standards or determining a course of action'* (Definitions & Translations, 2019). In principle the guideline is never mandatory neither binding or enforced. The guideline allows some leeway in its interpretation, implementation or use (Definitions & Translations, 2019).

0.2. Guideline definition

For the purpose of this master thesis, the researcher adopts a definition of a guideline and combines it with the strategic approach characteristics so that the final product can represent a strategic approach in a form of a guideline. Further in this paper the research outcome – guideline – is defined and should be understood as *'information intended to advise CRE managers on how do shape smart technology implementation initiative which benefits office employees. The guideline consist of: (1) sketch of a smart technology implementation process which acknowledges end users and includes*

barriers which have to be overcome, and (2) list of smart technologies which can add value to end users (and CREM)'. The research output directly relates to the research objectives which had been already pictured in figure 5 on page 33.

1. CREM

The following section provides a deeper understanding of elements related to the starting point of this research: Corporate Real Estate Management (CREM). In order to answer the 1st research sub-question it is important to understand CREM, its objectives and its internal structure (stakeholders). Only then it makes sense to explain its relationship with an organization and office employees. While this explanation is complete the adding value framework is addressed. The information gathered within this section formulate an answer to the 1st research sub-question: 'how can CREM add value to office employees?'.

1.1. CREM definition and main objective

CREM refers to a '*real estate management* by parties *that are both owners and occupiers of their real estate'* (den Heijer, 2011). Initially CREM was defined as a range of managerial activities which aimed at making the right fit between real estate and corporate performance. Corporate real estate management (CREM) used to (and still does) focus on providing cost effective and good quality services or products to its clients. These days the focus of CREM changes. From the end of 20th century it is widely recognized that fulfilling only the two mentioned objectives does not guarantee a success of real estate and it does not directly improve an organizational performance. (Krumm, Dewulf, & de Jonge, 1998)

According to Jansen et al. (2013) *'CREM focuses on alignment of real estate to corporate needs and objectives, incorporating the needs and wishes of stakeholders (…)'* (Jansen, Sarasoja, van der Voordt, & Coenen, 2013). De Jonge et al. (2008) presents broader CREM's definition which express wider goals of CREM. CREM had been defined by them as: *'a range of activities undertaken to optimally attune the institution's accommodation to organizational performance'*. Both actors emphasise the importance of providing a tailor-made solution to people/organizations which occupy a RE and establishing therefore a competitive advantage.

Establishing a competitive advantage can be done by representing a proactive approach, within which the focus is given to the direct CRE stakeholders – including end users. This proactive approach which includes end users adopted by CREM can provide a tailor-made solution for an organization (Krumm, Dewulf, & de Jonge, 1998), in other words attuning the institution's accommodation to organizational performance.

In line with real estate management, CREM also focuses on providing internal benefits to an organization which occupies the real estate. In order to enhance organizational performance real estate managers have to recognize and find a match between demand and supply of space designated to an organization (den Heijer, 2011). Those are further explained in the framework of adding value by CREM in section 1.3.

1.2. CREM stakeholders

CREM is an interactive form of RE management which touches upon four main perspectives. Those incorporate many stakeholders. Some of them are described below.

CREM managers

Hans de Jonge et al. (2009) contribute largely to the knowledge creation related to real estate. In the publication 'DAS Framework – Corporate Real Estate Management' authors recognize the division of certain domains in real estate management practices. Proposed by the authors

framework is based on four factors: focus on institution, focus on real estate, organizational perspective and strategic perspective. The original framework distinguishes between general, asset, facility and maintenance management. The framework is later evaluated by other researchers including Alexandra den Heijer (2011). She proposes a model which distinguish between fours perspectives: strategic (general), financial (asset), functional (facility) and physical (maintenance) (see figure 8).

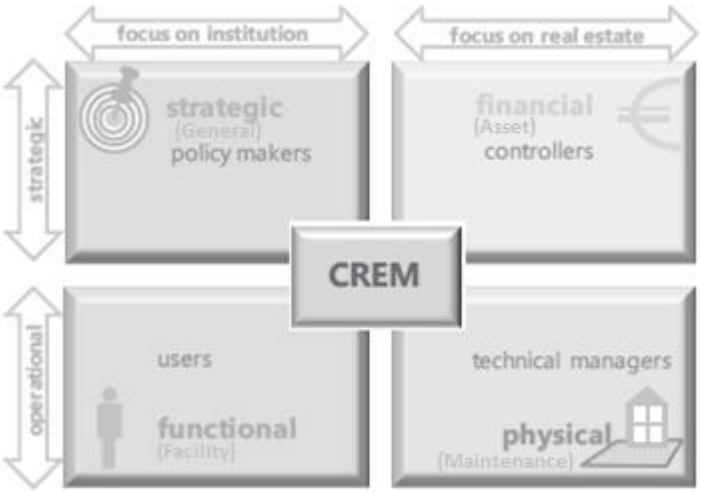

Figure 9 CREM perspectives; source: based on (den Heijer, 2011)

Each of the four perspectives is represented by different group of stakeholders. The strategic perspective is represented by a group of policy makers (also called strategic managers) who develop an overall vision for the real estate portfolio management. The group of financial controllers (also called asset managers) keep the asset management on track, they ensure an efficient and cost effective real estate management. The technical managers take care of building design, construction and maintenance process which are reflected in the real estate physical quality. Finally, the functional perspective (performed by facility managers) aims at providing good services and products to end users of real estate.

Jansen et al. (2013) in his research brings together four conceptual models created by different researcher about CREM structure, which present different perspectives on CREM. The author presents less detailed framework than den Heijer (2011), he distinguishes between Facility Managers (FM) and Corporate Real Estate Managers (CREM). Both of them are strongly related to the resource based view place within strategic management thinking. They also pay attention to stakeholders and relationship management, however FM is mainly service and process oriented (that is delivered to an end user) while CREM is more transaction and project oriented (connects building science with business objectives and finance). (Jansen, Sarasoja, van der Voordt, & Coenen, 2013) Since, models presented by Jansen et al. (2013) had been designed by a different researcher, there are multiple differences between them. Nevertheless each of them recognizes 'end user satisfaction' as an added value parameter which can be fulfilled by FM and/or CREM.

1.3. Adding value to office employees

Jansen et al. (2014) distinguish six different types of added value. The first type from the paper is a use value which reflects *'quality in relation to the needs and preferences of the users'*. This parameter is linked to the FM goals. This category is reflected (in adopted by den Heijer (2011) CREM framework) in a facility perspective - where end users play central role (see figure 8).

An office employee is an inseparable element of corporate real estate management (CREM). In line with the framework presented in figure 8, CREM (including FM) act as a provider of property and services delivered to an internal part of organizations – its end users. Therefore, an office employee

represents a demand side which has to be incorporated in real estate management decisions. (Heywood & Keneley, 2012)

Hans de Jonge (2008) contributes largely to the knowledge creation and management practices related to real estate. His framework recognizes 12 ways off adding value to an organization via CREM practices. All of them are incorporated in a model created by den Heijer (2011) (see figure 9 and table 6).

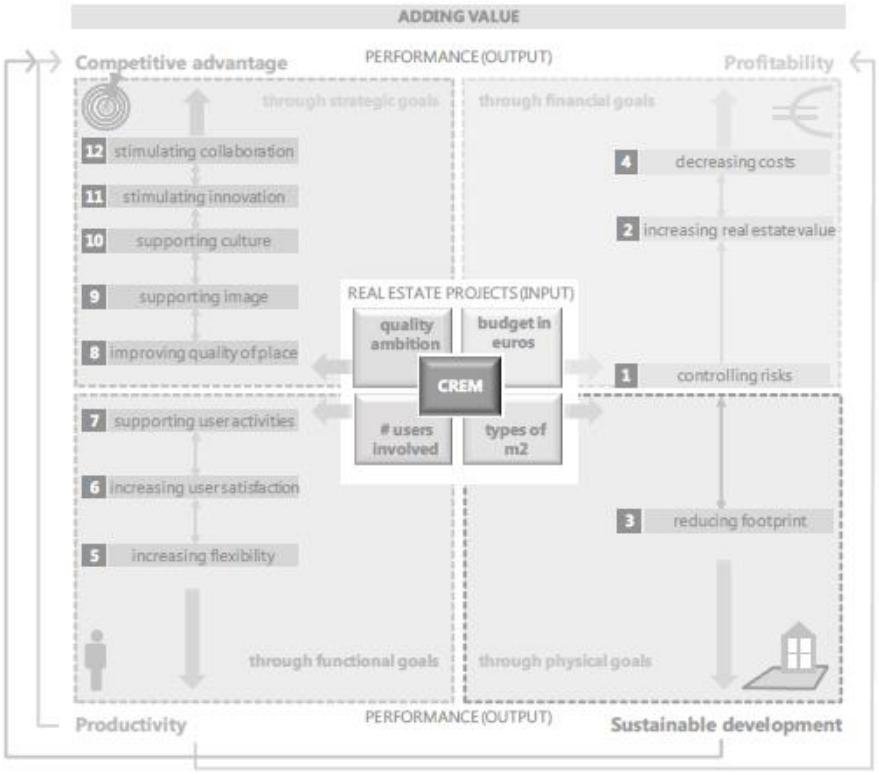

Figure 10 Adding value framework which incorporates 12 'adding value' approaches; source: (den Heijer, 2011)

The framework presented in figure 9 shows three components: input, process and output. The process of adding value to real estate aims at connecting real estate decisions (input) through real estate goals to performance criteria (output). As explained before, facility managers gain recently a significant role in smart office real estate management. In line with the proposed framework, the input for facility manager's activities should be defined by end users of real estate – office employees. Their demands should be incorporated in the process, which reflects the organizational and real estate goals such as: supporting office workers' activities, increasing their satisfaction and increasing flexibility. (den Heijer, 2011) At the same time, the adding value framework indicates that the researcher should take a broader perspective and also recognize other goals which can be fulfilled due to smart technology implementation. Further literature review is primarily linked to the mentioned two objectives, however the final analysis acknowledge briefly remaining framework components. For that reason the table below (see table 6) briefly explains all the framework components.

Two approaches of adding value to end users had been selected for further analyzes: supporting user activities and increasing user satisfaction. The indicated two approaches had been primarily selected because they can be largely supported by new technological solutions incorporated (by the FM) in an office working environment (Canon, 2017). The choice to organize it this way is mainly steered by appointed scope of this master thesis research.

Value	Explanation
Stimulating collaboration	Stimulate the communication and team work (due to space interventions and facilities provision).
Stimulating innovation	The objective is related to collaboration and culture. Shaping a place where people can meet and share their knowledge so that new ideas can be created.
Supporting culture	Enhancing the organizational culture by providing appropriate RE portfolio to its end users.
Supporting image	Showing the organizational characteristics through the RE portfolio.
Improving quality of space	Improving the workplace concept, space quality and services due to space interventions.
Supporting user activities	Provision of necessary facilities and good indoor working environment conditions.
Increasing user satisfaction	Upgrading the quality of space in order to respond to the trend 'focus on end users' and bringing extra benefits to an organization.
Increasing flexibility	Having a flexible portfolio which can be easily modified when there is change in a demand.
Decreasing costs	Minimizing operational costs (by minimizing personnel and/or space).
Increasing RE value	Raise up the RE market value (incl. land value) due to upgrading the RE.
Controlling risks	Monitoring and managing financial, functional and technical risks.
Reducing footprint (CO2)	Minimizing energy consumption.
Reducing footprint (m2)	Minimizing occupied space.

Table 6 Adding value framework components explanation; source: (den Heijer, 2011) (Valks, Arkesteijn, & den Heijer, 2018)

1.4. Conclusion

CREM stands for Corporate RE Management which is an interactive form of RE management that touches upon four main perspectives: strategic (general), financial (asset), functional (facility) and physical (maintenance) (den Heijer, 2011). *'CREM focuses on alignment of real estate to corporate needs and objectives, incorporating the needs and wishes of stakeholders (…)'* (Jansen, Sarasoja, van der Voordt, & Coenen, 2013). An office employee is an inseparable element of CREM. In line with the framework presented in figure 8, CREM (including FM) act as a provider of property and services delivered to an internal part of organizations – its end users. (Heywood & Keneley, 2012)

CREM (incl. FM) can add value to office employees in two ways: supporting user activities and increasing user satisfaction. The indicated two approaches had been primarily selected because they can be largely supported by new technological solutions incorporated (by the FM) in an office working environment (Canon, 2017) and they closely link to the use value - *'quality in relation to the needs and preferences of the users'*. (Jansen, van der Voordt, Coenen, & Sarasoja, 2014)

The studies show that CREM can also add value to other RE stakeholders by: stimulating collaboration, stimulating innovation, supporting culture, supporting image, improving quality of space, increasing flexibility, decreasing costs, increasing RE value, controlling risks, reducing footprint (m2 & CO2) (den Heijer, 2011).

2. Adding value via smart technology at office

The following section presents a literature review related to the 3rd research objective ('recognize smart technologies at office real estate which add value to an office employee (and CREM)'). The information provided in this section explain the concept of smart office, enabling it technologies and their added value to the office end users and CREM.

The goal of this section is to explain to the reader relevant themes and link them with the remaining research sub-questions. Moreover, the section is important since it forms the case studies research approach and enables both, the reader and the researcher, to fully understand and analyse the case studies findings.

The section only partially provides an answer to the 3rd research sub-question: 'what are the existing smart technologies implemented within (investigated) offices that add value to office employees (and CREM)?'. The full answer to this question can only be given after the case studies research is conducted.

2.1. Smart office development: end user demand

People living in The Netherlands are found to be the happiest and the healthiest people in the world, however burn-out rates keep on raising. In line with this trend, research observe worldwide growing awareness of stress outcomes such as depression and burn-outs. Partially due to these factors employees demand a healthy working environment. (CBRE, 2018a)

In practice, the provision of corporate facilities is mainly aligned with the business processes and corporate strategic goals (Ratcliffe, Saurin, Paybaraud, & Kristensen, 2009). Research suggest that office workers' demand should also be incorporated within organizational strategic goals (Anderson, 2018). Moreover, research confirm that there is a relationship between people's working environment, their well-being, health and their performance at work (Al Horr, et al., 2016) (CBRE, 2018b). The contributing factors to burn-outs and stress can therefore be localized at a workplace (an office). In principle, the office should serve office workers and enable them to perform at their best (CBRE, 2018a) instead of contributing to social issues such as burn-outs.

Majority of a knowledge-based sector operate in office buildings, that is why it is important to understand and constantly improve the indoor office environment (Al Horr, et al., 2016). Multiple research proves that indoor working environment conditions can largely contribute to office quality. In principle the office space should support end user activities and in fact improve office employees' productivity (Al Horr, et al., 2016) (van Dijk, 2018) (CBRE, 2018b) (Ratcliffe, Saurin, & Puybaraud, 2008) (Verhoeven, Maaijen, & Brink, 2015).

Grey literature recognizes an upcoming transition from Smart into Healthy office (CBRE, 2018b) (CBRE, 2018a). This approach represents a very good direction of an office indoor environment development, since it recognizes the societal issue – burn-outs. Nevertheless healthy office is to great extend enabled by smart technology, that is why it is important to take a step back and elaborate upon smart technology value for the end user and its' implementation within so called smart office.

2.2. Smart office

These days technology is the most important factor which influences and enables most of changes within a workplace. Smart Workplace appears to be an inevitable future of many real estate. (Wellener, Manolian, Michalik, & James, 2019) The smart office concept does not have one holistic definition. In general the word 'smart' stands for buildings with network connectivity, the ability to communicate and if applicable interpret data about the objects, their status and performance (Wellener, Manolian, Michalik, & James, 2019).

The smart office can be defined as *'an office space equipped with IoT devices, and thus connected to the internet(….). It represents an intelligent ecosystem which relies on number of connected devices that, in general, monitor, control, and manage various operations and working conditions'* (IoT for all, 2019). Nevertheless, this definition can be easily challenged. In most developed countries building services within smart office space aim at satisfying occupants' comfort needs. (Labeodan, Zeiler, Boxem i Zhao, 2015) The definition should therefore not only focus on the physical

characteristic of the smart building but also on its purpose. Furthermore *'an office is not truly smart until all its parts, from technology to services, fully support each and every individual that work there. It is the employees who are to be supported in the office and all the parts, from process to services, need to be in place so that the office can fully support the employees in their work'* (COOR, 2019).

A Smart Workplace in principle reflects '*a workplace infrastructure that empowers employees through self-regulation, engages employees through collaboration and communication, promotes a strong environmental ethic and sustains organizational agility, all of which are enabled through the adaptation and implementation of new technology platforms'* such as Internet of Things (Ratcliffe, Saurin, Paybaraud, & Kristensen, 2009). For the sake of this master thesis an umbrella definition of a smart office had been created. The smart office is further understood as *'an office space which is equipped with multiple connected IoT devices which monitor, control and manage indoor working environment and support office workers activities due to communicating with them the real-time information as well as provide CREM with data which can influence managerial decisions'.*

2.3. IoT technology

The term Internet of Things (IoT) was first defined by Asthon in 1999. Since then it has gained significant attention. These days it is perceived to be the evolving technological trend which influences many professions, including CREM. The International Telecommunication Union (ITU) defines the Internet of Things (IoT) as *'a global infrastructure for the Information Society, enabling advanced services by interconnection (indoor and virtual) things based on, existing and evolving, interoperable information and communication technologies'* (Wortmann & Flüchter , 2015).

In practice, Internet of Things refers to a network which interconnects indoor objects and devices (things) with their virtual representation. Thanks to IoT things are able to exchange information about the status change noticed in their environment in order to become smart and responsive to an external impulse (stimuli). Accordingly, IoT has a potential to *'enable one to create useful applications in various service domains'*. (Ryu, Jun, & Yun, 2015)

While zooming into the office environment: the technological advances in the field of Internet of Things enable identification of things and contactless data exchange. This is done due to building up an integrated sensors network, improving wireless communication and shaping a universal mobile network (Wi-Fi). Besides, Internet of Things does not only reflect connections between physical objects. People can also be interconnected to the IoT platform via smart bands, smartphones or any other computer devices. (Mehl, 2018)

The key to a successful implementation of IoT solutions lays down in selecting an appropriate technological tool which will enable the business to measure and constantly strive for improvement of

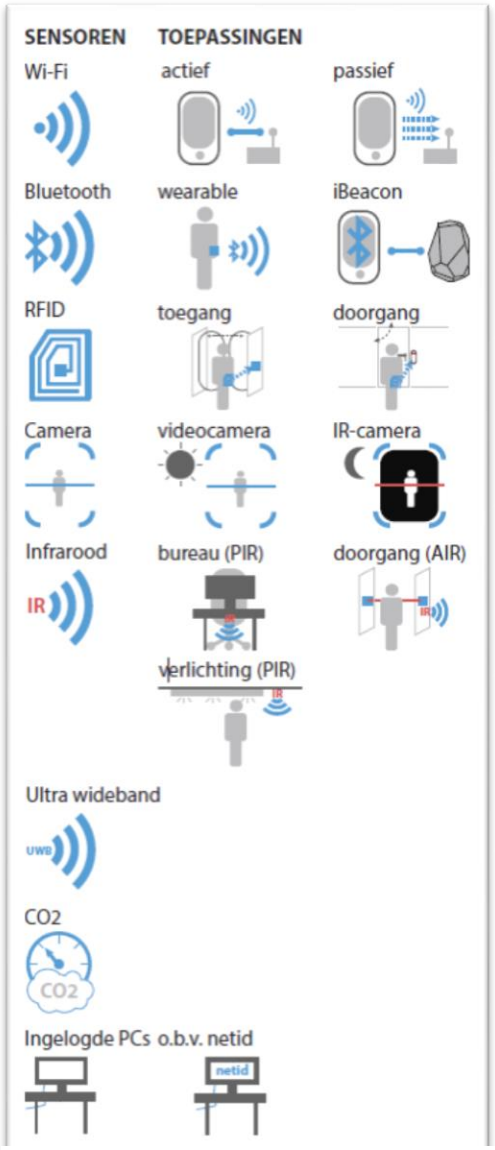

Figure 11 Overview of sensing technology; source: (Valks, Arkesreijn, den Heijer , & Vande Putte, 2016)

appointed goals (Lunn & Stephenson, 2000). The technological tool can be interchangeably called a smart tool (ST). The research paper adopts the smart tool definition proposed by Valks et al. (2018). The smart tool is therefore understood as *'a service or product that collects information on space use real-time to improve space use in an office on the one hand, and to support decision-making on the future of an office on the other hand'.*

'Smart campus tools' (2016) presents research on various smart tools and their utility to public (university) real estate. The framework is presented in figure 10. This research makes use of the framework while conducting the case studies and learning about sensing technology which enables smart system at offices. The 2nd publication is supplemented by analyzes of private RE. In the 1st publication authors present sensors overview.

In short, IoT can bridge people with people, people with things and things with things in an office RE. The general benefits of incorporating various IoT elements in an office environment are for example minimizing energy resources usage, boosting teamwork and collaboration, providing more comfortable physical environment or enhancing employees productivity. (Mehl, 2018) More specific description of certain benefits is presented in the next paragraphs.

2.4. Adding value to office employees (and CREM) due to IoT implementation

Office space shortcomings

Workspace located in modern office buildings is often characterized by an open floor plan which is constantly questioned for noise control, privacy (CBRE, 2018a), ambient uncontrollable conditions (such as thermal comfort, lightening), constant distractions or high level of social density (Samani, 2015). The thermal comfort and lightening have gained the most attention in revised literature (see table 7). These two factors have a lot to do with a customizable setup that can be managed by smart technologies.

	(Samani, 2015)	(Snow, Soska, Schraefel, & Chatterjee, 2016)	(Berelson, Tryfonas, Simini, & Cooper , 2018)	(Nehchiri, Vahedprast , & Esfahani, 2018)	(van Dijk, 2018)	(Al Horr, et al., 2016)
Indoor climate (HVAC)		X				X
Indoor air quality	X	X		X		X
Lighting quality	X		X	X		
Thermal comfort	X	X	X	X		X
Acoustic						X
Noise level	X		X		X	X
Low social density	X	X				
Privacy (visual)	X				X	

Table 7 Hypothetical shortcomings which requires an improvement in an open floor plan office; source: author based on literature review

A Digital Workplace is defined in the report of CoreNet Global and Deliotte as *'a workplace that includes technologies that directly or indirectly interface with employees to enhance the workplace experience. That includes technologies which make employees more mobile, safer and better informed as well as those that support CRE organizations in automating business processes, driving efficient interactions with stakeholders, and improving business insight'* (Charaya, Senguputa , & Tare, 2018). Mobile applications and informative screens in an office space serve the end user,

whereas various dashboards are intended to give CREM an insight into data related to the building performance and its usage and/or exploitation.

These days, CREM has to put a lot of effort into a provision of a good quality workplace, which serves office employees and adds value to an organization. Supporting office employees' activities is in fact assigned to facility manager responsibilities, who ensures provision of a suitable workplace and good working conditions (including indoor working environment conditions – together with technical managers) which can have a positive impact on office employees' satisfaction level. (CBRE, 2018)

Supporting office employees activities

Smart office is characterized by a great use of technology, which makes the time spent there easier and more comfortable. It is an office where *'responsive devices communicate over the Internet to analyze and optimize all aspects of the workplace'* (CBRE, 2018b). The responsive devices can be interchangeably called sensors or ST (see figure 10). It is important to emphasize that within the smart office there is an established connection between the building, the technology and peoples' behavior due to - among others - Internet of Things technology. (CBRE, 2018b)

Various sensors sent real-time data to integrated systems. These communicate with the end users of an office. The IoT concept can enable office employee to faster and easier preform their working activities. The deployment of most popular technologies is clearly prioritized so that it can enable improved experience and efficiency of office employees (Acoba, Charaya, James, & Rahalkar, 2018).

Figure 12 presents technologies appointed in order to fulfill certain Digital Workplace objectives. The following objectives are strongly linked to office workers activities:

- Manage Workplace,
- Support Connectivity & Collaboration,
- Enable Associate Productivity.

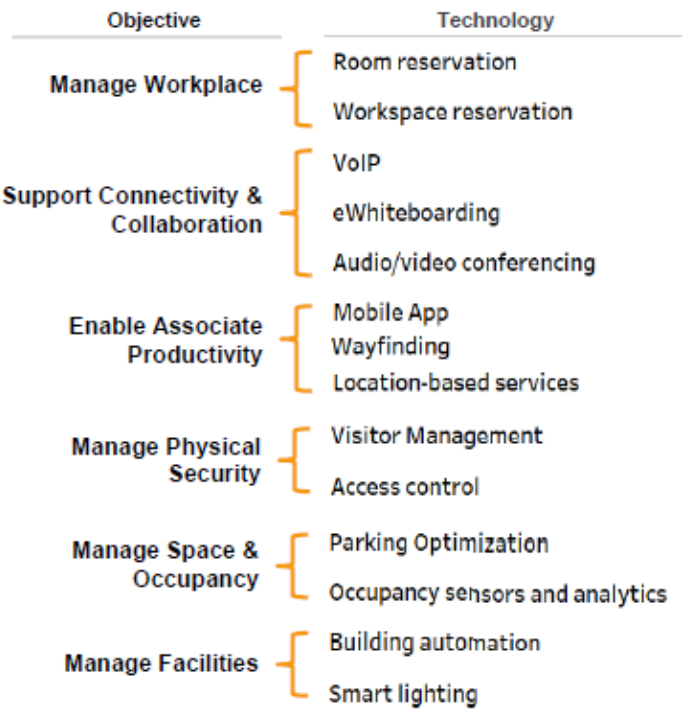

Figure 12 Most common technology at Digital Workplace; source: (Charaya, Senguputa , & Tare, 2018)

Provision of an IoT concepts which helps an office employee to easily book and/or find a desired space, see the overview of meeting rooms and/or booking opportunities, locate team members in order to collaborate, find a way to certain service (e.g. printer) or quickly communicate in various ways with a colleague to great extend support office workers activities (Acoba, Charaya, James, & Rahalkar, 2018).

There are many more functionalities that a REM can add to the application which is handed in to end users. They depend on installed devices and strategic goals. Security cameras, motion sensors, noise monitoring systems, CO2 sensors, air quality measurement devices, smart lockers, doors openers, access control systems are already being used in SRE. (Driedger, 2019)

Further research via case studies' analysis is necessary in order to define various IoT solutions at office properties, its added value to office employees and CREM in general as well as data which can be extracted due to certain functionalities implementation.

Enhancing office employees satisfaction

Borghero (2018) recognizes technology as a critical factor which can help to enhance office employees engagement. Thanks to the technology an office employee can be given a control and

choice over office indoor working environment. In line with smart office, employees' satisfaction can be largely supported by provision of smart applications which enable office employees to modify their indoor working environment in line with their personal preferences. In practice it means for instance adjusting air quality, having control over the temperature around them or being able to have control over the light intensity. (Brugmans, Appel-Meulenbroek, Kemperman, & Dinnissen, 2017) Nehchiri et al. (2018) present possible smart systems, which enable end users to create desirable environment and enhance their comfort (see figure 12).

The physical conditions of a desirable work environment:	Intelligent systems:	The system performance	The impact of the system performance on the staff
Lighting:	Lighting control system:	- Adjusting the light intensity proportionately to the space use	The prevention of eyestrain and dysfunction of visual perception
		- Adjusting the light intensity proportionately to the natural light intensity	
		- Adjusting the light intensity based on time	
		- Preventing the environment brightness level from changing continuously	
	Awnings and shutters system:	- Controlling the awnings based on the time of sunrise and sunset	The prevention of fatigue, depression and restlessness with optimal use of natural light
		- Controlling the awnings based on different times of a year	
Temperature	Air conditioning system	- Adjusting the heating and cooling degree according to the desired temperature	The prevention of dysfunction in employees' cognitive, physical and perceptual performance
		- Adjusting the ambient temperature by opening and closing the windows	
		- Adjusting the ambient temperature based on the air temperature outside the building	
		- Adjusting the ambient temperature based on the presence or absence of staff	
		- Adjusting the ambient humidity	

Figure 13 Smart systems which enables end users to create desirable indoor environment conditions and enhance their comfort; source: (Nehchiri, Vahedprast, & Esfahani, 2018)

Employees who have control over various aspects of their workplace and work experience are more empowered and engaged in organizational development. Employees' engagement positively correlates with workplace satisfaction level (Borghero, 2018). Benefits of an engaged employee are for example: employee retention, higher productivity, better health hence an organizational profit growth. Parallel to that, the satisfaction level of their office working environment is most likely to increase. (Borghero, 2018) (Anderson, 2018) (Earle, 2003)

Adding value to CREM

The Internet of Things (IoT) is recognized as a valuable tool thanks to which the data can be combined with smart processing, display and analysis (MidSphere, 2018). IoT presents a wide range of opportunities, including those that bring benefits to office employees. One of the main sources of so called by CREM big data is the Internet of Things platform. Thanks to this platform data collected by smart tools (including sensors, wi-fi networks etc.) can be easily distributed in between actors who manage a smart office. The goal is to use the data in order to better understand and improve usage of available spaces (occupancy measurements) and improve an indoor climate (indoor working environment). (Berelson, Tryfonas, Simini, & Cooper , 2018)

Due to the use of smart technologies facility manager can improve employees' health, satisfaction, performance and productivity (Kejriwal & Mahajan, 2016) and CREM can make sound decisions about RE and REM. Sensors incorporated within Internet of Things technology enable this by for instance measuring and adjusting temperature, humidity, pressure and light (Deloitte University Press, 2018a). Due to monitoring office employees' activities CREM can better accommodate users'

needs, optimize the use of available space and reduce costs. It can also contribute to a collection of personally interesting information by the end users (Deloitte University Press, 2018a).

Furthermore CREM can track office employees' movements and their preferences assigned to specific activities and spaces. Due to collection of this valuable input CREM can provide more better quality space which responds to end users' demand and minimize the unoccupied space. The following approach makes the resource (RE) management more efficient. Finally the, information can form basis for collaborative decision-making process, which is essential while taking strategic decisions related to real estate (Krumm, Dewulf, & de Jonge, 1998). The communicated via Internet of Things real-time feedback can put CREM in a position where they can take sound decisions related to their asset (CBRE, 2018b).

2.4. Conclusion

The smart office is had been defined as *'an office space which is equipped with multiple connected IoT devices which monitor, control and manage indoor working environment and support office workers activities due to communicating with them the real-time information as well as provide CREM with data which can influence managerial decisions'*. The IoT is a network of things which communicate with each other via an internet connection.

The existing smart technologies implemented within offices can be divided into display devices for end users (mobile application, interactive screens) and those for CREM (servers which gather historical data, automatized BMS). Mobile applications and informative screens in an office space add value to office employees, whereas various dashboards are intended to add value to CREM by giving CREM an insight into data related to the building performance and its usage and/or exploitation.

According to the literature technologies which support user activities aim at making the time spent at a smart office easier and more comfortable (CBRE, 2018b). Provision of an IoT concepts which helps an office employee to easily book and/or find a desired space, see the overview of meeting rooms and/or booking opportunities, locate team members in order to collaborate, find a way to certain service (e.g. printer) or quickly communicate in various ways with a colleague to great extend support office workers activities (Acoba, Charaya, James, & Rahalkar, 2018)

Technologies which increase user satisfaction are characterised by the fact that they enable end users to modify their working conditions in line with their preferences (Borghero, 2018). In practice it means for instance adjusting air quality, having control over the temperature around them or being able to have control over the light intensity. (Brugmans, Appel-Meulenbroek, Kemperman, & Dinnissen, 2017) (Nehchiri, Vahedprast, & Esfahani, 2018).

The general benefits to CREM of having an insight into historical data about an office environment and occupancy are for example: minimizing energy resources usage (reducing footprint), boosting teamwork and collaboration (stimulating collaboration), providing more comfortable physical environment (improving quality of space) or enhancing employees productivity. (Mehl, 2018)

3. IoT implementation process

In order to answer the 2nd research sub-question ('how is the IoT implementation process organized?'), it is important to learn more about the various aspects of the IoT implementation initiative. The 2nd research sub-question had been splatted into two sub-questions which touches upon aspects discussed in this section.

