Building an implementation strategy to enhance knowledge capture the intricacies of implementating a cloud-based tool, a case study

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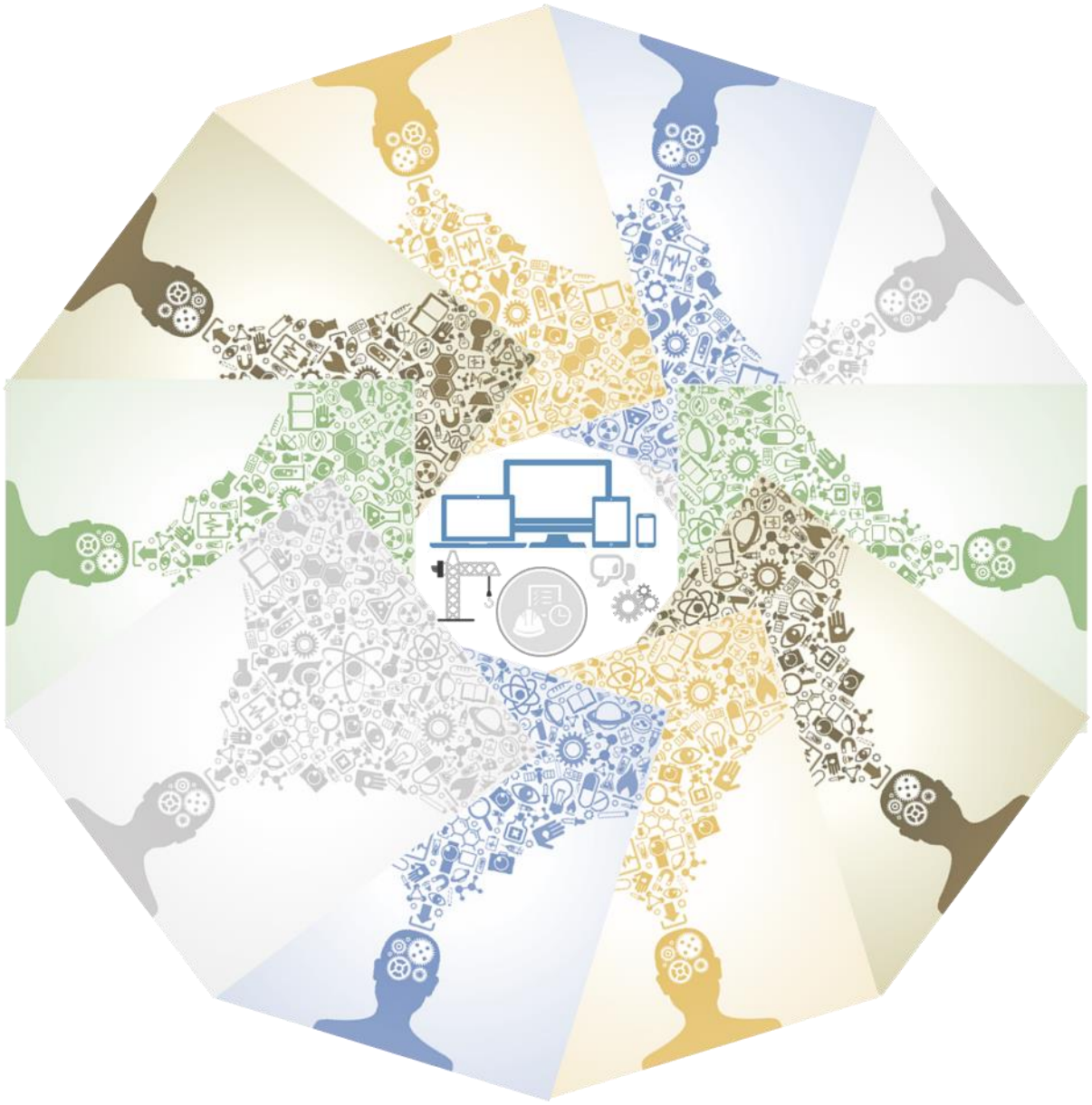

Building an implementation strategy to enhance knowledge capture: The intricacies of implementing a cloud-based tool, a case study

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Master of Construction Management and Engineering
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Building an implementation strategy to enhance knowledge capture: The intricacies of implementing a cloud-based tool, a case study

Colophon

Master Thesis Project

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Preface

I am pleased to present my graduation project carried out in collaboration with Eindhoven University of Technology and TBI. This project reflects the work carried out from February to July 2017 to achieve my Master in Construction Management and Engineering. It was developed within the field of knowledge management, seeking for its understanding through the assessment of the collection of knowledge on construction site. As a result of this investigation important information was gathered from practical experiences that allowed me to carry out this research.

I would like to thank all the people that were involved in this project. Firstly, I would like to thank my supervisors from Eindhoven University of Technology for their support with which this graduation project was successfully carried out. Aant van der Zee for his feedback, guidance and the time he made to assist me with my research, and Jos Trienekens for his input regarding the scope of this project. Additionally, I want to thank Audrey Debije for her time and advice. Furthermore, I want to thank Andreas Hartmann from the University of Twente for his time and feedback.

Secondly, my thanks also go to TBI. First of all, to the TBI Kennislab team who supported me. Specially, I want to thank Jeroen Pat and Hans Vogel who guided me inside the organization to be able to understand the working methods that I needed to enter the flow of the companies. Furthermore, for their help getting in touch with the people I needed for the interviews and meetings. Moreover, I want to thank the people within Comfort Partners and JP van Eesteren who made the time to meet me and helped me with all the information I needed to recreate and understand the process considered in this research project. Finally, my thanks go to further participants who endow my research.

Finally, I want to thank my family, friends, and colleagues who withstood and supported me during this process. Margarita my special thanks goes to you, that you've always guided and encouraged me to pursue all my dreams - Margarita mis más especiales agradecimientos van para ti quien siempre me ha apoyado y motivado a cumplir mis sueños.

María Camila Duarte Duarte
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Executive Summary

The construction industry is known to be a project-based industry in which a vast amount of knowledge is produced among interdisciplinary teams during the execution of projects. The produced knowledge, namely tacit knowledge can be described as lessons learned that come from experienced situations that remain inside team members' minds. Even though construction projects are considered to be unique, the produced knowledge can be of use for future projects to prevent and decrease problems. Additionally, the produced knowledge can help improving processes trough the enhancement of good practices. Considering the value and positive impact of produced knowledge on construction organizations, it can be said that knowledge management (KM) is fundamental.

This research project started focusing on processing captured tacit knowledge produced in construction projects at JP van Eesteren to be able to reuse it. Nevertheless, the lack of content in the information evidenced that the translation from tacit knowledge to explicit knowledge was not enough to analyze it and reuse it. Therefore, the new focus of this project was directed towards the step of knowledge capture within KM cycle. The new scope assesses the process of implementation of a cloud-based tool that sought to supports the capture of knowledge. The assessment was performed through the development of an implementation strategy to see if the lack of content of the captured knowledge lied on the wrong choice of the tool, the implementation of the tool, or the misunderstanding and misuse of the tool.

This project started with literature review, through which KM and its components, the basis for implementation, and the needed background to understand the current situation at JP van Eesteren were studied. KM is defined as a process based on the identification, capture, sharing, understanding and use of knowledge. This process is used to leverage organizations' performance. The type of managed knowledge is classified into tacit knowledge and explicit knowledge. To manage and transfer knowledge, capture and codification of knowledge is needed. The capture and codification is done through the translation of tacit knowledge into explicit knowledge, the structured organization of explicit knowledge, which can be supported by KM systems, and conversely the translation of organized explicit knowledge into tacit knowledge to put into practice the gathered knowledge.

The need for KM and KM systems unveiled the importance of implementation strategies and management of change. Therefore, an implementation strategy framework (ISF) and the theory of management of change were studied to gain the basis that allowed the development and analysis of the implementation strategy. Furthermore, to understand the current state of KM in the construction industry, literature that showed that the adoption of KM is in its infancy was studied, even though it has been broadly studied before. Additionally, it was found that new regulations and high demands from clients will call for KM to comply with requirements, and assure quality control.

The literature review gave the basis for the revision of internal processes of the company to understand the practices and the current state of KM. Moreover, the principles that govern the company and the documentation of the implementation of BIM 360 were studied to define the elements that allowed building the implementation strategy. From the study of the different elements mentioned before, a clear process of identification, capture, dissemination and reuse of knowledge inside the company was not found. The only trace of KM that was

found were development of dossiers and communities of practice taking place inside closed groups or within projects. Nevertheless, this knowledge does not appear to be shared with the rest of the organization. Therefore, it is concluded that KM as a process is not evidently defined implicitly or explicitly. Based on this conclusion, it can also be said that regardless of the problems of the rolled-out implementation of BIM 360, part of its drawbacks are given by the lack of a defined process to support.

Even so, the implementation strategy was developed to assess the specific implementation process that took place looking for deviations that can be improved in the current and future implementations. This assessment was made considering that in the future implementation of processes or tools will have a well-defined processes to support them.

Having as a basis the ISF, the developed implementation strategy was founded on the analysis of the company's internal processes and governing principles that helped structure the external and internal context. Also, the implementation strategy was based on the documentation and contracts held for the implementation of BIM 360 that were used to define the implementation content and the operational processes. The implementation strategy was validated with whom is considered the main driving force of the implementation. The validated strategy was used to define missing definitions compared to the framework. Furthermore, the recreation of the rolled-out implementation of BIM 360 at JP van Eesteren was based on four interviews and one observation session. The results from the rolled-out process were holistically analyzed and compared with the proposed implementation strategy, from which some gaps and objectives not achieved were evidenced. To approach the missing definitions and the objectives not achieved, recommendations were proposed based on elements needed to complete the implementation and the basis of management of change.

The nature of this thesis led to draw conclusions pointing towards a practical and a theoretical approach. From the practical approach it can be said that construction organizations need to comply with the requirements of the different stakeholders and the surrounding environment. Therefore, organizations must realize the need for change to successfully adopt and implement KM. Once the need for change is recognized, addressing change is possible with the different required implementations of processes and tools bearing in mind the importance of balancing technology and human capital. Finally, the implementations need to be carried out, well-structured, and coordinated to achieve proposed objectives.

Regarding the theoretical approach, it was concluded that the studied ISF offers easy guidance to develop an implementation strategy based on the clear description of the different categories and elements that it contains. Additionally, it was found that this framework is suitable with the studied implementation because the different definitions of the implementation can be clearly matched with the given guidelines. Nevertheless, the ISF does not contain guidance or references regarding behavioral aspects. In this order of ideas, it could include a parameter of assessment of readiness for change in the organizations, to measure the openness to coming change, as only the implementation planning may not assure success. Additionally, the dynamism and complexity of real-life environments and the interaction with ongoing strategic developments can be involved through the planning of possible adaption.

Abstract

Knowledge management (KM) is considered to be a fundamental key for industries' improvement in efficiency and competitiveness. The construction industry could benefit from KM's adoption due to its multidisciplinary nature and the large amount of knowledge produced during the projects' life cycle. Nevertheless, the adoption of KM in the construction industry is in its infancy. It has been shown that the construction industry has difficulty in knowledge holding and reuse which can be translated as a deficient practice of KM. Therefore, the enhancement of KM in construction industry is essential. This research seeks to understand existing barriers in the phase of knowledge capture within KM cycle in the execution of a construction project supported by a cloud-based tool.

During an initial investigation, the content of the gathered knowledge supported by the cloud-based tool was found to be incomplete. This shortcoming led this project to focus on the implementation of the cloud-based tool with which was sought to support knowledge capture during the execution of construction projects. The assessment was based on the comparison between an implementation strategy developed according to the initial proposed process, and the recreation of the deployed implementation of the cloud-based tool. The results coming from this research highlighted the lack of awareness regarding KM and its importance, despite the existence of practices such as communities of practice and development of dossiers which are just one of the components of KM. Furthermore, the results showed the need for change within construction organizations in order to successfully adopt and implement KM. In terms of the implementation process it was found that the first shortcoming came from the lack of a defined process to support. Further weaknesses came from gaps in the initial proposed process of implementation and subsequently unachieved objectives after the deployment.

Finally, using implementation strategies was found helpful to strengthen implementations in organizations, including the implementation of KM and additional required processes and tools.

Contents

Abbreviations

AEC: Architecture, Engineering, and Construction
BIM: Building Information Modeling
BIS: Built implementation Strategy
CoP: Communities of Practice
EBA: Enterprise Business Agreement
ERP: Enterprise Resource Planning.
HSE: Health Safety, and Environment
HSEQ: Health, Safety, Environment and Quality.
ICT: Information and Communication Technology
ISF: Implementation Strategy Framework
IT: Information Technology
JPvE: JP van Eesteren
KM: Knowledge Management
KPI: Key Performance Indicators
RI: Rolled-out Implementation
RM: Risk Management
SCO: Service Confirmation Order - Plan developed to reach goals with in an EBA
SECI: Socialization, Externalization, Combination and Internalization
TBI: TBI Holdings B.V.
TC: Team on Construction site or user
TP: Tool Provider
TT: Implementation Team inside TBI
Wkb: Quality Assurance Act for the Building Process (Wet kwaliteitsborging voor het bouwen)

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1 Introduction

The success of construction projects is measured in benchmarks of costs, schedule, quality, and safety (Zwikael, 2009). The performance of these benchmarks is affected by factors and risks to which a construction project is exposed for its duration. The risks become bigger as a result of the implementation of different new technologies that allow the development of more complex projects. The new technologies allow the development of challenging projects as well as the implementation of new building methods (Zou, Kiviniemi, & Jones, 2015).

As defined by Zou, Zhang, & Wang (2007) a risk is *"the chance of something happening that will have an impact on objectives; may have a positive or negative impact"*. In construction, risks appear because of the intricacy of the projects and their organizational features, such as long lasting projects, complex environment, financially demanding, and challenging organizational structures (Zou, Zhang, & Wang, 2007). These characteristics affect the way in which the construction industry behaves and how the industry is perceived around the world since it can hardly deliver projects within budget and on time (Iqbal, Choudhry, Holschemacher, Ali, & Jolanta, 2015). The impact that risks entail to the process are evidenced by project's over budget, schedule delays, rework due to unachieved project quality requirements, safety matters, and environmental impacts (Irimia Diégueza, Sanchez Cazorlaa, & Alfalla Luquea, 2014).

Taking into account that complete elimination of risks with negative impact is not possible, it is important to acknowledge that successful projects are the ones that can manage those risks (Zou, Zhang, & Wang, 2007). Therefore, risk management (RM) is used to serve the purpose of accomplishing successful completion of the projects. According to Zou, Kiviniemi, & Jones (2015) RM *"…is a logical, systematic, and comprehensive approach to identifying and analyzing risks, and treating them with the help of communication and consultation to successfully achieve project goals"*. Moreover, RM can be supported by knowledge management (KM) as a mean to bring together and manage appropriately knowledge to cope with the different risks (Talet & Talet , 2014). KM can help create awareness of the existence of risks and enhance their prevention, therefore, it is important to have the required knowledge that allows identification, avoidance and/or minimization of risks (Mercier-Laurent, 2016). Additionally, KM can be used to improve efficiency and competitiveness through existing knowledge and develop a collaborative sphere (Park, Lee, Lee, Jiayi, & Yu, 2013). To ease the access to existing knowledge it is essential to organize it in manuals, services, databases, and processes among others (Dave & Koskela, 2009). Finally, in terms of knowledge transfer and lessons learned, in every phase of the construction project, there is a chance to capture and expand this type of knowledge. When this knowledge is well implemented, it could reduce inconveniences and improve the process (Dave & Koskela, 2009). Or, as said by Dave & Koskela (2009) *"… it will reduce waste caused by of [sic] 'reinventing the wheel' "*.

These concerns are relevant to TBI Holdings B.V. (TBI), which finds the practice of KM important for the success of a company. TBI, just as companies in other industries, has to recognize that to implement KM it is important to approach knowledge in both forms tacit and explicit. As stated by Makambe (2015) the organizations must gather tacit knowledge or knowledge contained in the mind of people, as well as explicit knowledge or knowledge contained in documents. In other words the organizations should maintain their documented

knowledge and uphold their employees as one of their most valuable knowledge sources. Hence, for holding relevant knowledge, it is important to identify tacit knowledge and then ensure its organized codification and storage to ease its retrieval and use in the future (Stewart, 2000). The process of creation and reuse of knowledge should look like the one depicted in Figure 1 (Dave & Koskela, 2009).

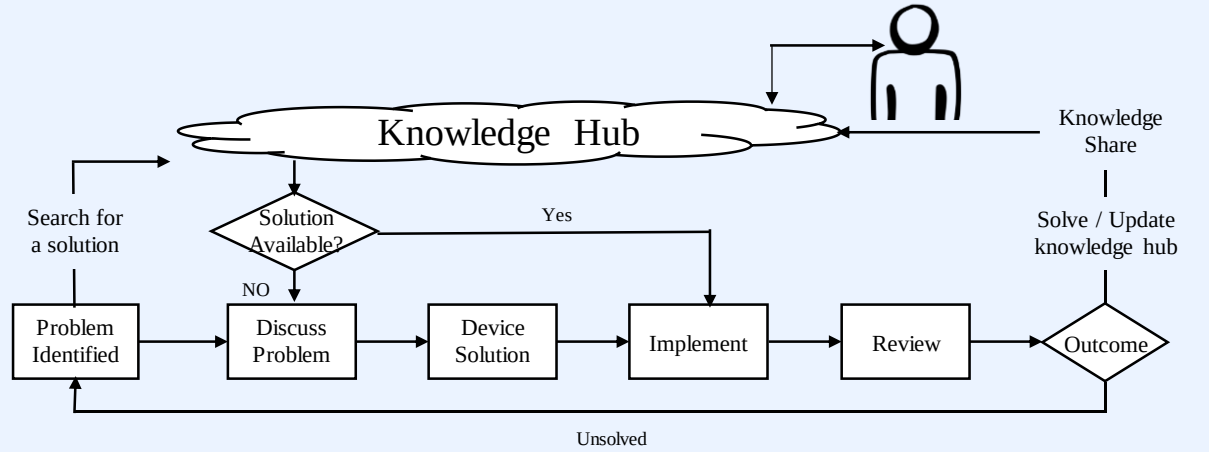

Figure 1. Knowledge creation process. Adapted from Dave & Koskela (2009)

It is of interest to TBI to know that appropriate implementation of KM is proven to be of help in the development of the construction industry (Tan, et al., 2006). Components such as production of vast amounts of knowledge during the execution of projects, and the involvement of different stakeholders in the different phases of a project, make clear the relevance of handling tacit knowledge in the construction industry. Nevertheless, this type of knowledge generally stays within execution teams and it does not get transferred across the organization (Kazi & Koivuniemi, 2006). For KM implementation it is also important to produce and maintain suitable and organized explicit knowledge in the form of documents, manuals, etc. However, it is common knowledge that the construction industry is inefficient in knowledge retention and reuse (Dave & Koskela, 2009).