The following section focuses on: (1) IoT implementation process phases, (2) actors involved within the process and their responsibilities, (3) end users involvement within the process and finally on (4) issues which can occur during IoT implementation initiative.

3.1. Process of IoT implementation

The process of IoT implementation can be compared to the process of a project development. The figure below (see figure 14) indicates that the very basic division of the process phases can be presented as: Strategy & Planning, Deployment and Operational Support (Charaya, Senguputa , & Tare, 2018). Those phases presents some similarities with Design, Development and Operational phases which can be observed within RE project development. What is also interesting in figure 14 is the indication of actors involvement per phase, however their responsibilities are not further explained in the publication.

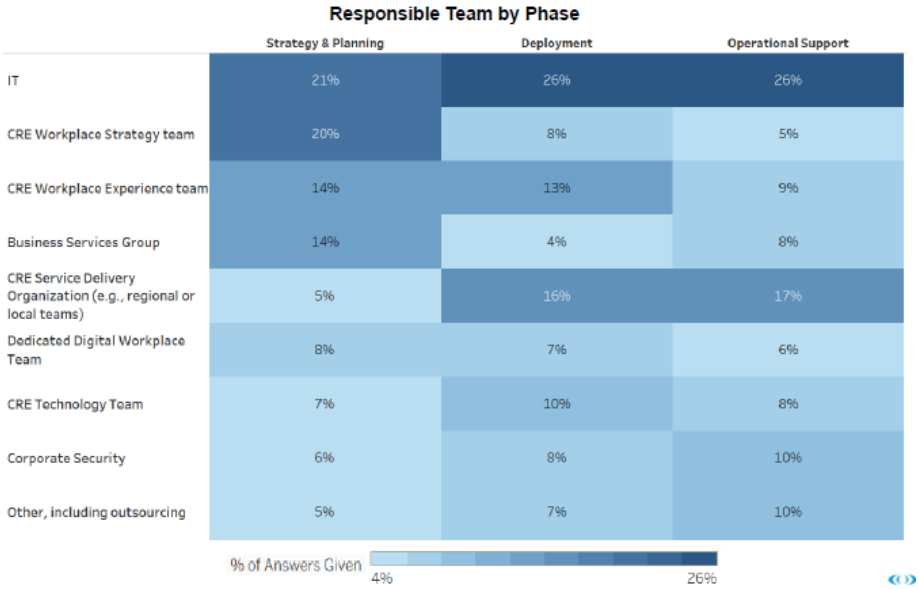

Figure 14 Digital Workplace implementation phases and assigned actors; source: (Charaya, Senguputa , & Tare, 2018)

Valks et al. (2018) in the publication *'Smart Campus Tools 2.0'* research smart tools (ST). The methodology consists of comparative case studies. One of the factors that the authors have distinguished within various institutions is the phase of a smart tool development. The figure below (15) combines the two frameworks (ST and the one presented in figure 14) in order to show relation between them.

Project phase	**Phase *'Smart Campus Tools 2.0'***	**Phase description**
Strategy & planning	Research	When a ST is a part of a scientific project
Strategy & planning	Product development	When a ST is being developed towards a market-ready product
Deployment	Pilot	When a ST is market-ready and is being tested with objective of assessing if it can be applied on a big scale
Deployment	Expansion	When a ST is currently being implemented on a large part of the portfolio
Operational support	Implementation	When a ST has been implemented and is now part of the regular operation

Figure 15 Initiative phases overview; source: author based on (Valks, Arkesteijn, & den Heijer, 2018) and (Charaya, Senguputa , & Tare, 2018)

The indicated project development phases can serve as a core of the IoT implementation process design, nevertheless enormous amount of information related to the process organization is missing. The literature does not provide a comprehensive overview of activities which are taken within specific phases, therefore the research is supported by case studies organized in line with the developed interview which helps to learn more about the process organization.

3.2. Actors and their responsibilities

The actors and their responsibilities in relation to IoT implantation are yet not widely researched. The scientific literature present involvement of CREM in the IoT implementation, however it does not say much about their responsibilities related to it. The researchers also picture possible benefits of IoT, however they do not present an overview of relevant stakeholders. That is why the IoT implementation process is a part of this research.

The paragraphs below sketch possible roles division of the mentioned actors in relation to the IoT implementation process at office RE. More research is required in order to recognize and assign responsibilities related to the IoT implementation process. In order to collect more relevant information the researcher decides to investigate the issue further via case study approach.

Organization (board)

Within the next few years technical solutions are going to be intuitive and embedded, the importance will be placed on the development and management of property process and people. Even though the technical solutions are going to be controllable by each individual the access and information protection will be the primary focus of an organization. (Ratcliffe, Saurin, Paybaraud, & Kristensen, 2009)

Traditional project development starts at an organizational board level. The board is responsible for making decisions related to an organization's activities. Based on those the board makes further investment decisions. Those are supported by previously analyses opportunities, threats and challenges related to the project development. (Winch, 2010a)

CREM

'Local sensing is not by itself capable of orchestrating a complex process' (Devenport & Lucker, 2015) that is why it makes sense to look at the IoT as a whole. Gathering data and networking things does not add value. The information (data) creates value only when it is positively influencing future decision-making and actions. The conscious decision-making process can make use of the utilized information and ideally stimulate a learning process (Thomas, Devan, & Khan, 2018). In line with the smart tools definition, CREM can extract various collected data in order to make sound decisions related to the REM.

As explained before, due to the use of smart technologies facility manager can improve employees' health, satisfaction, performance and productivity (Kejriwal & Mahajan, 2016) and CREM can make sound decisions about RE and REM. For both those activities actors need to have an access to the databases and have an impact on their setup. Finally the, information can form basis for collaborative decision-making process, which is essential while taking strategic decisions related to real estate (Krumm, Dewulf, & de Jonge, 1998).

Described CREM's benefits already indirectly address CREM's position within the IoT implementation process. The CREM involvement reflects a strategic perspective due to the fact that it presents a bigger picture and incorporates strategic goals (and ends up with strategic decision-making based on data).

The figure 14 (presented on page 55) presents results of a survey performed by Deloitte and CoreNetGlobal (2018). The results indicate specific actors and their involvement in specific project phases. Multiple specific actors are involved in the process and when it comes to CREM stakeholders, the survey indicates few relevant teams which play a big role in the initiative. Those are: CRE Workplace Strategy team, CRE Workplace Experience team, CRE Service Delivery Organization and CRE Technology team.

Facility manager

The Smart Workplace emerges as a new model of an office environment. In this new model, facility managers' role shift, from a reactive function to the one that deals with complex and unpredictable

environment. It is predicted that in the future, the role of a facility manger is going to become increasingly strategic. He or she is no longer going to focus only on the building provision. Sooner or later, FM is going to be responsible for the workplace provision and its agility. (Ratcliffe, Saurin, Paybaraud, & Kristensen, 2009)

FM can steer smart technology implementation and extract important data. Moreover he/she is very close to the users of a real estate therefore he/she bridge people and smart technology. Furthermore FM can gather relevant data and add value to real estate portfolio. Meanwhile the facility manager can raise up people's awareness of the smart technology and achieve benefits for both - the office end users and its owners. (Ratcliffe, Saurin, Paybaraud, & Kristensen, 2009)

Prior to IoT implementation, it is essential to recognize the desired data and make use of them (EY, 2016). That is why facility manager presents a person who can bridge demand and supply side of CREM. Nevertheless, facility manager can not manage the challenging process alone.

IT

Privacy related issues put a lot on pressure on executives who have to ensure proper security of sensors and collected data (Deloitte University Press, 2018a). Wortmann & Flüchter (2015) state that *' received models of managing IT as a standaralized commodity and aligning IT to business strategy need to be questioned and complemented by new frameworks, which view IoT technologies not only as a support function but as a core element of value creation and as a source of competitive advantage'*.

The IoT requires a lot of work in order to be successfully implemented. Due to many concerns, executives at a strategic level start to evaluate opportunities and threats caused by the IoT emergence. Rigorous hardware and agile software culture start to clash. Decisions also have to be made about managerial challenges at an operational level. (Wortmann & Flüchter , 2015) Ensuring proper security requires a strong collaboration with Information Technology (IT) departments.

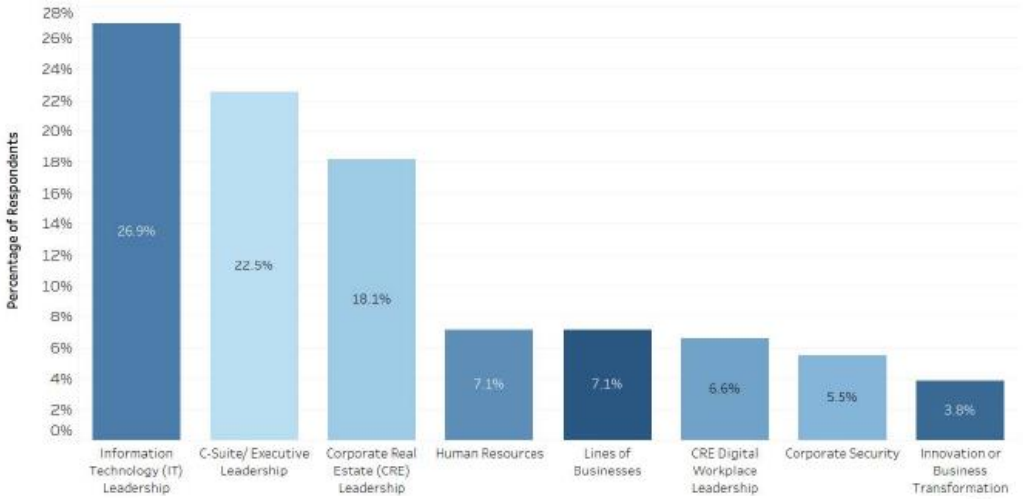

Figure 16 Groups responsible for Digital Workplace investment and budget decisions; source: (Charaya, Senguputa , & Tare, 2018)

Surprisingly it is no longer asset managers who make decisions related to the budget allocation when it comes to smart technology (part of smart building) development. The decision-making authority appears to be given to IT departments. At the same time the researcher observes a big variation in terms of given responsibility per actor (presented in the figure 13). In the end groups responsible for investment and budget decisions can be very fragmented across multiple functions and organizational levels. (Charaya, Senguputa , & Tare, 2018)

HR

There is a need for an integration of human resources (HR), CREM and new technologies however it is difficult to present a clear picture which would specify roles of various stakeholders in the 'adding value' challenge (Jensen, van der Voordt, Coenen, & Sarasoja, 2018).

The role of Human Resources (HR) department is yet unknown. Some papers recognize HR as an actor which can communicate with office employees about possible changes in an office environment and contribute to cross-functional teams' work. Those cross-functional teams aim at analyzing and understanding users' needs more deeply so that CREM can better meet their demands (Narasima Venkatesh, 2017) (McKinsey&Company, 2016) (Supheert, 2018) (Kaczmarczyk & Murtough, 2002). Nevertheless, it is not clear when would they be appointed to fulfill not fully defined tasks and how would they perform it in relation to other actors within the process.

In short

The actors and their responsibilities (expressed as certain tasks) are presented in the table below (see table 8).

Role	Responsibility
Organization (board)	- Evaluating opportunities and threats related to the IoT - Evaluating operational challenges - Investment decision - Ensuring data security
CREM	- REM - IoT implementation (strategic decision) - Data analysis - Adding value from four perspectives due to data analyses - Collaborative decision-making with end users - Evaluating operational challenges - Investment decision
FM	- Improving health, satisfaction, productivity of office employees - Workplace provision and its flexibility - Gaining strategic importance - Steering IoT implementation - Data analysis - Bridging people and smart technology - Raising up awareness of end users
IT	- Security of sensors input/data - Strong collaboration with other stakeholders - Budget allocation
HR	- Collaboration with teams which sketch user profile and define users' needs - Communication with end user

Table 8 Actors and their responsibilities; source: author

3.3. End users (office employees) involvement

These days, multiple demographic drivers, issues and trends impact CREM practice and change the demand. An employee participation in a creation of a workplace is becoming widely recognized as an essential input for decision-making. Office employees' participation in decision-making can help to minimize or even avoid problems related to indoor working environment conditions therefore improve the quality of space (CREM objective). Due to the proactive approach and feedback received from office employees, CREM and FM can support office workers' health and wellbeing (Ratcliffe, Saurin, & Puybaraud, 2008) as well as fulfil the some CREM goals.

Organizational culture, office employees involvement and indirect benefits

Technical innovations (such as Internet of Things) which can be implemented by CREM within office space are already available on the market. Technical innovation should support social and organizational change which should be reflected in an organizational culture. Nonetheless it is difficult to rephrase an organizational culture. Very often, even if the change is intended,

institutional infrastructure, managerial skills, support and business processes are lagging behind. The strategic change in real estate management practice requires a social change. (Dutton, 2014)

Furthermore, organizational culture in an office environment can largely influence employees performance. According to Hoskins (2014) power of choice and autonomy over employee's working environment has a positive effect on employee's happiness, motivation and performance. The author states that *'every organization should carefully consider what they can do to give employees the spaces and tools that enhance and support their workday tasks as well as corporate goals'* while acknowledging that 'one-size-fits all' approach should be avoided. Last but not least, it is likely that if an office employee will be ignored the office space might lost its value to an office employee and stop to be a demanded workplace. That can have an impact on talents requirement, workforce retention, organizational performance and make the organization lose their competitive advantage. (Earle, 2003) (de Jonge H. , et al., 2009)

Optimal alignment of tools and technology (delivered by CREM) should be supported by organizational policy which gives an employee power and autonomy over their workplace and indoor environment conditions (Hoskins, 2014). An additional layer of choice does not have to be work-related, it can be for example related to the emerging trend of Internet of Things (IoT), since this tool can serve office workers in their daily activities at an office.

IoT in office employees' hands

The literature related to real estate management reveal two contrary paradigms: control and enabling paradigm. The first one – control paradigm - aims at improving productivity through greater efficiency. In practice this approach is often expressed through reduction of financial resources or actual space. Unlike control paradigm, enabling paradigm recognizes the importance of human contribution to the organizational overall productivity. Haynes (2007) calls interchangeably the *'enabling paradigm'* a *'value added paradigm'*.

In the perspective of an enabling paradigm, office employees should be given a decision-making power over their workplace due to the fact that human asset are the means of improving office productivity. Due to an involvement of office workers in decision-making related to their working environment CREM can strengthen an organizational culture. Moreover, it can contribute to a creation of an competitive advantage of an organization, influence office workers productivity and hence influence organizational performance. (Haynes, 2007) An additional layer of choice does not have to be work-related, it can be for example related to the emerging trend of Internet of Things (IoT), since it is a tool that can serve office employees.

Haynes (2007) states that the psychological needs of individuals related to a workplace and personal preferences should be addressed in a workplace design. He explains that the human resource is an essential component which contributes to organizational productivity level. Due to an adaptation of a proactive approach which involves office employees in decision-making about their workplace, the office productivity can grow hence organizational performance can be improved.

Explained previously smart technology, that enables office employees to personalize their working environment and enable them to make use of multiple application functionalities, manifest itself in previously discussed enabling paradigm. However Brugmans et al. (2017) recognize three conditions which has to be fulfilled in order to ensure that the office employee experiences (perceived) personal control over the workplace. Those are:

(1) the application has to be simple so that it can be easily used by an employee,
(2) smart technology should help to solve a problem – help an employee to change the working environment so that is suits his/her demands,
(3) the results and the process of implementing smart technology should be visible to an employee.

These conditions pinpoint the value of a joint implementation process. In order to fulfill them office employees – end users of a real estate managed by CREM - should be consulted. In that way they

can assess the quality of an mobile application, define recognized problems in office working environment and learn about the implementation process. In short, it is necessary in order to make sure that the space demand matches the supply of a workplace characteristics and enabling it technology. That also implies that the technology fulfill its objectives which the end user can revise. The findings show that the end user should be involved in the IoT development initiative.

3.4. Office employee-oriented IoT implementation barriers

No initiative which involves smart technology is complete without indicating barriers/obstacles which can have negative impact on, or even block the development of IoT. While designing the office-employee oriented IoT implementation process it is important to realize that lack of strategic vision, privacy constrains and uncertainties, data security and technical capabilities of the technology can impose a big barrier to the initiative development. The paragraphs below briefly explain why those aspects are crucial and should be taken care of.

Strategic barriers

Multiple obstacles can be exposed to CREM practice related to the SRE development. CoreNetGlobal and Deloitte (2018) have asked actors from CRE industry about challenges which affect the Digital Workplace implementation efforts. Participants have indicated barriers such as: lack of executive support, lack of strategic vision, lack of cross-functional/departmental collaboration or outdates KPIs. Additionally participant state that lack of quantifiable business case can cause limited investment opportunities. (Charaya, Senguputa , & Tare, 2018) Those factors can be summarized as multiple barriers which have to be solved on a strategic level of CREM activities.

Privacy

Future workplace will probably be: highly technology enabled, environmentally friendly, offer a sense of community and It will balance indoor security with a sense of openness (Ratcliffe, Saurin, & Puybaraud, 2008). Within the next few years technical solutions are going to be intuitive and embedded, the importance will be placed on the development and management of property process and people. Even though the technical solutions are going to be controllable by each individual the access to information and its protection will be the primary focus of an organization. (Ratcliffe, Saurin, Paybaraud, & Kristensen, 2009)

The privacy concerns arise because people are anxious about facts such as: who actually have an access to the collected information and for what are these information used, as well as how are they utilized (Valks, Arkesteijn, & den Heijer, 2018). This concerns relate to a trust level that office employees have in data management performed by CREM. In order to minimize privacy concerns the uncertainties related to the ownership and control over collected data have to be communicated with end users of an office. As explained before (see ‘organizational culture’), users should gain control over their privacy settings. (Dutton, 2014)

Privacy concerns can be resolved in many different ways. Those have to be proposed by organizations itself. Some examples presented by Valks, Arkesteijn, & den Heijer (2018) are: complying with privacy law, giving end users a choice about which data do they share with an organization and/or CREM (personal data ownership), direct anonymization of data before it is analyzed, anonymous data collection due to choosing a technology which cannot recognize an individual.

Security arrangements and technical concerns

Deloitte (2018a) recognizes challenges related to an adaptation of sensors at a worplace which is expressed in data access and utility. The IoT platform uses various sensors which collect information about ‘things’. Since evey sensor is an electronic device which can be virtually accessed or hacked, privacy related issues put a lot on pressure on executives who have to ensure proper security of sensors and collected data. (Deloitte University Press, 2018a)

Due to the fact that evey sensor is an electronic device powered either through in-line connections or batteries, general power consumption can increase. This can be a trouble for technical managers who aim at minimizing operational costs. In that sense, the issue has a lot to do with asset managers who aim at increasing organizational ravenous and decreasing operationailization costs.

Last but not least the current platforms and legacy technologies as well as limited technical stuff with relevant expertice can impose a big challenge throughout the initiative (Charaya, Senguputa , & Tare, 2018).

In short

The process of employee-oriented IoT implementation initiative can be divided into three phases: strategy & planning, deployement, operational support. Discussed previously barriers related to the initative had been linked to the process phases (see figure 16).

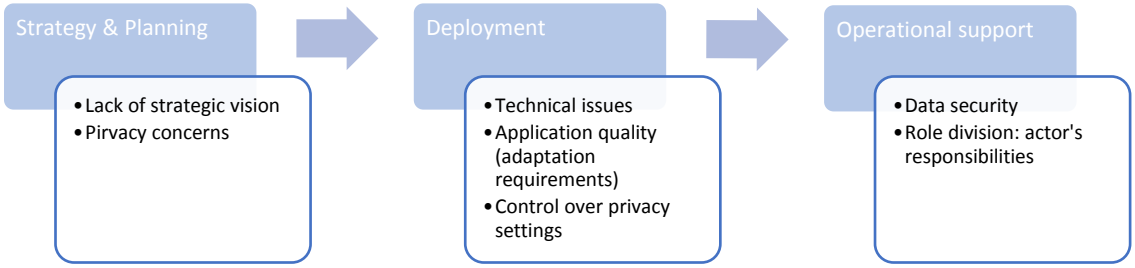

Figure 17 Process phases and barriers; source: author

3.5. Conclusion

The division of the process phases is: Strategy & Planning (Research, Product development), Deployment (Pilot, Expansion) and Operational Support (Implementation). (Charaya, Senguputa , & Tare, 2018) (Valks, Arkesteijn, & den Heijer, 2018) The indicated project development phases can serve as a core of the IoT implementation initiative, nevertheless enormous amount of information related to the process organization and actors activities within it is missing.

An organizational board has been recognized as a starting point of SRE development. However, CREM had been recognized as an actor which can shape an office employee-oriented IoT implementation initiative from the RE perspective. (Ratcliffe, Saurin, Paybaraud, & Kristensen, 2009) The literature review indicates that there is a need for an integration of CREM, FM, IT, HR however it is difficult to present a clear picture which would specify all stakeholders in an 'adding value' challenge. The actors' tasks/responsibilities are discussed in more details in section 2.1. (see table 8).

An employee participation in a creation of their workplace is becoming widely recognized as an essential input for decision-making. (Ratcliffe, Saurin, & Puybaraud, 2008) Due to the proactive approach and feedback received from office workers, CREM and FM can support office workers' health and wellbeing . (Ratcliffe, Saurin, & Puybaraud, 2008) (Kejriwal & Mahajan, 2016). Optimal alignment of tools and technology (delivered by CREM) should be supported by organizational policy which gives an employee power and autonomy over their workplace indoor environment conditions and involves them in the process. (Hoskins, 2014)

While designing an office-employee oriented IoT implementation process it is important to realize that lack of strategic vision, privacy constrains and uncertainties, data security and technical capabilities of the technology can impose big barrier to the initiative development (Charaya, Senguputa , & Tare, 2018). In order to minimize privacy concerns the uncertainties over ownership and control over collected data have to be communicated with an end user of an office. Moreover, users should gain control over their privacy settings. (Dutton, 2014)

The literature does not provide a comprehensive overview, that is why this research aims at developing an interview which will allow to learn more about the process (with the main focus on how, when and by who can the perspective of end users be acknowledged).

4. Summary & brief discussion

The following section ('knowledge basis') had discussed concepts which allowed the researcher to either formulate an answer to the research sub-question or indicate knowledge which is missing and have to be learned through case studies research. The answers to the research sub-questions are given at the end of each section (see 'conclusion' in black frames).

The literature sufficiently covers CREM's objectives and its relationship to the end users of a RE. It also clearly defines how can CREM add value to office employees. The studies provide the answer without linking it yet to the smart office concept. Further study aims at linking CREM's goals to the smart technology (IoT) a smart office.

The existing smart technologies implemented within offices can be divided into display devices for end users (mobile application, interactive screens) and those for CREM (servers which gather historical data, automatized BMS). Mobile applications and informative screens in an office space add value to office employees, whereas various dashboards are intended to add value to CREM by giving CREM an insight into data related to the building performance and its usage and/or exploitation. The case study research aims at exploring implemented smart technologies, learning specific application functionalities/features and data which in practice (within 5 case studies) add value to office end users and CREM.

There is very little knowledge available about the process of IoT implementation. In order to manage the IoT implementation initiative which adds value to office employees it is important to recognize actors and their specific activities within the process and relationships between them. It is important since the IoT implementation process requires multiple actors cooperation. Naming just the process phases and actors, without linking them is not sufficient.

Learning further about relevant issues which can be encountered during the IoT implementation initiative is going to enrich the analysed barriers and present solutions which ensure their overcoming.

The goal of creating the knowledge basis was to explain relevant to the research topics and define relationships between them, so that they can be validated and supplemented with the knowledge gathered via case studies.

After analysing the available literature, researcher has decided to supplement the research by case studies approach. In order to learn the missing information the following elements are going to be researched per case: (1) project info, (2) end user involvement strategy, (3) barriers, (4) process overview (with highlighted moments when the end user perspective had been acknowledged), (5) technology overview, (6) access to data and (7) additional lessons learned.

PART IV
Case studies main findings

1. Case studies

Part III had addressed the knowledge basis. The knowledge basis presented relevant for the research themes: CREM, IoT implementation process and the concept of adding value to office employees due to smart technology (IoT) implementation. The goal of creating the knowledge basis was to define relationships between the research themes so that they can be validated and supplemented with the knowledge gathered via case studies. The literature reviews revelled themes which are not sufficiently covered and require further case studies research.

Following the previous section, the researcher aims at learning the following elements per case: (1) project info, (2) end user involvement strategy, (3) barriers, (4) process overview (with highlighted moments when the end user perspective had been acknowledged), (5) technology overview, (6) access to data and (7) additional lessons learned. Paragraphs below briefly introduce the case studies findings, for more details the reads should see appendix D.

1.1. The CORE, CBRE, Amsterdam

Project info

The CORE is a new office building of CBRE. The building hosts only one tenant which functions as both, landlord and occupier. Internal drivers which had steered the development of the SRE are: supporting image, stimulating innovation, stimulating collaboration, supporting user activities and increasing user's satisfaction (see figure 18).

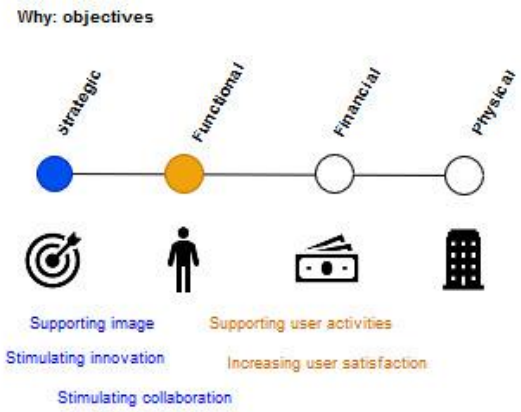

Figure 18 Why smart RE, The CORE; source: author

Technology overview

Application: adjusting temperature, adjusting lightening, desk occupancy status, room occupancy status, book a room, book a desk, colleague finding, communicate.

Data: desk occupancy, desk booking, rooms occupancy, rooms booking, application usage (planned).

Added value: stimulating collaboration, stimulating innovation, improving quality of space, supporting user activities, increasing user satisfaction, increasing flexibility, decreasing costs, increasing RE value, reducing footprint (m2).

Process overview

Figure 19 presents the steps taken within the process of the CORE development. For more details please see appendix D.

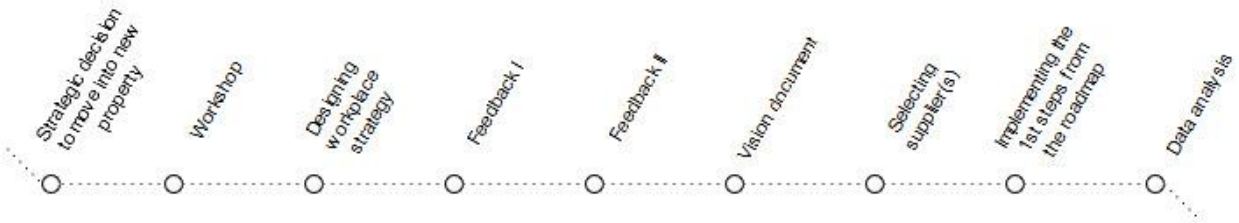

Figure 19 Process overview, the CORE; source: author, based on (Stam, 2019)

1.2. The Outlook, Schiphol & Microsoft, Amsterdam

Project info

The Outlook building is an asset within Schiphol Real Estate portfolio. The Outlook is the first smart building developed within 'smart airport city'. Microsoft had been a very important tenant for Schiphol while Schiphol aimed at developing 'smart airport city' (on the whole campus) in order to remain competitive and attractive. This factor in combination with Microsoft's profile (tech company) let to an ambition of developing '*the smartest building in Europe'*. (van der Ven W. , 2019) The main objectives which had steered the development of SRE are summarized in figure 20.

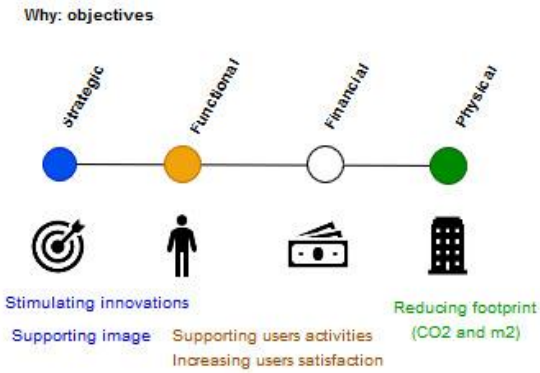

Figure 20 Why Smart RE, Outlook; source: author

Technology overview

Application: Adjusting temperature, adjusting lightening, desk occupancy status, room occupancy status, localizing employees, parking overview.

Data: information about the building performance, indoor climate, air quality, heatmaps of occupancy, noise level, people flow through the building, wayfinding, anonymized occupancy data, no-shows (booking data + occupancy).

Added value: all values from the framework introduced in 'part III knowledge basis'.

Process overview

Figure 21 presents the steps taken within the process of the Outlook office development. For more details please see appendix D.

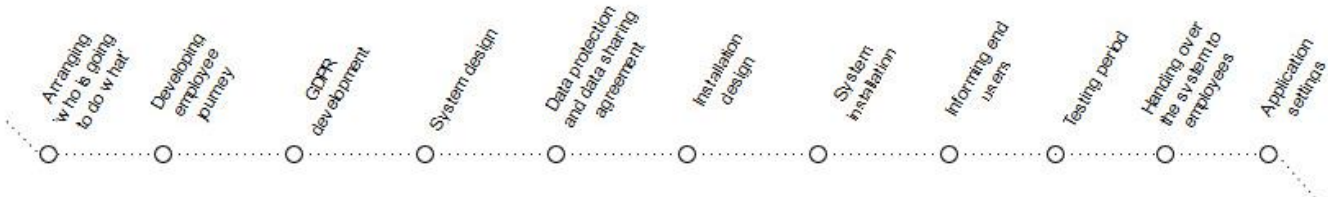

Figure 21 Process overview, the Outlook; source: author, based on (La Grouw , 2019) (van der Ven W. , 2019)

1.3. The EDGE, Deloitte, Amsterdam

Project info

The EDGE is Deloitte's office located at Zuidas in Amsterdam. The building was developed by OVG RE, is managed by CBRE and occupied (leased) primarily by Deloitte. The IoT is recognized as the foundational principle of the EDGE. (Jalia, Bakker, & Ramage, 2019) The main objectives which had steered the development of SRE are summarized in figure 22.

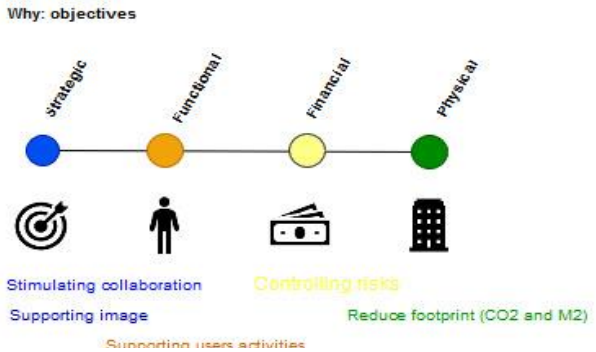

Figure 22 Why smart RE, the EDGE; source: author

Technology overview

Application: adjusting temperature, adjusting lightening, desk occupancy status, room occupancy status, no-shows (unoccupied booked space), booking a room, localizing employees, elevator synchronization, parking overview.

Data: desks occupancy, rooms occupancy, no-shows (booking data + occupancy), hallway occupancy, heatmaps, gym occupancy, cafeteria occupancy, energy performance and post processing for energy analysis, building usage monitoring for FM, installation monitoring for TM.

Added value: supporting user activities, increasing user satisfaction (the interviewee did not sent the interview appendage bac therefore more added values were not identified on the basis of the interview).

Process overview

Figure 23 presents the steps taken within the process of the EDGE office development. For more details please see appendix D.

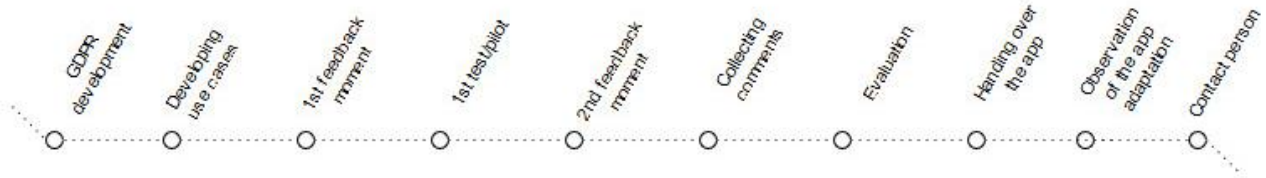

Figure 23 Process overview, the EDGE; source: author, based on (Halstead, 2019)

1.4. EDGE Olympic, EDGE Technologies, Amsterdam

Project info

EDGE Technologies is a development company which believes that *'the world needs better buildings'*. In line with that principle the company has created the innovative, healthy and sustainable office building – EDGE Olympic. (EDGE Technologies, 2019a) EDGE Olympic incorporates in its design a digital structure, which connects people and things (IoT) to a cloud platform. The main objectives which has steered the development of the SRE are summarized in figure 24.

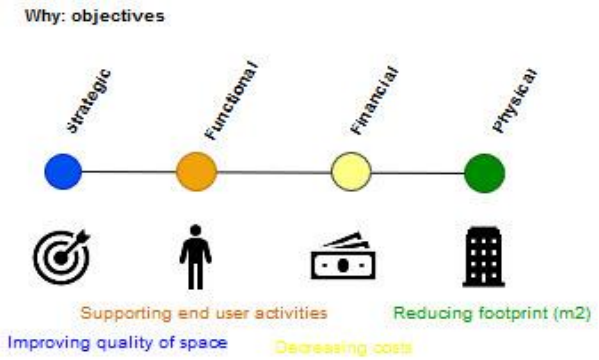

Figure 24 Why smart RE, EDGE Olympic; source: author

Technology overview

Application: adjusting temperature, adjusting lightening, desk occupancy status, room occupancy status, booking a room, localizing employees, vecos lockers, parking overview, garage access control.

Data: energy performance, installations control, HVAC performance, ambient data (temperature, CO2, air quality), heatmaps of occupancy, noise level, application usage, room usage statistics, desk usage statistics.

Added value: supporting user activities, increasing user satisfaction (the interviewee did not sent the interview appendage bac therefore more added values were not identified on the basis of the interview).

Process overview

Figure 25 presents the steps taken within the process of the EDGE office development. For more details please see appendix D.

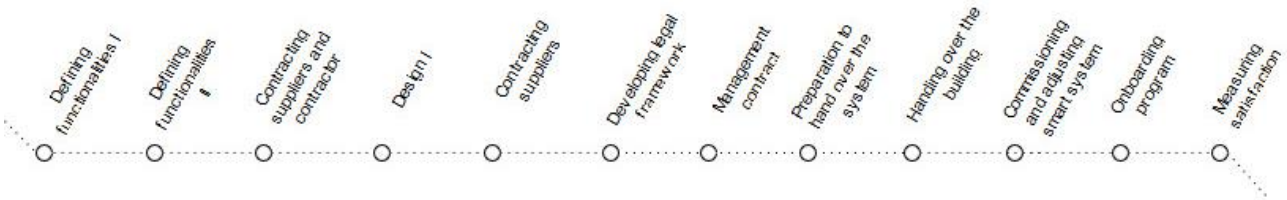

Figure 25 Process overview, EDGE Olympic; source: author, based on (Gritti, 2019)

1.5. ECORYS, ECORYS, Rotterdam

Project info

ECORYS office is located in Rotterdam at Watermanweg 44 in a multitenant office building. In 2016 the company had decided to move their office from the first three floors to the three top floors. While designing the concept of the new office, the moving committee had recognized the need for a software which would help employees during their day at work. The moving committee has selected the Floorplanner software. (van der Ven F. , 2019). The main objectives which has steered the development of the SRE are summarized in figure 26.

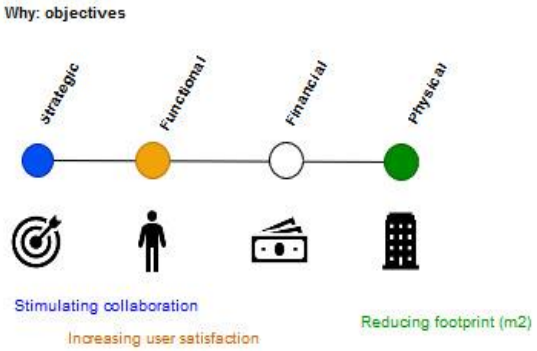

Figure 26 Why smart RE, ECORYS; source: author

Technology overview

Application (interactive screen): adjusting temperature, desk occupancy status, booking a room, rooms occupancy status, localizing employees.

Data: Occupancy data (real-time), colleague location (real time).

Added value: supporting user activities, increasing user satisfaction (the interviewee did not sent the interview appendage bac therefore more added values were not identified on the basis of the interview).

Process overview

Figure 27 presents the steps taken within the process of ECORYS office development. For more details please see appendix D.

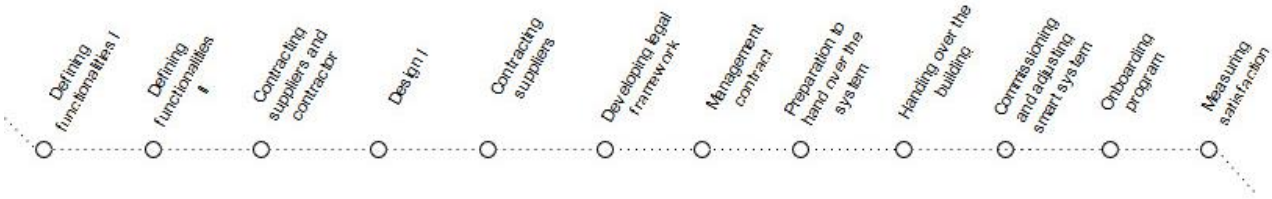

Figure 27 Process overview, ECORYS; source: author, based on (van der Ven F. , 2019)

PART V
Analysis

Analysis

The following section analyses the knowledge gathered through mixed research methodology. The analysis answer the three research objectives, which provide the answer the main research question. In the text below, author evaluates case study findings (see part IV and appendix D) and confronts them with the literature study (see part III 'knowledge basis') in order to validate and/or supplement the findings.

1. Smart technology and the added value

The focus of this research had been at first primarily given to an objective of adding value to office end users, nevertheless while conducting further study the researcher had noticed that the smart technology can also add a great value to other stakeholders. In line with this finding, the research scope related to the 3rd research objective had been modified. As a result of fulfilling the updated 3rd research objective, the paper presents broader framework which links the smart technology with all the elements from 'adding value framework'.

The goal of presented below analysis is to combine the input provided by interviewees with performed literature study so that the findings related to adding value to end users due to smart technology implementation can be generalized. The researcher also aimed at learning about the remaining framework elements, however only two interviewees had sent the in-dept interview appendage back. The paragraphs below describe added value per application functionalities and per data analysis (the distinction is made into two types of smart technology: application functionalities, data analysis). The overview of information discussed below can be also found in appendix E 'adding value via smart technology implementation'.

1.1. Analysis: application features and the added value

Application functionalities/features

The following section aims at recognizing the application features/functionalities and defining their added value to office end users and CREM. Multiple application functionalities had been recognized within literature review and 5 case studies (for more details see appendix F). Those are grouped into the following categories (each category lists relevant application features):

- Ambient control
    - Adjusting temperature
    - Adjusting lightening
- Real time occupancy data
    - Desk status (free/occupied/booked)
    - Room status (free/occupied/booked)
    - No-show communicates
- Booking workspaces
    - Book a room
    - Book a desk
- Collaboration features
    - Localizing employees/colleague finding
    - Communicate (chats/vide calls)
- Additional services
    - Elevator synchronization (with end user location, after request)
    - Parking overview (plots occupancy and wayfinding)
    - Smart lockers (lockers occupancy and wayfinding)

As stated before, an mobile application is a key remote device for an office employee to his working environment. The findings of the analysis are systematized in figure 28.

Application features and their added value

The 1st and most common application functionality is ambient control. The application feature combines 'temperature and lightening adjusting' functionality. Literature states that organizational culture can steer the engagement of an employee through enabling him/her to self-regulate his/her working indoor conditions (Ratcliffe, Saurin, Paybaraud, & Kristensen, 2009). The act of empowering employees through self-regulation strengthen the (if applicable) organization culture and enhance employees' engagement which can lead to higher employee retention, higher productivity, and better employees' health (Borghero, 2018). In principle, developing the SRE with such system, supports an image of companies which aim at being a frontrunner on the RE up-to-date market (see: Microsoft's ambitions as a tech company, CBRE goal to develop a showcase) (van der Ven W. , 2019) (Stam, 2019). Implementing a feature which allows office employees to align their indoor working conditions with their preferences indirectly improves the perceived quality of space and supports office employees' activities by providing them with appropriate temperature and light intensity (van der Ven W. , 2019) (Stam, 2019), and finally increases their satisfaction out of the workplace (Borghero, 2018) (Halstead, 2019) (Gritti, 2019) (van der Ven F. , 2019).

Ambient control added value: supporting culture, supporting image, improving quality of space, supporting user activities, increasing satisfaction.

Acknowledging office employees about real-time occupancy data (both rooms and desks status) can bring great benefits, as it strongly supports office employees' activities. Learning the real-time occupancy data help an employee to localize a desired workspace therefore the employee can be efficient and avoid hassles (Acoba, Charaya, James, & Rahalkar, 2018) (Stam, 2019) (Halstead, 2019) (Gritti, 2019) (van der Ven F. , 2019). The feature in combination with booking system has a direct impact on the goal of increasing office employee satisfaction level (Stam, 2019) (Stam, 2019) and improving quality of space (van der Ven F. , 2019). In addition to that, the room occupancy status display contributes to the objective of stimulating collaboration, since it enables office employees to reserve/use a space for teamwork (van der Ven W. , 2019) (Stam, 2019).

Last but not least, the real-time occupancy data provision to end users strongly support culture and image of Flex offices. The flexible office spaces at the same time gain added values such as increasing flexibility, reducing footprint and decreasing costs due to space usage optimization (m2) which means that the smart technology which displays real-time occupancy data is indirectly linked to more objectives of CREM (van der Ven W. , 2019).

Real-time occupancy data added value: stimulating collaboration, supporting culture (flex), supporting image (flex), improving quality of space, supporting user activities, increasing user satisfaction, reducing footprint (m2), increasing flexibility (flex), decreasing costs (flex).

In line with the in-depth interview appendages the functionality of booking a room 'scores' more added value then booking a desk. It can be caused by the fact the 'booking desk' functionality had been recognized only at the CORE.

The 'booking workspace' features strongly support image and culture within vibrant Flex office environments (van der Ven W. , 2019). Implementation of those features at Flex office spaces can be also linked to the strategic goal recognized within the literature study as 'enhancing workplace experience' (Charaya, Senguputa , & Tare, 2018). Furthermore the functionality in combination with the Flex office concept leads to increased portfolio flexibility (van der Ven W. , 2019), decreased costs and footprint due to space optimization (m2) (Stam, 2019) (van der Ven W. , 2019).

In fact both booking space features strongly support office employees' activities which had been clearly indicated by all interviewees and literature studies (Charaya, Senguputa , & Tare, 2018) (Stam, 2019) (Halstead, 2019) (Gritti, 2019) (van der Ven F. , 2019) (van der Ven W. , 2019). The interviewees also had indicated that the app functionalities indirectly increase users satisfaction, because the end users can make sure that they can occupy workspace which matches their preferences and needs (Mehl, 2018) (Stam, 2019) (van der Ven F. , 2019). Just as in case of real-time

occupancy data, the opportunity of booking a room indirectly stimulates teams collaboration (Mehl, 2018) (Stam, 2019) (van der Ven W. , 2019).

Booking workspaces added value: stimulating collaboration, supporting user activities, increasing user satisfaction, supporting culture (flex), supporting image (flex), reducing footprint (m2), increasing flexibility (flex), decreasing costs (flex).

The collaboration features are expressed in an application by two functionalities: (1) localizing employees/colleague finding and (2) communication platform. Both of them add value due to stimulating employees' collaboration (Mehl, 2018) (Ratcliffe, Saurin, Paybaraud, & Kristensen, 2009) (Charaya, Senguputa , & Tare, 2018) (Stam, 2019) and supporting their working activities - teamwork (Acoba, Charaya, James, & Rahalkar, 2018) (Stam, 2019). Both findings are strongly supported by the literature. Additionally Borgero (2018) explains that through communication (also for instance with FM while reporting broken facilities) end user's engagement is enhanced which has a positive impact on their satisfaction level. The geolocation feature (localizing employees/colleague findings) strongly supports culture of Flex offices and organizations which emphasize teamwork (van der Ven W. , 2019). The feature is closely linked to real-time occupancy data, which can help CREM to increase RE portfolio flexibility (van der Ven W. , 2019).

Collaboration features added value: stimulating collaboration, supporting user activities, increasing user satisfaction, increasing flexibility (flex).

Listed additional functionalities are very often unique per case study. That means that the researcher cannot generalize those findings. Nevertheless the gathered information is still included in figure 28 since it presents implemented smart solutions within investigated case studies.

The elevator synchronization functionality enable EDGE's end users to recognize the elevator position and request it through an app. That do not only supports the Deloitte's

Perspective	#NAME? Perceived added value	Application functionality: Adjusting temperature	Adjusting lightening	Desk status (free/occupied /booked)	Room status (free/occupied /booked)	Book a room	Book a desk	Localizing employees/ colleague finding	Elevator synchronization	Communicate	Parking overview	Smart lockers
Strategic	Stimulating collaboration	☐	☐	☐	☑	☑	☐	☑	☐	☑	☐	☐
	Stimulating innovation	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Supporting culture	☑	☑	☑	☑	☑	☑	☑	☐	☐	☑	☐
	Supporting image	☑	☑	☑	☑	☑	☑	☐	☑	☐	☐	☐
	Improving quality of space	☑	☑	☑	☑	☐	☐	☐	☐	☐	☐	☐
Functional	Supporting user activities	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
	Increasing user satisfaction	☑	☑	☑	☑	☑	☑	☐	☐	☑	☑	☑
	Increasing flexibility	☐	☐	☑	☑	☑	☐	☑	☐	☐	☐	☐
Financial	Decreasing costs	☐	☐	☐	☐	☑	☐	☐	☐	☐	☑	☐
	Increasing real estate value	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Controlling risks	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Technical	Reducing footprint (m2)	☐	☐	☑	☑	☑	☐	☐	☐	☐	☑	☐
	Reducing footprint (CO2)	☐	☐	☐	☐	☑	☐	☐	☐	☐	☑	☐

Figure 28 Application features/functionality and the added value; source: author, based on analysis

image (occupier of the smart RE), but also supports employees daily activities (Halstead, 2019). The smart lockers had been only implemented within EDGE Olympic, but literature confirms that the smart lockers implementation aims at supporting office employees' activities (Driedger, 2019) (Gritti, 2019). At the EDGE Olympic the functionality increases office employees' satisfaction out of their office space (Gritti, 2019). Finally, the parking overview functionality for the Outlook office brings an added value in many ways: it supports the culture of Microsoft (tech company, office tenant), supports employees' activities, indirectly increases their satisfaction and decreases operational costs as well as reduces footprint (van der Ven F. , 2019).

Additional functionalities added value: supporting image, supporting culture, supporting user activities, increasing user satisfaction, decreasing costs, recusing footprint (m2 & CO2).

1.2. Analysis: data and the added value

Many of the described previously features can be in a way defined as tools which help CREM to gather and analyse data. This data provides CREM further with valuable insight, which helps to make decisions related to the RE portfolio (Charaya, Senguputa , & Tare, 2018).

Collected data

The research shows that CRE managers collect and analyse data in order to further improve their RE portfolio. The smart technology which allows CREM to collect and analyse data are servers which store data, various Building Information System (BMS) and Facility Management Information System (FMIS). Information provided to those systems is called 'data'. The data is gathered via various ST when the RE is occupied by office employees.

It is important to acknowledge that gathering data and networking things does not add value itself. The information (data) creates value only when it is positively influencing future decision-making and actions (Thomas, Devan, & Khan, 2018). In line with the smart tools definition, CREM can extract various collected data in order to make sound decisions related to the REM which can bring benefits/add value to REM and an organization (Riratanaphon & van der Voordt, 2015) (Arata III & Hale, 2018). The analysis do not present a direct added value. Instead the analysis indicate how certain data gives CREM an opportunity to add specific value.

Majority of real-time data provided via a mobile application add value to end users. In principle, CREM from its four perspectives, is more interested in historical data analysis over the real-time data since their goal is to align the RE portfolio with current and future demand. Historical data analysis can provide a clear information to CREM which supports their decision-making (see process design: feedback loop from data to CREM).

The vast amount of recognized data and its added value is presented in figure 29. The researcher groups the data into three categories (consistently with the process design elements presented in figure 29) and lists specifically what do the categories consist of. The data are mainly understood as historical collected data unless indicated otherwise. The recognized data are:

- Application usage
    - Application usage (features recognition)
- Workplace
    - Desk occupancy
    - Room occupancy
    - No-shows: booking data + occupancy
    - Desk booking
    - Room booking
    - Noise level (heatmaps)
- Building performance
    - Energy performance
    - Building usage monitoring for FM

    - Installation monitoring for technical management
    - Indoor climate, air quality
- Additional occupancy data
    - Hallway occupancy (heatmaps)
    - Gym occupancy
    - Cafeteria occupancy
    - People flow through the building (incl. wayfinding)

The analysis below explains the recognized added value per data group (see above). More detailed information per data itself are indicated in table 22 and appendix E.

Data collection and analysis added value

Smart technologies give an opportunity to gain enormous insight into the workplace occupancy (incl. workplace booking data) (Charaya, Senguputa , & Tare, 2018). When combined, all of the previously listed workplace data (according to the interviewees and literature) fulfil every added value from the framework. The development of SRE in general and enabling a tenant to gain data insight in principle increases RE value. In that sense, almost every point on the horizontal line of figure 29 can be linked to this objective.

Developing SRE general added value: stimulating innovation, increasing RE value.

Workplace booking and occupancy data (incl. no-shows) gives an indication of current demand of space which indirectly increases RE portfolio flexibility, controls risk of vacancy and if possible (due to space optimization) reduces costs and footprint (van der Ven W. , 2019) (van der Ven F. , 2019) (Charaya, Senguputa , & Tare, 2018). Improving the RE portfolio due to data insight directly corresponds with improving quality of space and improving end user satisfaction. The end user satisfaction can also be indirectly caused by provision of workplace which fully supports users' activities. (van der Ven W. , 2019) In that sense, due to space improvements based on historical data insight CREM can add value to multiple stakeholders. In case of Flex offices, all the historical data can further support organizational image and/or culture (van der Ven W. , 2019). Additional occupancy data reflects the added value defined for workplace occupancy data category (for more details see figure 29). Even stimulating collaboration had been marked as an value. It can be recognized whether the collaboration is stimulated due to learning about noise levels within spaces (van der Ven W. , 2019).

Workplace occupancy and booking data possible added value: increasing flexibility, controlling risks, reducing footprint (m2), improving quality of space, increasing user satisfaction, supporting user activities, supporting culture (flex), supporting image (flex), stimulating collaboration.

The interviewees had linked the building performance data to the stimulating innovation value. In fact the development of SRE is perceived by them as an innovation itself (van der Ven W. , 2019) (Stam, 2019). Not every RE can respond to real-time building performance data (which is also known as building automatization), that is why it is important to analyze historical information about the building performance. The analysis can help to make sound decisions which can lead to an improvement of quality of space and building performance (Charaya, Senguputa , & Tare, 2018) (van der Ven W. , 2019) (Lunn & Stephenson, 2000) (Driedger, 2019), decreasing costs (Stam, 2019) (van der Ven F. , 2019), controlling risks (van der Ven W. , 2019) and in the end reducing footprint (CO2) (van der Ven W. , 2019). While published and handed over to the end users, the data analysis can promote strong environmental ethics (Ratcliffe, Saurin, Paybaraud, & Kristensen, 2009) therefore support an organizational image and culture.

Energy performance data possible added value: improving quality of space, decreasing costs, controlling risks, reducing footprint (CO2), supporting image (sustainability), supporting culture (sustainability).

Finally, according to van der Ven W. (2019) the data about application usage can give an indication of office employees satisfaction level with the office space and office working conditions. For instance Gritti (2019) - an interviewee from EDGE Olympic - states that using too much of the 'ambient control' functionality indirectly indicated that the end user is not satisfied with the indoor working environment and the HVAC system setup should be adjusted. Those patterns can be only visible while analysing anonymized historical data gathered through longer period of time.

Application usage data possible added value: increasing user satisfaction.

		Data collection and analysis																		
Perspective	Perceived added value	Workspace: desk occupancy	Workspace: rooms occupancy	No-shows: booking data + occupancy	Workspace: desk booking	Workspace: rooms booking	Application usage	Hallway occupancy, heatmaps	Gym occupancy	Cafeteria occupancy (time)	Energy performance	Building usage monitoring for FM	Installation monitoring for technical management	Noise level - heatmaps of occupancy	People flow through the building, way finding	Indoor climate, air quality
Strategic	Stimulating collaboration	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☑	☑	☐
	Stimulating innovation	☑	☑	☐	☐	☐	☐	☐	☐	☐	☑	☑	☑	☑	☑	☑
	Supporting culture	☑	☑	☑	☐	☐	☐	☑	☑	☑	☐	☐	☐	☐	☐	☐
	Supporting image	☑	☑	☑	☑	☑	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Improving quality of space	☑	☑	☑	☑	☑	☐	☐	☑	☑	☑	☑	☑	☐	☐	☑
Functional	Supporting user activities	☑	☑	☑	☑	☐	☐	☑	☑	☑	☐	☐	☐	☑	☑	☐
	Increasing user satisfaction	☑	☑	☑	☑	☑	☑	☑	☑	☑	☐	☑	☐	☑	☑	☑
	Increasing flexibility	☑	☑	☑	☑	☑	☐	☑	☑	☑	☐	☐	☐	☐	☐	☐
Financial	Decreasing costs	☑	☑	☑	☑	☑	☐	☑	☑	☑	☑	☑	☐	☐	☐	☐
	Increasing real estate value	☑	☑	☑	☑	☑	☐	☑	☑	☑	☐	☑	☐	☑	☑	☐
	Controlling risks	☑	☑	☑	☑	☑	☐	☐	☐	☐	☑	☑	☑	☐	☑	☐
Technical	Reducing footprint (m2)	☐	☐	☐	☐	☑	☐	☐	☐	☐	☑	☐	☑	☐	☐	☑
	Reducing footpring (CO_2)	☑	☑	☑	☑	☑	☐	☑	☑	☑	☐	☑	☐	☐	☐	☐

Figure 29 Data and the added value; source: author, based on analysis

1.3. Conclusion

The smart technology implemented at office in order to add value to office employees is in general a mobile application. The mobile application can consist of various functionalities. Those are:

- Ambient control: adjusting temperature, adjusting lightening
- Real time occupancy data: desk status (free/occupied/booked), room status (free/occupied/booked), no-show communicates
- Booking workspaces: book a room, book a desk
- Collaboration features: localizing employees/colleague finding, communicate (chats/vide calls)
- Additional services: elevator synchronization (with end user location, after request), parking overview (plots occupancy and wayfinding), smart lockers (lockers occupancy and wayfinding)

Each application functionality supports office employee's activities and increases their satisfaction. Additionally some functionalities add remaining values from the 'adding value framework' (for more details see previously discussed section 1.1. Application features and the added value).

The smart technology which allows CREM to collect and analyse data are servers which store data, various Building Information System (BMS) and Facility Management Information System (FMIS). The data is gathered via various ST when the RE is occupied by office employees. The analysis show that it is difficult to name a direct added value of specific database extracted due to smart technology implementation. In fact, the analysis indicate how certain data gives CREM an opportunity to add specific value.

The smart technology analysis defined in the previous section are an input to the 'smart tools container' placed within the strategy & planning phase in the 'employee-oriented IoT implementation process'.

2. IoT implementation process

As explained before, the guideline content responds to the research objectives. Research objectives had been clarified and explained on the basis of strategic approach components. Following the definition of the guideline (see section 'guideline', p. 41) the advice to CREM should consist of '*sketch of smart technology implementation process which acknowledges end users and includes barriers which have to be overcome'*. The findings from literature related to the process are described in section '2. IoT implementation process' (p.51), the findings related to the process design are summarized in section 'case studies main findings' (see part IV) and 'process overview' (see appendix D).

In order to shape an employee-oriented IoT implementation process it is necessary to clarify the process of a smart technology implementation. Paragraphs below present first analysis of gathered information related to the IoT implementation process. The comprehensive analysis are combined in order to present the clear description of the IoT implementation process (section '1.3. Process design). The findings are being translated into the process design (see figures 31 and 32).The process design is going to be further evaluated and if necessary modified in the discussion section (see part VI 'conclusion & discussion').

2.1. Process: actors & responsibilities

Within this section actors and their responsibilities in the process are recognized and analysed. The starting point of this analysis is the framework created in the section '3.2. actors and their

responsibilities' in part III. The table below (table 9) summarizes the findings concluded in the part III 'knowledge basis'. The information gathered in the table below is being further confronted with case studies' findings related to the processes overview (see appendix D).

Role	Responsibility
Organization (board)	- Evaluating opportunities and threats related to the IoT & operational challenges - Investment decision
CREM	- REM - IoT implementation (strategic decision) & evaluating operational challenges - Data analysis; adding value from four perspectives due to data analyses - Collaborative decision-making with end users - Investment decision
FM	- Improving health, satisfaction, productivity of office employees - Workplace provision and its flexibility - Gaining strategic importance - Steering IoT implementation; bridging people and smart technology - Data analysis - Raising up awareness of end users
IT	- Security of sensors input/data - Strong collaboration with other stakeholders - Budget allocation
HR	- Collaboration with teams which sketch user profile and define users' needs - Communication with end user

Table 9 Knowledge basis: actors and their responsibilities; source: author

Strategy & Planning: strategy

One of the first steps of a process was indicated in the interview related to the CORE development (CBRE office). While shaping the organizational strategy, the organizational board took care of recognizing their current supply (their portfolio and its condition), organizational goals, and their RE alignment to the current and future organizational demand. The activity had been taken by the organizational board. (Stam, 2019) Similar starting point had been recognized at ECORYS (van der Ven F. , 2019). The remaining three out of five case studies do not clearly specify the activities taken at the very beginning of the process (on the organizational level). Instead the interviewees mainly started their process description with an overview of activities which contributed to creation of a RE strategy (not organizational strategy) development.

The CREM's activities start with the FM expertise on current space supply and defining necessary changes related to it (defining desired space functionalities). The step had been observed at ECORYS, where the FM is recognized to be the strategic actor involved in the so called 'moving committee' (van der Ven F. , 2019) and at the CORE. The role of FM at the CORE had been taken over by Workplace Strategies department (WPS), however the interviewee indicated that FM had to give a feedback on designed by WPS, workplace strategy (Stam, 2019). Additionally within the development of these two offices (ECORY and the CORE), HR had been recognized to be a discussion partner, which creates so called end user(s) profile. The end user profile specifies for instance office employees working activities, their needs and preferences related to the space. According to the literature, HR should also ensure a proper communication with the end users (see table 9). The input provided by HR contributes therefore to the development of workplace strategy, and indirectly to the further development of RE strategy (by CREM).

At this point it is important to specify how do the organizational strategy and RE strategy come together. Unfortunately none source explains it in details, nevertheless the decisions taken by CREM had to be approved by the board. The findings had been clearly sketched within the process of ECORYS office development (van der Ven F. , 2019). Furthermore, CREM has to shape the RE strategy in line with organizational goals in order to ensure the proper alignment of RE to the organizational activities (de Jonge H. , et al., 2009). Only then, the decision whether to develop a SRE or not, can be taken. The decision is evaluated on the basis of both strategies -organizational and RE strategy (see table 9).

The last significant step recognized within the early stages of RE strategy making (within the strategy & planning phase) is developing an user journey (also called an use case or an employee journey). The user journey is a method used to describe and visualize a series of steps which express scenarios where end user interacts with the smart office. The step had been performed and emphasised within 3 cases studies – EDGE, Outlook, EDGE Olympic (Halstead, 2019) (van der Ven W. , 2019) (La Grouw , 2019) (Gritti, 2019). In practice the step allows multiple actors to recognize and acknowledge end user's perspective on the planned (to be develop) RE (incl. the IoT design). Within the process, the findings of this user journey creation, organizational strategy and RE strategy objectives are combined in the SRE specifications document.

Strategy & Planning: planning

When the SRE specifications are defined, it is time to select proper smart tools which can support the well-thought RE concept. Two case studies (Outlook and EDGE Olympic) indicate that in order to sketch an integrated system design it is important to specify three components: hardware (sensors), software (mobile application) and backbone (BMS) (for more details see appendix D, process overview).

In case of the CORE development, the budget had been blindly assigned by the organizational board at the beginning of the process (Stam, 2019). Contrary to that, the literature suggests that the main actor responsible for budget allocation is the IT department (Charaya, Senguputa , & Tare, 2018). In fact the evaluation of the CORE development process indicates that the budget allocation should be supported by the IT department expertise (Stam, 2019). The practice at ECORYS also says a lot about budget estimation at the beginning of the process (within planning phase). At ECORES the 1st proposal of the new office development consisted of system and installations design as well as budget estimation. The proposal had been made by the moving committee which also included an actor from IT. (van der Ven F. , 2019) In the end, the only relevant actor which is able to consciously recognize costs related to a general system integration and budget estimation is the IT department/group. At this point suppliers do not join the process yet. They are only hired while the general vision of SRE is shaped and when the budget is allocated, that is why they cannot contribute to the process at this moment. First the business case feasibility has to be evaluated by an organizational board. (van der Ven F. , 2019) Otherwise hiring external suppliers would mean more expanses to the organization and/or CREM.

The next two significant moments indicated by the interviewees are: creation of data sharing agreement (Outlook, EDGE Olympic) and shaping a vision document (the CORE). Both activities can be combined into a roadmap document which positions necessary actions within a timeframe (Stam, 2019) and specify access to data for various interested parties. The roadmap content should respond to previously defined organization goals (expressed in organizational strategy and RE strategy) and intended data analysis as well as step-by-step plan of the systems integration within time. Practice shows that a document with similar content had been created by dedicated in-house team at CBRE and EDGE Technologies, however there was also a room for hiring external advisors (for instance legal advisor -data sharing agreement- or experienced specialized team -roadmap) which could provide the document. The party is named in the process as "SMART team'. The so called 'SMART team' should consist of CREM members (incl. FM). Only then CREM (incl. FM) can fulfil the tasks specified in table 9: appointing data for further data analysis, steering the IoT implementation initiative.

The strategy & planning phase is completed when the final design of SRE is created. La Grouw (2019) while explaining the Outlook development process, indicated that there are multiple similarities between the usual project development process and SRE development process. Following the usual project development process, the document which steers the design is a smart building brief. The Outlook case study shows however, that smart installation design provided by suppliers is a step within the process which proceeds the deployment phase (van der Ven W. , 2019) (La Grouw , 2019). For this reason figure 31 presents the design as a fusion of smart building brief and smart installation brief.

Deployment

The deployment phase itself is not widely covered within this research. The implementation of the design consists of many technical steps which are based on project planning and specific project design. Many interviewees (except of Geert Stam – the CORE) have skipped this step and proceeded to the description of activities which follow the project 'handing over' (for more details see appendix D, processes overviews).