According to existent research, some companies do not have documented information and other companies have only some documented information. This means that companies do not follow the practice of effectively documenting information (Dave & Koskela, 2009). Lastly, research found that companies which have appropriate documentation, place it in archives as useless information (Turner, Keegan, & Crawford, 2000; Newell, Brenem, Edelman, Scabrought, & Swan, 2006; Purdon, 2008; Dave & Koskela, 2009). Besides having correct documentation, it is important to give value to the codified knowledge because as stated by Zhang, Mao, & AbouRizk (2009) *"knowledge will not bring any value unless it is used actively"*

In this order of ideas, KM would be of help for the construction industry in general. Figure 2 displays what could be considered a current process of creation and reuse of knowledge (Dave & Koskela, 2009). Hence, it is essential to define a way to capture, store, disseminate, and reuse lessons learned from past projects. This knowledge will allow new projects to prevent and avoid problems based on previous experiences (Wiewiora & Murphy, 2015).

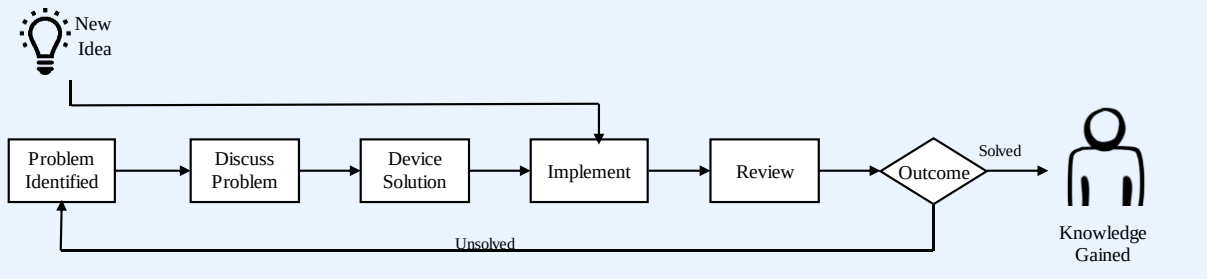

Figure 2. Current Knowledge creation process. Adapted from (Dave & Koskela, 2009)

The initial research focus of this project concerns the search to assess KM and how information produced during the execution of construction projects can be used. It is based on the implementation of a cloud-based tool that collects knowledge during the development of a project within a construction company, in this case JP van Eesteren (JPvE), construction company hold by TBI. This research aims to leverage the appropriate documentation of experiences to manage this gained knowledge and use it in future projects.

1.1 Research Problem and Objectives

As presented in the previous section KM can support RM processes. However, research has established (Kazi & Koivuniemi, 2006; Dave & Koskela, 2009; Turner, Keegan, & Crawford, 2000; Newell, Brenem, Edelman, Scabrought, & Swan, 2006; Purdon, 2008) that there is a barrier in implementing KM in the construction industry. Therefore, the study and understanding of knowledge and how it is managed inside a construction company can be of help to create new processes and methodologies seeking to improve KM implementation.

For this master's project one of the construction companies part of the TBI Holdings, a Dutch company, provided a real-life opportunity to study KM theory in practice. For more information about TBI see subchapter 4.1. This project started with a scenario which had the objective of enhancing the use of gathered explicit knowledge during the execution of construction projects, to create valuable lessons learned that could be used in future projects. However, it was found during the initial investigation phase of this project that the content of the database could not serve as a start for finding lessons learned because it provided limited information for the purpose of the research project.

The information provided from the database was the data gathered in BIM 360 during the execution of some projects. This information can be extracted in a PDF or Excel file. In this case the information was extracted in an Excel file. Based on this file, it was found that this type of file cannot display all the information contained in the cloud. To be able to have an insight into the details of the issues it is necessary to open the specific issue that contains the location, pictures, and further annotations and actions. Additionally, without seeing the picture and having the location it is difficult to understand the problem that occurred because the observations are directed at the person responsible, who understands the content of the comment and its relation with the executed elements. In this context, it was found that this information cannot be processed without further analysis of the issues. Analysis that should be done individually and is not easily automatized. Therefore another line of inquiry was established to extend the scope in the process of implementation of a cloud-based tool to support KM.

To extend the original scope this project looks at the process of KM and how it could be assessed in the current setup at JPvE, TBI's construction company. It is important to understand KM in order to see its relevance to this project. KM is the process of discovering and handling knowledge within organizations, through the identification, capture, organization, and transfer of knowledge by means of people and technological tools (Omotayo, 2015). The understanding of this definition shows that the lack of information in the content of the database, captured during the process of knowledge gathering from JPvE, causes difficulties in the completion of the KM cycle due to a deviation in the capture of knowledge.

Encountering this gap led the author of this thesis to perform an empirical analysis of KM supported by the implementation of a cloud-based management tool. This analysis addressed the specific implementation of BIM 360, the cloud-based management tool that was used, seeking to support the steps of KM starting with knowledge gathering. This analysis was aimed at getting a better insight into the existing shortcomings in real-life codification of tacit knowledge during the execution of a construction project.

The analysis approached the involved parties and the process of implementation of BIM 360. The initial assumptions for this research project were: first that KM as a process was in place implicitly or explicitly and second that the problem was possibly something related to the tool itself: either it was simply the wrong choice of tool or the tool was poorly implemented or the tool was not well understood and used. Furthermore, it was assumed that the knowledge was created during the execution of the project. For these assumptions to be verified, data collection about the implementation process was necessary to assess the roll-out and perceptions of the different stakeholders to find the probable source of the problem. Nevertheless, the analysis of the gathered data for the development of this project indicated that the problem was not related to the tool and its use but rather the problem was related to an operational gap in the implementation of processes. Therefore, the usefulness of the tool cannot be measured because it is supposed to support KM, and that process has not yet been implemented.

As a result of the above, the initial and revised aim of this research are presented next.

- To analyze the process of implementation of the cloud-based tool intending to support KM and knowledge collection on a construction site at JPvE, the implementation process and precisely the step of capturing knowledge were addressed. The objective was to assess the implementation process of the tool and its use to capture detailed information regarding the existing problems during the execution of a construction project. However, in the process of understanding the implementation through gathering and analysis of data, this objective evolved into an analysis of the strategy of implementation of processes and the requirements that are not fulfilled in an operational process that will influence the implementation of the cloud-based tool and KM.

- Based on the analysis and findings mentioned in the former bullet point, the new aim is to develop an implementation strategy according to the proposed process of implementation. This baseline implementation strategy allows to understand if the process that took place in the implementation of BIM 360 had gaps that should be pointed out and filled. Moreover, the findings help generate recommendations concerning the strategy's gaps, focusing on KM

and the implementation of BIM 360. This strategy can be taken as a basis to improve and strengthen the process of implementation in the company.

1.2 Research question

This section will present the research question used to approach the problem of the gap in the strategy of implementation of a cloud-based tool intended to support knowledge capture and KM in JP van Eesteren, one of TBI's construction company, as described in subchapter 1.1. Furthermore, with this research question this project will strive to achieve the proposed objectives found in the same subchapter within the existing limitations.

Research question

RQ: How can an implementation strategy help strengthen the processes of implementation in organizations?

To answer this main research question a number of aspects have been considered in literature:

- KM
- Structure and theories of KM process
- Implementation Strategy Framework (ISF)
- Theory of change

Additionally, inside TBI and JPvE certain aspects are revised to understand the internal process of knowledge capture and the implementation of the cloud-based tool:

- TBI's governance
- JPvE's governance
- JPvE's internal processes
- Implementation of BIM 360 to support KM process at JPvE

The research question with its considered aspects also triggered the following sub-research questions.

Sub-research question

- SQ1: How can the development of an implementation strategy be guided by an ISF?
- SQ2: How can a rolled-out implementation be assessed with the development of an implementation strategy?

1.3 Practical and Scientific Relevance

The scientific and practical relevance of this project is established by the attempt to enhance and contribute to the solving of the existing problem of implementation of KM in the construction industry. This approach was carried out through an empirical methodology based on a case study. According to Shokri-Ghasabeh & Chileshe (2014), in practice construction industry has not highlighted the importance of KM and this has led to the failure of its implementation. This failure happened regardless of the vast research and the recognition by the construction industry of the need and importance of KM and the appropriate collection of knowledge acquired in the execution of projects.

By investigating in depth the process of implementation of a cloud-based tool supporting knowledge gathering during the execution phase of a construction project at one of TBI's construction companies, the expected contribution to the field of KM points towards the development of a basic implementation strategy that can be used as a reference for implementation and for further research. With this research project the intention is to add empirical knowledge regarding KM in the industry and the need for organizational change in the construction industry. Additionally, it points to recommendations and conclusions that can support to some extent the implementation of KM, taking into account that some of the findings may be similar to the existing research.

1.4 Research Outline

The research outline briefly introduces the organization of this research project. The project is organized in four sections, which contain the process that leads to solve the established problem by answering the research question and research-sub questions presented in this chapter. Following the description of the four sections is done according to the chapter.

Chapter 2

The methodology followed throughout the development of the graduation project is described in this first section. The reasoning behind using a case study, the selected data collection methods, interview and observation sessions; the analysis technique, logic models; and the expected results are contained in this section. Additionally, the definition of the basic criteria for the case study and for the development of the implementation strategy are included.

Chapter 3

This chapter shows the literature review, which brings into this project the necessary solid basis of understanding regarding KM, KM practices, and the state of KM in the construction industry. Also, the background information needed to develop this project is described. The background information contains ISF, managing change, cloud computing in the construction industry, and Dutch regulation.

Chapter 4

Subsequently, this chapter describes the development of the project. The definition of background to define the implementation strategy that is developed based on literature review. Moreover it contains the development of the case study describing the process of data collection and result from which the analysis and recommendations are elaborated.

Chapter 5

In this last chapter the conclusions and possible recommendations for future research are presented.

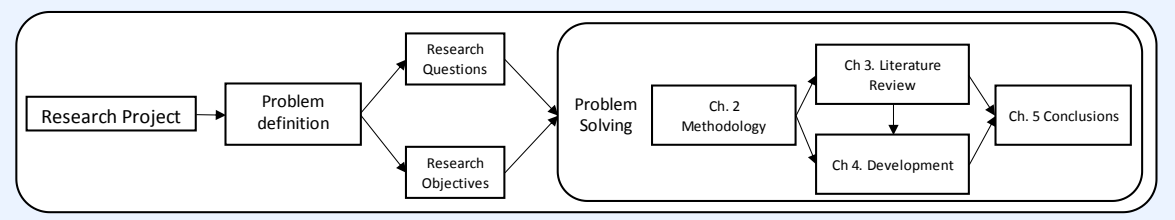

Figure 3. Research outline diagram.

2 Research Design

The fundamental goal of this graduation project is to assess and understand the KM cycle in a real-life scenario, during the execution of a construction project. This research is approached through the qualitative analysis of the process of knowledge capture with the support of the cloud-based tool BIM 360, within the execution of a construction project at JPvE, in order to evaluate the implementation process and its state of development so recommendations can be generated for its improvement.

The choice of using qualitative analysis as a research method in this project is based on the fact that it is considered to be an adequate method to assess particular societal settings (Mack, Woodsong, MacQueen, Guest, & Namey, 2005). The setting of this project is the analysis of a process implemented and carried out by professionals in the construction industry. The analysis is carried out through a case study focusing on the KM process implemented in a company and the development of one of its projects. More specifically in the process of knowledge capture during the execution phase. The outcome of the case study allows the development of a logic model, specifically an implementation strategy, which aims to improve the process of knowledge collection during the execution phase of a construction project.

This chapter covers the research design and the methodologies followed in the project. It gives the parameters and states the followed steps. Based on these guidelines, the background and the state of the art of KM were researched, and the case study was structured in order to accurately answer the research question and sub-questions. Figure 4 shows the methodology that was followed.

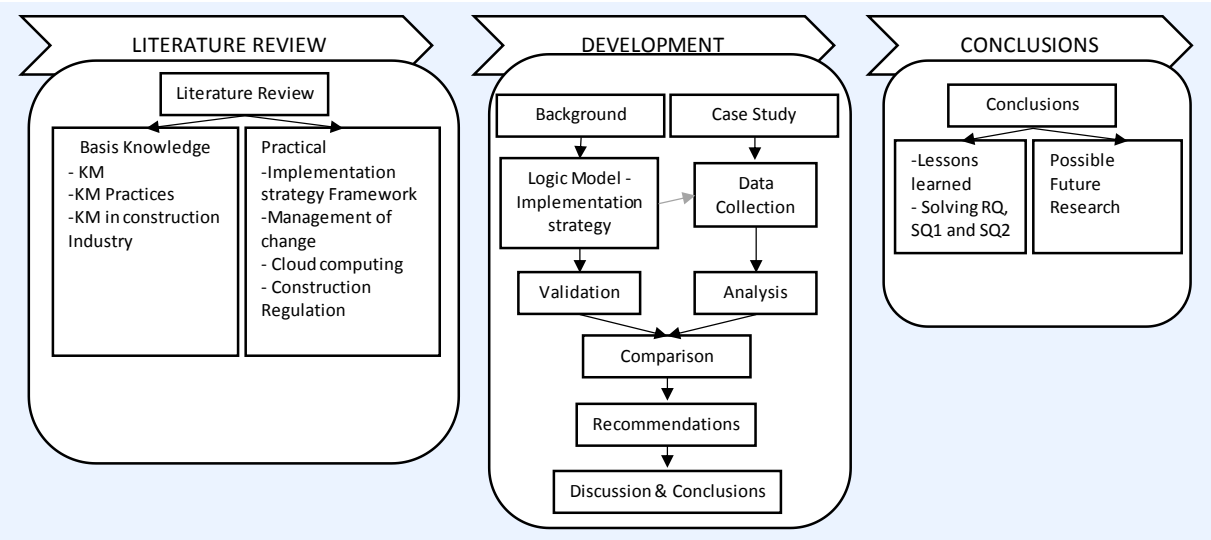

Figure 4. Graphical Research Model

2.1 Literature Review

The literature review assesses the background, context, and existing knowledge regarding a specific topic (Academic Skills, 2013). It is indispensable to acknowledge the context, the state of the art, and the existing gaps in the research because it makes possible to outline the outset for the definition of the case study and the data collection (Yin, 2014).

This literature review focuses on KM, its process and its situation inside the construction industry. The intension is to help understand the concepts and steps of KM process. Furthermore, it is expected to help in devising the current KM stand point in the construction industry and the strategies and tools supporting it. Additionally, a practical connection is made through the gathering of information that helps understand the current situation at JP van Eesteren and also helps undertake the practical needs. The theory and learning from this literature review is the starting point and the base for the development of the implementation strategy and the case study.

2.2 Methodology

This research project is carried out through the application of an ISF to a real-life implementation. A framework is defined as "particular set of rules, ideas, or beliefs which you use in order to deal with problems or to decide what to do." (Collins Dictionary, 2017). For this case, the set of ideas defined by Okumus (2003) regarding implementation strategy are going to be used to organize and assess the information of the deployed implementation process of BIM 360 at JPvE.

This case was addressed through a case study research, which according to Yin (2014) is a method that can be applied in studies interested in addressing social environments and perceptions in real-life situations, focusing on a specific case. The study of this case looked to understand the existing problems and barriers regarding the phase of data collection in the implementation of KM process, based on a construction project in execution at JPvE. Furthermore, to address the case study a deductive process was used. The deductive process is described as a method that starts with a set of facts or assumptions that serve as a lead to study and obtain theories founded on logical deduction (de Neufville , 1998).

Following are characterized the components of the case study, the data collection, how the analysis will be done based on the ISF and the developed strategy, and the expected results.

2.2.1 Case Study

The unit of study that outlines this case is the implementation process of BIM 360 in the execution of a construction project to support the capture of knowledge. The implementation and deployment process should be defined by an implementation strategy that outlines the company's general and specific contexts, leading to its aim and plan of execution. Furthermore, it should be considered who is going to be involved in the process and to whom the implementation is going to be directed. The involvement of different parties and managerial support are crucial (Okumus, 2003). Additionally, the participants to whom the implementation will be directed are very important since they are the ones producing the knowledge and the ones that will boost or threaten the implementation (Jimmieson, Peach, & White, 2008). Consequently, this case is based on the roll-out of the implementation of BIM 360 and its current state in JPvE. This assessment will consider the background of the process

as well as the objectives of the implementation and whether they were met. Besides, it is going to study the perception of the roll-out process of BIM 360 and its practical use.

2.2.2 Data Collection

For the study of the case defined in subchapter 2.2.1, there are several methods to collect data that contribute to the correct execution of a case study, such as archival records, direct observation, documentation, interviews, participant-observation and physical artifacts (Yin, 2014). Analyzing the unit of study and the context of this case study, it has been decided that there are two appropriate methods for the collection of data: interviews and direct observation. Yin (2014) defines interviews as *"the mode of data collection involving verbal information from a case study participant…guided by the researcher's mental agenda…"* Additionally he states that *"they are one of the most important sources of case study evidence…"* Also, he states that direct observation is a way to complement the case study by seizing the opportunity to obtain information from the observation of real-life situations.

Considering the previous, the design of the interviews is meant for two of the three main involved parties: the tool provider (TP), and the implementation team of JPvE (TT). All of the interviewees took part in the implementation or joined the process replacing former colleagues, so the interview follows the same basis guidelines. The chosen type of interview for this case study is a semi-structured interview, it is a guided conversation with an established order that keeps an extent of flexibility to reach a fluent exchange (Dunn, 2010). The interview guideline is based on the developed implementation strategy explained in subchapter 2.2.3 and focuses on the aim of the implementation, the type of knowledge that is produced during the execution phase of construction projects and its use, the used methods and tools to collect this knowledge and the process of implementation and deployment of the cloud-based tool and the interviewees' perception regarding the outcomes. The used guideline for the interviews can be found in Appendix B.