The moment of handing over a SRE differs from the traditional RE development process. In the traditional RE development process only the building is handed over, while in the SRE development process there are in fact three components, which are being completed and transferred to the end users and CREM. The components are: the building itself, the privacy policy and the application manual (see appendix D, cases: Outlook, EDGE Olympic). At the moment when the SRE starts to be occupied, the 1st system testing have to take place in order to ensure its proper functioning (van der Ven W. , 2019).

The data which can be gathered during system testing (1st and permanent testing) can indirectly give feedback on the IoT system performance, building performance and the building and/or application adaptation. The direct user feedback can have a form of a survey which measures user satisfaction with the implemented smart system (as it took place at the EDGE Olympic or at the ECORYS). Learning the direct feedback can be assigned to FM's activities (bridging people and smart technology, see table 9), the marketing committee responsibilities (see appendix D, ECORYS case) or an external party (see appendix D, EDGE Olympic case). The results of data analysis and direct users' feedback are performed in order enable CREM to properly manage RE (Stam, 2019), involve end users in the process, evaluate operational challenges and add value from four CREM's perspectives (see table 9, CREM's responsibilities).

At the EDGE Olympic the 'testing' step is repetitive (Gritti, 2019). The interviewee at first had named the 'testing' as 'commissioning and further improving the smart solution'. The 1st and permanent/repetitive testing is important in order to strive for the SRE improvement. The permanent testing activity falls under the operational support phase. The constant data analysis gives and opportunity to indicate whether the system is compliant with initial SR specifications and whether the SRE design requires any changes.

Operational support

Finally there come activities which are performed during the operational support phase. As explained above the continuous testing and data analysis should be perceived as a constant repetitive process performed while the building is occupied (in the operational support phase).

The literature states that the FM is responsible, within the initiative phase, for raising up awareness of end users and bridging technology and people (see section 'facility manager', p. 54). In practice those responsibilities had been outsourced to an external party – application provider – and/or special team (involved in the onboarding program) which is represented by a contact person. Two cases (Outlook and EDGE Olympic) have the same application provider. The application provider organized for both tenants an onboarding program which consists of: lectures, tutoring and an appointed contact person. Thanks to the onboarding program end users can better learn and understand the implemented smart systems. (van der Ven W. , 2019) (Gritti, 2019) (La Grouw , 2019) There is also a contact person appointed at the EDHE. The contact person there gives the end users an opportunity to address a direct feedback related to the IoT/smart system (Halstead, 2019). Ideally the onboarding program should be permanent because there is a high possibility of office employees joining and leaving the company/occupied office therefore the process of raising up the awareness has to be constant (Gritti, 2019).

2.2. Process: barriers

In order to recognize barriers, author had combined findings from literature study and case studies (interviews and desk research). The overview of barriers is presented in the table 10. The case studies findings are summarized in appendix D, each case description consists of paragraphs which elaborate upon relevant barriers/challenges recognized by the interviewees and process overviews. Linking those two components allows to specify steps which have to take place within the process in order to overcome the barriers. The steps are implemented within the IoT implementation process design.

Phase	Barrier	Literature	CBRE	ECORYS	Outlook	EDGE	EDGE Olympic
Strategy & Planning	Lack of strategic vision	X					
	Privacy concerns	X			X	X	
	Internal communication		X				
	Role division: actor's responsibilities		X				
Deployment	Technical issues	X		X			X
	Application quality (adaptation requirements)	X			X		X
	Control over privacy settings	X			X		X
	Communication with end users		X				
	Scaling up: handing over the application				X		X
Operational support	Data security	X			X		
	Role division: actor's responsibilities	X	X				
	Direct feedback: application usage data						X

Table 10 Employee-oriented IoT implementation initiative barriers; source: author

In table 10 the listed barriers are linked to specific project phases. Those are assigned on the basis of previously discussed phases characterises (see section 'process of IoT implementation', p. 52) and process diagrams of case studies (see part IV and/or appendix D). The goal of the analysis is to recognize steps within the process of smart technology implementation which have to be taken in order to overcome the barriers. The findings are summarized in table 10 and later on visualized in the process design presented on figure 31 and 32. The steps which have to be made in order to overcome specific barrier are marked by '*' and a number which responds to barriers recognized below.

Strategy & Planning

The main barrier indicated by the literature study, which occurs at the beginning of the process, is 'lack of strategic vision' (see section 'strategic barriers', p. 57). The researcher observes that none of the interviewees had indicated this problem. Instead all of them had presented clear organizational goals and RE strategy which together had steered smart technology (IoT) implementation initiative. The findings indicate the first two steps which have to be taken throughout the process in order to avoid this barrier (creating clear organizational and RE strategies).

Second important barrier in line with the previous research discussed in part III (knowledge basis) is 'privacy concerns'. In order to minimize the privacy concerns it is important to involve end users in the IoT implementation process. While investigating the case studies, the researcher sees that the issue had been taken into account by many actors, however not all of them had recognized it as a barrier. Microsoft & Schiphol (Outlook) and Deloitte (the EDGE) have dealt with it smoothly by developing a privacy policy and informing end users about it. In line with the privacy policy the office employees got an opportunity to modify their 'visibility settings' related to the IoT system via a mobile application (for more details see appendix D). At the same time, at the EDGE Olympic, office employees received an application manual and a privacy policy document via an email which intended to raise up their awareness and minimize privacy concerns (Gritti, 2019).

During the strategy and planning phase CBRE concludes that a big barrier for smart office development was an internal collaboration. The internal collaboration is strongly linked to the fact that for many actors the process is a challenge since there is no clear division of actor's responsibilities within the process and some roles can be easily missing on the job market. (Stam, 2019) In contrary, one of the first steps taken by Schiphol and Microsoft was 'defining actor's responsibilities' (La Grouw , 2019) (van der Ven W. , 2019). In order to avoid the issue faced by CBRE at the CORE, it is important to have a clear process and role's division overview. Last but not least the literature states that the issue can also appear during the operational support phase after the building is handed over and operated.

Deployment

Within the literature study technical issues are mainly related to installation and deployment of sensors (hardware). Within case study research, the technical barriers had been linked to the existing characteristics of current supply (the RE) which can block adaptation of certain IoT systems (van der Ven F. , 2019). The technical problems directly link to the importance of recognizing current supply before any modifications to it are planned.

The EDGE Technologies highlights the importance of an application and its adaptation (Gritti, 2019). EDGE Technologies is aware that the key to data collection and service adaptation lays down in hands of end users. In order to ensure a successful IoT implementation it is important to acknowledge barriers related to the application functionalities and its settings since the *'smartphone is the key and remote control for the building'* (EDGE Technologies, 2019a). The findings from EDGE, confirm the importance of an application quality and present the great effort which have been made in order to properly develop an application and hand it over to end users (Halstead, 2019). The experience gained at the EDGE and EDGE Olympic shows that in order to achieve full potential of a mobile application it is important to make following the steps within the process: develop user journey in order to learn end users' perspective, hand over an application manual to end users, request end users' feedback on the designed solution and perform an onboarding program. (Stam, 2019) (Gritti, 2019) (Halstead, 2019) The problems faced by the end users can be explored while developing an user journey (also called 'use case'). The outcome of user journey consists of indication of application functionalities which can support end users at a smart office. The findings complement SRE specifications by drawing the picture of desired IoT systems. (Halstead, 2019) The case studies findings confirm the requirements recognized by the literature: the smart technology should help to solve a problem, the result of the process of its implementation should be visible to an employee (see section '3.3. IoT in office employees' hands, p. 56).

The EDGE Technologies recognized the GDPR as a technical barrier. The interviewee indicated that any ST/IoT has to be compliant to the GDPR what sometimes can be a challenge, the challenge closely links to the 'control over privacy settings' barrier. (Gritti, 2019) The requirement for an opt-in application functionality puts a lot of pressure and responsibility on actors which are responsible for selection of IoT components and their integration (for instance IT, SMART team, CREM, organization). Following the issue of 'privacy concerns' and 'control over privacy settings' it is good to acknowledge the strategy of the Outlook development. The Outlook developers (Schiphol Re and Microsoft) took a close look on the challenge of *'getting the people to participate, without forcing them to do so'* (van der Ven W. , 2019). For that reason, the system had been strongly developed towards the opts of end users it means that, they can choose the level on which they are visible to the IoT system (for more details see appendix D). The implemented solution is directly enforced by developed (by Schiphol RE legal department) GDPR and data sharing agreement (between: Schiphol RE, Microsoft, suppliers chain). (van der Ven W. , 2019) (La Grouw , 2019) The big effort into GDPR development is also noticed at the EDGE. Deloitte (the EDGE tenant) is aware that the privacy concerns can have big impact on the IoT implementation initiative, that is why special effort have to be made in order to successfully hand over the mobile application (Halstead, 2019). Case studies research indicate that handing over an application manual can help to make end users aware about the application settings, the extend to which they can modify them which leads to overcoming the barrier of 'control over privacy settings'.

The solutions which help to minimize privacy concerns in practice are compliant with those proposed by Valks, Arkesteijn, & den Heijer (2018): complying with privacy law, giving end users a choice about which data do they share with an organization and/or CREM (personal data ownership), direct anonymization of data before it is analyzed (the case of Outlook), anonymous data collection due to choosing a technology which cannot recognize an individual (the case of the CORE).

Further barrier related to the application adaptation can occur in the later stage of the deployment phase while scaling up the solution and ensuring proper delivery of the SRE (incl. mobile application). Case studies research shows that many steps have to be taken throughout the process in order to ensure successful delivery of a SRE. Starting from the beginning, it is important to ensure proper integration of hardware (sensing tech.), software (application) and backbone (systems) so that the IoT solution can fulfil its objectives smoothly (La Grouw , 2019). Creating a comprehensive design and implementing it, should be followed by a testing period. The testing period can be observed at Outlook and EDGE Olympic. In both cases, the testing period had helped the actors to recognize system shortcomings and improve it (incl. application features) (Gritti, 2019) (van der Ven W. , 2019). Next, the IoT system has to be maintained, updated and if necessary modified. Hence it can be beneficial to perform the tests also during operational support phase, just as it is done at EDGE Olympic (Gritti, 2019). Finally when the IoT system is tested and commissioned, the company should establish an onboarding program. The onboarding program aims at raising employees' awareness about the SRE (EDGE Olympic) and establishing a contact person which can permanently be addressed with any feedback related to the RE and IoT system. (Gritti, 2019) Those steps help to gather the direct feedback on the basis of internal communication.

The internal communication recognized by CBRE during the strategy & planning phase, also touches upon the communication with the end users. The internal communication is perceived as a barrier in the deployment phase. (Stam, 2019) That is closely linked to the barriers: lack of the strategic vision, process steps, actor's responsibilities and facing technical issues. The complexity of SRE development makes it difficult to formulate a clear message to office employees therefore very often the communication with the end user does not occur. (Stam, 2019) The involvement of end users in the process have to be well-thought. In that sense, it is beneficial to establish feedback loops and a contact person within the IoT implementation process. (Gritti, 2019).

Operational support

Data security in its pure technical dimension depends mainly on a proper integration of multiple systems (backbone, hardware and software). The barrier is very specific and touches upon the IT practice. Nevertheless the barrier has to be also notified from the organizational and CREM's strategic point of view. Except of van der Ven (2019) none of the interviewees had named that specific barrier. While developing the Outlook it was crucial to ensure proper data security (van der Ven W. , 2019) therefore it is important to properly design the IoT system and create clear data sharing agreement.

When it comes to the app usage and the feedback related to it, EDGE Technologies does not have a control over the feedback adaptation. Data analysis of application usage is performed by an external provider (MapIQ) therefore it is difficult for EDGE Technologies to learn from it. (Gritti, 2019) The problem is recognized as one of the barriers ('direct feedback: application usage data') which can occur during the operational support phase. While developing Outlook office, partners had created a data sharing agreement which had clearly specified what type of data is extracted, for what reasons and who has an access to it (van der Ven W. , 2019). This step had not been noticed in the process of the EDGE Olympic development, instead the barrier occurred in the last process phase. It is not clear how CBRE and Deloitte came to the current data sharing settings. Both cases present however a wide variety of actors which are involved in comprehensive data analysis. (Stam, 2019) (Halstead, 2019) Finally, the issue is also not recognized at ECORYS RE since the CREM do not gather historic data and there is no mobile application at the office.

In short

The table below (see table 11) summarizes steps within the process of smart technology implementation which have to be taken in order to overcome discussed barriers. The findings are also visualized in the process design presented on figures 31 and 32 on p. 82 and 84.

Phase	Barrier	Step in the process which ensures overcoming the barrier
Strategy & Planning	(1) Lack of strategic vision	-Recognizing organizational goals -Formulating RE strategy -Linking Organizational strategy with the RE strategy while reflecting on SRE initiative implementation
	(2) Privacy concerns	-Designing opt-in functionalities in the application -Handing over to end users application manual -Developing privacy policy (following GDPR) -Informing end users about privacy policy
	Role division: actor's responsibilities	-Clear process overview
	Internal communication	-Clear role's division
Deployment	(5) Technical issues	-Defining supply -Cooperation between CREM and IT -Feedback on the business case feasibility -Feedback on the design
	(3) Application quality (adaptation requirements)	-Developing user journey -Making if visible to the end user: handing over an application manual -Gathering feedback from end users while testing the solution -Performing onboarding program
	(2) Control over privacy settings	-Designing opt-in functionalities in the application -Handing over to end users application manual -complying with privacy law
	(6) Communication with the end users	-Establishing clear strategic vision -Multiple feedback loops -After handing over the SRE: establishing contact person
	(3) Scaling up: handing over the application	-Ensuring comprehensive SRE design (incl. integration of hardware, software and backbone) -Performing 1st test -Performing permanent technology testing in order to ensure its proper function -Establishing onboarding program: lecture, tutorials, contact person -Handing over (together with the building) application manual
Operational support	(4) Data security	-Ensuring comprehensive SRE design (incl. integration of hardware, software and backbone) -Creating data sharing agreement
	Role division: actor's responsibilities	-Clear process overview -Clear role's division
	(6) Direct feedback: application usage data	-Establishing user feedback loop during permanent tests -Gathering multiple data into comprehensive analysis - Creating data sharing agreement

Table 11 Steps within the process of smart technology implementation which have to be taken in order to overcome the barriers; source: author

The goal of the analysis was to define and place the steps in the process design so that the barriers can be prevented/overcome. The barriers in their pure form are not further mentioned in the process design, only the relevant steps.

2.3. Employee-oriented IoT implementation process design

Following section summarizes the analysis by placing the recognized steps and actors within the IoT implementation process design. The text describes the figures 31 and 32. The process design is 'holistic' since it brings into light important actors, link them to their responsibilities and includes steps which have to be taken in order to overcome barriers recognized in this research paper. The

process is later on discussed and supplemented in the discussion section so that the final process design is created. The final process design is a part of the guideline for CREM which explains how to shape a smart technology implantation process.

Figures 31 and 31 present two inseparable parts of the process (they had been divided only due to the page size and should be read together as one figure). The process figures mark specific process phases within the light blue boxes with dotted line. The 'strategy & planning' phase should be read as one holistic phase which consists of steps linked to a strategy creation (strategy) and project planning. The 'deployment' phase clashes with 'operational support' phase, but those two can be read separately. The very 1st testing moment does belong to the 'deployment' phase, while permanent testing and continuous data analysis should be positioned by the reader within 'operational support' phase. The details in the figure 30 present the legend which explains process elements.

Strategy & Planning: strategy

The process design indicates that the process should be initiated by an organization. Organizational board on the basis of their organizational goals, supply and demand related to their RE should be able to evaluate their match and come up with a suitable strategy for further organizational development. Alternatively, there is also a possibility that the process starts from the FM angle and is mainly guided by the RE strategy shaped by CREM. However even them, the RE strategy have to take into account the organizational goals. In that case, FM is responsible for recognizing the current supply of an office and formulating required space functionalities which reflect current supply and future points of improvement. Analysis have indicated that HR can greatly help FM in creation of workplace strategy due to recognizing and defining employees'/users' profile(s). In order to perform this task, HR can extract knowledge from previously made interviewees or directly approach office end users. The user journeys can be developed by FM and/or HR. At this point, the end users should be acknowledged within the process since they can give the best insight into their daily activities, problems and needs related to the space.

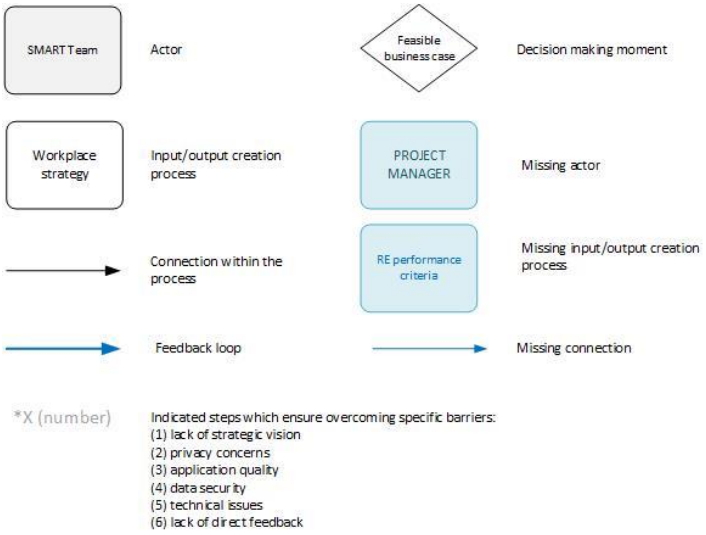

Figure 30 Legend, Employee-oriented IoT implementation process design; source: author

Strategy & Planning: planning

At the moment when one or the two strategies (RE strategy and/or organizational strategy) are completed, both bodies (CREM and organizational board) should decide whether they aim at developing SRE or not. If they do, the user journey and both strategies should be at this point translated into SRE specifications. The goal is to define what type of technology and which application features are needed in order to fulfil RE strategy, organizational strategy and add value to end users. The 'smart tools container' presented on figure 31 consists of available on the market technologies which should be in line with the previously defined in the process SRE specifications. The challenge at this point, is to select appropriate software and hardware components as well as plan backbone (system design). The integration of those elements should be sketched by IT. Only then it is possible to estimate budget and discuss the business case feasibility. The business case should be evaluated on the basis of budget and SRE specifications (which indirectly addresses two strategies and user journey).

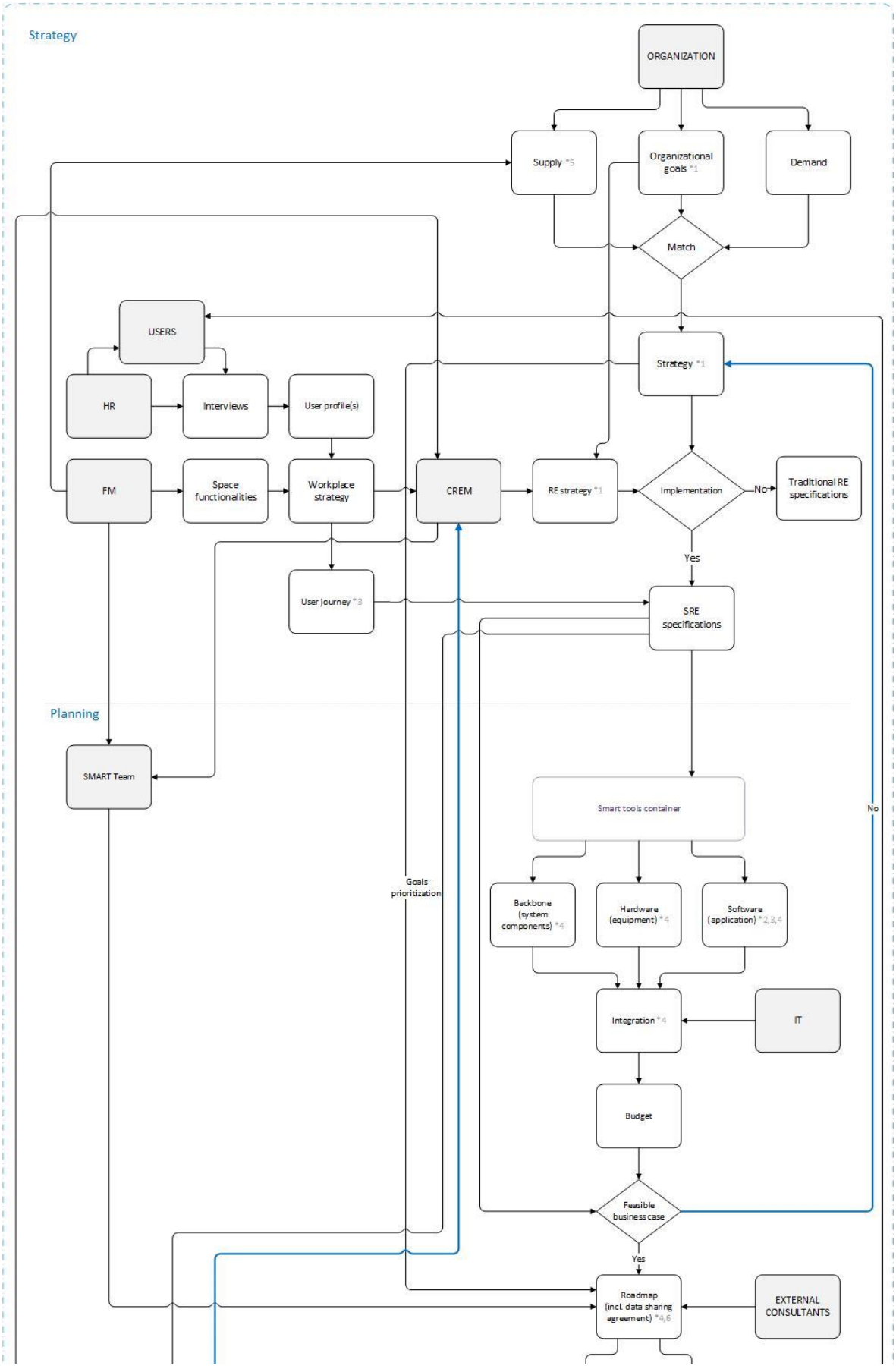

Figure 31 Employee-oriented IoT implementation process, part I; source: author

If the business case is not feasible it should be communicated with the organization that possibly their strategy have to be modified (for instance a scope has to be limited) – 1st feedback loop. On the figure 31 the link is made from 'business case feasibility' to the 'strategy' box. When the business case is feasible the decision about developing SRE can be made. At this moment, the actors can also change their decision after learning the results (business case feasibility) or change the prioritization of their goals. If the business case is feasible, the integrated system development can be translated into a roadmap.

The roadmap should specify steps on a timeline which have to be taken in order to fulfil previously discussed goals. There is a specific actor linked to the creation of the roadmap: SMART team (mentioned in the lit. as 'dedicated digital workplace team', see figure 14, p. 52). Ideally the SMART team should possess knowledge about SRE development and its management. For this purpose, the actors included within the team derivers from CREM (incl. FM) field. It can be that not every CREM is knowledgeable enough to create the document by themselves. In that case, there is a room for hiring external experts.

In line with the analysis, the roadmap document has to be further translated into smart building brief and smart installation brief (developed by selected suppliers). Those two documents have to be then incorporated in a SRE comprehensive design. At this point the 'strategy & planning' phase is completed. The 'roadmap' box consists of data sharing agreement which is steering further privacy policy development and data analysis.

Deployment

The deployment phase is described in less details. The reason for it is that it is no longer an activity directly assigned to CREM. The main research question therefore leaves it out of the scope. In the box 'implementation' the researcher includes all steps which have to happen in order to deliver finalized SRE. Those activities have to be clearly defined on the basis of SRE design and supported by project planning documents.

The deployment of SRE is different than handing over a completed RE project. In order to get the software and hardware up and running properly there are multiple additional steps which have to be taken. At this point not only the building have to be handed over, but also the information related to the smart system (IoT) have to be passed to office end users. The two documents have to be communicated with the end users: a privacy policy and an application manual.

While the building/office is handed over, tents start to operate it. That is the moment when the first test takes place. The 1st testing moment is in practice performed by suppliers. The goal is to check whether the system is working properly, whether the intended data can be extracted and what is the opination of end users on the IoT system (application adaptability). At this point brief analysis can be conducted in order to show results derived from gathered data. If the analysis and the system fulfil intended strategic goals (SRE specifications) the deployment phase is being completed. If not, the feedback loop indicates that the comprehensive SRE design should be checked and improved (by suppliers).

Operational support

The analysis shows that testing the smart solution should be a repetitive process which helps to ensure data consistency. The research had recognized three main categories of data which are relevant for CREM: workplace, building performance and application usage (for more details see section '2. Adding value via smart technology implementation'). Due to having data sharing arrangement in place, the organization and CREM can constantly improve and further develop their SRE.

Learning on the basis of the interviewees' expertise, the operational support should also consist of a permanent onboarding program. The goal of the onboarding program is to make sure that end users can learn anytime about the smart technology (both implemented and planned) and have a direct contact person to which they can address their feedback.

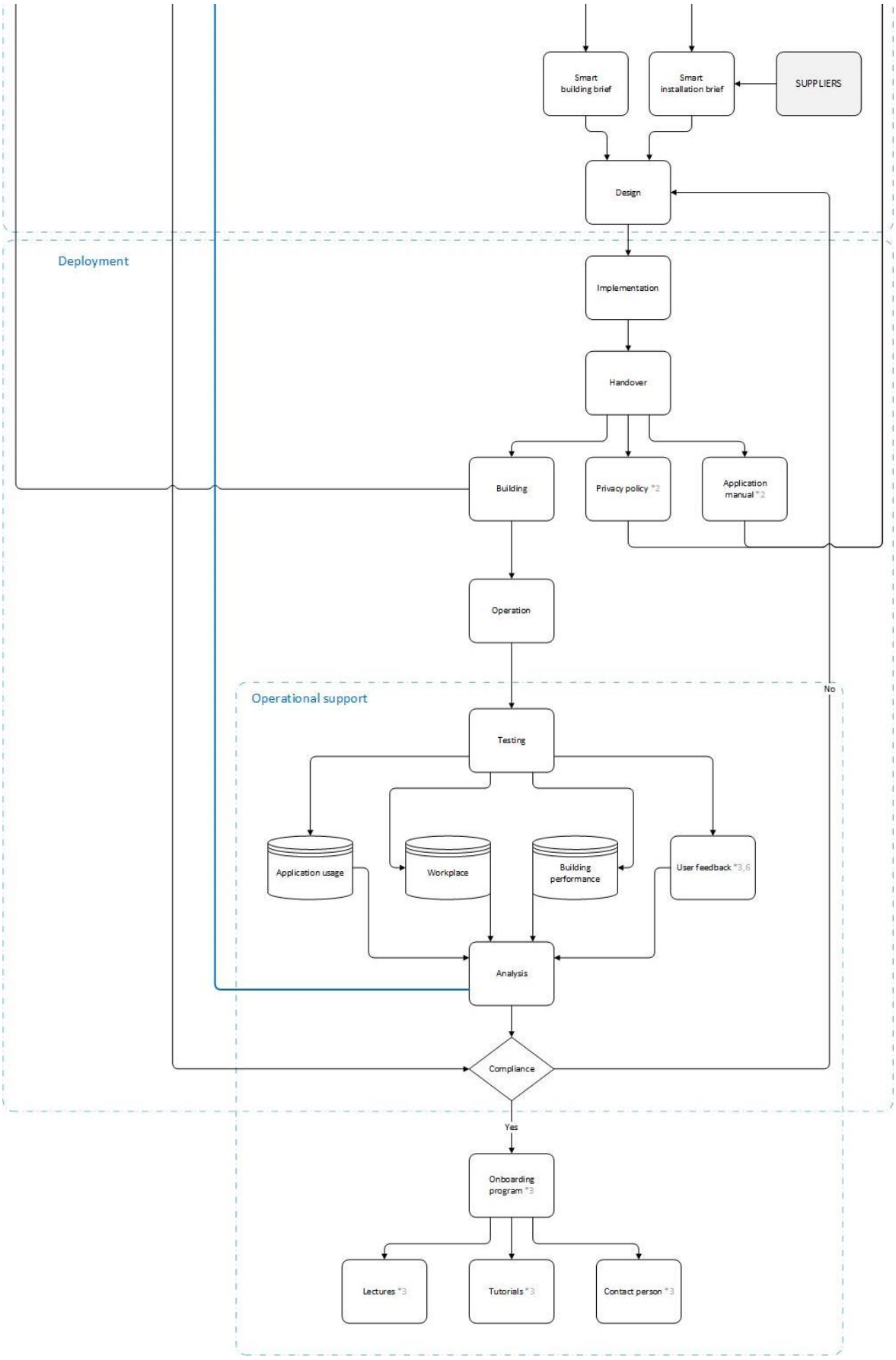

Figure 32 Employee-oriented IoT implementation process, part II; source: author

2.4. Conclusion

The process of IoT implementation can be built on the basis of three phases: (1) strategy and planning, (2) deployment and (3) operational support. The 1st phase can be divided into two parts: strategy formulation & project planning. Within the 1st part two strategies are created and combined: organizational strategy and RE strategy. The 2nd (planning) translate the strategies into a SRE design. The deployment phase touches upon the physical development of a SRE. After the SRE is handed over, the 1st testing period ensures its compliance to the initial strategies. After performing the 1st testing of SRE, the operational support phase stars. The operational support phase combines permanent tests, data analysis and onboarding program.

The perspective of end users can be acknowledged at the strategy and planning phase. The HR can directly contact the office employees (and/or) make use of the already possessed information about end user perspective) in order to create end user profile(s). The end user profile(s) further steer a development of the workplace strategy created by FM. Both actors, FM and HR, acknowledge the end users perspective while creating an user journey, which also have an impact on the SRE specifications. The workplace strategy which in its content touches upon the perspective of an office end users, is further passed to CREM so that the RE strategy can also reflect end users needs and preferences.

Further in the process the perspective of end users is acknowledged during the deployment phase. CREM can gather the direct end user's feedback on the developed SRE and combine it with the gathered data in in order to check the project compliance with the appointed RE strategy and/or revaluate their RE strategy. As the building is approved and operated, the direct end user's feedback constitute to the analysis, which gives CREM the information about their RE. Additionally The perspective of end users can be acknowledged by the contact person form an onboarding programme which should help employees to fully understand and adopt the implemented smart technology.

The perspective of the end users is therefore strongly acknowledged by HR, FM and CREM in the strategy and planning phase (while formulating RE strategy and SRE specifications), by CREM during the deployment phase (1st testing), and by CREM (and an external contact person) in the operational support phase.

As stated before, in order to shape a successful SRE development it is important to learn about the initiative barriers and steps which help to overcome it. The main recognized barriers are: (1) lack of strategic vision, (2) privacy constrains, (3) application quality level, (4) data security, (5) technical issues, (6) communicating with end user. The steps which ensure overcoming the barriers are presented in the process design figures (see figure 31 and 32).

PART VI
Research findings, Conclusion and Discussion

1. Research findings: answers to research sub-questions

The goal of this master thesis research was to 'expand knowledge on adding value to office employees (end users) due to smart technology implementation'. The research goal had been made more specific by adding the research sub-objectives, which had served as a basis for the research sub-question. Fulfilling the research objectives resulted in creation of the process design and two frameworks which attempt to recognize possible added value that can be gained due to smart technology implementation. The paragraphs below present answers to the research sub-questions.

1.1. 'How can CREM add value to office employees?'

CREM (incl. FM) can add value to office employees in two ways: supporting user activities and increasing user satisfaction (den Heijer, 2011). The indicated two approaches had been primarily selected within the literature study and confirmed during case studies research as approaches which can be largely supported by new technological solutions incorporated in an office (Canon, 2017) (Jansen, van der Voordt, Coenen, & Sarasoja, 2014).

The studies show also that CREM can also add value to other RE stakeholders by: stimulating collaboration, stimulating innovation, supporting culture, supporting image, improving quality of space, increasing flexibility, decreasing costs, increasing RE value, controlling risks, reducing footprint (m2 & CO2) (den Heijer, 2011). The added value to the other stakeholders (not only office employees) do have an indirect impact on user satisfaction level (for instance: stimulating collaboration) and can correlate with the objective of supporting user activities (by for instance: improving quality of space).

1.2.'How is the IoT implementation process organized?'

The process of IoT implementation can be built on the basis of three phases: (1) strategy and planning, (2) deployment and (3) operational support). (Charaya, Senguputa , & Tare, 2018) (Valks, Arkesteijn, & den Heijer, 2018). The 1st phase can be divided into two parts: strategy formulation & project planning. Within the 1st part two strategies are created and combined: organizational strategy and RE strategy. The 2nd (planning) translate the strategies into a SRE design. The deployment phase touches upon the physical development of a SRE. After the SRE is handed over, the 1st testing period ensures its compliance to the initial strategies. After performing the 1st testing of SRE, the operational support phase stars. The operational support phase combines permanent tests, data analysis and onboarding program (for more details see part V analysis '2. IoT implementation process, p.73).

An organizational board has been recognized as a starting point of SRE development. However, CREM had been recognized as an actor which can shape an office employee-oriented IoT implementation initiative from the RE perspective. (Ratcliffe, Saurin, Paybaraud, & Kristensen, 2009) The literature review indicates that there is a need for an integration of CREM, FM, IT, HR. The practice shows that all those actors are involved in the process of IoT implementation, however their roles and responsibilities vary within the case studies. The process design (see figure 31 and 32) present a systematized IoT implementation process design which positions them and their actions in the IoT implementation initiative. The case studies research bring to the process new actor: suppliers.

2a. 'How, when and by who can the perspective of end users be acknowledged?

The perspective of end users can be acknowledged at the strategy and planning phase. The HR can directly contact the office employees (and/or) make use of the already possessed information about end user perspective) in order to create end user profile(s). (Stam, 2019) (van der Ven F. , 2019) The end user profile(s) further steer a development of the workplace strategy created by FM. (Stam, 2019) Both actors, FM and HR, acknowledge the end users perspective while creating an user

journey, which also have an impact on the SRE specifications (van der Ven W. , 2019) (La Grouw , 2019) (Stam, 2019). The workplace strategy which in its content touches upon the perspective of an office end users, is further passed to CREM so that the RE strategy can also reflect end users' needs and preferences (Stam, 2019) (van der Ven F. , 2019) (Halstead, 2019).

Further in the process the perspective of end users is acknowledged during the deployment phase. CREM can gather the direct end user's feedback on the developed SRE and combine it with the gathered data in in order to check the project compliance with the appointed RE strategy and/or revaluate their RE strategy. As the building is approved and operated, the direct end user's feedback constitute to the analysis, which gives CREM the information about their RE. (La Grouw , 2019) (van der Ven W. , 2019) (Gritti, 2019) (Stam, 2019) Additionally The perspective of end users can be acknowledged by the contact person form an onboarding programme which should help employees to fully understand and adopt the implemented smart technology (Gritti, 2019).

The perspective of the end users is therefore strongly acknowledged by HR, FM and CREM in the strategy and planning phase (while formulating RE strategy and SRE specifications), by CREM during the deployment phase (1st testing), and by CREM (and an external contact person) in the operational support phase.

2b. 'What are the barriers that have to be overcome in order to implement smart technology which benefits office employees?

While designing an office-employee oriented IoT implementation process it is important to realize that (1) lack of strategic vision, (2) privacy constrains, (3) application quality level, (4) data security, (5) technical issues, (6) lack of communication with end user can impose barriers to IoT implementation initiative. (Charaya, Senguputa , & Tare, 2018) The steps which ensure overcoming the barriers had been recognized while performing analysis (for more details see part V) and are presented in the process design figures (see figure 31 and 32).

1.3. 'What are the existing smart technologies implemented within (investigated) offices that add value to office employees (and CREM)?'

The existing smart technologies implemented within offices can be divided into display devices for end users (mobile application's functionalities, interactive screens) and those for CREM (servers which gather historical data, automatized BMS, FMIS). Mobile applications and informative screens in an office space add value to office employees, whereas various dashboards are intended to add value to CREM by giving CREM an insight into data related to the building performance and its usage and/or exploitation.

'What are the existing smart technologies implemented within (investigated) offices that add value to office employees?'

The smart technology implemented within investigated offices has a form of a mobile application. The mobile application can consist of various, unique functionalities. Those are:

- Ambient control: adjusting temperature, adjusting lightening
- Real time occupancy data: desk status (free/occupied/booked), room status (free/occupied/booked), no-show communicates
- Booking workspaces: book a room, book a desk
- Collaboration features: localizing employees/colleague finding, communicate (chats/vide calls)
- Additional services: elevator synchronization (with end user location, after request), parking overview (plots occupancy and wayfinding), smart lockers (lockers occupancy and wayfinding)

Technologies which support user activities aim at making the time spent at a smart office easier and more comfortable (CBRE, 2018b). Provision of an IoT concepts which helps an office employee to

easily book and/or find a desired space, see the overview of meeting rooms and/or booking opportunities, locate team members in order to collaborate, find a way to certain service (e.g. printer) or quickly communicate in various ways with a colleague to great extend support office workers activities (Acoba, Charaya, James, & Rahalkar, 2018)

Technologies which increase user satisfaction are characterised by the fact that they enable end users to modify their working conditions in line with their preferences (Borghero, 2018). In practice it means for instance adjusting air quality, having control over the temperature around them or being able to have control over the light intensity. (Brugmans, Appel-Meulenbroek, Kemperman, & Dinnissen, 2017) (Nehchiri, Vahedprast, & Esfahani, 2018).

Additionally some functionalities add remaining values from the 'adding value framework': stimulating collaboration, supporting culture and image of flex office spaces, increasing flexibility, reducing costs, reducing footprint and controlling risks (see part V analysis and appendix D).

'What are the existing smart technologies implemented within (investigated) offices that add value to CREM?'

The smart technology which allows CREM to collect and analyse data are servers which store data, various Building Information System (BMS) and Facility Management Information System (FMIS). The data is gathered via various ST when a RE is occupied by office employees. The technologies gives CREM an opportunity to gain data insight, which can steer further their actions which can add value in various manners.

The general benefits to CREM of having an insight into historical data about an office environment and occupancy are for example: minimizing energy resources usage (reducing footprint, reducing costs), boosting teamwork and collaboration (stimulating collaboration), providing more comfortable physical environment which responds to current demand (improving quality of space, reducing footprint (m2)) or enhancing employees productivity, supporting culture and image of flexible offices, increasing flexibility, monitoring building performance and performing preventive maintenance (controlling risks) (Mehl, 2018) (van der Ven W. , 2019) (La Grouw , 2019) (Stam, 2019).

Last but not least, the case studies research indicate an implementation of the smart technology adds value due to stimulating innovation and increasing RE value (van der Ven W. , 2019) (La Grouw , 2019) (Stam, 2019), however the findings cannot be quantified.

2. Main conclusion

The following section provides a direct answer to the main research question. The conclusion is framed on the basis of the process design framework and the analysis of smart technology and its potential added value. The reader should not take the conclusion for granted and also take a close look on the 'discussion' section which further build upon the research findings.

2.1. Answer to the main research question

The main research question of this master thesis is:

> *How can Corporate Real Estate Managers (CREM) shape Internet of Things (IoT) implementation initiative which adds value to office employees?*

The direct answer to the main research question is:

CREM can shape the IoT implementation initiative by imposing (on other actors) and following the 'comprehensive employee-oriented IoT implementation process design' framework. CREM should follow the framework presented in figure 33 & 34 (on page 93 and 94), which supplement the results of the research due to taking a critical look on the research findings (process design). Finally, CREM should ensure implementation of a mobile application. All recognized within this research

application functionalities add value to office employees due to supporting their activities and increasing their satisfaction. The finding confirms that the mobile application adds value to office employees. The mobile application functionalities should however respond to the RE and the organizational strategy. The RE strategy should be strongly based on the end users' input.

While shaping the IoT implementation initiative, CREM can ensure a successful smart technology implementation by making sure that the office employees are involved in the IoT implementation process. The office end users can be acknowledged in various moments throughout the process:

- Strategy and planning phase: the office employees' needs and preferences related to the working environment should highly steer a workplace strategy concept developed by FM. The insight should be further translated by CREM into RE strategy and SRE specifications.
- Strategy and planning phase: the selection of smart technology (application functionalities) should respond to the SRE specifications created on the basis of CREM's RE strategy, organizational strategy and users' input (user journey).
- Strategy and planning phase: SRE specifications document is a basis for the roadmap document and the design document. The SRE specifications document takes into account the perspective of office employees (through user journey).
- Deployment phase: the end user perspective can be acknowledged while directly communicating privacy policy and application manual with office employees (done by HR).
- Deployment phase: gathering a direct end users' feedback after the building is handed over ensures that the users' feedback contributed to the analysis results handed over to CREM.
- Operational support phase: continuously gathering the end users' feedback for data analysis.
- Operational support phase: establishing an onboarding programme and appointing a contact person for office employees, who they can approach if they have any comments related to developed smart office.

Additionally, CREM should form an interdisciplinary team – SMART team – while shaping the IoT implementation initiative, in order to maintain an important position within the process and further steer the IoT implementation initiative. Within the process, the SMART team creates a roadmap document which includes data sharing agreement. Defining the data sharing agreement is a crucial step for CREM because such an agreement can give CRE managers an insight into data, which gives CREM an opportunity to add more values related to CREM.

3. Discussion

The discussion section gives the researcher an opportunity to take a critical look on the research findings and strive for their improvement. The explorative character of this research and limited amount of responses to the in-dept interview appendage had imposed certain shortcomings of the research findings. Those are discussed in the paragraphs below. First the smart technologies and their added value is discussed, next the comprehensive IoT implementation process is presented. The IoT implementation process design is supplemented by missing elements and presented in figures 33 and 34.

3.1. Discussion: smart technology and the added value

The analysis had indicated the added value of specific application functionalities and gathered data. Within the analysis figures 28 and 29 are read vertically. An alternative would be to read the figures horizontally, however the selected way of analysing it responds better to the research 3rd objective. The reader is free to read figures 28 and 29 vertically. In that way the reader will recognize functionalities/data which can help him/her to add certain value instead of learning values per functionality/data.

It has been concluded that the smart technology which adds value to office employees is a mobile application. The mobile application can consist of various functionalities. Smart technology which adds value to CREM aims at collecting historical data, which can be further analysed in order to steer data-based future decisions (the approach which gives CREM a possibility to consciously add certain/desired value). The paragraphs below discuss in general the implemented, within investigated case studies, smart technology and its possible added value in relation to the four different CREM perspectives (based on the 'adding value framework' introduced in section '1. CREM' p.42-45). The discussion is based on the researcher observations, experience and knowledge gained while conducting the research.

Strategic perspective

The strategic perspective combines objectives such as: stimulating collaboration, stimulating innovation, supporting image and culture, improving quality of space. Starting with the mobile application added value, the research shows that functionalities enabled by geolocation help organizations to boost teamwork which can be directly translated into the objective of 'stimulating collaboration'. Furthermore displaying real-time occupancy and booking data on end users phones enhance the concept of flexible office spaces. If an organization operates in a flexible office space and seek for a vibrant, collaborative working experience, the implementation of mobile application, which includes functionalities such as: real-time occupancy overview, booking workspace functionality, can support the image and culture of the company. The insight into historical occupancy and booking data gives CREM a great opportunity to improve a quality of space. That can be done by CREM by analysing the most and the least occupied spaces, comparing their characteristics and striving for an improvement of underutilized workplaces. The action should be repetitive in order to ensure high quality of office space. Furthermore the FM can have an insight into space utilization and gather notifications from end users (if something is out of order). Those information can steer his actions – ensure a preventive maintenance which can also contribute to the goal of 'improving quality of space'. Finally, the research shows that the development of a SRE can by itself be linked to the adding value objective 'stimulating innovation'.

Financial perspective

The financial perspective combines goal such as: decreasing costs, increasing RE value, controlling risks. The operational costs of RE can be decreased due to smart technology implementation which enables preventive maintenance and ensures space optimization. No conclusion can be made about decreasing investment costs. Many researchers claim that the development of a SRE can by itself be linked to the adding value objective 'increasing RE value'. Unfortunately many research lack quantified findings which can ensure this conclusion. The energy performance data and information provided to technical managers (through installation monitoring systems) among others add value due to 'controlling risks'. The risk of vacancy can be also controlled due to having an insight into occupancy data and adopting the RE portfolio to a current demand.

Functional perspective

The functional perspective combines goals such as: supporting user activities, increasing user satisfaction, increasing flexibility. The two goals had been in the centre of this master thesis: supporting user activities and increasing user satisfaction. All listed within this research application functionalities add value due to 'supporting office employees' activities'. The ambient control functionality provides office employees with good indoor conditions and appropriate light intensity. The booking functionalities help end users to quickly select and reserve a workspace which suits their need within a working day. The occupancy overview helps office employees to choose a workspace which best suits their preferences and their current needs. The colleague- and way-finding functionalities as well as communication platform enable office employees to act more effectively and productively throughout the day. In the end, application functionalities which directly support office employees' activities most of the time indirectly increase office employees' satisfaction, since they help an office employee to work at the most suitable for him/her workplace. The data about an office occupancy can enable CREM to increase RE portfolio flexibility. Additionally,

data about an application usage can indirectly suggest end users' satisfaction with the indoor working conditions (strongly linked to the ambient control functionality).

Physical perspective (incl. sustainability)

The physical perspective touches upon the RE sustainability since the goal is to reducing footprint either by reducing m² or CO2 emission. The insight into energy performance data (both real-time and historical) can promote strong environmental ethic within an organization. Furthermore it can give suggestions to office employees and CREM whether and how should the energy consumption (CO2 emission) be minimized. The historical occupancy data on the other hand can enable CREM to reduce footprint by optimizing the RE portfolio size if the data shows that many m² are not utilized.

Additional insight

There are three challenges which make it difficult to define the added value to CREM of specific data. Same goes for defining a direct added value of a mobile application functionalities. The 1st challenge is caused by the fact, that some of the boxes checked in 'interview appendage' do not present a direct added value. Author argues that specific application functionality's and data's added value is not always adding the value directly. For instance 'parking overview' does not directly support the organizational culture, instead it enables employees to be more efficient and increases their satisfaction. If the organizational culture emphasises productivity and well-being of their employees, the functionality can indeed have an impact on 'supporting culture'. In order to add a direct value data have to be further proceeded/analysed so that a strategic decision can be made. The 2nd reason can be found in the lack of responds from interviewees and brief in-depth literature study related to data added value. Furthermore, it is important to acknowledge the 3rd challenge. The case studies research shows that every organization is characterized by different set of strategic objectives and performance criteria. It implies that, for every organization (incl. CREM various actors) different data and/or application functionalities can be valuable therefore the findings should not be generalized.

Last but not least, the implementation of the IoT or smart tools can only be approved, by CREM and an organizational board, when the business case if feasible. The business case feasibility should not be only assessed on the basis of a budget estimation but also to great extent on the basis of smart technology capabilities of achieving/supporting appointed strategic goals. In that sense, all the CREM perspectives play a role while making a decision about IoT implementation.

3.2. Process design: comprehensive employee-oriented IoT implementation process – missing elements

While taking a critical look on the process design it is clear that certain steps, feedback loops and actors are missing within the process. Without them the process itself can be followed, however it might bring some challenges to actors involved. Incoherent implementation may confuse and discourage utilization of implemented smart technology. That is why author revises the process analysis and adds logical lines (feedback loops) and boxes (actors and/or process element) to the process design (see blue lines and boxes on figure 33 and 34).

An additional box in the process design is the 'RE performance criteria'. The RE performance criteria are created on the basis of RE strategy designed by CREM and the organizational strategy. The RE performance criteria gives an implication whether the actors aim at developing a SRE. Later within the process, the design document can be assessed by CREM and an organizational board on the basis of the RE performance (additional feedback loop).

The user journey is an element which helps to further specify SRE specifications. The user journey arises from the created primary by FM (together with HR) workplace strategy. The researcher draws an additional line between SMART team and user journey and proposes that the team can contribute to its development (in case it cannot done by FM and/or HR).

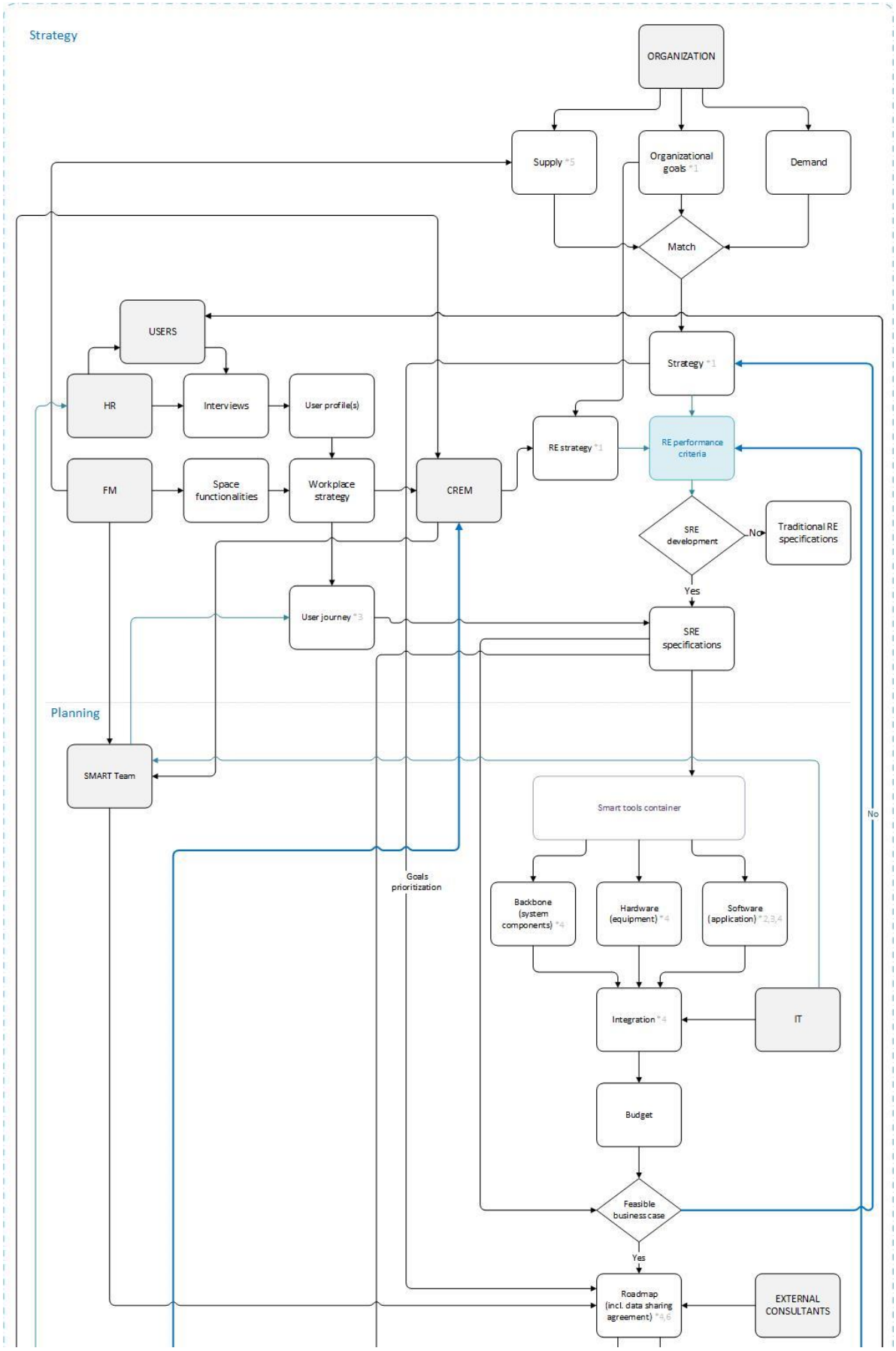

Figure 33 Comprehensive employee-oriented IoT implementation process, part I; source: author

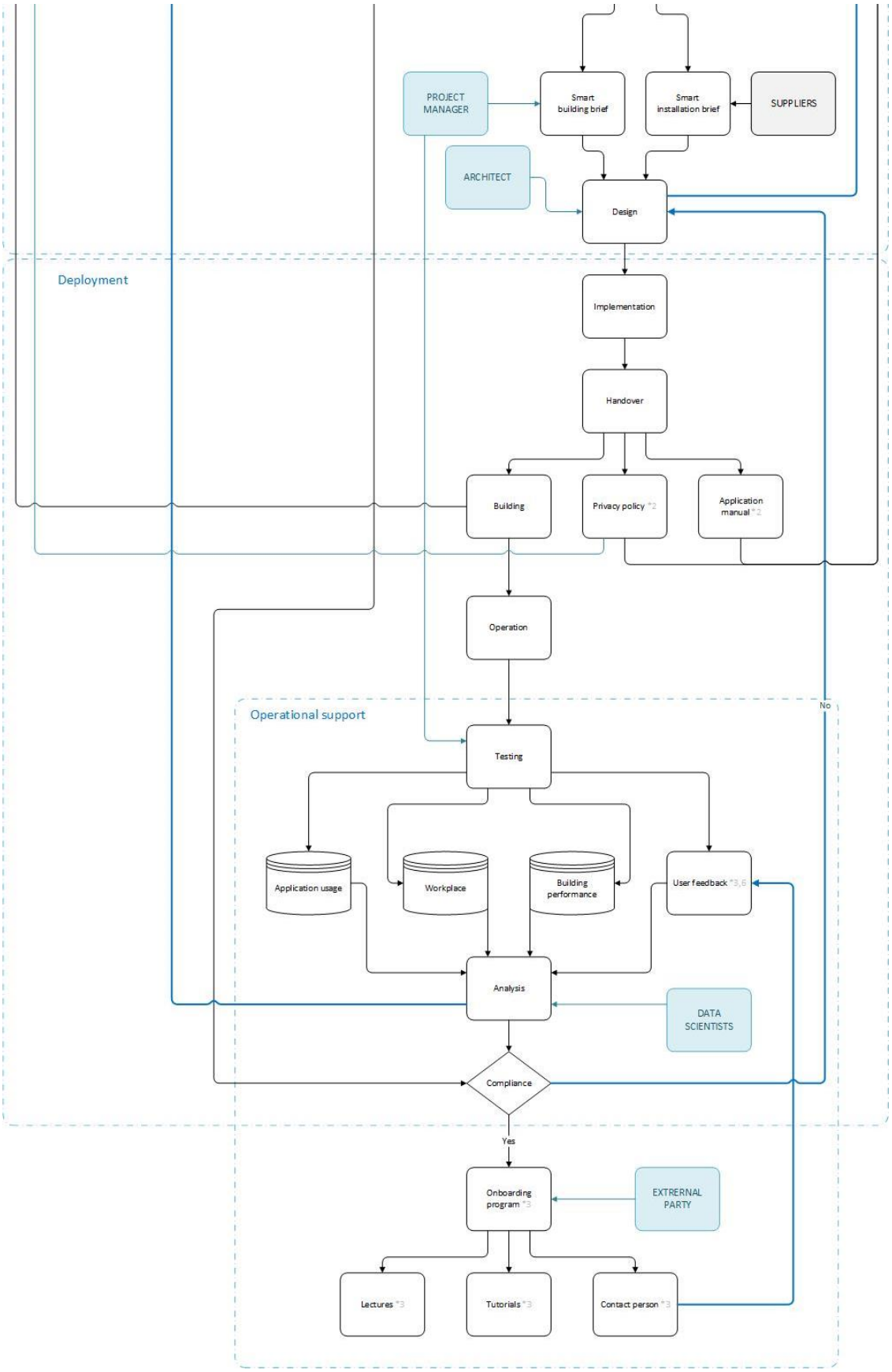

Figure 34 Comprehensive employee-oriented IoT implementation process, part II; source: author

The crucial moment of system first integration (within strategy & planning: planning phase) presents a significant role of IT department in the whole process. Once the IT would be out of the picture, there would be no more knowledgeable actors which could estimate costs related to hardware, software and backbone integration. The additional link is made between the SMART team and the IT department. The IT expertise (linked to elements such as; the system integration and the budget estimation) is an valuable input for the SMART team while shaping the roadmap document. The roadmap document aims at specifying which smart technology will be implemented, and within what time. The proper estimation of those actions requires IT knowledge and skills, since the actions related to the system integration closely relate to steps which have to be specified in the roadmap document. Originally the SMART team (which arise from CREM) had been assigned to this activity, nevertheless author argues that IT group can largely support the team in the next step within the process (creation of a roadmap document).

Following the process, smart building brief and smart installation brief are being created. Those have to be later combined into a full design. The design differs from the traditional architectural design, since it combines two indicated components: a building design and an installation design. Practice shows that the smart installation brief is being made by suppliers, however there is no actor assigned to the comprehensive design creation. In line with the researcher knowledge and experience she assigns a project manager to the creation of a building brief and an architect to the creation of a comprehensive design. The reader needs to acknowledge that the architect has to understand the challenge of providing a comprehensive SRE design (which does not only reflect the building physical design but also installations design which support the SRE). Due to the challenge, it might be difficult to appoint an appropriate architectural office in practice (from the market), nevertheless it has to happen in order to ensure successful IoT implementation.

Next, the feedback loop had been drawn from the privacy policy document to HR. The HR can ensure the compliance between privacy policy and SRE operations and communicate clearly those information with other stakeholders. In the end, there has to be an actor within an organization who is fully knowledgeable about the implemented systems and its legal framework. In that case it could be HR.

Meanwhile the project manager had been assigned to the permanent action called ‘testing’. Unfortunately, the analysis did not specify who could perform this actions during the deployment phase, therefore project manager (or alternatively RE manager during the ‘operational support phase’) could fill in that gap.

Same goes for the organization of an onboarding program. Practice shows that this action is fulfilled by external parties, such as an application provider. In order to ensure the communication between an established contact person and CREM it is important to draw an additional feedback line. Within the operational support phase the contact person should pass the gathered information from office employees (direct users’ feedback) for further analysis.

Last but not least, the analysis has to be performed by data scientists and presented to CREM, so that CREM can learn from it in order to make appropriate decisions based on data in-sight. The data scientists should have a good understanding of REM in order to extract appropriate data and present clear results.

3.3. Research limitations

The in-dept interview appendage

The in-depth interview appendage came into picture relatively late, after P3. There are two reasons for it: (1) for a very long time the focus of this research paper had been given only to office end users, (2) selecting only the two components form the 'adding value' framework had greatly helped the master student to limit the scope so that the thesis can be completed within one academic year.

The student had received a feedback to adopt the other components of the framework. The feedback had led the author to develop an unified 'why: strategic goals' framework which is described per case study in appendix D. Only after P3 the feedback had been linked to recognized per case study application functionalities and data. This task could not have been performed before finalizing case studies research because the horizontal part of the table could not be filled in.

Due to the time constrain (upcoming P4) the researcher had fully completed the initial research objective and defined the technologies which add value to end users. Further studies were a challenge due to time limitations and lack of respondents (only two interviewees filled in the table). The initial research objective had been fulfilled, however the results gathered through the in-dept interview appendage indicates that there is a room for further research in this field.

3.4. Opportunities for further research

Further research on the smart technology implementation within office RE should fully focus on scientifically defining the added value of specific data bases to 4 different CREM perspectives. The goal would be to adopt the basic framework created within this research and collecting more empirical research which will provide more reliable and generic research findings (within this research the topic is mainly covered in the discussion, since it is concluded that *'the smart technology gives CREM an opportunity to gain data insight, which can further steer their actions. In that sense the technology does not add value directly, neither does data. The added value can be gained while data-based REM decisions are made.'*). The challenge for a researcher which would continue further study on the smart technology added value would be to define the direct impact of an application functionalities and/or data on the appointed 'adding value' framework elements.

The IoT implementation process design could also be recommended for further research. The goal of the further research should lay down in applying and testing the framework in relation to specific corporate objectives and organizational performance outcomes. The process design should be investigated further by more case studies research. While looking at more case studies, it is possible that further research can provide valuable process actions/elements therefore improve the created framework.

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PART VII
Reflection

1. Reflection

The following section presents personal reflection on the process of conducting master thesis. The reflection touches upon various elements such as: (1) relationship between the research, selected graduation laboratory and master track, (2) reflection on the appointed research methodology, (3) match between the research output and research disseminations, (4) graduation internship (5) 'practice' observation and finally (6) reflection on the research process.

1.1. Relationship between the research, SRET laboratory and MBE

The thesis falls under the Graduation Laboratory called 'Smart Real Estate Tools' organized in line with Master Track 'Management in the Built Environment' (MBE). The goal of the master thesis was to conduct an academic research based on which the author can formulate the guideline. The guideline had been specified as '*information intended to advise CRE managers on how to shape smart technology implementation initiative which benefits office employees'*. In order to reach this goal it was necessary to specify more precisely what does the guideline consist of. Two elements were selected as an input for the guideline: (1) process design and (2) recognizing the added value of smart technology in offices.

Designing the process clearly corresponds with the MBE track, since the process management and REM had been emphasised throughout significant part of the studies. At the same time, recognizing added value of smart technology directly links to the (C)REM practices and integration of four thought perspectives. The final output links to the 'Smart Real Estate Tools' however while looking at the previously developed student master theses, the research took a bit different form: focusing on the process design and elaboration upon investigated smart technology. Nevertheless, the research output still fits well within the graduation laboratory.

1.2. Appointed research methodology

Clarifying research objectives in order to select appropriate research methods

After the feedback received on P2, the master student has undertaken the following steps in relation to research methodology:

- Setting clear research objectives,
- Improving largely research methodology: philosophical underpinning, frameworks for cases analysis and specified research output,
- Interview protocol based on theoretical framework (improved).

At this point, the P5 report clearly presents aspects related to the appointed research methodology. Author follows the steps of literature review, in-dept interviewing and desk research. Due to lack of publications related to the theme the case study method had become the primary research methodology.

Author is aware that it would be best to use an additional research method which will ensure that data are reliable and clear. That is why desk research is necessary. In order to clarify the research process multiple graphs had been created and are presented in part II of this P5 report.

The research itself had a primary explorative character. The literature study had created knowledge basis for the further case studies research. That was a good starting point, however a lot of information had been missing in order to create the final research output. Long interviews and detail interview protocol provided the researcher with valuable knowledge which had been later translated into intended guideline (research output).

Interviewees selection

The selection of interviewees was challenging due to described below circumstances. Ideally the master student had been looking for facility managers who had been responsible for smart technology implementation at the office real estate. The reality has shown, that the facility manager is almost never responsible for conducting this process. Most often, an additional person is temporarily appointed, for such an initiative, within an organization. The actor can be therefore named in various ways, which were confusing while the researcher was making a decision about choice and number of interviewees.

Luckily, the snowball effect based on broad social network allowed the researcher to recognize actors which were involved in the smart technology implementation process within the appointed case studies. Those were in the end various actors: project manager, development manager, IoT department manager, Smart Solutions team leader, product excellence director, and finally a facility manager. These actors agreed to contribute to the research by giving an interview.

1.3. Match between the research output and research disseminations

The research had been intended to provide valuable information to professionals who contribute to the process of IoT implementation within RE. Due to the strong focus on office workers the pinpointed persona was first recognized as a facility manager who aims at adding value to end users of RE. Within time the research has also indirectly started to address remining CREM stakeholders and additional actors. Practice shows that there can be a specific (unique) position created within organizations, which is appointed to manage the initiative (such as the SMART team). In that case, this professionals can also benefit from learning the outcome of this study. Furthermore remaining actors can benefit due to being provided with clear process overview.