Likewise, one session of observation took place on the construction site with the third party, to be precise one of the users from the team on the construction site (TC). The method of observation gives a complete insight into the context and the complexity of the case, and can provide evidence that helps avoid biased perceptions (Mack, Woodsong, MacQueen, Guest, & Namey, 2005). The application of the method in this case has the intention of capturing and revealing the understanding and use of the tool in the execution of a construction project. During the observation session the process of use of the cloud-based tool was documented in a detailed and objective way. Pictures were not taken due to confidentiality. In addition, this session serves as a way to approach a direct user of the cloud-based tool through an open conversation, to understand his perception and position concerning the cloud-based tool and the implementation process.

2.2.3 Implementation Strategy and Data Analysis

The theory regarding data analysis that is going to be pursued and the following explanations are based on the concepts and definitions given by (Yin, 2014) regarding case study research. Data analysis is known as the assessment, sorting and combination of data to reach empirical and analytical conclusions through the use of different techniques, some of which are pattern matching, explanation building, time-series analysis, logic models, and cross case-synthesis. To carry out this project, the chosen technique is logic models that consist of the analysis of a

sequence of events that take place during a continuous and lengthy period of time. This technique was chosen based on the nature of this case, which is the study of the implementation process of a cloud-based tool. This means that the planned and the actual path for the implementation can be expressed as a chain of events. The development of this technique will be based on a proposed implementation strategy. This implementation strategy is based on a background explanation built up on existing documentation, processes and regulations. Furthermore, the development of this technique will be based on the gathered data about the implementation process throughout four interviews and one observation session. The analysis will assess the convergence and divergence between the proposed logical model and the conclusions from the perceptions of the real-life implementation. The importance of this type of technique is based on the help provided to explain the outcomes resulting from the comparison between the explanation and the circumstances experienced.

Following, for the development of the implementation strategy the explanation that is built is based on the external and internal context, and the requirements that were meant to be covered by the implementation of the tool. Furthermore, it includes the initial conception of the implementation project and the steps that were intended. Based on these factors, which outline and explain the background of the implementation, the implementation strategy will be conceived based on the strategic implementation framework defined by Okumus (2003). In this framework he summarizes the implementation factors in the following 4 areas of grouping: strategic content, strategic context, operational process and outcome. These areas will be further explained in subchapter 3.5.

The outcome resulting from the 4 interviews and the observation session will be assessed through the comparisons of the perspective of the participants, TP, TT, and TC, with the implementation strategy. Comparing the established process with the process that took place leads to a deduction of the weaknesses of the process and why the expectations are not being completely fulfilled. The characterization of the shortcomings will allow the development of recommendations for the current process: what can be improved and what could be used for future implementations.

2.2.4 Expected Results

The expected outcome is the development of an implementation strategy that could serve as a basis to bridge gaps and fulfill requirements in order to reach a successful deployment of implementations. This strategy will be based on Okumus (2003) ISF and will be built with the existing information and documentation regarding the process of implementation of BIM 360. The real-life situation based on the execution is going to be considered for further analysis, which will result in the identification of gaps. Furthermore, considering the gaps found with the help of the data analysis, recommendations will be made on how to improve the implementation strategy that was carried out. These recommendations are intended to lead to an improvement in implementations in general, basing their results on a real-life implementation. The recommendations will, if possible, be connected with specific guidelines to address KM and the implementation of the cloud-based tool. Awareness of the problems in the process and of the importance that KM has on an organizational level has to be created. Additionally, future research is recommended based on the outcome and the discoveries of this project.

3 Literature Review

This chapter will attempt to give a further grip on and understanding of the topics and their development on which this project is going to be based, with the purpose of solving the problem found at JPvE as explained in subchapter 1.1 and summarized in Figure 5. These topics are KM, and its processes and elements. Moreover, the current state of KM is studied inside the field of construction. Finally, the basis background required for the practical understanding and development is explained through the implementation framework, managing of change, cloud computing and construction regulations.

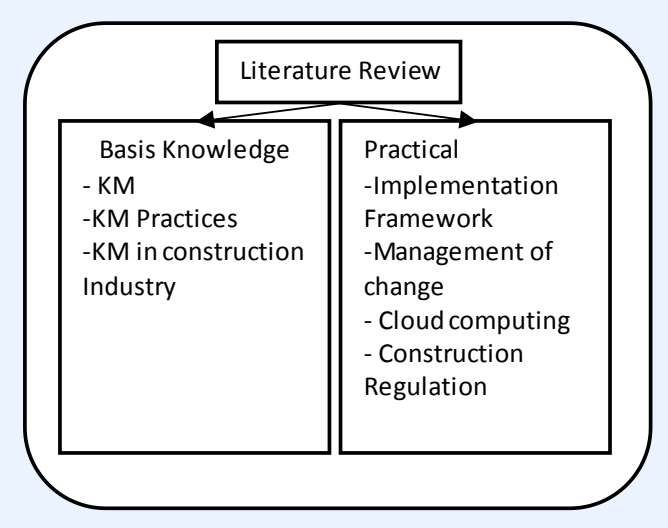

Figure 5. Development – Literature Review

3.1 KM

Nowadays, KM is a process that can benefit organizations in different sectors, since its aim is to give organizations the tools to improve competitiveness, as well as capacity, and therefore productivity (Jeon, Kim, & Koh, 2011). Hence, it has a great importance for the development of all sectors, even traditional industries (Zack, 2003). These statements show a suitability with organizations in the construction industry and therefore organizations such as TBI, which raises the possibility of studying and understanding KM components. KM is the process of discovering and handling knowledge within organizations. This process was reinforced as a response to the transition of businesses from financial-based to knowledge-based, caused by globalization (Omotayo, 2015). This change triggered the need to embrace knowledge in order to improve practices, by sharing it and learning from it. KM is based on the identification, organization, transfer, and reuse of knowledge, which comes from people and their gathered experiences from different events (Griffiths & Lemenyi, 2008). The knowledge that should be managed is the one that will successfully endow the organization with knowledge provided to the appropriate people (Servin & De Brun, 2005).

As the name implies, KM revolves around knowledge, which is defined in the Collins Dictionary (2017) as *"information and understanding about a subject which a person has, or which all people have."* This definition proves that people are one of the main assets when it comes to knowledge since they are the main holder and consequently the main source of information. Omotayo (2015) states that people can produce knowledge, additionally, by internalizing new experiences from which they produce that new knowledge, making them a unique source of information. In this order of ideas, existent knowledge in people's minds allows them to judge

situations and through the creation of knowledge reach appropriate solutions (Makambe, 2015).

Knowledge can be classified as explicit or tacit. According to researchers, explicit knowledge is the knowledge that can easily be compiled and communicated. It is organized in a methodical and formal way and is expressed as data. It can be found in documents, manuals, information technology (IT), etc. (Terzieva, 2014; Omotayo, 2015). Moreover, explicit knowledge plays an important role in the creation of new tacit knowledge (Lin, Wang, & Tserng, 2006). Likewise, but in the opposite direction, Omotayo (2015) states that explicit knowledge originates in the materialization of tacit knowledge. Meaning that explicit knowledge is the decoding of mental representations or tacit knowledge (Kanapeckiene, Kaklauskas, Zavadskas, & Seniut, 2010). Tacit knowledge is explained as the knowledge gathered from experiences that through understanding, leads to building lessons learned and is contained in people's minds. This type of knowledge is captured in a personalized way that makes it difficult to retrieve and communicate (Lin, Wang, & Tserng, 2006). Based on the complexity and importance of knowledge, the conclusion is that it is necessary to approach it through efficient strategies to make its documentation and sharing possible, and avoid that it is lost (Makambe, 2015; Pathirage, Amaratunga, & Haigh, 2007; Lin, Wang, & Tserng, 2006).

Omotayo (2015) expresses that *"organizations need a good capacity to retain, develop, organize, and utilize their employees' capabilities in order to remain at the forefront and have an edge over competitors".* She also identifies KM as the framework that can help organizations to reach these requirements. KM can be considered as a framework for construction companies, especially those that want to implement it as a means to improve and become more competitive, companies such as the one studied in this project. Furthermore, it is necessary that these companies comprehend that the main type of knowledge that is held in their organizations is tacit knowledge based on experiences gained on site. Finally, they must recognize and gain understanding of the KM cycle to implement it correctly, aiming to tackle the shortcoming exposed in the introduction regarding the difficulties the construction industry has in keeping and using knowledge gained from past experiences (Dave & Koskela, 2009).

As stated by Loforte Ribeiro (2009) different authors have proposed KM models; based on this, he defines that a KM cycle is a method that contains different phases which creates feedback loops that allow the iteration and evolution of knowledge in organizations. Thus, in order to understand a KM cycle, it is necessary to identify and comprehend the different phases that comprise it.

3.2 KM cycle

In order to gain adequate understanding of KM phases for the development of this project the different KM cycles will be studied. There are many defined cycles, however, different authors (Dalkir, 2005; Kayani & Qamar Zia, 2012; Mohapatra, Agrawal, & Satpathy, 2016) have identified four main KM cycles, these are Wiig KM cycle(1993), Zack KM cycle (1996), McElroy KM cycle (1999), and Bukowitz and Williams KM cycle (2003). Below the 4 cycles will be illustrated according to Dalkir (2005).

Wiig KM cycle – 1993

The Wiig cycle is centered on the identification and use of organizational knowledge[1] to enhance and create value for members and groups within the organization, in order to achieve better outcomes by linking knowledge and production. According to the theory of this cycle there are three conditions that should exist for the successful development of organizations.

The three conditions are the existence of business and customers, the presence of resources such as capital, people, etc., and the capability to act. This third condition is determined by knowledge that gives guidelines about what to do, which would allow for a better performance. As a main aim of KM, the possibility of making organizations act smart is identified by the construction, gathering, distribution and use of quality knowledge. This smart-acting will make the organization's members react to different situations with greater capabilities and expertise based on the available quality knowledge. The steps to carry out this process can be followed in any order and can be repeated. Furthermore, they can be undertaken in sequence or parallel. The approach of this cycle includes different sorts of learning including training, experience, formal education, among others. Moreover, the knowledge that is considered can be tacit or explicit, and it can be retrieved to be used according to the requirements of the situations. Figure 6 illustrates this cycle and its activities.

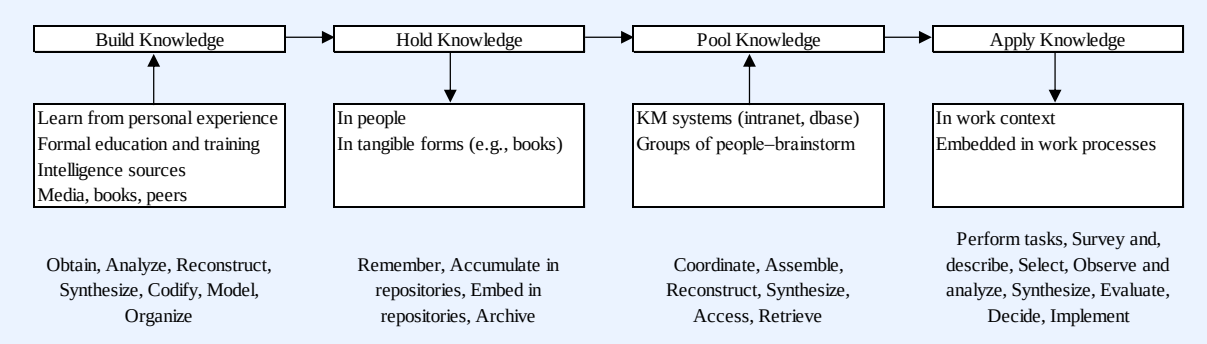

Figure 6. Wiig KM cycle and Activities 1993 - Adapted from Dalkir (2005)

The Wiig's cycle starts with the building of knowledge by activities such as obtaining, analyzing and organizing knowledge. The activities to create knowledge are pursued through experiencing, experimenting, training, and/or including new knowledge contained in documents or people's minds. The gathered information will serve as a start to generalize the knowledge in values and set parameters, to compare it with existing knowledge, in order to update it and define goals and objectives. The modeling and codification are the comprehensible representation of this knowledge recorded in models and documents for future use. In order to use the existing knowledge it is important to hold it and accumulate it in storage spaces like repositories. It is also important not only to possess it but also to maintain it by discarding obsolete information. The retained information will be used by the organization in the knowledge pooling phase, in which the access and retrieval of the knowledge will be coordinated by collaborating teams. These processes conclude in the application of knowledge to support the organizations' procedures. This method shows a concept focused on the reuse of organizational memory to enrich its performance.

[1] Organizational knowledge is considered as the collection of produced and acquired knowledge from experience that leads to creation of habits an routines inside an organization. (Tenório, et al., 2017)

Zack KM cycle – 1996

Zack cycle entails increasing the value of products based on existing knowledge. This theory is based on the design and deployment of products, however, it was extended to knowledge management. This cycle is founded on the idea of repositories, which allow the capturing and storage of information or knowledge that will allow its future usage and implementation to support decision-making or help to reach defined objectives. The focus of this cycle is on the processes of storing, retrieving, and use of knowledge, differentiating between knowledge management and document management. This method is defined by its author as the *"Refinery",* and its steps are acquisition, refinement, storage, distribution, and presentation as shown in Figure 7.

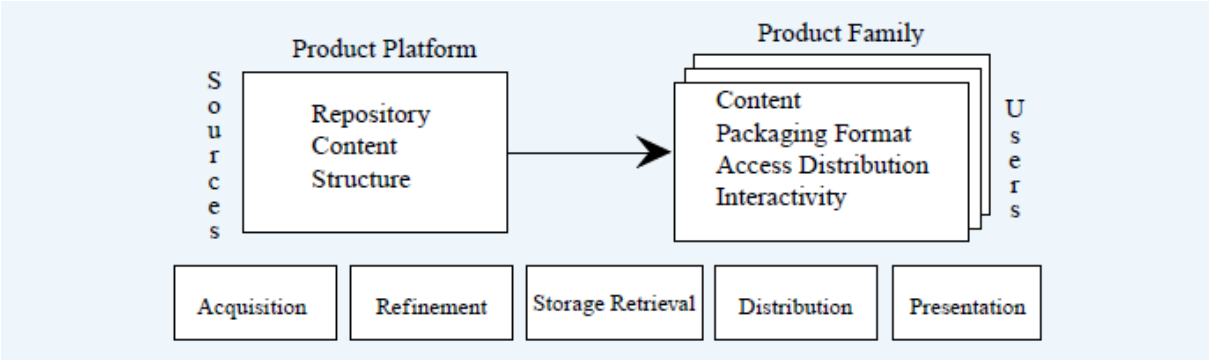

Figure 7. Zack KM cycle 1996 – Retrieved from Dalkir (2005)

The established steps are expected to lead to a successful result from the implementation of the KM cycle. The cycle starts with the acquisition step, where the information must be gathered as precise and clear as possible since it will be the main source of the process. Following with the refinement, the information will be handled, sorted out, and standardized to make it useful for the storage step, in which the resulting information will be connected by compiling it and allowing its withdrawal. The handling of the linked information will be carried out during the distribution step, where it will be delivered to the right user at the correct time to permit its use and to support procedures and decisions. Finally, during the presentation step, the different outcomes will be taken into account, and they will show the created value and whether the cycle succeeded or failed.

McElroy KM cycle – 1999

McElroy cycle is described as the production and integration of knowledge involving single or double feedback loops towards *"organizational, memory, beliefs, and claims and business processing environment"* (Dalkir, 2005). The definition of the method stresses that the knowledge contained in people's mind and the knowledge explicitly expressed is the core knowledge distributed inside organizations. Once the knowledge is used within the organization, it will yield outcomes that will or will not fulfill proposed expectations and goals. Thus, the fulfilling results will lead to the reuse, maintenance, and improvement of knowledge, otherwise, it will cause a change in behaviors and inclusion of new knowledge into the knowledge management process. Figure 8 illustrates the high-level KM cycle of McElroy.

This model is subdivided in processes. The knowledge production process is the one initiating this cycle, here the inquiry and search for the gap in knowledge is developed, through the assessment of knowledge gathered inside a company in codes based on individual and group

innovations, including the acquisition of information by means of claims and external information. At the end, the knowledge claims will be assessed via the knowledge claim evaluation process, to define the value and reliability of the claim; this process indicates that claims' value is greater than the value of the knowledge's bases in the organization. Finally, the knowledge integration process is responsible for adding new knowledge claims or eliminating old knowledge claims from the operating environment. This includes the sharing and dissemination of knowledge. This cycle is concerned with the identification and assessment of knowledge content's value to the organization.