As intended, the 1st part of the guideline (research output) presents possibilities for end users involvement in the implementation process, whereas the 2nd part of the guideline (research output) helps office employees to better understand the opportunities related to the new technology. Due to adaptation and implementation of this double sided framework (dedicated to CREM and to office end users) privacy concerns and process related barriers can be overcome.

Until now, author did not recognize scientific literature which would integrate information about SRE development process and IoT/smart technology added value. The master thesis research paper adds knowledge to the scientific framework.

1.4. Graduation internship

Half January 2019 the master student had started a graduate internship at CBRE. The internship was closely linked to the development of the CORE (smart office, one of the case studies). Although the research could dive deeply into one organization and one project development, author sought for more case studies so that the findings can be generalized.

The intern position has helped a lot while having a trouble with scheduling interviews and looking for appropriate interviewees. Being involved in the Smart Solutions team has helped the master student to better understand and learn CREM practices, SRE development process and most importantly gain an experience of SRE end user.

The process design had been shaped externally, that means that the team neither the board were able to adopt it at the already handed over office building. The discussion included in the research paper touches upon missing elements and undefined links which the researcher had discover. Few days ago, the organizational board and CREM members had evaluated their office development and have made couple of points which should have been planned differently through the process. The evaluation results were very sati factionary for the researcher since they have confirmed discussed research findings: IT involvement, 1st smart technology selection and integration by IT, delivery of

smart installation brief, conducting permanent testing loops and establishing an permanent onboarding program.

1.5. 'Practice' observation

The researcher had gained a deep understanding of smart technology implementation while following the graduation internship and conducting the case studies research. The research findings indicate that the smart technology implemented within office portfolio should respond to both, a RE strategy and an organizational strategy. Practice observations reveal that sometimes those strategies are not reflected in the smart office equipment/technology. Furthermore, the observations shows that CREM tends to implement as many smart technologies as possible (available on the market) without thinking the concept through. In the end, the 'practice' observation confirms the research relevance and strengthen the importance of the research findings.

1.6. Reflection on the research process

The research process has started in September 2018. Back then, the research proposal development had been mainly steered by the researcher personal interests and brief, explorative literature studies. The researcher had struggled with defining the research scope for quite a long time. In winter 2018, the researcher had a chance to contact multiple professionals involved in the IoT implementation initiatives (Geert Stam, Onno Willemse, Roy Halstead). Those men had helped the researcher to understand the IoT implementation initiative in practice, by having extensive discussions about the IoT implementation initiatives and their shortcomings. Soon after that, the researcher had an opportunity to get involved in the process of the CORE (smart) development. Ever since then the scope of the research had become concise and clear.

Throughout the process the researched had always tried to comply with (or at least respond to) the feedback received from the metros. In retrospect, the researcher believes that the feedback moments could have happen more often. That would bring more clarity toward the feedback and the research development.

The workload in the period within P2 and P5 had been very intensive. The process have ren rather smoothly within the last 5 months – after the research objectives were clearly defined. The 'data collection phase' had a bit of the delay, which in the end have an indirect impact on the research limitations discussed before in part VI.

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Table of figures & tables

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Appendixes

1. Appendix A: research plan – timeframe after P2

P2-P3

Main tasks that I have done (in line with my planning) between P2 and P3 are:

- ✓ Further literature study
- ✓ Improving the theoretical framework (knowledge basis; limiting the extensive literature review)
- ✓ Creation of the interview protocol (until 16 February 2019)
- ✓ Scheduling interviews (until 10 February 2019)
- ✓ Conducting and transcribing interviews (from mid-February until end of March)
- ✓ Closing internship agreement

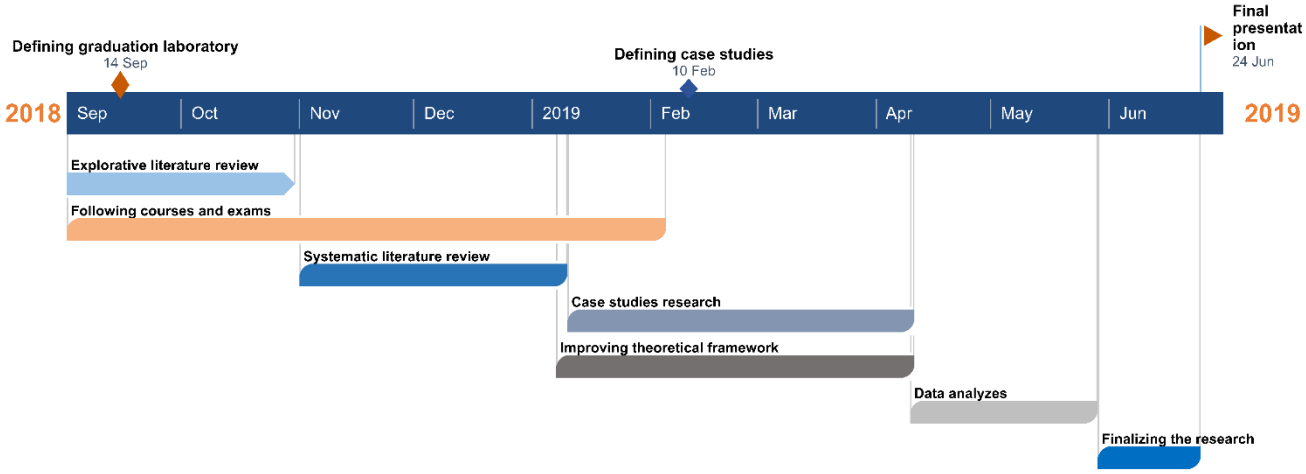

Figure 35 Research plan P2; source: author

P3-P4

Between P3 and P4 I have completed the following:

- ✓ Transcribe remining interviews (14 April 2019)
- ✓ Document remining case studies (28 April 2019)
- ✓ Improve theoretical framework (3 May 2019)
- ✓ Summarize the case study findings (3 May 2019)
- ✓ Write analysis (11 May 2019)
- ✓ Create the research output – draw conclusions (14 May 2019)
- ✓ Write personal reflection related to the research process and management summary (17 May 2019)
- ✓ Hand in the P4 report (17 May 2019)
- ✓ Give the P4 presentation (24 May 2019)

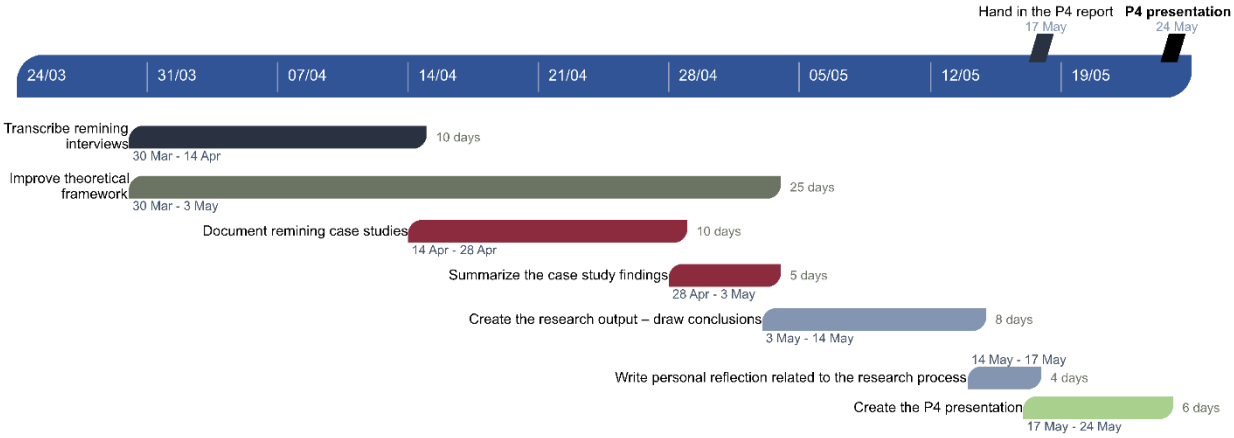

Figure 36 Planning between P3 and P4; source: author

P4-P5

Between P4 and P5 I plan to do the following:

- ✓ Improve my research document (18 June 2019)
- ✓ Improve the management summary (18 June 2019)
- ✓ Hand in the P5 report (18 June 2019)
- ✓ Give the P5 presentation (25 June 2019)

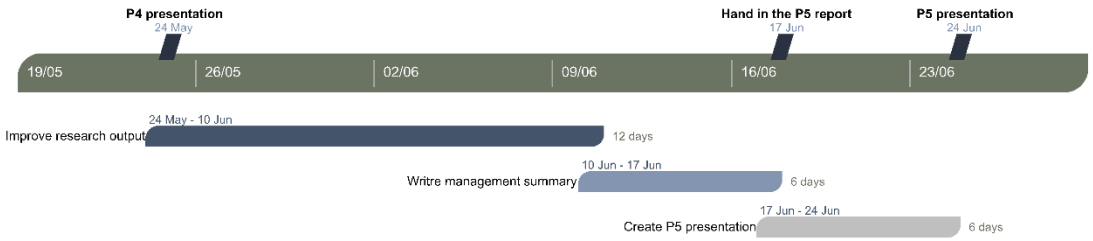

Figure 37 Planning between P4 and P5; source: author

2. Appendix B: interview - opening statement and consent form

Opening statement

Dear participant,

First of all, I would like to thank you for accepting my interview request. The interview is designed for the Master Thesis 'Internet of Things (IoT) in Real Estate. Designing a guideline for employee-oriented IoT implementation in office real estate'.

The purpose of this interview is to gather and analyse information related to the process of smart technology (Internet of Things/Smart Tools) implementation at office real estate: XXX. The implementation process is understood as a sequence of events which take place from the initiative phase, through decision-making moment(s), placing the solution on site up until the operational phase. The interview aims at learning about the added value of the smart technology to employees (office workers).

The outcome of this interview gives the researcher an overview of the project. That includes: strategic objectives, process (phases, actors and their responsibilities, end user involvement/acknowledgement, barriers) implemented technology and its added value. If applicable the interviewee is asked to pinpoint moments during which the employee has been involved (explain why and how) in the process and how it did affect the process outcome.

Your knowledge related to those themes is strongly valuable to my further academic research.

Thank you in advance for accepting my interview request and for your time designated to this interview.

Kind regards,

Hanna Majchrzak

Consent form

Dear participant,

In order to properly conduct the research I would like to record our interview. It will allow me to clearly report our conversation and make my research founding feasible. Please sign the following document if you agree with it.

For your information, only the project researcher (Hanna Majchrzak) will have an access to the recording. The recording will be destroyed after finalizing the master thesis.

Additionally, I kindly ask you to fill in provided below consent form. It is essential to the research, since the researcher needs to meet (assigned by TU Delft) Human Research Ethics Committee requirements.

Please tick the appropriate boxes	**Yes**	**No**
Taking part in the study		
I have read and understood the study information dated [11/02/2019], or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	○	○
I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.	○	○
I understand that taking part in the study involves giving my permission to record the interview.	○	○
Use of the information in the study		
I understand that information I provide will be used for the research called 'Internet of Things (IoT) in Real Estate. Designing a guideline for employee-oriented IoT implementation process' conducted by a master student Hanna Majchrzak. The information can be presented in a form of a written report and presentations.	○	○
I understand that personal information collected about me that can identify me, such as [e.g. my name or where I live], will not be shared beyond the study team.	○	○
I agree that my information can be quoted in research outputs.	○	○

Future use and reuse of the information by others

I give permission for the researcher to archive the interview transcript and distribute the research outcomes to which this interview contributes. ○ ○

I understand that I can be contacted by the researcher in case of any additional questions related to the interview. ○ ○

Thank you for your participation.

Signatures

XXX

_____ _____ _____

Name of participant [printed] Signature Date

I have accurately read out the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands to what they are freely consenting.

Hanna Majchrzak

_____ _____ _____

Researcher name [printed] Signature Date

Study contact details for further information:

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3. Appendix C: interview – interview protocol/guideline

Interview questionnaire

A. Background questions: Corporate Real Estate Management

1. How was the initiative/project started?
    a. Could you indicate how the initiative for smart technology was taken? What were the problems that needed a solution via smart tools?
    b. On which level/by who was the decision made to implement Smart Tools and develop Internet of Things within the office?
2. Did the process run in a straight way or with lots of twists and why?
    a. Do people raise up objectives towards IoT/ST? What are the objectives?
    b. How were various complains/issues addressed by office workers solved? Can them address them somewhere and gain some more insight into its implementation process?
3. How does the implemented technology impact RE management and office workers?
    a. Which goals had been achieved due to smart technology implementation?
    b. Were some goals not achieved?
    c. Are there any extra benefits recognized?
4. What data/information (gathered by IoT/ST) are currently available and to who?
    a. In what form is the information presented and to who?
    b. What information was not possible to gather but would benefit RE management? What were the barriers?

B1. Project specific questions: IoT implementation process

1. What were the phases of IoT implementation?
    a. When did the project start? When did it finish?
    b. Can you please describe key steps of the process?
    c. What were the key deliverables? Did they close/open certain process phases?
2. Which actors had been involved in the IoT implementation process?
    a. Who were the internal stakeholders? When did they join/leave the process?
    b. Who were the external stakeholders? When did they join/leave the process?
    c. How has the perspective of end users be included?
    d. When was the office worker involved and why?
3. What were actors' responsibilities within the process?
    a. When were the internal stakeholders involved/in relation to which deliverables?
    b. When were the external stakeholders involved/in relation to which deliverables?
    c. What was office workers' input?
    d. Which/whose responsibilities were not clearly defined, therefore problematic to assign?
    e. Who were the key players and at which phase?

B2. Project specific questions: Adding value to office workers in an office enabled by smart technologies

1. What technology (kind of Smart Tools) have been implemented?
    a. What smart technology has been implemented in the office building that aims at adding value to office workers?
2. How does the smart technology (ST/IoT) support office workers' activities?
    a. What was its objective in relation to office end users (office workers)?
    b. Have the working conditions been improved due to ST/IoT implementation?
    c. What is the impact of 'supporting office workers' activities' due to implementation of smart technology on organization?
3. How does the IoT enhance office workers' satisfaction?
    a. How do you think office workers' satisfaction (out of their working conditions) developed throughout the process of smart technology implementation?
    b. How do you measure it?
    c. What is you your view (and your organization perspective) on office workers' satisfaction in relation to decision making power within the smart technologies implementation process?

B3. Project specific questions: Involvement of end user in IoT implementation process

1. Do you see space for improvement in the communication with the office workers about the implemented smart technology?
    a. Who should be responsible for it?
    b. Do you think acknowledging office workers about smart technology would enhance smart technology capabilities?
    c. How do you think involving the end users in the smart technology implementation process could impact their satisfaction (out of their working conditions)?
2. How did you evaluate the process and the outcome?
    a. Did the implementation of ST/IoT contribute to creation of a successful (satisfying) working environment? How did you measure it?
    b. How do you collect the opinion of your employees regarding new smart technology implemented at their office?
    c. Did you notice any change(s) of office workers' opinion on ST/IoT? If yes, what were they and what do you think has caused them?

C. Closing question

1. What were the challenges in driving integrated programs and strategies for IoT/ST implementation?
    a. How and by who is the quality, functionality, costs, physical conditions assessed?
    b. What were the organizational, financial and technical barriers to overcome (or not overcame)?

Thank you very much for your time.

4. Appendix D: case studies findings

4.1. The CORE, CBRE, Amsterdam

Project info

Figure 38 The CORE; source: author

The CORE is a new office building of CBRE. The building hosts only one tenant which functions as both, landlord and occupier. CBRE is an advisory company in the field of office buildings development and management. Due to its business focus and knowledgeable employees the organization had decided to take care of the development of the CORE internally. Office employees has moved into the CORE in February 2019. (CBRE, 2018d)

The organization (CBRE) had been experiencing rapid growth in the last few years. In line with the prognosis it had decided to look for an office space which can fit CBRE's employees. The strategic vision for the new office space incorporated unique workplace strategy and the ambition to develop SRE. By developing the smart and well-designed (in line with strategic objectives) office CBRE aimed at supporting the image and *'making a statement'* within its field of expertise. (Stam, 2019)

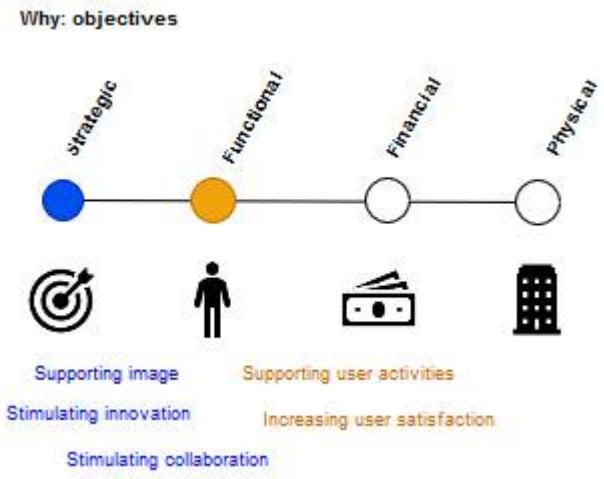


Figure 39 Why smart RE, The CORE; source: author

Geert Stam (2019) during the interview named drivers which had steered the development of the SRE. Those are: supporting image, stimulating innovation, stimulating collaboration, supporting user activities and increasing user's satisfaction (see figure 39). All of these goals are also expressed in the space design and the workplace strategy. (Stam, 2019) The strategic goals are often summarized by the organization as: co-work, co-create, innovate and focus. The strategic goals are strongly reflected in types of spaces that employees can find at the CORE: open ground floor, client lab, CB café and library. (CBRE, 2018e) Smart technology implemented at the CORE enables the work strategies and contribute to the 1st strategic objective. (Stam, 2019).

End user involvement strategy

As explained before, CBRE had a competitive advantage while developing its new office (due to possessed in-house knowledge and skilled employees). Workplace Strategies (WPS) department had strongly contributed to the CORE development. In order to address end users' needs at the new office WPS had developed two types of user journeys: per office space, per office space enabled by smart technology. Furthermore the WPS had researched people's working activities and needs. The research had strongly steered the workplace concept and technology functionalities' design. This two approaches indirectly addressed end users perspective. (Stam, 2019)

The end users had been involved directly by CBRE during open sessions (organized at auditorium) and small workshops (for selected employees, around 25 people). The communication/feedback moments had been organized only when CREM had defined a context in which they were seeking for feedback. (Stam, 2019)

By 2020 the organization aims at monitoring 'application engagement' and application features usability. This approach will provide CREM with end user's indirect input for strategic decision making. Last but not least the interviewee ensures that 'there is *'a continuous feedback loop from people in the organization to a body within CBRE'. The interviewee is aware that the people who give feedback are strongly interested in the new concept* therefore their feedback can be not equivalent (Stam, 2019).

'I think there is already a trend going on where we really see the office workers as the end users and almost as the real clients. Because if you bring value to them you bring value to the organization. I think that is also a real change that you now have with workplace strategy combined with smart that we can cater much more towards that experience to the office worker and keep on improving on that.'

Head of Smart Building Solutions
Geert Stam

Last but not least, the interviewee recognizes the trend which steers the CBRE activities. The statement presented above strongly supports this research objectives.

Barriers

For CBRE the main recognized barriers for smart office development was time and internal collaboration. The internal collaboration factor is strongly linked to the difficulty of defining actor's responsibilities within the process and fulfilling a role of missing actors (for instance somebody who is knowledgeable about smart and can make a functional design – smart building brief). (Stam, 2019)

'There is just a real price to be paid in terms of time and collaboration. These barriers are basically there. I think that anybody who would start to implement smart within their organization is really testing the whole organizational collaboration, commitment, patience. Because nothing is what it seems. I think it is almost like a mirror to an organization when it shows us on how many assumptions we actually operate. (…) easily improving people's collaboration on things that they do not know how they work I think it is a much bigger challenge.'

Head of Smart Building Solutions
Geert Stam

The difficulty also appears in relation to communication. Due to the complexity of the SRE development and its novelty it is difficult to clarify clear messages which can be communicated and/or discussed with office employees.

'We have seen that people had been extremely eager to know what is there but in terms of the project we were still on the huge unknown and that is very different when you would have a fixed product, that would not change. You would know what it is then you can also tell it the moment you sign the contract. And in this case we are still negotiating features and planning specific installations on the timeline.'

Head of Smart Building Solutions
Geert Stam

Process overview

The process overview is presented in figure 40. The two feedback moments (marked in blue) allowed to confront the new office development strategy with the end users' perspective. Stam (2019) indicated that within this process it was very important and at the same time difficult to ensure proper internal communication with all relevant stakeholders.

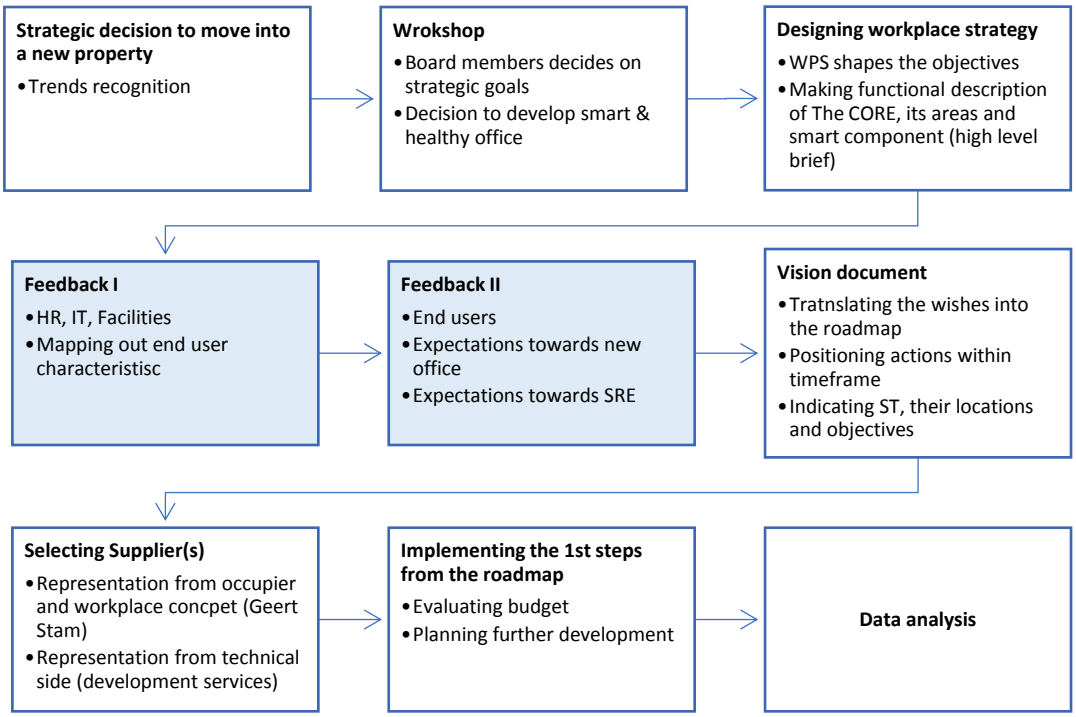


Figure 40 Process overview, The CORE; source: author, based on (Stam, 2019)

The process explained by the interviewee does not cover steps which are still intended (the process is going to continue), it only explains what has happened until now. The researcher is aware that the organization has performed a session during which UX designer had met with office employees. During the session office employees had given feedback on the current mobile application, its features and its usage throughout the working day at the office. The workshop has provided a valuable input for the team which will further develop new mobile application (HOST).

Technology overview

Currently the organization uses Flowscape application. Before 2020 this application is going to be replaced by developed in-house app (HOST). The new application will supplement Flowscape with features like ambient control, communication, and localization (wayfinding services). The current and planned application functionalities are summarized in table 12. The measurement method (ST) is pictured on figure 41.

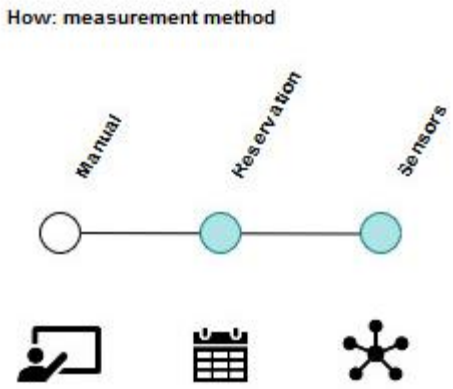


Figure 41 How: measurement method, The CORE; source: author

	SMART TOOL	FUNCTIONALITY	USE CASE	ADDED VALUE
	Thermostat; Planned: sensor Infrared PIR	Adjusting temperature	Planned: via application	Developing healthy office, indirectly increasing satisfaction
	Planned: sensor Infrared PIR/AIR	Adjusting lightening	Planned: via application	Developing healthy office, indirectly increasing satisfaction
	Sensor: Infrared PIR	Desk occupancy status (free/occupied/booked)	Screen, application	Supporting workplace concept, indirectly supporting user's activities
	Sensor: Infrared PIR; Outlook booking system	Room occupancy status (free/occupied/booked)	Screen, application	Supporting workplace concept, indirectly supporting user's activities
	Sensor: Infrared PIR; Outlook booking system	Book a room	Via application	Supporting workplace concept, indirectly supporting user's activities
	Sensor: Infrared PIR	Book a desk	Via application	Supporting workplace concept, indirectly supporting user's activities
	Sensor: Bloetooth, iBeacons	Colleague finding (opt-in)	Application, (un)visible modes	Indirectly supporting office worker activities and increasing satisfaction
	None	Communicate	Planned: via application	Indirectly supporting office worker activities and increasing satisfaction

Table 12 Technology overview; source: author, based on (Stam, 2019)

Functionalities related to space occupancy status and booking are developed in order to support the workplace strategy. The workplace strategy itself aims at supporting users activities therefore the technology indirectly fulfil this goal due to enabling the strategic goal. Further roadmap of the CORE development emphasises certain sensors installation (for air quality measurements) and system integration which will lead to WELL certified healthy office status. Increasing users' satisfaction (and productivity) is going to be achieved due to provision of a healthy office (WELL certified) and learning from its usage through time. (Stam, 2019)

'Technology in the office can gradely improve people's satisfaction because it will quantitative over time. Basically every half year it will be better attuned to people's needs.'

Head of Smart Building Solutions
Geert Stam

Access to data

'Obviously smart becomes smart when you can actually learn from it, when it gives us direct feedback' therefore it is essential to collect, store and analyse data (Stam, 2019). Nowadays the Smart Solutions (SS) team (part of WPS) gathers data presented in table 13. The information is first extracted by IT department from Flowscape and Yanzi (sensor provider) database, it passes through SS framework which addresses strategic questions related to the space occupancy, employees' working habits and building performance (planned). Recently the data is being handed over to data

scientists who can visualize the findings. SS team presents these further to the CREM board and the team which works on the new app for CBRE. (Stam, 2019)

	DATA: WHAT	ACCESS: WHO
	Workspace: desk occupancy	SS + data scientists, WPS, team which develops the new app
	Workspace: desk booking	SS + data scientists, WPS, team which develops the new app
	Workspace: rooms occupancy	SS + data scientists, WPS, team which develops the new app
	Workspace: rooms booking	SS + data scientists, WPS, team which develops the new app
	Planned: application usage	SS, team which develops the new app

Table 13 Data access, The CORE; source: author, based on (Stam, 2019)

The SS team is recognized within the figure 42 as a 'support'. SS is an actors which passes the data analyses results further to CREM and WPS (also 'support').

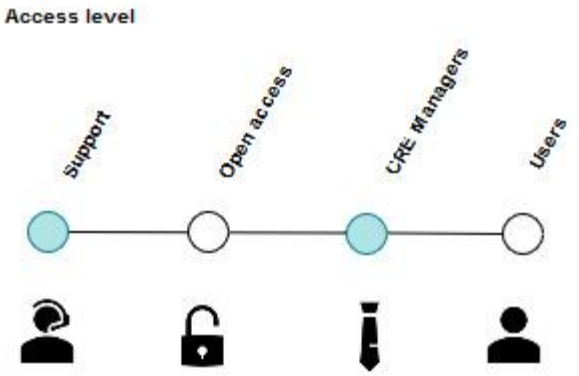
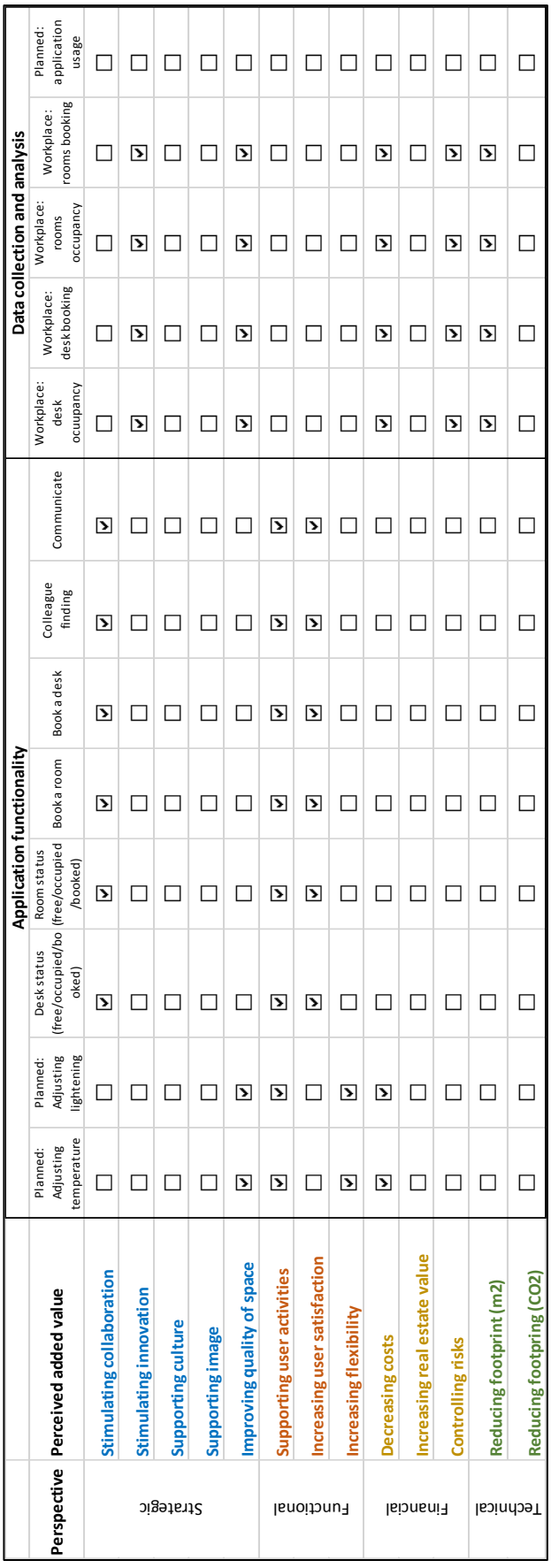


Figure 42 Access level, The CORE; source: author

Additional lessons learned

Due to the fact that there was not many experts on smart on the market back then, it was difficult to define ST which are needed while developing SRE. Lack of expertise also applied to suppliers who have provided a list of available ST without thinking about its utility to the organization. Throughout the interview Stam (2019) had indicated three critical aspects which need to be taken care of while developing the SRE: (1) being critical towards the ST suppliers, (2) missing an actor which could define necessary ST and write 'smart brief', (3) asking end users for feedback within the context.