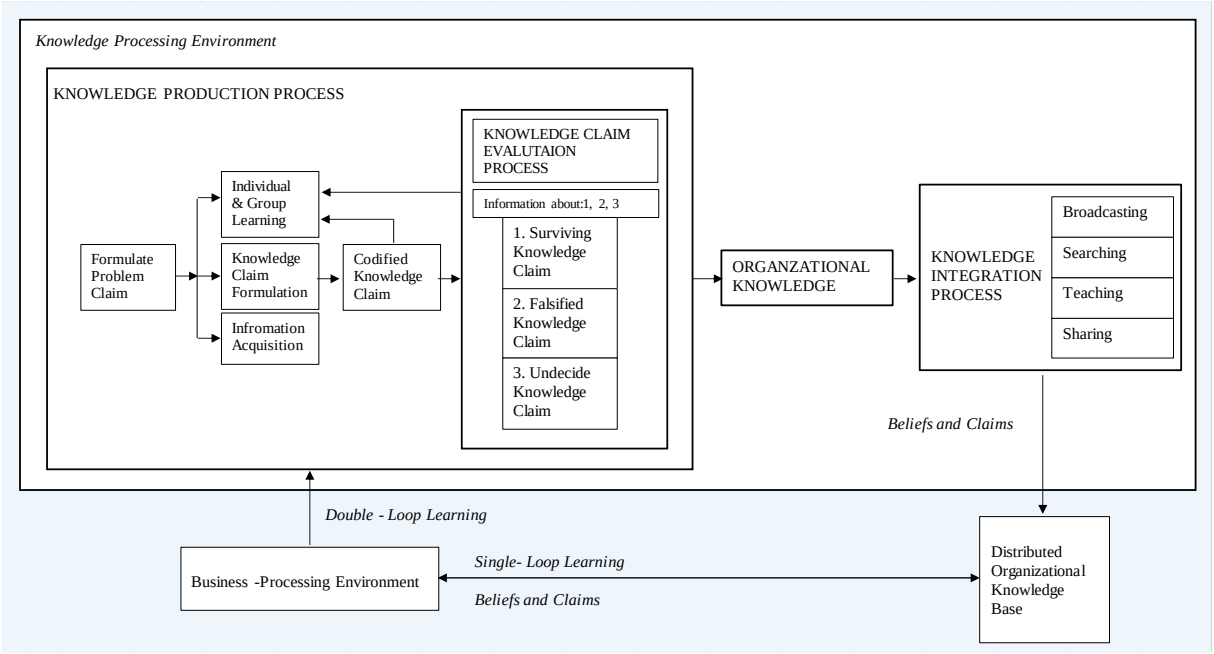

Figure 8. High-Level Process in McElroy KM cycle 1999 – Adapted from Dalkir (2005)

Bukowitz and Williams KM cycle – 2003

The Bukowitz and Williams cycle consists of the creation of value for organizations through the creation, preservation and the strategic disposition of knowledge. It takes into account learning and the judgment to keep or divest knowledge and includes the notion of tacit and explicit knowledge. This cycle is based on two elements, the first element is dependent on the market forces and opportunities and defines the first half of the cycle. It concerns getting, using, learning, and contributing to knowledge. Additionally, it is for strategic use within organizations, to support problem-solving and decisions, and to innovate. The second element is specified by changes in the external environment that cannot be controlled by an organization and consists of assessment, building and sustaining, or divesting phases for long term plans. This cycle can be found in Figure 9.

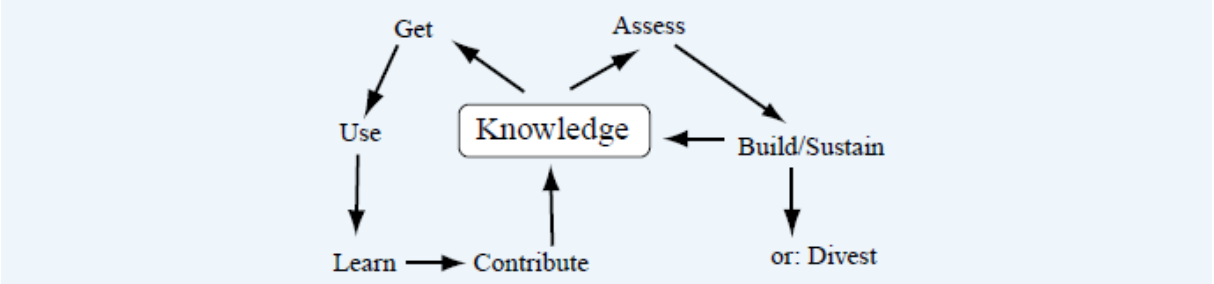

Figure 9 Bukowitz and Williams KM cycle 1999 – Retrieved from Dalkir (2005)

The phase of knowledge getting defines the search for knowledge, including tacit knowledge, and the difficulty in obtaining it. Next in line is the use of knowledge, gathered to support problem solution, decisions, and innovation in organizations. The real value of the knowledge will be defined by the use of it; its real implications will be defined by whether it was possible or not to learn from it. Furthermore, this learning process will achieve its goal through the contribution of people, with the creation and sharing of new knowledge. The process of capturing, using, and sharing of knowledge will be evaluated through a process of assessment of the resulting knowledge. It will be compared with future requirements to conclude and determine if the knowledge should be kept, maintained and enriched, or if it does not produce value, then it should be transferred or outsourced according to strategic means.

As can be seen in the different cycles, even though they have different approaches and are based on different principles they are similar and their aim is the same. Dalkir (2005) developed a cycle compiling the different principles.

Dalkir Integrated KM cycle – 2005

Dalkir (2005) proposes a cycle with three main phases, namely knowledge capture and/or creation, knowledge sharing and dissemination, and knowledge acquisition and application. This cycle can be explained as a feedback loop that recognizes and captures knowledge that is later spread out and understood, so it can be applied. This end point will feed the new start of the loop with updated knowledge. This cycle is shown in Figure 10.

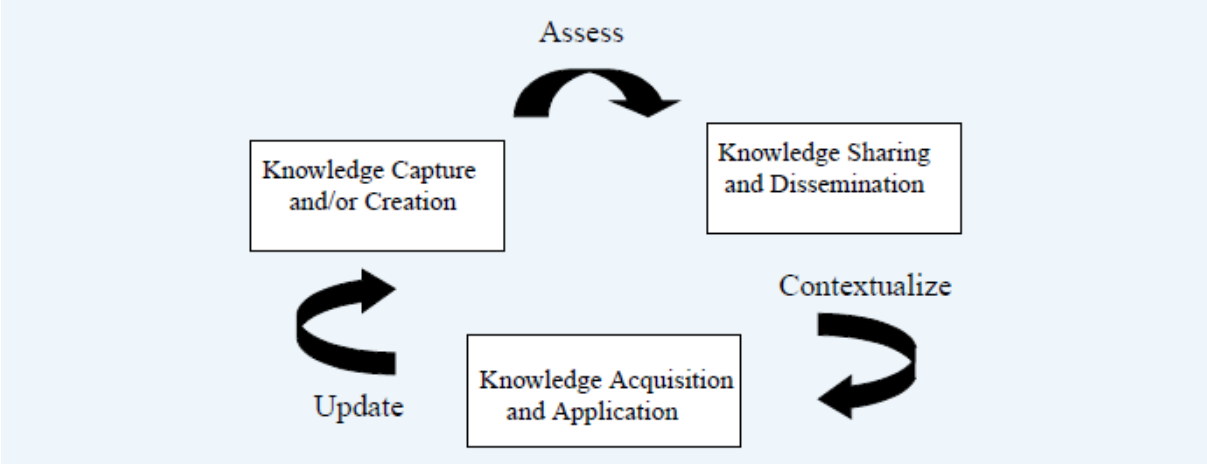

Figure 10 Dalkir Integrated KM cycle 2005– Retrieved from Dalkir (2005)

Taking into account the explained KM cycles, the conclusion can be that the aim of this process is to define how to approach and manage knowledge. This approach and management seek to improve the capabilities of organizations based on their knowledge assets and uniqueness. This approach and management is suitable for the construction industry and its concepts can be used for the development of this project, since the construction industry has been identified as a unique industry based on dynamic project development, where multidisciplinary teams work together, producing high volume of data (Dave & Koskela, 2009).

To summarize the identified process: it starts with the recognition of a gap and the identification of knowledge that could bridge this gap. The rest of the cycle centers on how to take advantage of the identification of this knowledge and its correct handling and capturing to disseminate it and use it, leveraging the organization's performance. Furthermore, it

focuses on enlarging the knowledge bases, by updating them with new valuable findings that will support future situations through the capture of good practices and gives parameters for problem-solving and decision-making. This process includes giving value to the gathered knowledge by putting it in use.

Linking the before described process with the definition and types of knowledge, it is important to specify how to relate and translate tacit knowledge into explicit knowledge and vice versa. This relation and linking will endow the development of this project with the understanding of how the tacit and explicit knowledge produced on site can be translated into one another and how can it be managed and exchanged through the KM cycle and inside the company. This definition will clarify the parameters necessary to understand how knowledge can be identified, created, and captured. This means understanding the first step of the KM cycle.

3.3 Knowledge Creation and Translation.

To implement and develop knowledge management in an organization like JPvE explicit and tacit knowledge should be taken into account (Lin, Wang, & Tserng, 2006). Furthermore, the involvement of people in the KM process and the process of knowledge creation must be understood to be able to integrate both tacit and explicit knowledge (Henczel, 2000).

Knowledge creation is defined by Nonaka & Takeuchi (1995) as *"a social process between individuals in which knowledge transformation is not simply a unidirectional process but it is interactive and spiral."* Additionally they state that knowledge creation starts with an individual. This individual's knowledge and knowledge creation can broaden and enrich knowledge within organizations. As established before in subchapter 3.1, knowledge in construction companies is widely produced during the execution of the projects by the multidisciplinary teams or individuals; this means that for this project the importance of the teams involved in KM should be raised.

Together with the aforementioned conclusions, Nonaka & Takeuchi (1995) developed *"The Nonaka and Takeuchi Knowledge Spiral Model."* This model is the *"Socialization, Externalization, Combination and Internalization (SECI) Model*", which approaches knowledge conversion at an individual level. Furthermore, based on this model, the *"knowledge spiral"* is developed, which explains how knowledge serves organizations by including individual knowledge creation inside its own knowledge creation.

SECI Model - Knowledge Conversion

Nonaka & Takeuchi (1995) describe in their SECI model how the knowledge can be translated through four different processes: socialization (tacit to tacit), externalization (tacit to explicit), combination (explicit to explicit), and internalization (explicit to tacit). As seen in Figure 11, the model is expressed in a four-quadrant graphic containing the processes.

The first process, **socialization**, is the conversion from tacit to tacit knowledge. This process consists of sharing knowledge through social interaction. This exchange is the easiest to carry out since it consists of direct communication, observation, and imitation. It allows a complete gain of knowledge because it is being experienced and learned within a context. However, this knowledge still remains in the participants' brains, since it is not captured during the process.

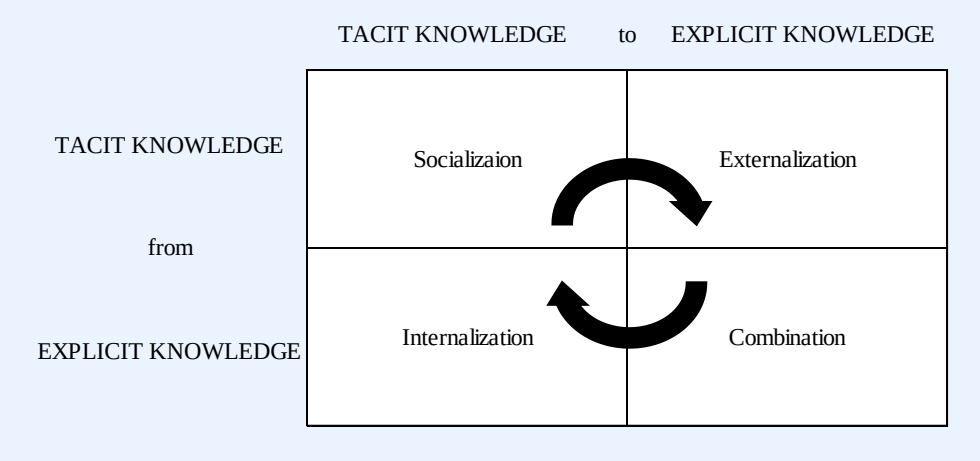

Figure 11. SECI Model – Source Nonaka & Takeuchi (1995)

The next process is **externalization**, it is the translation between tacit and explicit knowledge through the development of figures of speech and implied comparisons such as metaphors, concepts, and models, in order to ease its sharing and understanding and additionally to make it permanent and perceptible. This process will require parameters for the content and its codification, including authorship. The third process is **combination**, at this stage there is no new knowledge creation but the combination and gathering of explicit knowledge to achieve an organized synthesis. Finally, in the process of **internalization** dissemination and assimilation of knowledge takes place, where individuals get to internalize, understand, and complement new knowledge with their tacit knowledge achieving expansion and creation of new knowledge. In this last process knowledge turns into valuable resources, namely know-how and mental models.

Knowledge Spiral

When the SECI model reaches the last process it is not finished but it restarts the process, creating a spiral of knowledge, as can be seen in Figure 12. This characteristic defines this model as a continuous interaction between tacit and explicit knowledge that cannot skip any of the processes. The knowledge spiral can be adopted as the core of KM in organizations by using the individual knowledge and making it available to the different members of the organization, escalating and reaching the complete organization. In order to achieve this escalation, Nonaka & Takeuchi (1995) describe a set of five conditions that allow knowledge creation in the organization. These conditions are autonomy, fluctuation and creative chaos, intention, redundancy and requisite variety.

Below the set conditions for knowledge creation in organizations are explained. **Intention** is the desired objectives and their formulation as a business strategy. **Autonomy** refers to the support of autonomous behavior to access tacit knowledge of individuals and to boost the individual's knowledge creation. **Fluctuation and creation of chaos** seek to enhance interaction with the external environment by introducing a perception of chaos. That motivates individuals to get past mental boundaries in order to define and find solutions for problems. **Redundancy** is used as a management tool which will enhance the recognition of strengths of other individuals and the increase in knowledge. It is based on the overlap of information regarding different topics to prompt the creation of knowledge by influencing individuals to share tacit knowledge based on their perspectives. Additionally, it will help to

create consciousness in the individuals regarding their function in the organization by their rotation in different roles inside a team.

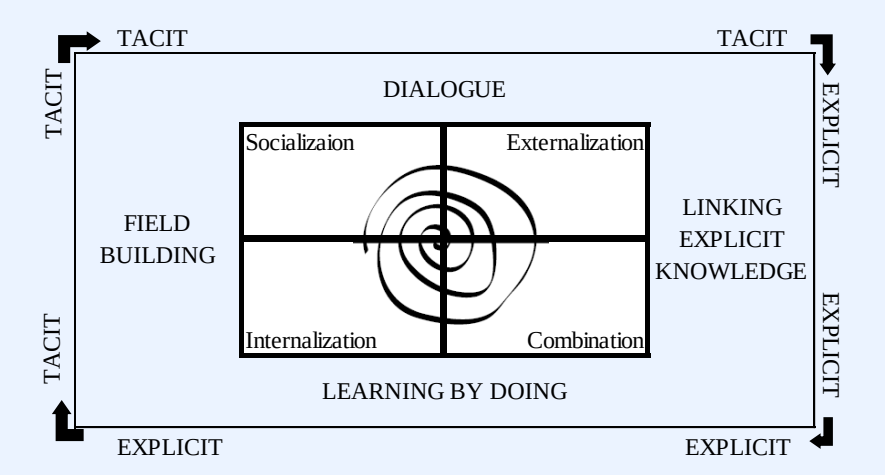

Figure 12 Knowledge Spiral – Source Nonaka & Takeuchi (1995)

Finally, **requisite variety** is the one that allows the achievement of balance between chaos and order, matching internal diversity with the surrounding environment and its challenges. The coordination is done by enabling the flexible and easy access to information in the organization. It is important to implement these conditions bearing in mind that they also have some shortcomings, thus, their implementation should be planned carefully.

In conclusion, Nonaka & Takeuchi (1995) defined the knowledge creation in organizations as *"the capability of a company as a whole to create new knowledge, disseminate it throughout the organization and embody it in products, services, and systems".* Once the knowledge is created the next step is to capture it in an organized way to be able to share it. This statement is reaffirmed by Makambe (2015) who states that it is fundamental for organizations to be able to access captured tacit and explicit knowledge by relevant members of the organizations. And, it is essential to give value to this knowledge by putting it into use, otherwise it just becomes information that is inert (Zhang, Mao, & AbouRizk, 2009). Therefore, it has to be considered for the study of this project that the creation of knowledge is done on site through the different experiences in the projects and it is important to capture, disseminate and use it.

3.4 Capturing and Codifying Knowledge.

Makambe (2015) defines knowledge capture, while referring to Becerra-Fernandez (2004), as *"the process of retrieving explicit or tacit knowledge that is within human beings, artifacts or organizational entities."* Besides, Dalkir (2005) specifies that tacit knowledge is extracted and captured, and explicit knowledge is organized and coded. Likewise, Mohapatra, Agrawal, & Satpathy (2016) state that the capture of knowledge is an indispensable task for knowledge creation. They also determined certain focuses that should be taken into account before starting the capture and codification of knowledge. These focuses point out how important it is for organizations to know what knowledge they need, what knowledge they have, how they want to use the knowledge, and how they want to organize and code the existing knowledge and the future knowledge. Therefore, the requirements of the organization in terms of knowledge should be defined. Also the existing knowledge and practices within the company

and the usefulness of its codification to develop tactics with the purpose of satisfying the defined requirements should be established. Thus, it is important to establish if the knowledge requirements have been identified at JPvE and the suitability of the tactics that are being used. The following tactics will outline how to make the existing knowledge functional, accessible, and comprehensible.

To understand the process of capturing and codifying of knowledge, it is important to review both types of knowledge, tacit and explicit knowledge, separately. Taking into account that collecting knowledge should have as a first focus people, since they are the main source of knowledge, the first component that will be studied is tacit knowledge, followed by explicit knowledge.

Capturing and Codifying Tacit Knowledge

The capturing and codification of tacit knowledge is an indispensable process, and even though it can be thought of as easy, it is very complex because of its nature, which is knowledge gathered over a long time that is located deep inside human minds (Mohapatra, Agrawal, & Satpathy, 2016). The identification and extraction of tacit knowledge start with sharing and creation of concepts as described by Nonaka & Takeuchi (1995). The different individuals should share their knowledge and experiences in order to make it available to others. This sharing of knowledge within groups is known as Communities of Practice (CoP), and is implemented through the networking between people with a common ground, who hold the knowledge, and can spread it and gain it (Omotayo, 2015). Once it is shared, it is important to deduct important concepts from all that was verbalized to transfer and transform the knowledge by incorporating it in explicit concepts (Dalkir, 2005). In this way access to useful extracted knowledge will be enabled by organizing and codifying it (Mohapatra, Agrawal, & Satpathy, 2016). At this point the translation from tacit to explicit knowledge has been achieved.

Capturing and Codifying Explicit Knowledge

The capturing and codifying of explicit knowledge is the conversion of tacit knowledge into explicit knowledge with a clear structure that allows easy access in order to make it useful and valuable for the members of the organization (Mohapatra, Agrawal, & Satpathy, 2016). Though it is established that the gathering of explicit knowledge is an easier task than gathering tacit knowledge, it is important to take into account its complications, which are based on quality. These quality shortcomings involve *"(1) accuracy, (2) readability/understandability, (3) accessibility, (4) currency, and (5) authority / credibility"* (Dalkir, 2005). Having created the awareness of the shortcomings, several methods have been developed for the codification of explicit knowledge. Three of these techniques are explained by Mohapatra, Agrawal, & Satpathy (2016). They are cognitive mapping, decision trees, and knowledge taxonomies.

- Cognitive Mapping

Cognitive mapping is used to embody the identified know-how. A cognitive map is the depiction of the mental models throughout codified knowledge. The cognitive map is composed of nodes and links. The nodes represent main concepts while the links represent the relationship between the concepts. In this way, the mapping of mental models draws the way people interpret and understand the different scenarios of the real world. The aim of

cognitive mapping is to capture and organize the translation of tacit knowledge into explicit knowledge to include it in the long-term organization's knowledge.

- Decision Trees

Another commonly used technique to codify knowledge is decision trees. It is a representation mostly in form of a flowchart, which has different routes that indicate consequences based on the different decisions that can be taken in juncture points. The path that should be followed is the one with the shortest route. The length of the routes will be defined by the consequences triggered by different rules found at the juncture points. This model is suitable for capturing process knowledge. It can be used as a management tool, supporting the process of decision-making.

- Knowledge Taxonomies

This technique is based on the classification of concepts. When main concepts have been identified, it can be demonstrated that they form blocks of knowledge and expertise. Therefore, they can be organized and represented graphically with blocks in a hierarchical way. This organization is what is known as knowledge taxonomy. In other words, it is the hierarchically arranged representation of knowledge in a specific area of expertise or in an organization and its interdependencies. This arrangement shows the depth in a topic, the lower the map goes the more specific the topic is. To code knowledge taxonomies and to carry out the categorization different models can be used, from manual concepts to automated processes. The manual processes are object-oriented which permits a specific classification in order to incorporate all the attributes. Hence, the more complex the taxonomy the more time it will take to categorize the attributes. The automated processes are based on the available information and communication technology (ICT) tools, they focus mainly on statistical analysis to classify the information in sets of groups with similar content. They are considered as not completely precise which triggers a need for validation. However, they are a good solution for large amounts of content.

Within the major taxonomic approaches that can be found for the codification of explicit knowledge are identified manual knowledge taxonomy and automated knowledge taxonomy. Based on the way industries and organizations are developing nowadays, Matayong & Mahmood (2013) consider it necessary to further develop and adopt automated systems. Moreover, the vast adoption of technology and IT and its presence in the different processes has shown that there are no specific IT systems that can support KM inside companies; instead KM systems can support it (Pandey, 2016). KM systems support and ease the capture, organization, and use of knowledge of complicated tasks composed of different activities (Matayong & Mahmood, 2013). To understand KM systems better and to identify if the cloud-based tool that JPvE has attempted to implement as support of the process of data collection is suitable, the existing literature of KM systems that was considered will be presented next.

KM Systems

Matayong & Mahmood (2013) define KM systems as *"an IT system developed to support and enhance KM practice into different processes, namely knowledge storage, sharing, retrieval, creation, and application."* Pandey (2016) adds to this definition that this type of information system manages the knowledge used at different levels inside the organization, such as

individual, group or organizational. Also, Maier (2002) states that KM systems that are a combination of ICT have the potential to strengthen and improve KM performance.

Two of the technologies that have been allowing and supporting KM are Enterprise Resource Planning (ERP)[2] and cloud computing (Huang, Newell, & Pan, 2002). ERP provides methods that allow the management of knowledge related to the core of organizations through technological business process' programs. To successfully adopt these programs it is recommended to develop a KM strategy (Pandey, 2016). A KM strategy's aim is to bridge a gap through the correct identification of what the organization needs and has in terms of knowledge (Maier, 2002). In (2004), in the European Guide to good Practice in Knowledge Management, KM strategy was defined as *"a declaration of how the organization will use KM methods, tools, processes and practices to achieve business objectives by leveraging its content, people and processes and how KM will support the organizations overall strategy"*. At the same time, cloud computing is a service in which providers make space available, mainly through internet means, for organizations to store and manage their information and knowledge (Pandey, 2016). Cloud computing is adopted because of the benefits it offers, such as agility, device and location independence, multi-tenancy, reliability, scalability, security and maintenance, benefits that can be translated into savings (Mohapatra, Agrawal, & Satpathy, 2016).

In conclusion KM systems can be understood as the structured gathering of information and documents from a specific setting, associated with experts, who can give value to the data in order to create, disseminate, apply and learn through sharing with others (Maier, 2002). In other words it is a framework within an organization regarding social and technology assets. The conclusion is that the intended adoption of the cloud-based tool by JPvE is one of the elements contained in KM systems, further, it is necessary to analyze whether this adoption also considers social assets. Additionally, Henczel (2000) concludes that even though KM is based on good data management some organizations ignore that the main source of information is the people who have the knowledge with which databases are created. Therefore, they focus on developing strategies that depend on technology only and do not balance both.

3.5 Implementation Strategy

Managing change is important, taking into account the different barriers and complications that a process of change like KM implementation involves. The strategies mentioned in subchapter 3.8 are useful and can be complemented with an implementation strategy outlined by clear steps.

The implementation framework strategy that will be used for the development of this master's thesis is based on the described implementation factors by Okumus (2003). These factors were identified and assessed in an exhaustive analysis of existing frameworks, from which the main elements were gathered that have an impact on the implementation strategies. Furthermore, Okumus (2003) grouped the factors in four categories: strategic

[2] ERP is defined as a *"tool to standardize and integrate business processes to accelerate access to common resources across the organization"* (Shen, Chen, & Wang, 2016)

content, strategic context, operational process and outcome which will be explained next and can be seen in Figure 13.

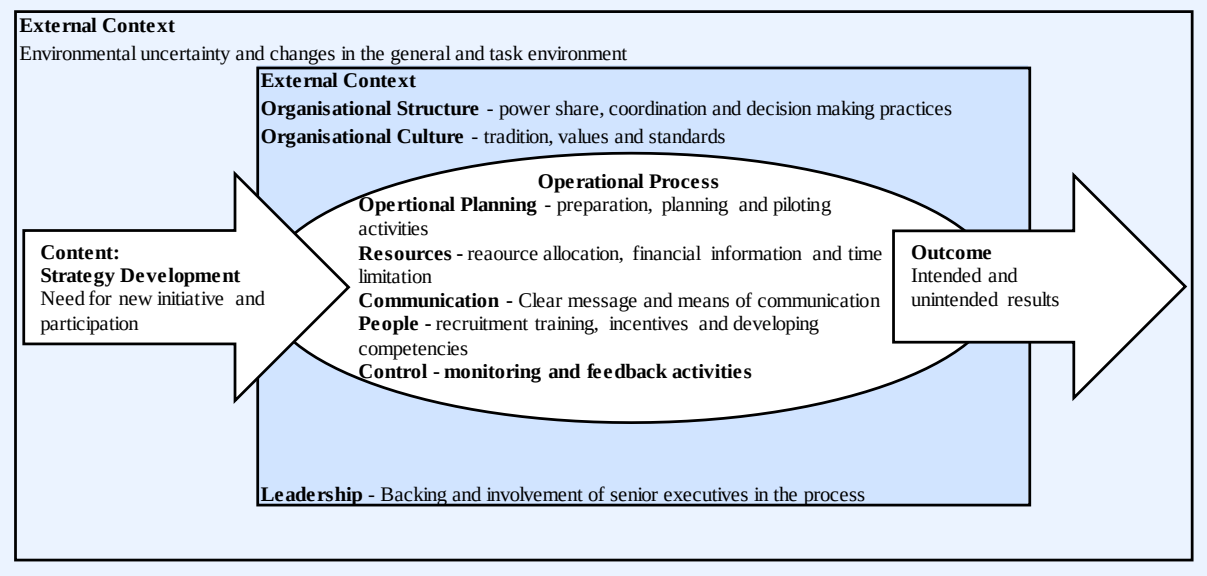

Figure 13. Strategy Implementation Framework. Adapted from Okumus (2003)

- Strategic Content

The strategic content refers to why and how the implementation strategy is proposed. This category contains the development strategy, it establishes that the implementation has to have clear identified objectives that are in line with the organization's purpose. All management levels have to participate actively, with the support of developers with excellent knowledge and expertise. Finally, this category has to evaluate the consequences that the implementation can have on ongoing and future projects and vice versa.

- Strategic Context

This category is divided into external context and internal context.

- External context

The external context is concerned with the uncertainty and changes to which the organization is exposed in the general business setting. It deals with the strategies that are needed for developments in the business setting and to ensure the strategies of the implementation process match with the market and trends in the business until it is completed.

- Internal Context

The internal context is concerned with the organizational structure, culture and leadership. The **organizational structure** is based on the organization and how it is coordinated. This includes the procedures, decision-making scenarios, and those responsible for decision-making. The structure of the organization and the freedom regarding coordination, cooperation and information flow is an important part of the implementation strategy. Additionally, it is useful to identify the impact that the implementation strategy will have on the different stakeholders and also the possible change in relationships and powers of decision-making. Further identification should be made of the dominant groups that are difficult to convince regarding new strategies. Finally, it is important to see how planning and communication structures can be used to reach people and manage resources. To continue, the **organizational culture** is based on the spoken and unspoken rules and behaviors in an organization. It involves the assessment of the impact the organizational culture has on the

organizational structure. Also, it is important to evaluate the repercussions that the implementation can have on the organization's culture and subculture and which initiatives and activities should be rolled-out to influence it. Finally, l**eadership** approaches the CEO(s) involvement in and support of the implementation. It is important that the CEO gets involved in the process of implementation and deployment and backs it up.

- Operational process

The operational process is focused on developing the organization's operational planning, resource allocation, and control and feedback of the implementation. **Operational planning** is the component in charge of formulating the implementation process. During this period it has to prepare and plan the activities that will be carried out during the implementation, as well as the planning for the resources needed. To validate the implementation activities, it must seek for participation and feedback of different management levels. Finally, it should establish the pilot projects and after the implementation, it should gather the lessons learned. This planning has a strong impact on the communication, activities and allocation of resources. **Resource Allocation** seeks to determine and evaluate the needed time, financial resources, and the available and required skills and knowledge. This assessment is done through the evaluation of the impact of the implementation on organizational structure and culture as well as defining procedures to ensure resources and how to allocate them. The resource allocation should also take into account the people, and therefore consider the impact on human resources management, the required training and incentives for current employees and the need for recruiting new personnel. Furthermore, communication has to be examined, meaning the information and the ways in which the information will be sent and received. Additionally, the obstacles in communication and their impact on organizational structure and culture have to be defined. Within this exploration, a clear message should be established about the new implementation, its requirements and implications. Finally, **control and feedback** is needed during the implementation so the progress of the process can be assessed by comparing the current situation and the proposed objectives.

- Outcome

The outcome is used together with the implementation process to evaluate whether the implementation was carry out according to what was planned and to see if the objectives were reached. Based on the elements assessed conclusions are drawn and it is checked what has been learned from the strategy implementation process and if the outcome was satisfactory for the involved parties.

From the different components of the implementation strategy a number of key steps have been defined to enhance and manage a successful implementation. These steps can aid this project and they will be presented next.

3.6 Managing change

Managing change is important, taking into account the different barriers and complications that a process of change, such as KM implementation, entails. The strategies mentioned in subchapter 3.8 and the implementation strategy in subchapter 3.5 are useful and can be complemented with some clear factors. The factors that will be considered are the ones described as success factors by John P. Kotter in 1995 and restated by himself later. Some of

these factors are also used in the formulation of recommendations to improve and fulfill the objectives of the process of implementation studied in this project.

According to Kotter (2007), these factors were developed based on observation of companies attempting to change their business in order to adapt to challenging and competitive environments. Based on these scenarios, he also proved that change in organizations is a process that takes time and to have a successful implementation some phases must be gone through. Below, in Table 1, the defined stages, their implications and difficulties are shown.

Table 1. Stages of change. Retrieved from Kotter (2007)

Stage	Actions Needed	Pitfalls
Establish a sense of urgency	• Examine market and competitive realities for potential crises and untapped opportunities. • Convince at least 75% of your managers that the status quo is more dangerous than the unknown.	• Underestimating the difficulty of driving people from their comfort zones • Becoming paralyzed by risks
Form a powerful guiding coalition	• Assemble a group with shared commitment and enough power to lead the change effort. • Encourage them to work as a team outside the normal hierarchy.	• No prior experience in teamwork at the top • Relegating team leadership to an HR, quality, or strategic-planning executive rather than a senior line manager
Create a vision	• Create a vision to direct the change effort. • Develop strategies for realizing that vision.	• Presenting a vision that's too complicated or vague to be communicated in five minutes
Communicate the vision	• Use every vehicle possible to communicate the new vision and strategies for achieving it. • Teach new behaviors by the example of the guiding coalition.	• Undercommunicating the vision • Behaving in ways antithetical to the vision
Empower others to act on the vision	• Remove or alter systems or structures undermining the vision. • Encourage risk taking and nontraditional ideas, activities, and actions.	• Failing to remove powerful individuals who resist the change effort
Plan for and create short-term wins	• Define and engineer visible performance improvements. • Recognize and reward employees contributing to those improvements.	• Leaving short-term successes up to chance • Failing to score successes early enough (12-24 months into the change effort)
Consolidate improvements and produce more change	• Use increased credibility from early wins to change systems, structures, and policies undermining the vision. • Hire, promote, and develop employees who can implement the vision. • Reinvigorate the change process with new projects and change agents.	• Declaring victory too soon—with the first performance improvement • Allowing resistors to convince "troops" that the war has been won
Institutionalize new approaches	• Articulate connections between new behaviors and corporate success. • Create leadership development and succession plans consistent with the new approach.	• Not creating new social norms and shared values consistent with changes • Promoting people into leadership positions who don't personify the new approach

Next the stages of change will be explained in more detail.

- Establish Sense of Urgency

This stage refers to the recognition and presentation of a specific situation that can influence the development of the organization and can have crucial consequences. The situation can be established based on troublesome circumstances such as competition, decrease in the market share, and lack of revenue growth. This stage has aims to awaken the awareness of the need for change.

- Form a Powerful Guiding Coalition

This stage is built by teamwork supported by someone from the key line management with a strong leadership. Additionally, it does not require a big group. Nevertheless, this group needs to be able to communicate and create levels of trust in order to spread the desired change in the organization.

- Create a Vision

Having a team based on coalition it is important to develop a concept of how the future is expected to be. This concept is developed with the purpose of managing the path necessary for the organization to reach the objective of the change. Furthermore, this concept should be easily communicable and attractive to the different parties involved in the change.

- Communicate a Vision
According to the created vision, a transformation is needed into a format in which the concept can be communicated, showing that the change is useful and possible. This communication should use all the available channels. Additional to verbal communication, there should also be an implicit communication through actions. The communication should be clear and it is important to make sure that people understand it, to enhance people's interest and willingness to change.

- Empower Others to Act on the Vision
It is important for the implementation of change to involve as many people as possible, strengthening the adoption. Additionally, interested people should be given the chance to contribute with new approaches and ideas. To enhance these attitudes it is important to help overcome the obstacles that can exist in an organization, showing empowerment of others and creating credibility in the effort of change.

- Plan for and Create Short Term Wins
Given that implementation of change is a long gradual process, it is important to plan and create short term objectives that have tangible wins when the process is paying off within the first 12 to 24 months. For instance these wins may be rewarded with elements such as recognition. Furthermore, the short term objectives can enhance the feeling of urgency which brings analytical thinking that can be positive for the process through revising and clearing visions.

- Consolidate Improvement and Produce more Change
To reach a successful implementation it is important not to damage the long term process by calling it successful for the short term only. Although it is important to celebrate short term wins it is important to continue the long term process by improving the elements that had not been covered or at that point become inconsistent in order to keep the vision on the transformation and avoid a false victory.

- Institutionalize New Approaches
Change takes root when it becomes "the way we do things around here," when it seeps into the bloodstream of the corporate body. Until new behaviors are rooted in social norms and shared values, they are subject to degradation as soon as the pressure for change is removed.
1. Conscious attempt to show people how the new approaches, behaviors, and attitudes have helped improve performance - Helping people see the right connections requires communication.
2. Taking sufficient time to make sure that the next generation of top management really does personify the new approach. If the requirements for promotion do not change, renewal rarely lasts. One bad succession decision at the top of an organization can undermine a decade of hard work.

In conclusion: personalization, KM strategy, codification KM strategy and the implementation strategy complemented with success factors for change could help with the deployment of implementation and modification of processes, in this case implementation of a cloud-based tool to support KM. Adil (2016) established that readiness for change depends on every industry and its specific business model. Below the different conditions of KM implementation

are considered as well as the readiness for change in the construction industry which is the field of interest of this project.

3.7 KM in the Construction Industry

Construction industry is a project-based industry, which carries out unique dynamic projects that involve the collaboration of different stakeholders during its life-cycle. The development of projects is based on multidisciplinary teams that can produce high amounts of knowledge along the different phases of project's lifecycle (Dave & Koskela, 2009). This knowledge includes understanding of the market and its requirements. Construction industry's knowledge is acquired by a combination of experiences and individuals' knowledge that over time becomes collective knowledge, meaning that a significant amount of the knowledge in construction industry is tacit knowledge (Abu Bakar, Yusof, Tufail, & Virgiyanti, 2016).

The dynamism and multidisciplinary collaboration makes that construction industry is considered a fragmented industry, since teams most probably will not continue working together in future projects. This fragmentation makes it difficult to capture and share knowledge (Dave & Koskela, 2009). The difficulties in capturing and sharing knowledge emerge from the separation of teams, changes in or retiring of personnel, implemented platforms, and lack of motivation among others (Dave & Koskela, 2009; Abu Bakar, Yusof, Tufail, & Virgiyanti, 2016). To overcome the fragmentation obstacle the industry needs knowledge to flow through the different stages of projects. This flow can be accomplished with the correct implementation of KM which can facilitate the capture and sharing of knowledge (Dave & Koskela, 2009).