In-depth interview appendage



Perspective	Perceived added value	Application functionality								Data collection and analysis					
		Planned: Adjusting temperature	Planned: Adjusting lightening	Desk status (free/occupied/booked)	Room status (free/occupied /booked)	Book a room	Book a desk	Colleague finding	Communicate	Workplace: desk occupancy	Workplace: desk booking	Workplace: rooms occupancy	Workplace: rooms booking	Planned: application usage
Strategic	Stimulating collaboration	☐	☐	☑	☑	☑	☑	☑	☑	☐	☐	☐	☐	☐
	Stimulating innovation	☐	☐	☐	☐	☐	☐	☐	☐	☑	☑	☑	☑	☐
	Supporting culture	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Supporting image	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Improving quality of space	☑	☑	☐	☐	☐	☐	☐	☐	☐	☑	☑	☑	☐
Functional	Supporting user activities	☑	☑	☑	☑	☑	☑	☑	☑	☐	☐	☐	☐	☐
	Increasing user satisfaction	☐	☐	☑	☑	☑	☑	☑	☑	☐	☐	☐	☐	☐
	Increasing flexibility	☑	☑	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Financial	Decreasing costs	☑	☑	☐	☐	☐	☐	☐	☐	☑	☑	☑	☑	☐
	Increasing real estate value	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Controlling risks	☐	☐	☐	☐	☐	☐	☐	☐	☑	☑	☑	☑	☐
Technical	Reducing footprint (m2)	☐	☐	☐	☐	☐	☐	☐	☐	☑	☑	☑	☑	☐
	Reducing footpring (CO2)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Figure 43 In-dept interview appendage, the CORE; source: (Stam, 2019)

4.2. The Outlook, Schiphol & Microsoft, Amsterdam

Figure 44 The Outlook; source: (de Architect, 2019)

Project info

The Outlook building is an asset within Schiphol Real Estate portfolio. The building has in total 38.000 square meters and hosts multiple tenants out of which Microsoft is one of the biggest (occupy 8.000 square meters). The building consists of office spaces and 900 parking spots. (de Architect, 2019)

The Outlook is the first smart building developed within 'smart airport city'. Sensors, innovative technologies, mobile application and smart building platform helps office workers to use their work environment much more efficiently. Additionally the data analyses enables multiple actors to effectively manage the RE (Schiphol RE, 2019a).

Microsoft is hosted by Schiphol RE since 10 years. 3 years before their lease agreement was going to expire, they have shaped their current strategic objective related to their new office (van der Ven W. , 2019). The goal of Microsoft office is to *'allow the building to act as a personal assistant for staff and visitors. This should lead to more satisfied staff, higher productivity, lower energy consumption, less waste and an improved wellbeing'* (Deerns, 2019). Microsoft had been a very important tenant for Schiphol and at that time Schiphol aimed at developing 'smart airport city' (on the whole campus) in order to remain competitive and attractive. This factor in combination with Microsoft's profile (tech company) let to an ambition of developing *'the smartest building in Europe'*. (van der Ven W. , 2019) The main objectives which had steered the development of SRE are summarized in figure 45.

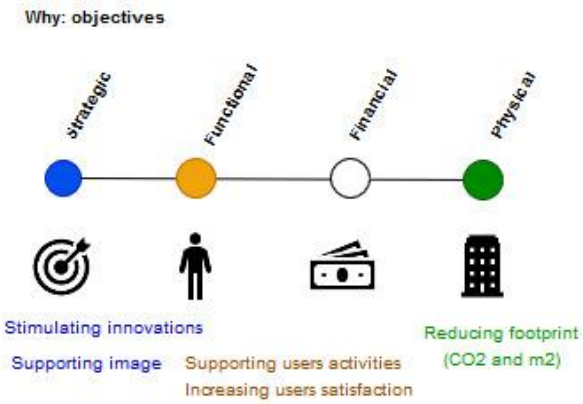


Figure 45 Why Smart RE, Outlook; source: author

'The main objective was to make the system that really improves the productivity and the comfort feeling for the people that work there and to make sure that we can manage the building in the more efficient way.'

Project developer,
Willem van der Ven

End user involvement strategy

For Microsoft the end users of their office had been at the heart of the project. From Schiphol RE perspective, the end user was not a simple office employee but the company itself - tenant. The project was unique, since the end user (Microsoft – Microsoft office employees) had not only been recognized as both the client and the development partner. (van der Ven W. , 2019)

Throughout the project development Microsoft had been very much interested in developing customer journeys. It is believed that through this method they can learn important touch points during the day of their employees and make a positive change in their working environment. Parallel the strong emphasis was given to an internal change management. (van der Ven W. , 2019)

'When you talk with Microsoft, everything they do starts with behaviour and change management. It goes (…) the way they want people to use the smart technology. If people do not change their behaviour to adopt to the possibilities of the system then there is no sense in investing in it. So obviously what they want is to use this system to help them to change the way that people work and in making life easier or more efficient for them'.

Project developer
Willem van der Ven

Barriers

From the strategic perspective the initiative did not face barriers. As explained before, the focus on end users was very strong therefore there was a lot of effort placed into the development of a system and its functionalities which respond to end users' needs (Microsoft office employees).

In order to avoid barriers related to privacy both parties took a close look on the challenge of *'getting the people to participate, without forcing them to do so'* (van der Ven W. , 2019). For that reason the system had been strongly developed towards the opts of end users. Office employees do not have to use the mobile application (which connects various sensing technology) at all if they do not want to. Nevertheless when they decide to use it, they can choose the level on which they are visible and share their information: not at all, to the sensing technology (only building, BMS), to the building and sensing technology which enable certain application functionalities (functionalities linked to space searching and space adjustment), to the previously mentioned systems and additionally to the colleagues. These solutions are directly enforced by developed (by Schiphol RE legal department) GDPR and data sharing agreement (between: Schiphol RE, Microsoft, suppliers chain).

Both interviewees indicated that further barriers related to the ST/IoT implementation initiative can be mainly encountered while scaling up the system. In order to reach the full potential of IoT it is necessary to put special effort into the successful handing over of the application (and interconnected building system) to the office employees. At the Outlook office that action had been organized and performed by MapIQ. Last but not least, an involvement of the office employees in the testing period had helped to improve the user interface of MapIQ therefore overcome technical barriers.

'MapIQ is our user interface but we have figured out that for people from Microsoft that are inside their building, using MapIQ is really complicated because it means that they have to dabble sign on. So they have to sign on, then they get some code on their phone and then they have to do it again and if they do not use the system for 15 minutes, they were shoot out and so the whole thing again. So we have found in the whole testing period that obviously nobody was using the system. So also that led to some really big changes in terms of the development of the entire system.'

Project developer,
Willem van der Ven

Process overview

While looking at the SRE development process, La Grouw (2019) sees a lot of analogy between the smart building developemnt and the regular project process. The initiative had started by developing the functionalities of the RE and specifying strategic goals. This had been adressed in the lease agreement and suplemented by developed employees journeys. Next, design steps were taken. In case of the smart building developemnt Schiphol RE had to consider not only architectural/functional design but also the system design. According to, La Grouw (2019) the technical difficulties should be solved by the RE developers and suppliers without bothering the end users.

Figure 46 presents the key steps, actors and deliverables which had played a significant role throughout the process of ST/IoT implementation initiative. Elements highlighted in blue present how, when and by who was the end users' (office employees) perspective acknowledged.

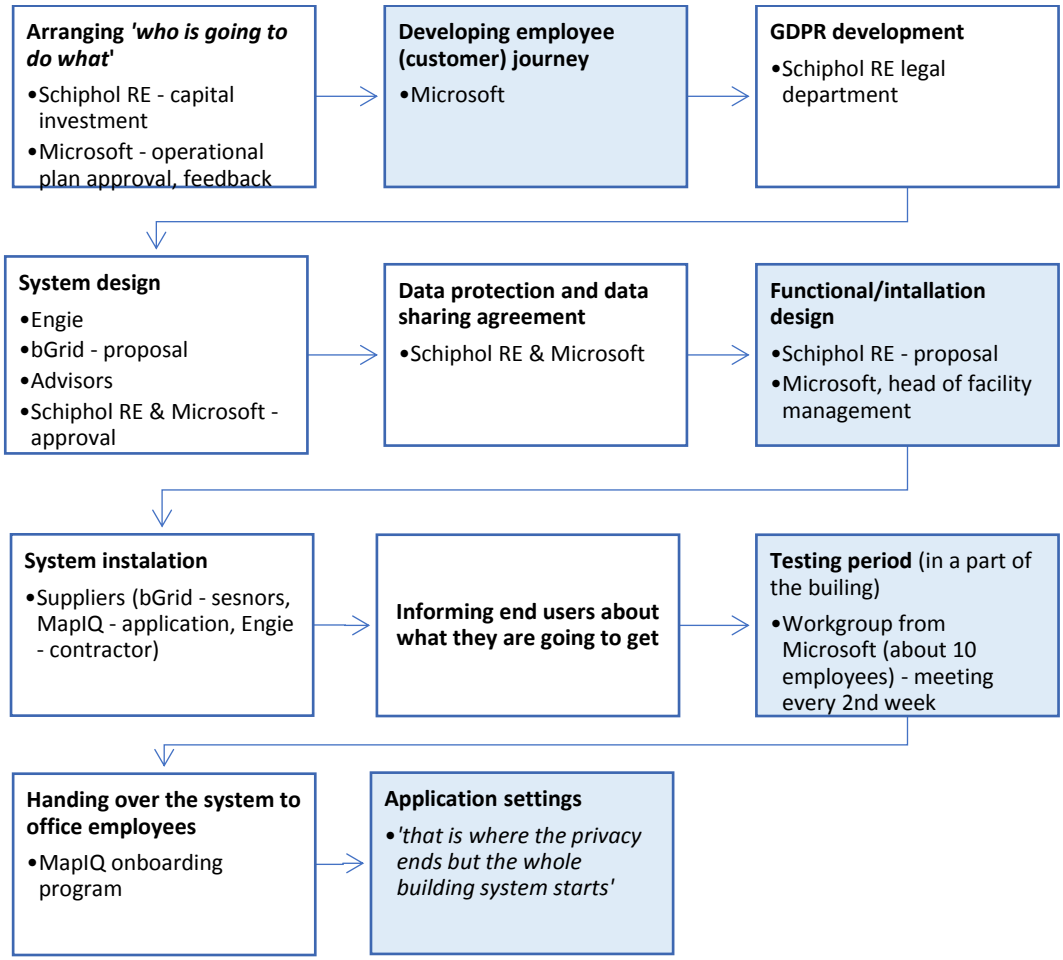


Figure 46 Process of the ST/IoT implementation at The Outlook; source: (van der Ven W. , 2019) (La Grouw , 2019)

The act of developing an employee journey allows organizations to look on the SRE through the eyes of its end user. Adopting this perspective can have a significant impact on system and functional design.

The functional/installation design in case of the Outlook had been checked by the head of facility management of Microsoft in order to confirm whether *'it is good for the employees'* (van der Ven W. , 2019). Before handing in the final product to end users, the testing period with the involvement of office employees had been conducted. That has helped to reveal some application and system problems, therefore contribute to the successful product handover and application settings adaptation.

'The system is installed, the product is never finished. Since the system is installed the focus that we are having now is on the roll out and the onboarding of their all employees.'

Project developer,
Willem van der Ven

Technology overview

The aim of this section is to present technology overview that is used by office employees and indicate how does it add value to end users. Required information had been collected via interviews and web search.

Both interviewees were asked about types of technology that is available at the Outlook office and can be used by the office employees of the Microsoft. In result 6 functionalities had been specified and presented in table 14. Figure 47 presents measurement method used within the building.

	SMART TOOL	FUNCTIONALITY	USE CASE	ADDED VALUE
	Sensors: Infrared PIR; thermostat	Adjusting temperature	Manual, intended to be via application	Increasing satisfaction
	Sensor: Infrared AIR	Adjusting lightening	Via application	Increasing satisfaction
	Sensor: Infrared PIR	Desk occupancy status (free/occupied)	Screen, application	Supporting office worker activities Increasing satisfaction
	Sensor: Infrared PIR; booking system	Room occupancy status (free/occupied/booked)	Screen, application	Supporting office worker activities
	Sensor: Bloetooth, iBeacon	Localizing employees (opt-in)	Application, (un)visible modes	Supporting office worker activities Increasing satisfaction
	Sensor: Camera (place resognition, line detection, occupancy)	Parking overview	Application	Supporting office worker activities Increasing satisfaction

Table 14 Technology overview, The Outlook; source: author, based (van der Ven, 2019) (La Grouw , 2019) and (Schiphol RE, 2019a)

The interviewees had been also asked to explain if and how 'does the specific ST/IoT adds value to office employees'.

'We have a way to support the employees at this moment and we think much larger. From here to the moon if you ask me. So right now, you come in and you can see where the workplace is available and set the controls to you preferences on the easy way.'

Project manager
Casper Le Grouw

The idea behind the mobile application (provided by MapIQ) is that is should support office workers activities. There are multiple systems incorporated into one user friendly platform. The big indication of the users' satisfaction (out of the smart technology) can be the data on application usage. (van der Ven W. , 2019)

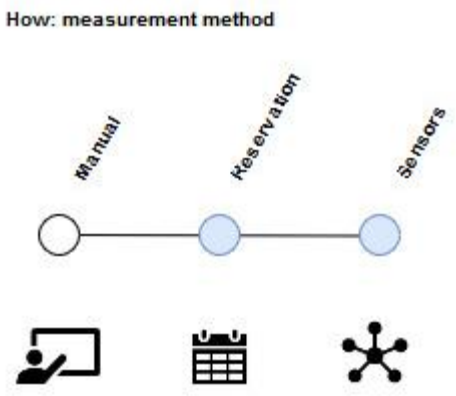


Figure 47 How: measure method, Outlook; source: author

Both interviewees believe that being capable of changing the light and/or temperature in line with personal preferences present a factor which can enhance end users' satisfaction. Another factors are: the ability to easily and fast find a colleague, find an appropriate and available place to work. It is important to notice that none of the factors are measured so far. It is due to two reason: (1) the office had been opened in October 2019, therefore it is too early to perform this measurements and (2) because the company had not been monitoring those factors before therefore there is no historical information which would allow to evaluate the findings.

Access to data

Microsoft and Outlook had created an agreement in which both parties agreed that the data are going to be used for three main purposes:

- To help Microsoft employees to be more productive and healthy,
- To improve the performance of the office building,
- To further develop 'airport city' concept.

Data related to employees are being automatically anonymized. This information is further available only to Microsoft. Other non-personal data can also be used by Schiphol RE in order to develop new application functionalities, new use cases and Schiphol 'smart city'.

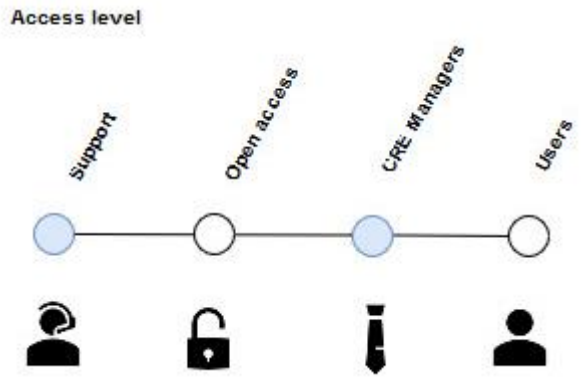


Figure 48 presents the overview of data access level. Table 15 presents in more details the access given to certain stakeholders (both: historical and real-time data). The indicated data is already being exported as dashboards. Schiphol RE highlights that multiple different dashboards can be created, for: facility managers, real estate managers, end users, depending on the data setup that they would like to access.

Figure 48 Access level, Outlook; source: author

	DATA: WHAT	ACCESS: WHO
	Information about the building performance	Schiphol RE: Facility manager, RE manager
	Indoor climate, air quality	Schiphol RE: Facility manager, RE manager
	Heatmaps of occupancy, noise level	Schiphol RE: Facility manager
	People flow through the building, way finding feature	Schiphol RE: Facility manager Microsoft: Facility manager
	Anonymized occupancy data	Microsoft
	No-shows: booking data + occupancy	Microsoft: Facility manager
	All data	Microsoft data scientists

Table 15 Access to data, The Outlook; source: author, based on based (van der Ven W. , 2019) (La Grouw , 2019)

Additional lessons learned

As explained before, the initiative was new on the market. Many activities could not be thought through therefore the process was complex. The partnership between Microsoft and Schiphol RE was the unique concept which had strengthen the strategic objectives of the concept.

'We have the perspective to involve the end users but I think it is a unique case because this is their business, this is what Microsoft does. So we have had not only end user in the sense of a client but also the end user in the sense of the partner with which we are developing together.'

Project developer,
Willem van der Ven

Additional obstacles which occurred during the process had a lot to do with the fact that it was a transformation project of an existing building. The building structure had to be adjusted and modified by multiple parties. That turned out to be difficult while implementing the IoT system due to physical constrains and multiple actors perspectives, as well as their level of experience in 'smart'.

In-dept interview appendage

(see next page)

		Application functionality							Data collection and analysis					
Perspective	**Perceived added value**	Adjusting temperature	Adjusting lightening	Desk status (free/occupied)	Room status (free/occupied /booked)	Book a room	Localizing employees (personalized)	Parking overview	Information about the building performance	Indoor climate, air quality	Heatmaps of occupancy, noise level	People flow through the building, way finding	Personalized occupancy data	No-shows: booking data + occupancy
Strategic	Stimulating collaboration	☐	☐	☑	☑	☑	☑	☐	☑	☐	☑	☑	☐	☐
	Stimulating innovation	☐	☐	☐	☐	☐	☐	☐	☑	☑	☑	☑	☐	☐
	Supporting culture	☐	☐	☑	☑	☑	☑	☑	☑	☐	☑	☑	☐	☑
	Supporting image	☐	☐	☑	☑	☑	☐	☐	☑	☐	☑	☑	☑	☑
	Improving quality of space	☑	☑	☑	☑	☐	☐	☐	☑	☑	☑	☐	☐	☑
Functional	Supporting user activities	☑	☑	☑	☑	☑	☑	☑	☐	☑	☑	☑	☐	☐
	Increasing user satisfaction	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☐
	Increasing flexibility	☑	☑	☑	☑	☑	☐	☑	☐	☐	☑	☑	☐	☑
Financial	Decreasing costs	☐	☐	☑	☑	☑	☐	☑	☑	☑	☑	☐	☐	☑
	Increasing real estate value	☐	☐	☑	☑	☑	☐	☑	☐	☐	☑	☐	☐	☑
	Controlling risks	☐	☐	☑	☑	☐	☐	☑	☑	☑	☑	☐	☐	☑
Technical	Reducing footprint (m2)	☐	☐	☑	☑	☑	☐	☑	☐	☐	☑	☐	☐	☑
	Reducing footprint (CO2)	☑	☑	☐	☐	☑	☐	☑	☑	☑	☑	☐	☐	☑

Figure 49 In-depth interview appendage, Outlook; source: (van der Ven W., 2019)

4.3. The EDGE, Deloitte, Amsterdam

Figure 50 The EDGE building; source: (Deloitte, 2018c)

Project info

The EDGE is Deloitte's office located at Zuidas in Amsterdam. The building was developed by OVG RE, is managed by CBRE and occupied (leased) primarily by Deloitte. The building was officially opened in 2015. These days the office is certified as the cleanest and most connected large space in the world. (CBRE, 2018c) The building got the highest BREEAM score (98,36%) which makes it the global assessor of sustainable buildings. The unique design and implemented digital solutions enhance building performance and workplace concept. (Deloitte, 2018c)

The decision to lease the space at the EDGE had been made by Deloitte's board during the building development. Roy Halstead (2019) indicates that the Deloitte's Real Estate division had an active role, however he also says that the 'growing IoT community played a part in bringing the budget'.

'At the EDGE bricks, bytes and behaviours are interconnected. (…) The focus of using smart technology in offices is not only to minimise the carbon footprint of a building but also to actively promote human interaction, collaboration and creativity among occupants.'

(Jalia, Bakker, & Ramage, 2019)

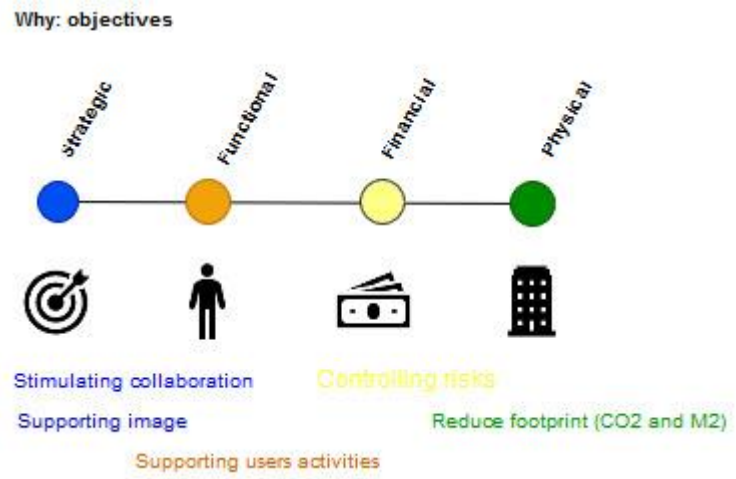


Figure 51 Why smart RE, The EDGE; source: author

The new office development had been steered by (Deloite's) three main strategic objectives: (1) enhancing employees experience, (2) learning and sharing experience with clients, (3) learning in order to further develop the building. The IoT is recognized as the foundational principle of the EDGE. Erick Ubels's (CIO) idea of developing SRE had been developed from bottom-up by various suppliers. The initial though was predominantly focusing on the workplace experience where technology was seen as an enabler within the working environment. (Jalia, Bakker, & Ramage, 2019) Finally Deloitte aimed at inspiring and 'revolutionizing and reinventing' the workplace. (Halstead, 2019) (Deloitte and ARUBA, 2018) The main objectives which had steered the development of SRE are summarized in figure 51.

End user involvement strategy

The interviewee did not speak about end user involvement strategy linked to the development of the office concept and the initial smart solutions selection (he was not involved during that project development phase). Nonetheless he has indicated that the office employees are involved in the development of use cases where Deloitte's IoT department test and validate some of the assumptions and smart solutions (for more details see the process overview section). The development of the customer journey helped the CREM to look at the building and IoT solution through employee's eyes. Last but not least UX designer and Service Design team constantly help to

design best solutions which are going to be handed in (improved and new) within the EDGE. (Halstead, 2019)

Barriers

The barrier related to the IoT development had a direct link to office employees. Roy Halstead (2019) knows that there are always people who have concerns related to privacy. That is why the IoT solutions have to be GDPR compliant and the IoT department is putting a lot of effort into making sure that employees' concerns are addressed and met.

Process overview

The interviewee could not describe the process of the building development since he was not involved during this phase of the project. Yet he has clearly described the process of use cases development and IoT solutions adaptation. That gives good insight into the operational phase of the RE management. For more details see figure 52.

Rolling up mobile application at the EDGE had been proceeded by test performed by selected office employees (20 to 30 people). When the application and its features had been approved, the application had been handed in. Office employees had been informed about it via by email (internal communication channel).

These days it is possible for IoT department to see result of the application adaptation (usage of it). The department also measures the satisfaction level of the technology. That takes place through the use cases' development. That enables Deloitte to learn about utility of the IoT solution. Same goes for application features. (Halstead, 2019)

Additionally these days (while the building is occupied) Deloitte's IoT department puts effort into constantly interviewing their employees. The interviews output allows them to define problems and criticalities related to the implemented in the building IoT system. After gaining the insight, IoT department develops use case, appoints testing group and conducts the 2nd round of interviews. The goal of this procedure is to improve current solution - make things better and more comfortable for office employees. (Halstead, 2019)

In his work (IoT department manager) Roy Halstead faces a challenge of bridging different stakeholders, their opinion, IT capabilities and legal regulations (GDPR) throughout the process of technology validation. His goal is to shape a visible business case.

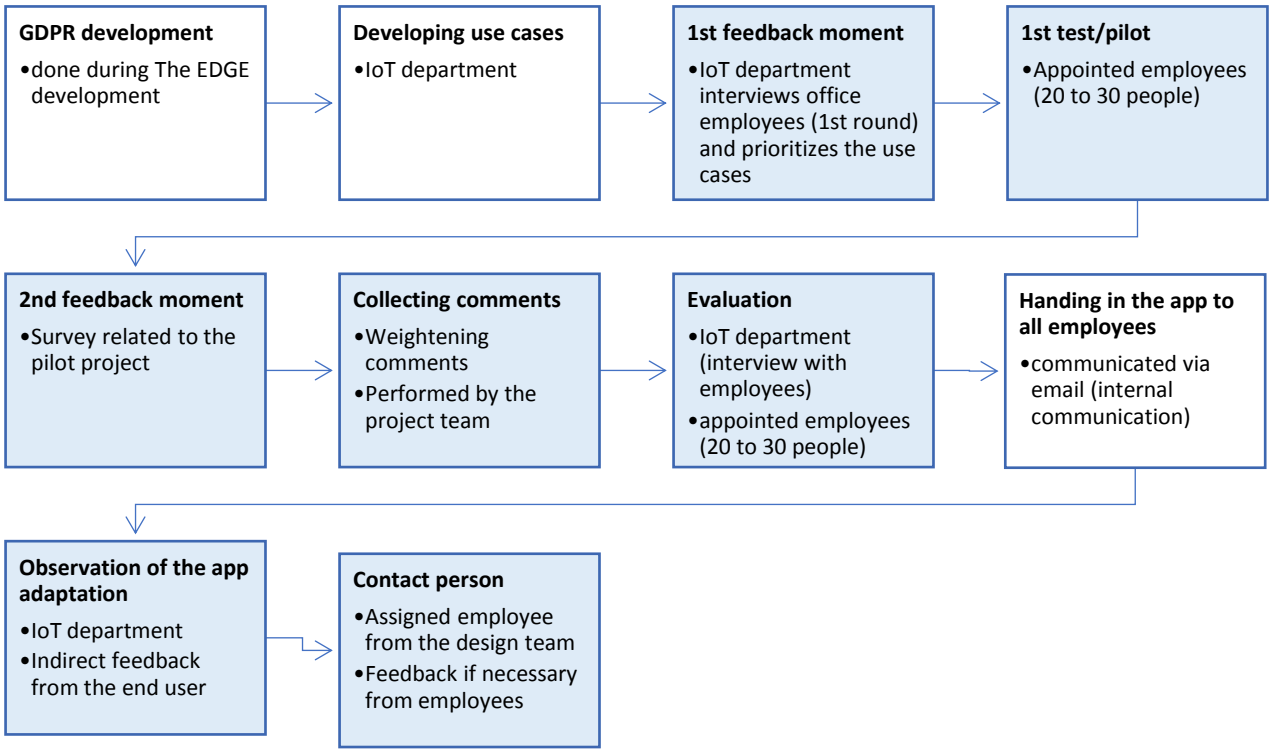


Figure 52 Process overview, The EDGE; source: author, based on (Halstead, 2019)

Technology overview

Table 16 presents the technology which is available at the EDGE - is used by Deloitte's employees. The mobile application developed by MapIQ is connected with the sensing technology (30.000 sensors) and building installations (which can improve the building performance by controlling lightening, temperature and adjusting accordingly to the occupancy level). The office employee can customize the temperature and light level via the app (by +-2°C), choose an unoccupied place to work (a desk or a room) and find the fastest way to it. (Halstead, 2019) (MAPIQ, 2019b) (BREEAM, 2019)

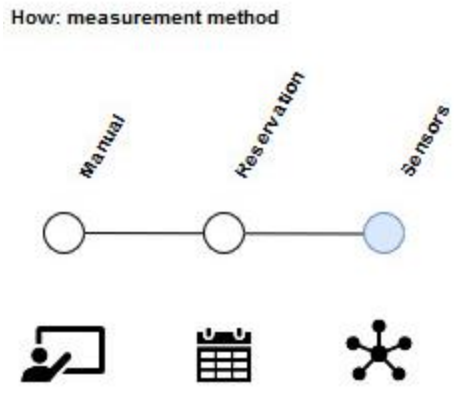


Figure 53 How: measurement method, The EDGE; source: author

The localization services are strongly linked to the feature 'find your colleague'. This feature is an opt-in setting which can be modified by an office employee via the application. Thanks to the localization services the parking free spots and the elevator position can be tracked by the employees so that they can plan their activities more effectively. (Halstead, 2019) (MAPIQ, 2019b) (BREEAM, 2019) Halstead (2019) has explained how do the specific features benefit the office employees. He believes that all the IoT components indirectly increases employees satisfaction. Finally figure 53 presents measurement method used within the building.

	SMART TOOL	FUNCTIONALITY	USE CASE	ADDED VALUE
	Sensor: Infrared PIR; Thermostat	Adjusting temperature	Via application	Indirectly increasing satisfaction
	Sensor: Infrared PIR/AIR	Adjusting lightening	Via application	Indirectly increasing satisfaction
	Sensor: Infraded	Desk occupancy status* (free/occupied)	Screen, via application	Helping employee to find the place faster, indirectly supporting office worker activities
	Sensor: iBeacons; booking system	Room occupancy status (free/occupied/booked)	Screen, via application	Easier and more efficient working activities, indirectly supporting office worker activities and increasing satisfaction
	Sensor: iBeacons; booking system	Room occupancy status: no-show	Via application (personal message)	Efficient use of space, indirectly supporting office worker activities
	Sensor: Infrared PIR; booking system	Book a room	Via application	Supporting office worker activities
	Sensor: iBeacon	Localizing employees (opt-in)*	Via application	Easier and more efficient working activities, indirectly supporting office worker activities
	Sensor: iBeacon	Elevator*	Via application	Easier and more efficient working activities, indirectly supporting office worker activities
	Sensor: Infrared	Parking overview	Via application	Helping employee to find the place faster, indirectly supporting office worker activities

*Localization services = showing a way

Table 16 Technology overview, The EDGE; source: author, based on (Halstead, 2019) (MAPIQ, 2019a)

Access to data

The access to data in that case is given to three main stakeholders: IoT department, office employees and RE managers (see table 17). The IoT department is an unique Deloitte division which serves advisory services to clients. The access to data helps IoT department to learn, develop new and improve old use cases which lead to offering better advice to clients. End users can access real-time space occupancy data which enable them to make conscious decisions about their location and activities. Facility managers can see real-time and historical building performance data related to space usage (helps to plan preventive cleaning and maintenance services), installations' technical condition (for instance leaks in pipes) and energy performance. (Halstead, 2019) (BREEAM, 2019)

	DATA: WHAT	ACCESS: WHO
	Workspace: desk occupancy	IoT department, office employee
	Workspace: rooms occupancy	IoT department, office employee
	Workspace: no-show	IoT department
	Hallway occupancy, heatmaps	IoT department
	Gym occupancy	IoT department
	Cafeteria	IoT department, end user, cafeteria services
	Energy performance and post processing for energy analysis	Facility managers
	Building usage monitoring for facility management	Facility managers
	Installation monitoring for technical management	Facility managers

Table 17 Access to data, The EDGE; source: (Halstead, 2019)

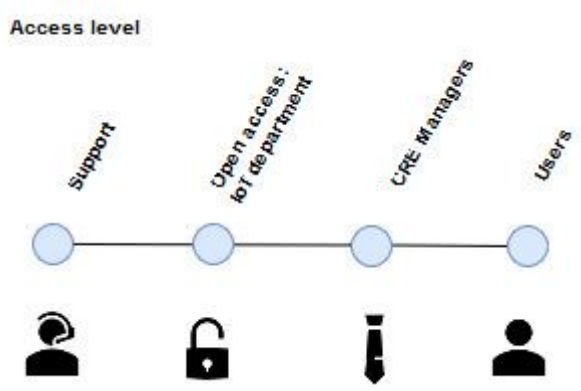


Figure 54 Access level, The EDGE; source: author

The access level is summarized in figure 54 and specified in more details in the table 17. The IoT department is recognized as the actor which has open access to majority of data bases.

Additional lessons learned

It is interesting to see that the IoT department is a unique concept therefore it is not present at many organizations. The IoT manager role is unique on current market, nevertheless is plays a crucial role.

I highly coordinate and conduct the use case adoption and also coordinate the development team within the IT department but also manage the stakeholders and make sure that their expectations are met but also manage the realistic functions to have results as quick as possible but it is not as easy as you can see.

IoT department manager,
Roy Halstead

The interview with Roy Halstead brings into light current trend related to IoT development within office real estate (see below). His view is shared by the IoT department and Deloitte's vision on the IoT implementation.