According to Rezgui, Hopfe, & Vorakulpipat (2010) during the last years different efforts have been made to developed and enhance KM in the construction industry. To characterize the progress of KM in the construction industry, Rezgui, Hopfe, & Vorakulpipat (2010) define the development of three generations of KM in architecture, engineering and construction (AEC), based on the evolution of management philosophies, the evolution of ICT solutions and the evolution of societal impact on KM. The schema of the development of KM is presented in Figure 14.

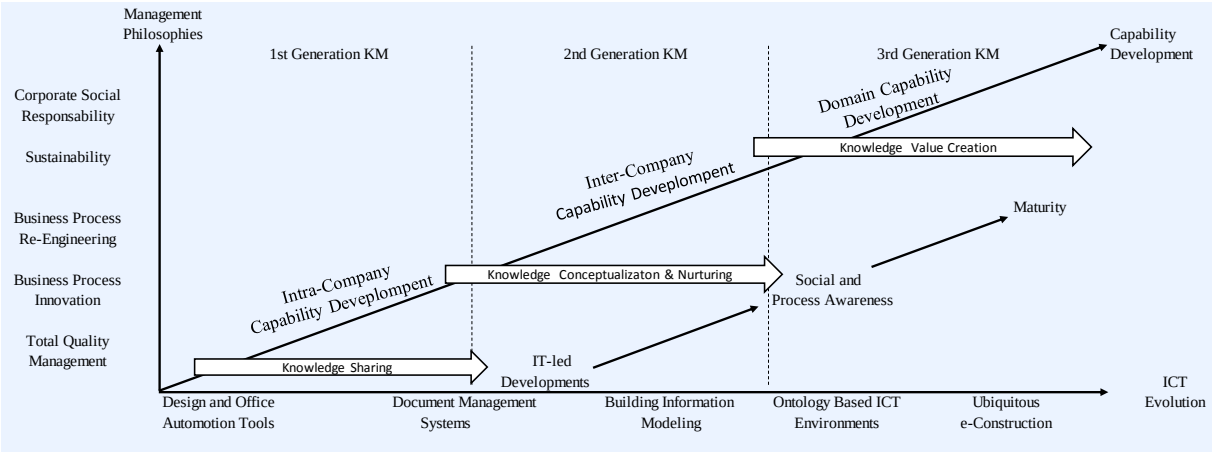

Figure 14. Generations of KM in AEC- Adapted from Rezgui, Hopfe, & Vorakulpipat (2010)

The first generation is technology-driven, displaying a main interest in business process and automation through strong ICT development and distribution, which required people's

interpretation. The second generation has a focus on knowledge codification with a perspective on knowing and acting that dealt with the awareness and integration of social, organizational and technological adoption factors. The third generation is based on the creation of knowledge value according to environmental and societal concerns. The change from tangible assets to intangible ones took place in this generation, aiming at creating value of knowledge enclosed in organizations and individuals. The conclusion taken from the three generations is that the appropriate strategy to adopt KM should include the development of main organizational skills and create intellectual capital.

Abdul (2005) affirms that KM is first a social and then a technological process. He emphasizes that the handling of knowledge is best done through communities and having the implementation of management systems as enablers of the process. He defines digital communities and social communities as the two main ways of knowledge sharing within communities. Also, he describes digital communities as a way of communication that connects people with digital sources, through the storage and sharing of knowledge via a digital medium. One of the developments that has been carried out to support digital communities is cloud computing, which offers the space to consolidate, store, and share knowledge associated with the projects' process. Additionally, it provides a space to uphold and give value to knowledge for its use in future projects (Beach, Rana, Rezgui, & Parashar, 2015). In the construction industry, cloud computing increases levels of collaboration between teams through real time communication using a virtual platform (Wong, Wang, Li, Chan, & Li, 2014).

3.7.1 Cloud Computing in the construction Industry

Cloud computing is defined by Mell & Grance (2011) in the Recommendations of the national institute of standard and technology as *"a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction."* The structure of a cloud computing application is shown in Figure 15. According to the findings established from literature review regarding cloud computing in the construction industry, Chong, Wong, & Wang (2014) characterize cloud computing in three categories: general cloud applications, cloud project management applications and cloud BIM applications.

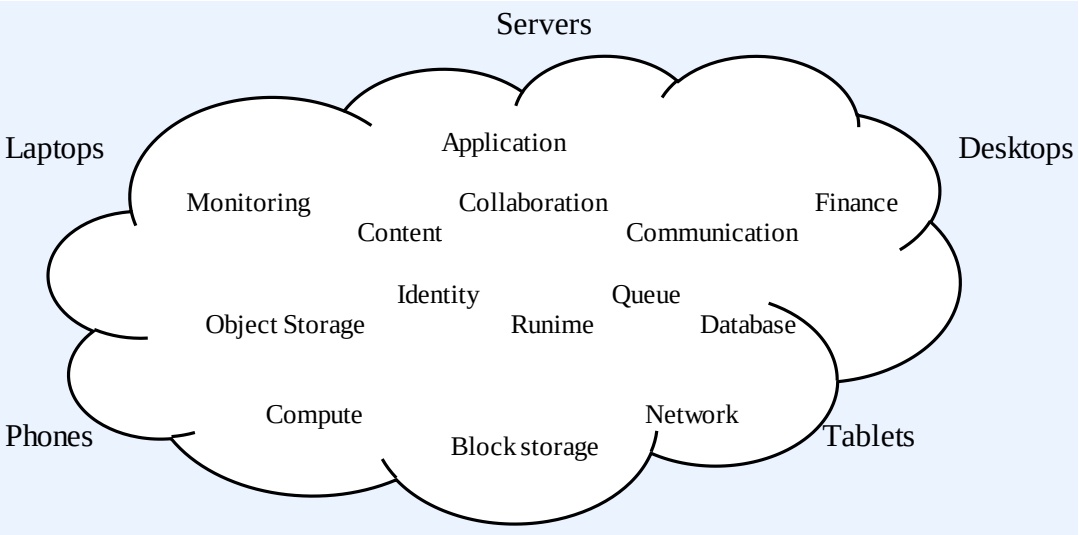

Figure 15. Cloud computing application structure. Adapted from Ul Haq Quddusi (2014)

Cloud BIM applications will be described following since it is the type that is considered in this research project.

Cloud BIM Applications

Cloud BIM applications are characterized by Chong, Wong, & Wang (2014) as the course of action to enhance BIM[3] use, this application has two different approaches. On the one hand there are developments that allow the designer to share the model in the cloud; the designer would be able to decide whether to make it public or private. This development converts computers into BIM servers, making them accessible in a web browser, aiming to improve and enhance collaboration. On the other hand there are developments that permit the visualization of the entire BIM software and support the project management. This virtualization of software provides availability even when the devices are switched off.

BIM has been present in the construction industry for a long period of time, and as stated by Wong, Wang, Li, Chan, & Li (2014) BIM continues its evolution in the AEC industry. Nevertheless, BIM's adoption and implementation is still relatively low (Chong, Wong, & Wang, 2014). Cloud BIM applications are considered to be an instrument that can enhance the use of BIM. This instrument can support the collaboration processes by offering improvements in sharing and accessing information, additional to providing real-time communication and extend BIM from design to construction (Beach, Rezgui, & Rana, 2011; Wong, Wang, Li, Chan, & Li, 2014; Matthews, et al., 2015).

According to the study carried out by Chong, Wong, & Wang (2014), Autodesk BIM 360 is the application that offers the most features compared to five other applications. They define it as a software that combines the design functions with the cloud computing capacities, and it can be installed on tablets or computers. Also they determined that the features that characterize it are clash detection and coordination, design tools, field management tools, energy analysis, 3D visualization, online file storage, online drawing viewing, online drawing editing, encrypted data, online sharing of files, simulations, product lifecycle management, web-browser access, offline access, mobile apps, additional supporting apps, file management system, and free trial. And the features that it lacks in comparison with the other five tools are hardware support, virtualized desktop, private cloud, IFC file recognition, change detection, and free open source software.

BIM 360

BIM 360 is a compound of cloud-based solutions focused on construction management. It seeks to connect projects to staff members from both office and the construction site, allowing the use and adjustment of shared documents. BIM 360 gathers documents such as models, drawings, checklists, and issue lists allowing site inspections, notifications and fast synchronization with the purpose of easing the flow of information in construction companies.

In conclusion the construction industry needs KM adoption in order to improve its process, communication, and performance. It is important that the industry creates and raises awareness of the importance of knowledge and that it creates value from knowledge, both in

[3] BIM (Building information modelling) is a term used *"to describe tools, processes and technologies that are facilitated by digital, machine—readable documentation about a building, its performance, its planning, its construction and later its operation."* (Eastman, Eastman, Teicholz, & Sacks, 2011)

tacit and in explicit form. To carry out KM implementation, it should be also recognized that a combination is necessary between human and technological resources, bearing in mind that people are the main source of knowledge and its interpretation. In regard to human and technological resources: the industry has had three stages in its development creating progress from only a technological scope towards a more social point of view. To boost the development of KM based on the existing tools and applications in the construction industry, the use of cloud computing in combination with BIM has been explored during the latest period, nevertheless, it has not been extensively adopted. This combination aims to broaden the range of BIM from design to further phases in the construction life-cycle. Furthermore, cloud BIM application can lead to a better communication in real time and a better documentation and storage of knowledge, to retrieve and use lessons learned from experiences.

3.8 KM Beyond Technology

The following research concerns literature that discusses the need to balance technology and social assets in the implementation of KM, thus assisting the development of the project. Imran, Rehman, Aslam, & Bilal (2016) confirm that in dynamic organizations change is the main way to remain active in the industry. It is a fact that the adoption of software has become necessary for the organization's adjustment to change (Imran, Bilal, Aslam, & Rahman, 2017). Additionally, it is important to understand that the implementation of KM is considered to be a change within organizations, and this change encounters challenges from the inception phase to the implementation stage (Mohapatra, Agrawal, & Satpathy, 2016). Also, for this change to be successful, it is important to take into account the organization's strategies and culture, and the motivation of employees to share knowledge (Forcada, Fuertes, Gangolells, Casals, & Macarulla, 2013).

Based on literature review Jimmieson, Peach, & White (2008) find that different authors have studied how the support by employees can determine the success or failure of a change implementation, based on their openness to coming change. The studies have encountered affective responses, such as organization cynicism and resistance, readiness to change, and receptiveness and acceptance to change. Some of these theories are the theory of reasoned action, the technology acceptance model and the theory of planned behavior. However, Matayong & Mahmood (2013) indicate that these theories only refer to the adoption or rejection of innovation by people that can decide autonomously, but not to the decisions of people at different levels. According to Imran, Bilal, Aslam, & Rahman (2017) KM strategies have a positive impact when it comes to implementations of change in organizations. This change is determined by three factors: readiness for change, change cynicism, and intellectual capital.

Readiness for change refers to the raising of awareness regarding the need for change among employees, and the preparation of strategies and appropriate resources to support change. These elements help the transition between processes by organizing the course of change and managing employee cynicism (Imran, Rehman, Aslam, & Bilal, 2016). Employee cynicism is associated with change cynicism, which is the negative perception that comes from employees having trouble in adapting to changes and losing their comfort zone (Aslam, Ilyas, Imran, & Rahman, 2016). It is important to address this factor since the lack of acceptance can lead to demotivation and deterioration of employees' performance (Imran, Bilal, Aslam, & Rahman,

2017). Finally, the last factor is the intellectual capital, defined by Coakes & Bradburn (2005) as *"the capital in which the knowledge residing within human capital is combined with systems, technologies, processes and knowledge repositories."* It is important to take intellectual capital into account because it is the basis to propose and implement change inside an organization (Imran, Bilal, Aslam, & Rahman, 2017).

KM strategies address the factors described previously, seeking to support implementation of change by helping people understand the importance and need for change, and the expected outcomes (Imran, Rehman, Aslam, & Bilal, 2016). The applied KM strategies are personalization and codification. Personalization strategy is based on tacit knowledge, and is the communication and explanation of the process in a personal discussion; it can be carried out in a group or by an individual (Hansen, Nohria, & Tierney, 1999). Contrariwise, codification strategy is based on explicit knowledge. This knowledge is the codification of tacit knowledge contained in a central repository which is accessible to everyone that is authorized to make use of it, and can guide or help solving the everyday problems faced in the implementation of change (Imran, Rehman, Aslam, & Bilal, 2016).

To conclude: it is essential for a successful implementation of KM to understand that it is a process of change in which different components may be involved. These components include interests and strategies of the organization, human resources that will have to adopt KM and will either enhance it or undermine it, and the technological tools that can support the fulfilment of KM's requirements. These conclusions and the components must be taken into account in this research project when analyzing the implementation of the cloud-based tool and the scenario in which the implementation was carried out. Moreover, it should be considered during the development of this project that the main barrier to the implementation of change is human resources.

There are methods that can assist people's understanding and acceptance of change, thus to overcome barriers. One of these methods is the KM strategies which offer a mechanism to communicate with people, allowing a better judgment regarding new processes and change. Lastly, the consideration of components such as employee acknowledgment of the need of change and implementation strategies will determined the readiness for change of an organization.

3.8.1 Knowledge Management Obstacles in Construction Industry

Despite the recognition by the construction industry of the importance of knowledge retention and management, and the efforts put into its development, the improvement in this area seems to be minor (Bigliardi, Galati, & Petroni, 2015). According to literature, knowledge management barriers have been assessed by means of two approaches. The first approach refers to the barriers of knowledge capture and transfer (Kamara, Augenbroe, Anumba, & Carrillo, 2002; Shokri-Ghasabeh & Chileshe, 2014). The second approach refers to the barriers regarding knowledge sharing by means of human capital (Styhre, 2008; Hartmann & Doree, 2013).

KM - Capture and transfer barriers

There are several theorectical studies concerning the need for KM and the frameworks within which KM should be adequately implemented and developed. Nevertheless, in practice this

scenario is proven different. According to the literature review and case study carried out by Shokri-Ghasabeh & Chileshe (2014) some barriers have been defined that hinder successful knowledge capture and transfer based on organizations' experiences around the world. Some of the identified barriers that have a high rate of occurrence are lack of employee time, lack of clear guidelines and processes, lack of senior management support, lack of money and organizational culture. Also, they show some of the recommended tools in the literature used to approach and decrease these barriers. Therefore, not only construction industry's awareness is required regarding KM and the importance of its implementation, but also recognition of the need to change internal processes and the implementation of pertinent measures that are required in order to make the implementation successful.

KM – Sharing Knowledge via Human Capital

The approach of sharing knowledge via human capital refers to the importance of individuals and the ease that exists in direct communication and knowledge-sharing in spaces such as communities of practice. Hartmann & Doree (2013), authors with a social capital approach, deviate from barriers described in the Capture and transfer approach because they considered them as limitations that can be solved. On the other hand, Hartmann & Doree (2013) showed the difficulty of sharing knowledge in the construction industry based on the ephemerality and intermittence of projects with different characteristics. Also they show the intricacy of knowledge-sharing based on complex and differing environments where technologies and procedures must be fulfilled dependent on the project's characteristics. They argue that these conditions lead to a documentation in which the meaning of the experiences disappears due to a loss of background and context. This statement is supported by Bigliardi, Galati, & Petroni (2015) who argue that in the documentation of project's decisions the background or conditions are unknown, which makes it difficult to learn from other projects. These statements support their aim to study a social approach which can boost project understanding and knowledge sharing, consequently KM.

The barriers discussed earlier that are creating obstacles for the implementation of KM in the construction industry, even though they have a different approach, should be analyzed and taken into account when designing a strategy in order to decrease the risk of encountering them and they slow down or threaten the implementation.

3.8.2 Construction regulations in the Netherlands

For the development of this case study, the need of KM in construction industry is further studied by considering the governmental regulations that organizations in the construction industry must comply with. For this specific case, the Dutch regulation is studied because TBI works mainly in the Netherlands. Specifically, the proposed quality assurance act for the building process (Wkb) is studied, taking into account the impact that it will have on the construction companies as a result of the changes in process that it demands.

The Wkb is a proposal that intends to enforce a system of quality assurance and improve the position of clients. It modifies the Civil Code, the Environmental Licensing Act on its general provision, and the Housing Act (Nieman, 2016). To understand the scope of this law the ongoing situation and the expected situation with the application of the proposed law is presented below.

The following concepts regarding the regulations and coming changes are based on Nieman (2016). The quality assurance process currently used is based on the building plan test, in which the competent authority, most of the times the municipality, assesses if the project planned complies with the Building Decree. This compliance is measured through a design check-up of the following requirements: safety and health, use, energy and sustainability and technical equipment. Furthermore, during the execution of the projects the competent authority appoints a private quality inspector to do the pertinent inspections of the project. Nevertheless, since the competent authority approves the permit based on the conformity of the building plan with the decree, this creates a difficult situation for the client to demand repairs and others. Ultimately, the Wkb seeks for the builder to take responsibility of the quality delivered and safeguard the clients from errors that take place during construction.

Once the Wkb comes into force the building decree test will be no longer a basis to grant a permit; on the other hand to start the process of requesting an environmental permit the applicant will have to send the definition of the place and the activities that will be carried out. Within this documentation the applicant has to define the authorized system that will be used for the quality assurance as well as appoint a quality inspector who must be authorized to apply the defined quality system. Based on this information, there will be a check-up of the project's compliance with the defined requirements by law and the compliance with an adequate environmental suitability and protection. Additionally, the development of an admission organization is proposed which will study if the defined instrument is part of the accepted ones and if the inspector complies with the requirements. After the approval, there will be a shift of the monitoring which will be done by the builder through the assigned quality inspector instead of the competent authority. This inspector will have access to the system and will audit the quality compliance during the process according to the established requirements and specification. This means that in order to do an accurate assessment the inspector must be well aware of the regulations and the contract between the builder and the client. This process will result in an as-built statement issued by the quality inspector that will state the compliance of quality of the project according to the building decree and the contract. This statement should be supported by a complete file with the tracking of the process and its compliance. Therefore, the different issues not written down will be considered as latent defects, and in case something is found to be out of order the contractor must prove that it is not his/her fault.

This law will be strengthened with what is known as right of detention, that is a deposit of 5% of the value of the contract held by the notary, which before used to be released three months after the hand-over. However, with the Wkb the release of this deposit will depend on the agreement of the consumer that all issues are solved and that the contract was fulfilled. To complement the process the correct functioning and use of the quality system will be followed and checked. Accordingly, the system provider should follow the operation of the instrument and the checks of the use of the instrument must show that it is being used correctly, otherwise sanctions can be imposed.