'We are living in a moment of shift. (…) What we do here also is we always we think how do we involve them at the level that people can say what is the direction that they would like to see. (…) On one end from the organizational perspective it is moving from the departments to new hybrid which embraces these kind of changes and we are also touching these elements. (…) It is a change and involving people is something that they want to do, they strive for it. The market is the customer, so our internal market is at peak and we experience it.'

IoT department manager,
Roy Halstead

It confirms current market situation and supports the problem statement proposed at the beginning of this research paper.

4.4. EDGE Olympic, EDGE Technologies, Amsterdam

Figure 55 EDGE Olympic; source: (MapIQ, 2019c)

Project info

EDGE Technologies is a development company which believes that *'the world needs better buildings'*. In line with that principle the company has created the innovative, healthy and sustainable office building – EDGE Olympic. (EDGE Technologies, 2019a)

The idea of developing a smart building had been pushed by Erick Ubels, who was fulfilling the roles of Chief Facility Officer and Chief Information Officer. His double position enabled the smart concept through project development phases. In the end, the company sees three main reasons for developing a SRE: sustainability (energy performance, material usage), efficiency (construction and space usage), costs benefits (during development and operational phase). While developing smart functionalities, EDGE Technologies aimed at taking away the hassles that an office employee can have throughout a day by incorporating many functionalities into one transparent system which helps employees to save time and be more productive. The building design and implemented technologies respond to observed by the company market trends: 'bringing your own device'/digitalization and office employees' well-being. (Gritti, 2019) The EDGE Technologies KPI's are: Optimal Asset Exploitation, Operational Efficiency, Daily Convenience, Sustainable Performance, Talent attraction and retention, Operations (EDGE Technologies, 2019b).

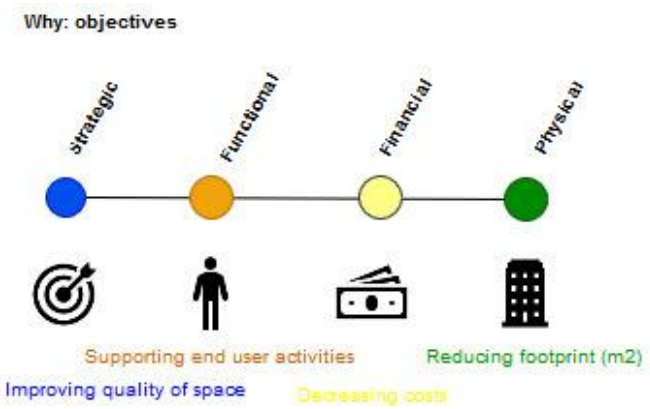


Figure 56 Why smart RE, EDGE Olympic; source: author

EDGE Olympic incorporates in its design a digital structure, which connects people and things (IoT) to a cloud platform. The digital infrastructure is designed in a way that allows to plug in extra services when the market trends change, regularly update the system, store data while bringing value to RE managers as well as office employees. (EDGE Technologies, 2019a) The main objectives which has steered the development of the SRE are summarized in figure 56.

End user involvement strategy

The IoT concept developed at the EDGE Olympic aims at adding value inner alia to the end users. The utility of the IoT system depends largely on the mobile application adaptation. EDGE Technologies had come up with a unique concept which ensures that the application is used by the office employees: the toothbrush test. The toothbrush test objective states that *'the application have to be used by the end users at least twice a day'*. Otherwise its functionalities will not be adopted. In order to achieve this objective, EDGE Technologies stimulates the necessity of using the app (for instance mandatory access control via QR code). (Gritti, 2019).

In fact, the end user involvement strategy is strongly linked to the application. The goal is to make sure that the application is frequently used and that office employees address their feedback on its functionalities to the contact person within the company (not MapIQ which gets the data on app usage).

Barriers

Sandra Gritti (2019) highlights the importance of the application. EDGE Technologies is aware that the key to data collection and service adaptation lays down in hands of end users. In order to ensure a successful IoT implementation it is important to acknowledge the barrier related to the application functionalities and its settings. In the end, she says that the *'smartphone is the key and remote control for the building'* (EDGE Technologies, 2019a).

> *'The function can be as good as you want but if those basics (application settings) do not make it very simple for people to get the app, the automatic updates do not take place or when it is not very intuitive for the user, you can have the most amazing functions which in theory could be ever thought of, but it will be not adopted.'*
>
> *Product Excellence Director*
> *(before: Concept Developer and Development Manager)*
> *Sandra Gritti*

Within EDGE Olympic the localization functionalities are enabled by Bluetooth technology. Making this functionality available by Wi-fi network would not make it possible to install an opt-in system control (invisible mode which is mandatory in line with GDPR) without turning on the wi-fi. This approach puts an office employee in a situation where he/she cannot perform his/her work (no internet connection if somebody wants to be invisible to the system). The technological solutions have to follow the GDPR, which can sometimes cause an obstacle for smart technologies implementation. (Gritti, 2019)

EDGE Technologies believes that there is a value which can be gained due to smart technology implementation. Nevertheless *'sometimes (…) you cannot prove that the value is there'* (Gritti, 2019). From the investor perspective that makes it difficult to make an investment in SRE. (Gritti, 2019) When it comes to the app usage and the feedback related to it, EDGE Technologies does not have a control over the feedback adaptation. That is performed by an external provider (MapIQ) therefore it is difficult for EDGE Technologies to learn from it. (Gritti, 2019)

Process overview

The interviewee had described in details the process of EDGE Olympic development (see figure 57). The process involved stakeholders such as contractor, suppliers and the client which are repetitive in any design and construction initiative which EDGE Technologies conducts. What was unusual in the process is the new role: expert on smart. (Gritti, 2019) The EDGE Technologies represented interests of end users due to developing user journeys, conducting sessions with the end users. Later they have defined IoT functionalities and made sure that the system is handed over correctly (emails,

testing and onboarding program). These days the company facilitates the satisfaction surveys (together with Leesman) and constantly maintain and manage the system.

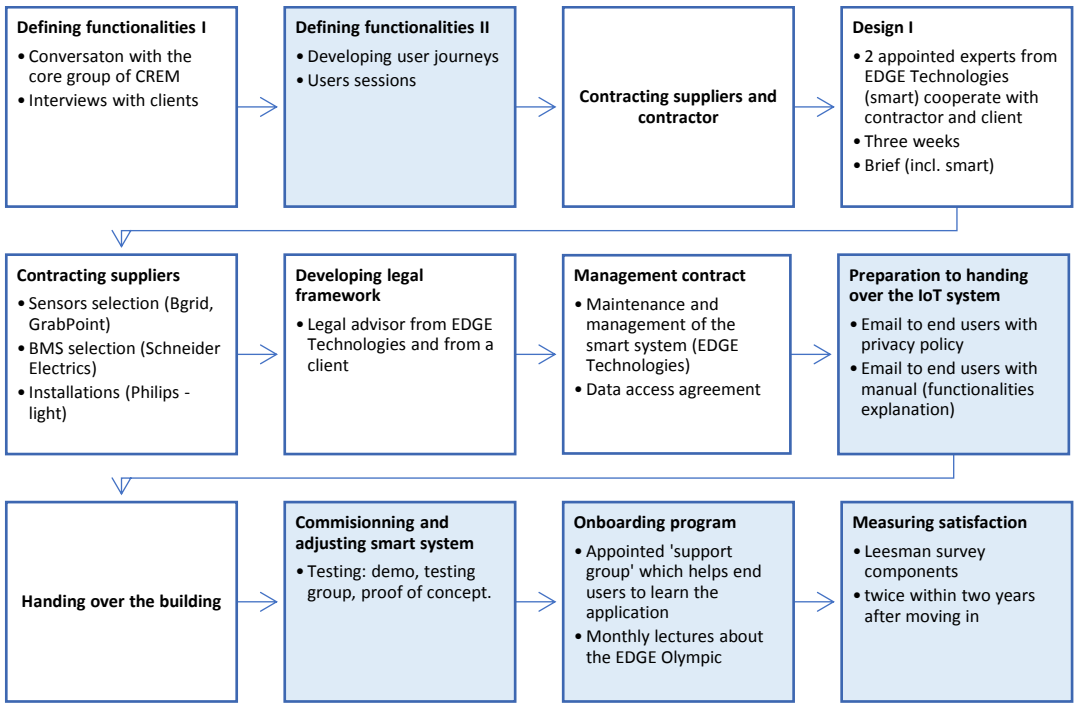


Figure 57 Process overview, EDGE Olympic; source: author, based on (Gritti, 2019)

Technology overview

EDGE Olympic is equipped with various sensors which communicate real-time information with the office employees. The technology overview is presented in table 18. The IoT system helps to increase comfort level at an office. The application gives employees an opportunity to personalize their working conditions (light, temperature) which highly contributes to employees' satisfaction, comfort and wellbeing. (MapIQ, 2019e)

Besides the functionalities which are listed in the table 18, the IoT system can offer (to the office employee) an advice on the workplace (both meeting room and desk) based on the manually updated favourite settings and real-time place/space availability (Gritti, 2019).

	SMART TOOL	FUNCTIONALITY	USE CASE	ADDED VALUE
	Sensors: Infrared PIR/AIR	Adjusting temperature	Via application	Increasing comfort, productivity and employee's performance, indirectly increasing satisfaction
	Sensor: Infrared AIR, iBeacon	Adjusting lightening	Via application	Increasing comfort, indirectly increasing satisfaction
	Sensor: Infrared PIR, iBeacon	Desk occupancy status (free/occupied)	Via application	Taking away the hassle, saving time, increasing productivity, efficiency and satisfaction, indirectly supporting office worker activities
	Sensor: Infrared PIR	Room occupancy status (free/occupied/booked)	Soon via application	Managing employee's time efficiently, indirectly supporting office worker activities

	Sensor: Infrared PIR, iBeacon; booking system	Book a room	Via Outlook (soon via application)	Managing employee's time efficiently, indirectly supporting office worker activities
	Sensor: Bloetooth; iBeacon	Localizing employees (opt-in)	Via application	Shaping a community, making working together easier indirectly supporting office worker activities and increasing satisfaction
	Vecos system	Vecos lockers (location, availability and control)	Via application	Efficient usage of lockers, enhancing employees productivity and satisfaction, indirectly supporting office worker activities and increasing satisfaction
	Sensor: Infrarood, iBeacon	Parking overview, control of the garage barrier/doors	Via Application	Not specified

Table 18 Technology overview, EDGE Olympic; source: author, based on (Gritti, 2019) (MapIQ, 2019c) (MapIQ, 2019d)

Figure 58 presents measurement method used within the building. Additional (besides the one indicated in table 18) sensors measure: day light, light density, humidity level, sound level, CO2 level and energy localization/heatmaps (based on temperature) (Gritti, 2019). These sensors help to ensure good quality indoor working environment and make sure that 'WELL outstanding' conditions are maintained.

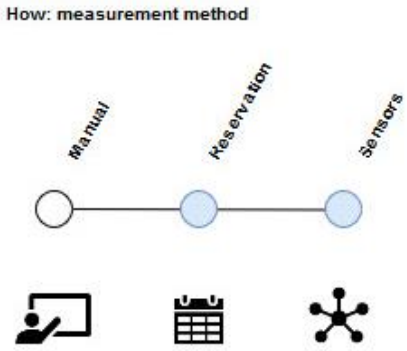


Figure 58 How: measurement method, EDGE Olympic; source: author

Access to data

The EDGE Olympic data can be accessed by various actors through the Power BI web portal or BI mobile app. Interested CRE managers and office occupiers can easily see the data displayed as dashboards and reports. Currently displayed historic data are summarized in table 19. (EDGE Technologies, 2019b) The actors which have access to the data are: CREM, building owner, building tenants, maintenance services and cleaning services (Gritti, 2019). The interviewee did not specify which shareholders have access to which data that is why those are further called 'interested parties' (the data are available to relevant parties which are interested in them) (see figure 59).

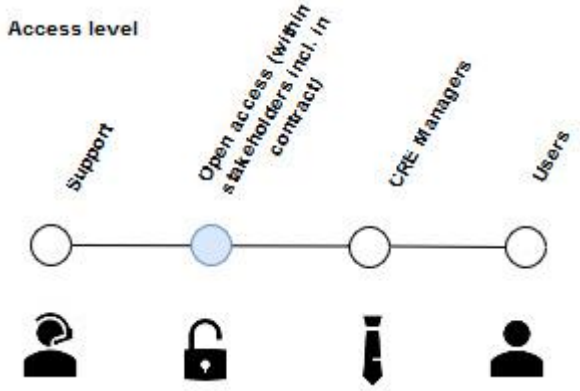


Figure 59 Access level, EDGE Olympic; source: author

	DATA: WHAT	ACCESS: WHO
	Information about the building performance: energy performance	Interested parties
	Information about the building performance: installations, HVAC performance	Interested parties
	Ambient data: temperature, CO2, air quality	Interested parties
	Heatmaps of occupancy, space acoustics (noise level)	Interested parties
	Application usage	MapIQ
	Room usage statistics	Interested parties
	Desk usage statistics	Interested parties

Table 19 Data access, EDGE Olympic; source: author based on (Gritti, 2019) (EDGE Technologies, 2019b)

The building system is capable of adjusting its energy settings. The building is responsive to real time data related to CO2 and temperature level therefore it minimizes the energy performance. (Gritti, 2019).

Additional lessons learned

After handing over the EDGE Olympic office building, EDGE Technologies had decided to take their time for smart solutions development. Their current strategic planning related to SRE development indicates that when the building is handed over to the tenant, EDGE Technologies still have 3 to 6 months for commissioning and handing over the smart solution (incl. application). (Gritti, 2019)

'We see that a lot of people are animals of habits, so you used to have those things realized in a stupid way at an office in the past, and you really need to show them exceptionally great benefits with really really good user interface to adopt a new way of working. I think that is the thing that we are learning the most: how important it is.'

Product Excellence Director
(before: Concept Developer and Development Manager)
Sandra Gritti

Last but not least the interviewee stresses that it is important to make the end user understand and appreciate the concept while implementing any smart technology. (Gritti, 2019)

4.5. ECORYS, ECORYS, Rotterdam

Project info

ECORYS office is located in Rotterdam at Watermanweg 44 in a multitenant office building. In 2016 the company had decided to move their office from the first three floors to the three top floors. At that time one out of the three lower floors had been barely occupied. The upper floors are smaller therefore they had appeared as a suitable solution for the company. While designing the concept of the new

Figure 60 ECORYS office; source: author

office, the moving committee had recognized the need for a software which would help employees during their day at work. The moving committee has selected the Floorplanner software. (van der Ven F. , 2019).

'We want to work together and meet each other so it is very useful to know where are my colleagues. If I am working on the same project I can join them.'

Facility manager
Frank van der Ven

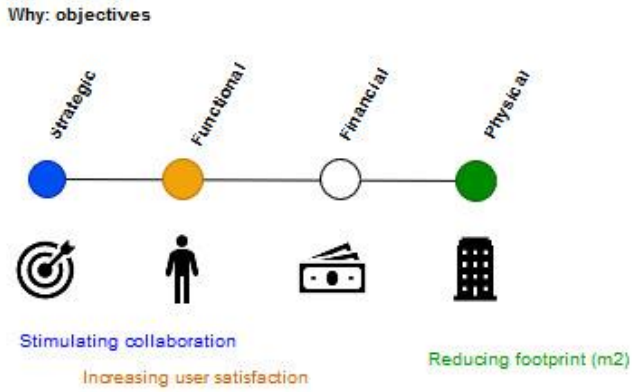


Figure 61 Why smart RE, ECORYS; source: author

These days the system helps office employees to find each other and work more effectively. Due to the improvement of the office space and implementation of the Floorplannner system ECORYS office is *'working on both sides: improving the efficiency by technology but also improving peoples satisfaction'* (van der Ven F. , 2019). The main objectives which had steered the development of a SRE are summarized in figure 61.

End user involvement strategy

Frank van der Ven (2019) had been strongly involved in the process of planning and organizing the new office. From the FM perspective he had actively contributed to discussions of the appointed 'moving committee'.

Throughout the process ECORYS had been supported by an external advisory company. The advisory company had proposed to organize regular meetings (so called 'lunch clinics') during which office employees could address their ideas, concerns and discuss proposed by the moving committee concepts. The clinic's discussions were mainly touching upon: how do people work at the office, what do they need/want, what do they like/dislike and/or what can be improved. (van der Ven F. , 2019)

These days the marketing and communication department is responsible for conducting surveys which indicate office employees' satisfaction level. The board is aware that in order to retain talents they have to make sure that their employees are happy and enjoy the office environment. (van der Ven F. , 2019)

In short, ECORYS can receive feedback from their employees, however there is no clear link between the addressed feedback concepts and the development of a smart office concept.

Barriers

Certain smart solutions cannot be developed within the ECORYS office. The space conditions and smart solutions implementation is limited due to the fact that the space is leased. The FM perceives barriers related to the development of smart indoor climate control system since the indoor climate conditions and related to installations which are managed by the building owner. (van der Ven F. , 2019)

Process overview

As explained before, the Floorplanner software had been implemented as an additional solutions which supports the new office. Figure 62 presents briefly the process of office development. It is

important to note that the steps (also those in blue – involvement of end users) refer to a broader office concept development (not only its smart part).

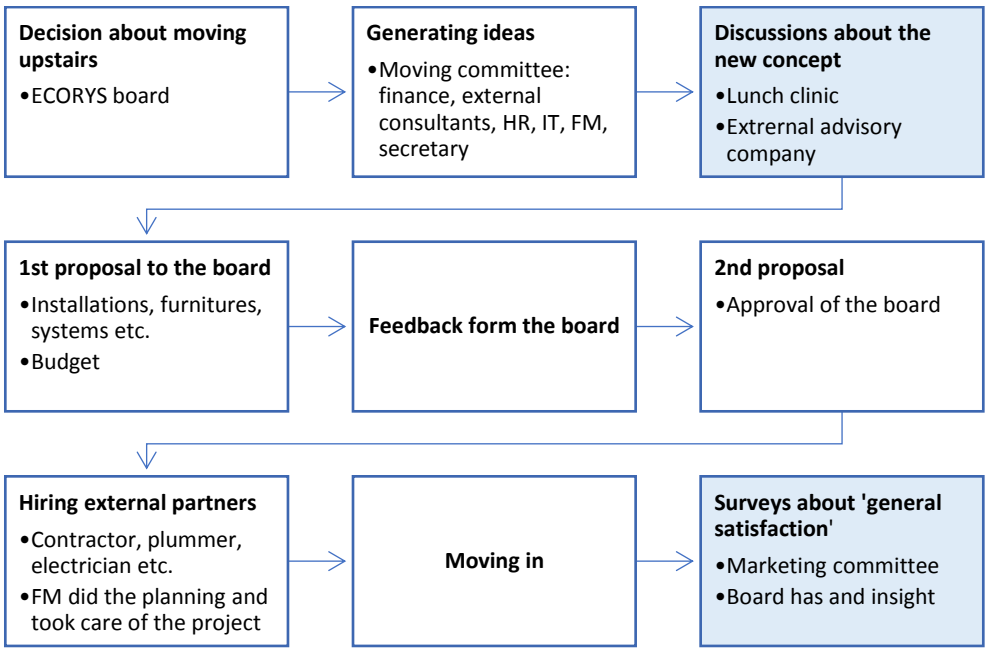


Figure 62 Process overview; source: author, based on (van der Ven F. , 2019)

The interviewee had distinguished within the process following key stakeholders:

- Managing Director (decision-maker)
- FM (manages the office)
- IT manager (manages the system, arrange suppliers, works on the Floorplan software development - app)
- HR (partner in the discussion during moving, as well as during operational phase)
- Contact person for employees (at the service desk).

Technology overview

At the ECORYS office in Rotterdam the moving committee had decided to implement Floorplanner software. The system communicates with the end users via a screen where the information is displayed (see table 20). Figure 63 summarizes the measurement methods implemented at the building. The system informs end users about space occupancy and colleagues location. Office employees can see which computer (desk) is occupied by who therefore they can easily find each other and work together. There is no opt-in option related to employees' visibility to the system. (van der Ven F. , 2019)

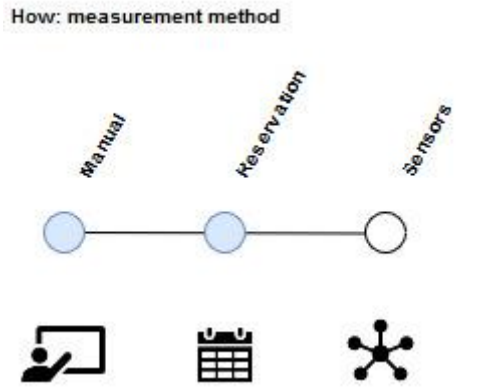


Figure 63 How: measurement method, ECORYS; source: author

	SMART TOOL	FUNCTIONALITY	USE CASE	ADDED VALUE
	Thermostat	Adjusting temperature	Manual, per room	Indirectly saving energy and costs
	Log in on a computer	Desk occupancy status (free/occupied)	Interactive screen	Indirectly supporting office worker activities
	Booking system Outlook	Book a room	Screen in front of the room (pilot), Outlook system	Indirectly supporting office worker activities
	Outlook booking system	Room occupancy status (free/occupied)	Screen on each floor	Indirectly supporting office worker activities
	Log in on a computer	Localizing colleagues (no opt-in)	Screen at every floor (after clicking a desk)	Indirectly supporting office worker activities

Table 20 Technology overview, ECORYS; source: author, based on (van der Ven F. , 2019)

The temperature can be manually adjusted (thermostat settings) by an employee in a room. That is the only solution which ECORYS can have at this moment due to the fact that the building owner is responsible for climate control system integration. (van der Ven F. , 2019)

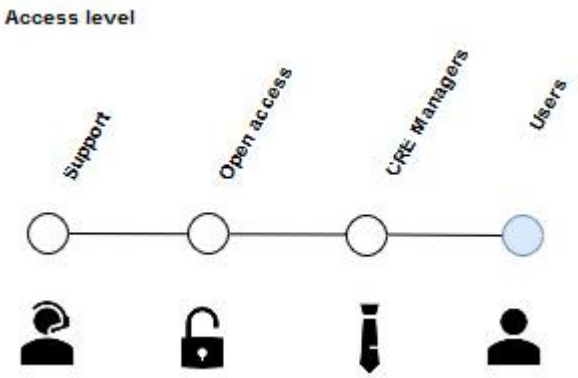


Figure 64 Access level, ECORYS; source: author

Access to data

The access to data is not assigned to any particular person neither a managerial body. The data are not collected neither stored. Only the office employee have an access to the real-time data communicated via the Floorplanner software on screens located around the office (see table 21 and figure 64).

	DATA: WHAT	ACCESS: WHO
	Occupancy data (real-time)	Office employees
	Colleague location (real-time)	Office employees

Table 21 Data access, ECORYS; source: author, based on (van der Ven F. , 2019)

Additional lessons learned

Frank van der Ven is a facility manager at ECORYS' office in Rotterdam. As he says the organization is very flat. When it comes to day to day office management there are only two people who carry out this responsibility: facility manager and IT manager. Frank have founf the organizational structure beneficial, since it is easier for him to discuss various managerial issues and ideas directly with relevant stakeholders. (van der Ven F. , 2019)

4. Appendix E: Adding value via smart technology implementation

Adding value framework	Added value explanation in relation to smart technology
Stimulating collaboration	Stimulate the communication and team work (due to space interventions and facilities provision): - Enhancing employees productivity (due to provision of communication platform and good indoor working environment) (Mehl, 2018) - Engaging employees collaboration through communication platforms (Ratcliffe, Saurin, Paybaraud, & Kristensen, 2009) (Charaya, Senguputa , & Tare, 2018) (Stam, 2019), - Boosting teamwork (Mehl, 2018), - Enable associate productivity, localization-based services (Charaya, Senguputa , & Tare, 2018) and colleague finding (Stam, 2019) (van der Ven W. , 2019), - Enabling employees to reserve space for team work (Stam, 2019) (van der Ven W. , 2019), - Occupancy data (noise heatmaps, peoples' flow through the RE) (van der Ven W. , 2019).
Stimulating innovation	The objective is related to collaboration and culture. Shaping a place where people can meet and share their knowledge so that new ideas can be created: - Data related to spaces reservation (closely linked to 'stimulating collaboration') (Stam, 2019), - Information about building performance and occupancy for further decision-making (van der Ven W. , 2019).
Supporting culture	Enhancing the organizational culture by providing appropriate RE portfolio to its end users: - Empowering employees through self-regulation via a mobile application (Ratcliffe, Saurin, Paybaraud, & Kristensen, 2009), - Enhancing employees' engagement (in the process and while occupying the SRE) which leads to higher employee retention, higher productivity, better employees' health (Borghero, 2018), - Supporting the Flex office concept (workplace occupancy and reservation features, colleague finding) (van der Ven W. , 2019) - Parking overview (van der Ven W. , 2019), - Occupancy data (incl. No-shows) (van der Ven W. , 2019).
Supporting image	Showing the organizational characteristics through the RE portfolio: - Enhancing workplace experience (Charaya, Senguputa , & Tare, 2018) - Developing SRE in general (Stam, 2019) (van der Ven W. , 2019), - Enhancing the Microsoft position as a tech company (workplace occupancy and reservation features) (van der Ven W. , 2019), - Occupancy data (incl. No-shows) (van der Ven W. , 2019).
Improving quality of space	Improving the workplace concept, space quality and services due to space interventions: - Measuring and improving appointed goals (Lunn & Stephenson, 2000), - Managing facilities – building automation (Charaya, Senguputa , & Tare, 2018) (van der Ven W. , 2019), - Air quality monitoring system (Driedger, 2019) (van der Ven W. , 2019), - Ambient control – application feature (Stam, 2019) (van der Ven W. , 2019) - Occupancy data for further decision-making (Stam, 2019), no-shows (van der Ven W. , 2019) - Communicating real-time workspaces status, occupancy overview (van der Ven W. , 2019).
Supporting user activities	Provision of necessary facilities and good indoor working environment conditions: - Managing workplace (room/workspace reservation) (Charaya, Senguputa , & Tare, 2018) (Stam, 2019) (Halstead, 2019) (Gritti, 2019) (van der Ven F. , 2019) (van der Ven W. , 2019), - Localizing desired workspace and services (Acoba, Charaya, James, & Rahalkar, 2018) (Stam, 2019), - Learning from real-time occupancy data (Acoba, Charaya, James, & Rahalkar, 2018) (Stam, 2019) (Halstead, 2019) (Gritti, 2019) (van der Ven F. , 2019), - Learning from historical occupancy data for further decision-making (van der Ven F. , 2019), - No-shows communicates (Halstead, 2019), - Communicating with a colleague (Acoba, Charaya, James, & Rahalkar, 2018) (Stam, 2019), - Enable associate productivity, localization-based services (Charaya, Senguputa , & Tare, 2018), colleague localization (Stam, 2019) (Halstead, 2019) (Gritti, 2019) (van der Ven W. , 2019), - Elevator synchronization (Halstead, 2019), - Smart lockers (Driedger, 2019) (Gritti, 2019), - Ambient control – adjusting working indoor environment (Stam, 2019) (van der Ven W. , 2019), - Parking overview and wayfinding feature (Halstead, 2019) (van der Ven W. , 2019).
Increasing user satisfaction	Upgrading the quality of space in order to respond to the trend 'focus on end users' and bringing extra benefits to an organization: - Measuring and improving appointed goals (Lunn & Stephenson, 2000), - Providing more comfortable physical environment (Mehl, 2018), - Noise monitoring system (Driedger, 2019), - Control over the office indoor working environment, ambient control (temperature and lightening) (Borghero, 2018) (Halstead, 2019) (Gritti, 2019) (van der Ven F. , 2019), - Enhancing employees' engagement (in the process and while occupying the SRE) (Borghero, 2018) - Room/workspace reservation and occupancy status (Stam, 2019) (van der Ven F. , 2019),

	- Colleague localization (Gritti, 2019) (van der Ven F. , 2019) (van der Ven F. , 2019), - Smart lockers (Gritti, 2019), - Parking overview (van der Ven F. , 2019) - Learning from historical occupancy data for further decision-making (van der Ven F. , 2019), - Information about building performance and occupancy for further decision-making (van der Ven W. , 2019).
Increasing flexibility	Having a flexible portfolio which can be easily modified when there is change in a demand: - Improving business insight – data analysis (Charaya, Senguputa , & Tare, 2018), - Ambient control, flexible technical installations (Stam, 2019) (van der Ven F. , 2019), - Learning from historical occupancy data for further decision-making, incl. no-shows (van der Ven F. , 2019), - Flex office concept: workplace occupancy and reservation features, colleague finding features (van der Ven W. , 2019).
Decreasing costs	Minimizing operational costs (by minimizing personnel and/or space): - Increasing productivity (Mehl, 2018), - Improving business insight (Charaya, Senguputa , & Tare, 2018), - Managing facilities – building automation (Charaya, Senguputa , & Tare, 2018), - Ambient control, energy savings (Stam, 2019) (van der Ven F. , 2019), - Space occupancy data (related to 'reducing footprint m2') (Stam, 2019) (van der Ven W. , 2019), - Parking overview feature (van der Ven W. , 2019), Room booking and occupancy data (real-time) (van der Ven W. , 2019).
Increasing RE value	Raise up the RE market value (incl. land value) due to upgrading the RE: - Managing physical security – visitor management, access control (Charaya, Senguputa , & Tare, 2018), - Managing space and occupancy – parking optimization (Charaya, Senguputa , & Tare, 2018) - Parking overview feature (van der Ven W. , 2019), - Workspace booking and occupancy data (real-time) (van der Ven W. , 2019), - Data: heatmaps (noise level), no-shows (van der Ven W. , 2019).
Controlling risks	Monitoring and managing financial, functional and technical risks: - Improving business insight – data analysis (Charaya, Senguputa , & Tare, 2018), - Space occupancy data (related to 'increasing flexibility') (Stam, 2019) (van der Ven W. , 2019), - Building performance data (van der Ven W. , 2019).
Reducing footprint (CO2)	Minimizing energy consumption: - Promoting strong environmental ethic (Ratcliffe, Saurin, Paybaraud, & Kristensen, 2009), - Measuring and improving appointed goals (Lunn & Stephenson, 2000), - Managing facilities – building automation (Charaya, Senguputa , & Tare, 2018) (van der Ven W. , 2019), - CO2 sensors (Driedger, 2019), (Gritti, 2019) - Parking overview (van der Ven W. , 2019), - Space occupancy data for further decision-making (Stam, 2019), incl. no-shows (van der Ven W. , 2019), - Room booking feature (van der Ven W. , 2019).
Reducing footprint (m2)	Minimizing occupied space: - Improving business insight – occupancy data (Charaya, Senguputa , & Tare, 2018) (Charaya, Senguputa , & Tare, 2018) (van der Ven W. , 2019), - Managing space and occupancy – parking optimization (Charaya, Senguputa , & Tare, 2018) (van der Ven W. , 2019), - Communicating real-time workspace occupancy data (van der Ven W. , 2019), - Room booking feature (van der Ven W. , 2019), - Data about the building performance (incl. indoor climate), room booking feature (van der Ven W. , 2019).

Table 22 Adding value via smart technology implementation; source: 'knowledge basis' and 'case studies findings'

5. Appendix F: application functionalities - case studies and literature review findings

Group	Application feature	Literature	The CORE	The EDGE	EDGE Olympic	Outlook	ECORYS
Ambient control	Adjusting temperature	X	X	X	X	X	X
	Adjusting lightening	X	X	X	X	X	
Real-time occupancy data	Desk status	X	X	X	X	X	X
	Room status	X	X	X	X	X	X
	No-show communicates			X			
Booking workspaces	Book a room	X	X	X	X		X
	Book a desk	X	X				
Collaboration features	Localizing employees/ colleague finding	X	X	X	X	X	X
	Communicate	X	X				
Additional services	Elevator synchronization			X			
	Parking overview			X	X	X	
	Smart lockers				X		

Table 23 application functionalities - case studies and literature review findings; source: author