To further follow the approval and implementation of this law it was found that certain things were discussed and clarified according to remarks made by the minister in order to improve the Wkb's scope. The explanation of this adjustments is going to be founded on Scholten (2017). The main approached points will be presented below.

The first point referred to the clarification of the role of the competent authority. In this clarification, the role of the administrative organization and the quality inspectors was reduced in order to enhance the role of the competent authority and allow it to best enforce the law and assure its compliance. The second adjustment was related to the license application, it was rectified that in addition to the aforementioned documents and requirements the provision of a technical risk assessment of the building plan according to the authorities' requirements was also required. Finally, the need of a transfer file was determined, containing the used technical solutions which will reduce failure cost, assure building with 100% compliance and guarantee long-term guarantees.

In conclusion the aim of the proposed law is to assure complete compliance of requirements and contracts by shifting the controlling responsibility from the competent authority to the builder, handing the responsibility to the builder to prove that the projects have been delivered with the expected quality and give customers the power to demand compliance with the contracts. The change of processes inside construction organizations is also required in order to achieve projects with quality and to be able to prove suitability and satisfactory work carried out during the execution according to requirements and agreements.

3.9 Conclusion

To conclude, it is important to emphasize which acquired knowledge from the reviewed literature is used in the development of this research project. The combined understanding and needed background will be presented below.

Firstly, the understanding of KM and its components are important to determine KM's value and its existence inside defined process at JPvE. Therefore, KM will be understood as the process to address and use knowledge throughout the stages of knowledge creation and capture, knowledge sharing and dissemination, and knowledge internalization and application supported by content evaluation, contextualization, and maintenance. Additionally, it is important to recognize that there are two types of knowledge: explicit and tacit, and that they are complementary. Therefore, even though they should be approached through different means they must be interconnected.

Based on the types of knowledge, it is important to acknowledge that in construction industry the main type of knowledge is tacit knowledge and it is produced in large amounts during the execution of projects among the interdisciplinary teams. To avoid losing the aforementioned knowledge, it needs to be processed through socialization, externalization and combination to accomplish its translation into explicit knowledge, which needs to be transferred and internalized at every level in JPvE to enhance the knowledge spiral process and strengthen the company's performance. Nevertheless, not all the knowledge should go through this process. Therefore, the company has to define the knowledge that is needed and how to organize it and code it to get the necessary information that can be seized with the quality needed. Furthermore, the way of organizing and coding the gathered knowledge should consider how to impede background loss. Once awareness about the importance of KM has been raised, and the need and use of KM has been defined by the company, KM implementation and the implementation of complementary systems such as KM systems and complementary tools can be contemplated.

The examination of KM and KM systems implementation, and the development of implementation strategies should include the assessment of their impact based on the internal change they will cause. Moreover, it has to be studied how to approach the barriers that change can bring considering the acceptance and readiness for change of the users. In other words the readiness for change of the organization has to be evaluated and how to manage change needs to be considered. For this case, the developed implementation strategy is based on the ISF defined by Okumus (2003), and the rolled-out process at JPvE to implement BIM 360, taking into account hat the initial assumption was the existence of KM in the company.

Finally, to develop recommendation for the found results, the changes and impact that will be acquired by the enforcement of a new law will be taken into account. Additionally, the fact that KM can support the gathering of information that will help the company comply with requirements will be taken into account. More importantly the fact that KM will help the company improve its performance will be considered. In the next sections, the development of the implementation strategy and the case study based on JPvE and its attempt to implement a cloud-based tool to support the capture, processing and sharing of knowledge produced during the execution of projects will be exposed.

4 Research Development

The research and development of this master project follow the methodology described in chapter 2, and summarized in Figure 16. It is focused on the process of knowledge capture as part of KM in the execution phase of a construction project. It assesses the knowledge capture supported by the implementation of a cloud-based tool. The basis of the assessment is the development of an implementation strategy based on the study of a real-life case. The aim of the case study is to find the existing shortcomings in the implementation process of the cloud-based tool. The found shortcomings are used to develop recommended improvements in the implementation strategy and in the current state.

This project has two phases: literature review and development. The first phase, literature review, presented in chapter 3, sought to understand KM theory and its current situation in the construction industry. Also, literature review considered the current scenario and context for TBI. The second phase, development, considers as a starting point the governance and processes inside TBI in the specific construction company in which the project that is approached is being developed. From the elements mentioned before, the confirmation of KM's presence as a process or within established processes is assessed. Additionally, the governance of the contract held with the provider of the tool for collecting data and the different existing information referring to this process are assessed. From the collected findings, an implementation strategy is built following the established framework in subchapter 3.5. This strategy will give an input for the development of the case study. Finally, the development of the case study will be approached through two qualitative methods: observation and interviews, which results are compared with the defined implementation strategy. The information, implemented processes, and findings with which this project is carried out are presented below.

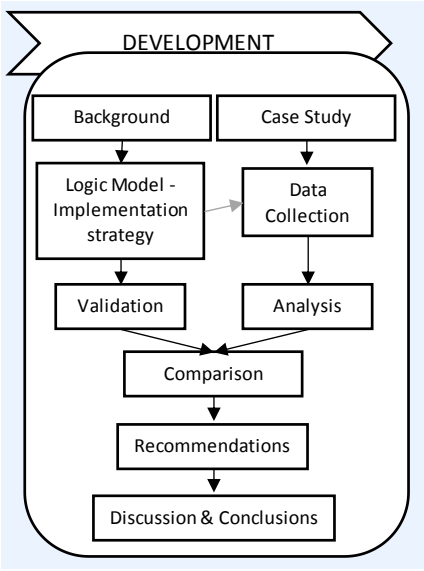

Figure 16. Development – Case Study Outline.

4.1 Background and Built Explanation

For the development of the implementation strategy, a background explanation about TBI and JPvE, the company in which the case study will be developed, is given. This assessment includes the external and internal context of the company. Following the line of this project, inside the internal context the established governance and processes to understand the mandate of the company are studied and KM and its involvement in the company's operation is considered. Furthermore, to study the implementation process of the cloud-based tool that supports the gathering of data the documents and the governance of the celebrated contracts that refer to it are considered. Nevertheless, some of this documentation will not be attached to this project due to confidentiality.

4.1.1 TBI

The following statements are based on TBI Holdings B.V. (2017) annual report[4]. TBI is a private company based on a govern structure of two separate boards of directors, with Stichting TBI as its unique shareholder. TBI is aware of the changing world in which we live nowadays and the challenges currently taking place and those expected to come. Within these challenges, a **digitalization era** is considered, seeking for environmental friendly transitions in terms of energy and urbanization. These challenges define the approaches considered for future projects in the different companies covered by TBI. Even though every company operates under its own name the aim is for them to work in collaboration to **strengthen multidisciplinary work**.

The companies are active in the fields of engineering, construction and infrastructure. For the development within the different fields, TBI has developed a **governance process[5]** that determines the management tools to plan, execute and guide the operation of the projects. TBI works as an umbrella organization which authorizes schedules and establishes management instructions for all the companies, including central processes and services. TBI establishes reporting guidelines according to laws and regulation. TBI's executive and supervisory board employs the guidelines of principle and best practices from the Dutch corporate governance code, guidelines that must be followed and applied by the management boards in every company. Based on the required management, TBI defines the main 4 risk categories that have to be taken into account and their corresponding impact on results. These categories are strategic/market, operational, financial and compliance.

Strategic/market

The strategic/market includes the following risks: changes in market conditions, scarcity in the labor market for specialists, increased competition and pressure on prices. With this category, TBI seeks to approach the different market sectors with a broad range of services aiming for client satisfaction. Also, it strives for recruitment of skilled professionals offering further training and good working conditions. Furthermore, it is always attentive to price changes, indices and time. Finally, it addresses the collaboration between internal knowledge centers, for market innovation and anticipation, with further cooperation with external partners.

[4] http://jaarverslag.tbi.nl/media/attachments/tbi_jv_en_2016_d.pdf

[5] Governance process is defined as a: *"framework of authority that ensures the delivery of anticipated or predicted benefits of a service or process."* (Zyngier, 2005)

Operational
The operational category covers project management and execution, insurable risks and liabilities, safety of employees and subcontractors, and environmental awareness. In these risks the compliance with internal processes and training for project managers is included. Additionally, the cases in which the high management approval for high risk investments, financing, or long-term contracts is needed are also considered. Furthermore, it approaches risk estimation by professionals including consultation of quantity and quality of the risks and their appropriate measures, and determination of insurable risks. Also, in terms of safety, it envisions prevention as a high priority, plus awareness creation and measures to be taken. Finally, in environmental terms it seeks for sustainability by reducing the impact of environmental hazards.

Financial
The risk category of finance focuses on financing and liquidity, credit, interest rate and foreign currency. These elements refer to the way in which the company finances its projects and which targets it wants to achieve, being careful with the movement of external finance. It additionally takes into account trade debtors and risks mitigation by credit insurance.

Compliance
This category treats risks directed towards compliance of laws and regulations, and tax risks. The laws and regulations are supervised through the monitoring of compliance with laws and regulations inside the companies through regular reports on risk and compliance. Also laws and regulations and their changes are monitored. Furthermore whistleblower schemes are monitored. Finally, the 'In Control' statement is signed by board members of TBI companies and it is issued to TBI.

By being prepared to tackle and mitigate the aforementioned risks TBI looks to build and maintain market position and a solid profile, develop a sustainable business and seek for integrity. Furthermore, the development of projects is focused on trust and respect, collaborating with and the fulfilling of clients' needs. As for the market for this project: the approach will be towards the utilities market which is the nature of the company that is being studied.

4.1.2 Commercial and industrial building market
The utilities market has had a tendency of late to outperform in the market cycle combined with a low demand for new buildings with non-residential characteristics. Furthermore, it has had to move forward with changes in its needs and demands. These changes can be seen in the shifting of managerial responsibility from client to builder, a demand for more sustainable and flexible buildings that can evolve in terms of functionality and therefore a request for maintenance and change of purpose. Also, the changes in needs and demands are seen in a higher demand for multidisciplinary cooperation and lately in a shift towards new forms of contracts, namely contracts that include design, building and maintenance. These contracts are concluded with clients from the government, semi-public sector, education, health, hotel branch, professional services and institutional investors, and they include activities like turnkey concepts, new buildings, renovation and transformation, maintenance and restoration. Furthermore, the new requirements have led to the adoption of processes such

as lean management and systems engineering supported by tools such as BIM (TBI Holdings B.V., 2017).

To address the previous demands TBI offers to clients its competence regarding total cost of ownership, acquaintance with the different contracts, multidisciplinary work, capacities and skills owned by employees and innovation based on knowledge centers among others (TBI Holdings B.V., 2017).

4.1.3 JP van Eesteren

To address the different requirements that arise JPvE, the company working in the development of utility markets as a TBI company, has invested in people, processes, and systems and expresses awareness regarding the need for innovation and change (TBI Holdings B.V., 2017).

In JPvE core values are set in order to accomplish goals of growth, good employment practices and corporate responsibility. These main values focus on clients, workforce and social responsibility. In order to accomplish the goals JPvE follows a path in which the ability of the workforce can be linked with technical skills in order to achieve better performance through operational management and widening scope for innovation. Additionally, they have a collaborative and frank communication and way of working with multidisciplinary teams with TBI parties and with parties outside of the holding (J.P. van Eesteren, 2017).

Finally, the company is supported by its expertise which allows it to offer new ideas concerning the raising of quality, speeding up building processes and reduction of costs. In order to accomplish the goals, a good coordination is required, this can be seen in the company's organization chart in Appendix A. Additionally, a definition of processes is necessary that set guidelines for the operation. For this case, the health, safety, environment, and quality (HSEQ) plan will be discussed, which is mandatory whenever a project lasts longer than 30 days and is executed with more than 20 employees. Furthermore, it should be done to assess how risky the project is and if the client asks for it.

4.1.3.1 HSEQ plan

The process to be followed is described in the HSEQ plan. The process establishes that this plan starts with the risk inventory and evaluation, and the gathering of adequate documentation regarding the risks. Based on this information, the HSEQ plan is compiled and revised by the project company manager or project manager and by the health safety, and environment (HSE) coordinator. Once the HSEQ plan is finalized, it is presented to the client for approval and to include it in the building report. After the plan's validation and signature, it is distributed among the stakeholders. Additionally, it is presented to be established and followed in the phase of execution. After the execution an HSE dossier is created based on the results and the work inspection plan.

Within this process, several check-ups and criteria are established by standards regarding project management execution, insurable risks and liability risks and safety of employees and subcontractors. These criteria and check-ups in terms of project management are defined by standard layout on how to save files, archiving, inspection plans, execution inspection, purchase requests, content of the HSE dossier, project specifications, drawings, contract

schedules and legal requirements. The insurable risks are defined by risk overview and the risk inventory and evaluation. Finally, safety of employees and subcontractors is defined by environment awareness created in the HSEQ plan.

4.1.3.2 Investment in Systems

To adapt to a changing environment and to accomplish the different proposed goals JPvE has invested in systems as established in subchapter 4.1.3. Here the enterprise business agreement (EBA) between Autodesk and TBI will be discussed, further referring to the specific implementation of BIM 360 in JPvE.

The EBA was proposed based on reasoning and needs in line with TBI's requirements. It was based on the need to maximize information sharing. This need arose due to the transformation taking place in the AEC field that includes higher clients' demands and government policies (improve efficiency, reduction of risk and increase sustainability). In order to help coordinate TBI's high aspirations and goals regarding BIM the EBA was entered into to facilitate the adoption of Autodesk products based on a token flex model. The formulated initiatives for this adoption were the transformation of business through BIM and field management and logistic optimization. Additionally, the implementation of the EBA was proposed with a communication governance. This governance consists of EBA meetings, visual strategy workshops, awareness meetings, product release reviews, support meetings, goal setting, reporting and KM. This last component, KM, referred to the development of a strategy for management of data and information in order to identify, capture and disseminate best practices, lessons learned and guidance on the use of Autodesk products.

The EBA consists of a support team, customer engagement plan, enterprise priority support plan, KM plan that embraces a communication and awareness program, and a production assurance program plan. Within the production assurance program plan a service confirmation order (SCO) can be found, described as a detailed plan developed to reach goals, set a schedule and proposed plan of works. Below the SCO determined for the roll-out of BIM 360 will be described.

4.1.3.3 Service Confirmation Order

The SCO referred to, contains the request to implement BIM 360 in seven companies of the holding and the system configuration and personnel training. The scope of this SCO included the following tasks: Project Approach and Standard Workshops, considers giving background and discuss with the attendees workflows and the standards that must be defined. It proposed to define the enterprise deployment approach, the team roles and their responsibilities. This includes development of standards, and setup per company defined per specialty, namely housing or utilities. Furthermore, it looked to develop standards for cross-project level, together with the use of reports and dashboards. The following task was management training, it sought to train BIM managers and regional BIM coordinators with standard setup and BIM 360 configuration.

Afterwards, the implementation of BIM 360 was considered in several steps. First, a project kick-off meeting was planned in which the components of the implementation could be explained, it looked at product overview, specific configuration and, requirements from the implementation team. Additionally, the definition of success criteria and key performance

indicators (KPI) was considered, and delivery timescales and detailed site training. Subsequently, a BIM 360 project setup and consulting was planned throughout collaborative work between Autodesk and TBI to ensure the correct implementation of the configuration defined in the kickoff meeting. Followed by the end user training or as defined in the SCO *"Onsite go live"*. Finally, the post implementation support carried out through monitoring and progress check was identified. Similar implementation processes were proposed for BIM 360 Glue, Autodesk point layout and BIM 360 layout implementation, based on the definitions from the kick-off meeting.

In order to revise outcomes after the deployment, the next task is to review and document initial results with the implementation managers to gather successes and challenges and improve the defined standards. Finally, setup and lead calls with implementation managers are planned in order to support the process. The aforementioned process of implementation is illustrated in Figure 17.

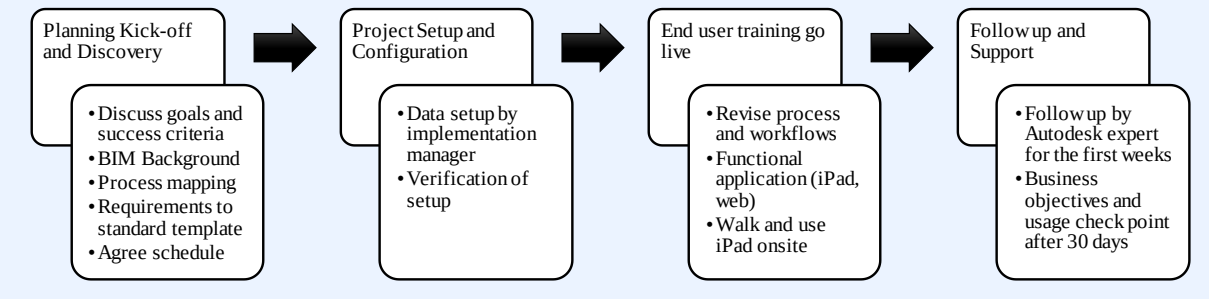

Figure 17. BIM 360 implementation map. Adapted from Kick-off Presentation

Based on the SCO, a kick-off meeting was held in which standard operation procedures and best practices were defined in terms of safety checklists, quality checks, model integration, model preparation workflow, tasks, photos and reports and KPIs. Within these definitions the definition of two main goals were found. The first goal was to improve projects performance which focuses on saving time and working more efficiently, improving quality and reduction of rework, production of complete documentation of quality and safety checks, and handing over complete construction information to the maintenance phase. The second goal was improving cross company integration, this goal looks to standardize communication and ways of working, improving future performance by increasing the ability to collect and analyze quality, commissioning and safety data, ease the adoption of BIM 360 in new projects, and acknowledge and communicate best practices and success factors. To revise these goals the proposal was made to conduct surveys after the deployment to measure improvements and document successes and challenges that could be presented internally to show the positive results of the implementation. The proposed surveys expected to measure time spent on non-value adding activities, rework, open constructability, issues at the start of construction among other KPIs.

After defining the main goals it was determined that a standard template and standard checklists were going to be used for the standardization of projects with the same functionality, such as utilities. Furthermore that they will be gathered in a master library for its use within this standardization, the development of the checklists that should be uploaded to the master library was planned. Furthermore, the HSEQ department was going to be asked to revise and approve processes for quality checks and content for safety checks, as well as

the agreement on the categorization of issue types. To go more in-depth regarding the definition of safety checklists and quality checks it was determined that the HSEQ department would take the lead on developing safety checklists, and check with implementation managers the standard formatting and structure. Additionally, it was determined that quality checks would be developed by the commissioning manager, site manager and lead engineer involved in architecture and engineering. These quality checklists were expected to be approved by project managers for each discipline in the project that is studied in this research project.

Following with the modelling standards, this definition was intended for projects that needed to track model objects during the construction and handover, and referred to the creation of tracking workflows indicating the protocol to be followed to standardize the process. The mentioned workflows can be followed to outline model management and multidisciplinary preconstruction coordination, issue tracking, quality inspections, equipment commissioning and handover to maintenance and/or operations, document and drawings management in the field, safety, tasks and reporting. Finally, a standard procedure was established to implement BIM 360 as well as the set-up of the projects.

The standard implementation process defined the following steps: creation of new projects from the standard template and checklist by the implementation manager. Afterwards, BIM 360 is introduced in a kick-off meeting with the project team, reviewing the goals, scope and functionalities, and checklists. Next, the template project will be configured according to specific project's requirements including drawings, model, authorized members, etc. Subsequently, training the team regarding the required functions of BIM 360 was considered. Moreover and as already mentioned, control of KPIs after 30, 60 and 90 days was scheduled to assure that the goals were achieved. Additionally, the parties that would be involved and take part in the BIM 360 implementation were also defined. These parties were TBI and subcontractors, the latter would preferably be trained in web format. The possibility to have more stakeholders join was left open, to be defined if needed. In terms of reports and KPIs it was determined that the scheduling of reports should be done per project regarding health and safety, and quality coverage including conformance rate. Moreover, updating these reports and checklists had to be supported by the information and conclusions that could be retrieved from BIM 360 usage. Lastly, IT resources should be confirmed 2 months in advance of the deployment of the BIM 360 project implementation.

For further definitions, the emails and communication between the different parties of the implementation team from Autodesk and TBI were followed. From those documents the following information was retrieved. The requirements in terms of human resources were established. A suitable implementation manager was described as a person experienced in the field and familiar with the company's methodology, plus with technological innovation experience. Additionally, an enthusiast person that could handle task organization and execution. In terms of time a person was expected to be available for 2 years and with an availability of half time. Regarding time issues, the time for the implementation in the project being studied 5 days were decided allocated like this: one day to determine the process, two days of setup, one day of training, and two half days of support. Also the digital resources were identified, the requests in these terms are the availability of iPads, wireless internet and installation of BIM 360™ Field and Glue on all laptops at least 30 days before going live.

4.1.4 Conclusions

For the successful characterization of the implementation strategy it was necessary to describe the different elements defining the process. The company has well-defined processes that describe the responsible department and expected outcomes. Additionally it was seen the existence of CoP in a project level. Nevertheless, in these processes and the revised documentation KM is not present, at least not explicitly. Even though the creation of dossiers based on results and work inspection plans are established, its application is explained as a follow up process, but not as part of the learning process characteristic of KM in which how to reuse gathered information is defined. Also it was noticed that the risk overview periodically assessed the incidents that took place and the surpassed risks. However, the inclusion of BIM 360 or documentation and reuse of issues in this process was not found. From this first conclusion the question is raised on the implementation of BIM 360 as a tool to support a process that was not found to be clearly defined.

The information retrieved from the governance of the EBA and other documentation was found useful for defining the logic model that will be expressed as an implementation strategy of the cloud-based tool. In the following chapter the information will be gathered and organized to build a strategy according to the aforementioned proposed plans.

4.2 Logic model - Definition of the Implementation Strategy

Strategy is defined as *"a general plan or set of plans intended to achieve something, especially over a long period"* (Collins Dictionary, 2017), and implement is defined as *"to carry out; put into action; perform"* (Collins Dictionary, 2017). Combining these two definitions, it can be said that an implementation strategy is the development and carrying out of a plan with the aim of achieving a specific goal in the long run. For the development of this research project an implementation strategy is created to reproduce and illustrate the implementation of BIM 360 at one of TBI's construction companies. The different theories that were used to develop the following strategy were enabled by the preconditions set before. These preconditions are: the framework of implementation strategy in subchapter 3.5, how to manage change, found in subchapter 3.6, the regulation in the Netherlands, described in subchapter 3.8.2, and the explanation built, in subchapter 4.1.

The understanding of the framework explained by Okumus (2003) and described in subchapter 3.5 and illustrated in Figure 13 in the same subchapter were taken as a basis to develop Table 2 with which the strategy to carry out the implementation of BIM 360 is defined. As explained before the framework consists of the following four category elements: strategic content, strategic context, operational process and outcome. Nevertheless, for the sake of clarity in this project, the defined strategic schema was defined with five categories because the strategic context was explicitly divided into external and internal context. The defined strategic schema can be found in Appendix F and its definition will be explained and illustrated below per category.

Table 2. Implementation Strategy - Framework

IMPLEMENTATION STRATEGY						
EXTERNAL CONTEXT						
Business Environment	**INTERNAL CONTEXT**					
	- Structure - Culture - Leadership	**IMPLEMENTATION STARTEGY CONTENT**			**Outcome**	
		- Why? - Aim - How? - Objectives - Management Participation - Impact on ongoing and future projects	**OPERATIONAL PROCESS**			
			- Planning	- Implementation process (Activities, Plan validation by management, establish pilot projects, plan feedback sessions, assessment of acceptance	Comparison	Planning vs Execution
					Conclusions	Where the objectives achieved?
			- Resource Allocation	- General (Time financial, Means of communication, available skills) - People (Time, training, Incentives) - Communication (Message - clear idea about what wanted to be communicated) - Control and feedback (Assessment of the process)	Satisfaction	Were involved parties satisfied?
					Lessons learned	Lessons learned from the implementation process
			- Control and Feedback	- Assessment of the process		

To fill in Table 2 and bring together the implementation strategy two steps were pursued as reflected in the different schemas per category. The first step shows a broad definition of elements that was defined based on the information retrieved from general documentation such as TBI Holdings B.V. (2017) annual report and the general knowledge regarding the adoption of the EBA and the implementation of BIM 360. The final step was based on an in-depth search carried out to define the specific elements. This search was executed throughout the thorough analysis of the aforementioned communications, documents, contracts, and processes among others. In the presented schemas it is evidenced the followed process.

External context

In the development of this strategy, the author understood external context as the variable components and conditions that constitute an environment under which a business setting is coordinated. The organizations that are part of this business setting are affected by the variable components and conditions, and cannot control them. Based on this understanding, the revision of documentation sought for elements that could not be controlled by TBI but affected TBI.

The general business setting for this case was defined as architecture, engineering and construction since is the environment in which TBI develops. In the first step, according to the studied documentation three out of the four risk categories established in the governance in TBI were found to belong to the presented understanding of external context. These categories are: strategic market, compliance, and finance. The strategic market contains changes in market conditions, scarcity in labor market for specialists, increased competition, and pressure on prices. Compliance contains law and regulations, and task risk. Finally, the financial aspect contains finances and liquidity, credit, interest rates, and foreign currency. As it can be recognized, none of the aforementioned categories or components can be controlled by an organization, but the change of all of them can severely affect organizations, which characterize them as components of the external context.

To further analyze these aspects and to narrow the risks strategies to the elements found to motivate this implementation, there were established two external factors in the business environment. The first factor was strategic market, which was defined by two elements. The first element, changes in market conditions, is the changes in the type of contracting as showed in subchapter 4.1.1 . Lately, contracts have been changing towards an integrated form, Design-Built-Maintain (DBM), which demands changes in process and customs in organizations. Additionally, clients have higher demands. The second element is an increase

in competition due to an increase in the adoption of BIM as expressed in the initial EBA presentation.

The second factor is compliance with law and regulations, described in the governance of the contract as changes in the public procurement directive from the European Union. Furthermore, for further analysis and recommendations this factor of compliance is extended in this project to include Dutch law, which aims to enforce the proposed law Wkb presented in subchapter 3.8.2. These factors and elements are related with the theory described to explain the context of this case study in subchapters 4.1. Furthermore, below in Figure 18 the process in which the external context of the implementation strategy was defined is given.

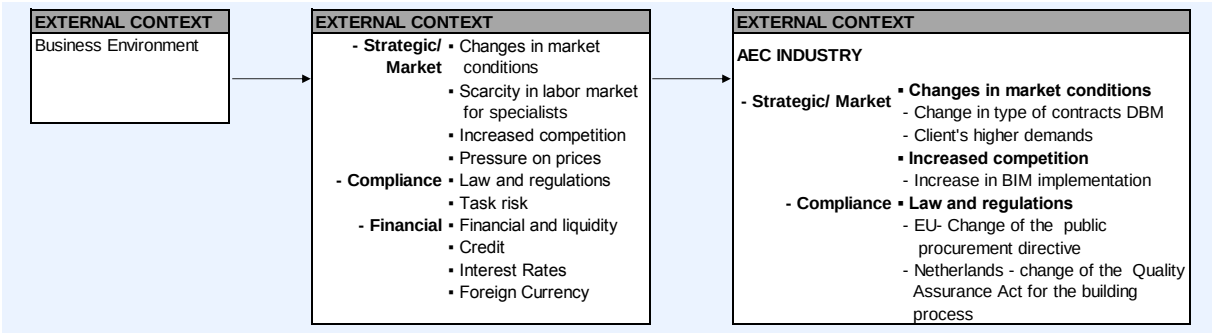

Figure 18. Definition of external context. First Category of the implementation strategy - Appendix E

Internal context

In words of the author of this project, the internal context is the way in which an organization is structured aiming to reach proposed objectives, including explicit and implicit structures, culture, and leadership. The explicit elements were studied through the documentation where was looked for organizational configuration, culture and established processes. In this evaluation it was found that the organizational structure is defined by TBI's standards, which apply directly to the companies of the holding. Furthermore, the organizational structure and leadership are defined by organigrams established in every company.

In terms of organizational culture, the study was carried out inside JPvE because even though TBI as a holding has subsidiaries, every company has the freedom to develop autonomously which makes every company different. The spoken and unspoken culture at JPvE was explored including project management, defined standards and working methods, risks and liabilities, safety of employees and environment awareness. For the spoken culture certain procedures were found to be defined in the company as explained in subchapter 4.1.3, such as archiving standard layouts, inspection plans, safety, health, environment and quality plan, and project specifications. Additionally, the implicit structure and culture were defined by the same parties involved coming mainly from within the industry as conservative and old fashioned.

The extensive information regarding the internal context and definitions can be found in subchapter 4.1. Figure 19 shows the internal context and its definition within the table of the implementation strategy.

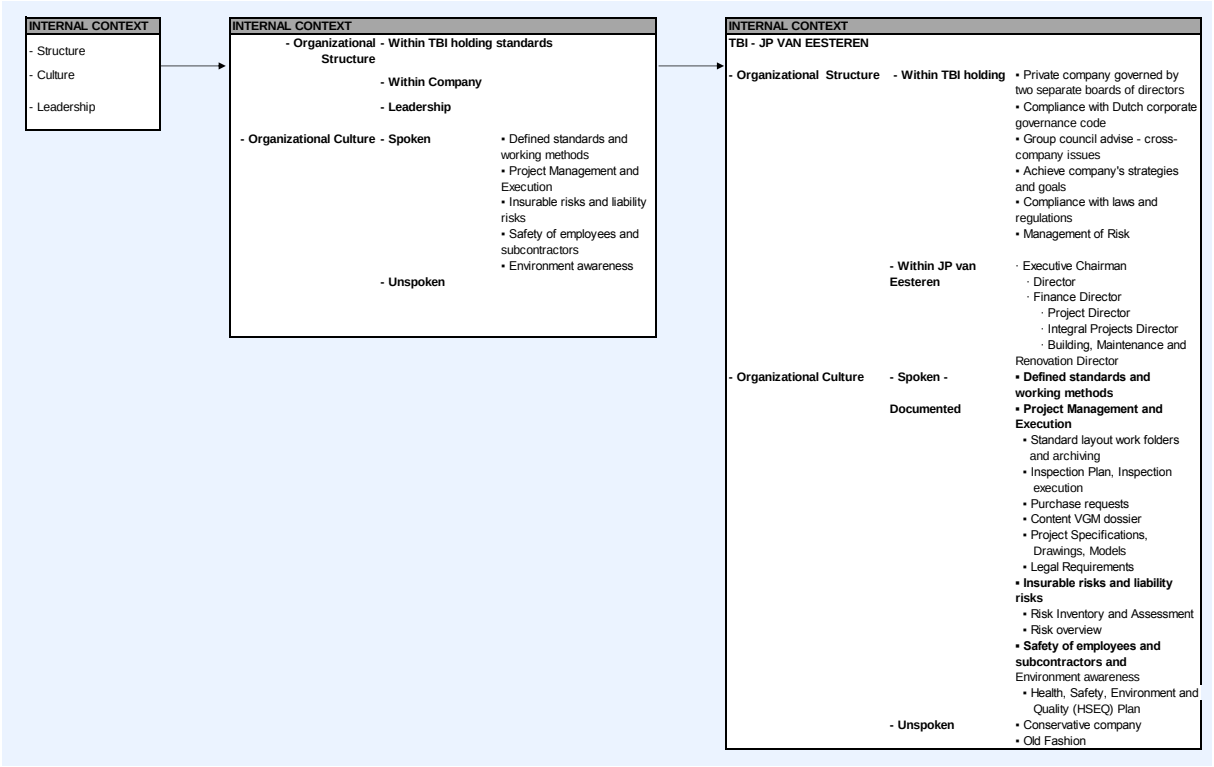

Figure 19. Definition of internal context. Second category of the implementation strategy - Appendix E

Strategic content

Based on what was established in the implementation strategy framework in subchapter 3.5, in this project the strategic content is understand as the definition of the implementation strategy, which explains why the implementation is needed and how it is going to help solving the needs. In other words, which needs the implementation is trying to fulfil and how it is going to fulfil them. To complement this definition it is also considered the managerial involvement and support, and the necessity of evaluating the impact that the implementation can have on the different activities and projects.

When revising the documentation, the different components of this category were found in the framework proposed and the governance established in the contract shown in subchapter 4.1.3. The assessed documentation presented the fundamental needs of TBI and how the systems contained in the EBA could align to fulfil them. The fundamental needs were determined based on workshops, interviews, and assessments of the ongoing situations carried out by Autodesk and TBI at the time. First, the requirement for which the enterprise business agreement (EBA) was engaged was identified to be the need to transform the business through the adoption and implementation of BIM and the need to widen the scope of contracts to fulfil demanding requirements. To extend this need it was also established that what the components of the EBA offered could serve as a mean of maximization of information sharing. It can be inferred based on defined needs that the adoption of the EBA attempts to fulfill the changes in market conditions exposed in the external context. Without ignoring the compliance with law and regulations that come implicit in management processes. Finally, to establish the EBA a communication governance was proposed, containing different elements as described in subchapter 4.1.3.3.

Moreover, it was found the need established specifically for BIM 360, tool contained in the EBA. The need was established as the necessity to improve and enhance collaboration inside projects and between office and construction site. Additionally, a need for management and logistic optimization on the construction site was found. The second part was determined by long-term objectives within TBI. The general objective for the holding was the improvement in cross cultural integration. Furthermore, within JPvE the objectives of performance improvement and improvement in future projects were defined, once more the content of these objectives can be found in subchapter 4.1.3.3. Moreover, in the revised information managerial involvement was not found. Finally, the assessment carried out in terms of projects showed that the definition of these projects was focused on the handover of one finishing project and the urgency to start in the new projects. Figure 20 shows the definition of this category.

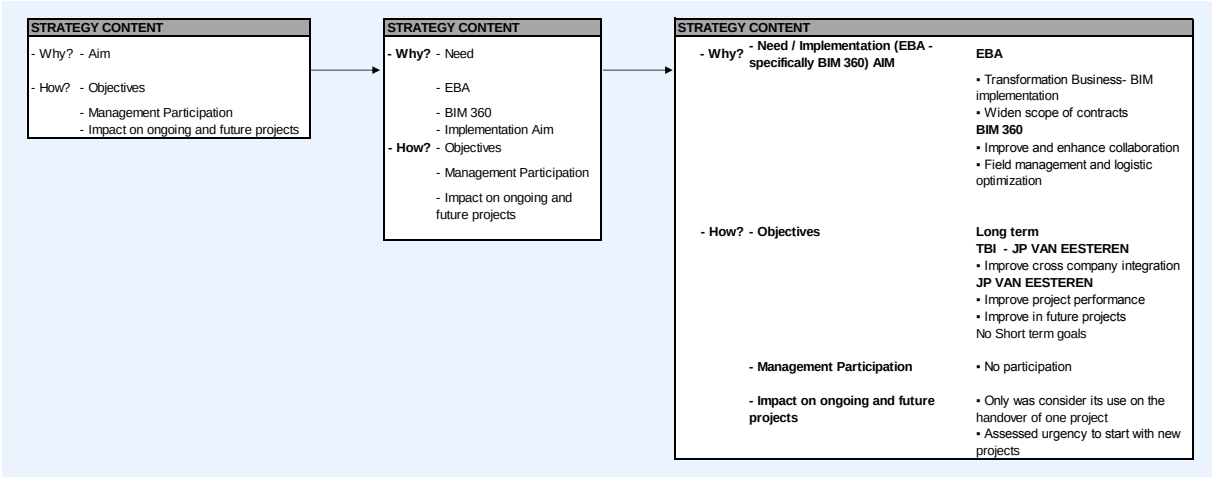

Figure 20. Definition of strategic content. Third category of the implementation strategy - Appendix E

Operational Process

The operational process was conceptualized as the procedure that outlines the roll-out of an implementation. The operational process is characterized by the preparation, and planning of activities and resources. Furthermore, the preparation and planning includes communication, which combines the establishment of a clear message and the means through which it should be delivered. Moreover, when preparing and planning the process possible obstacles are considered in order to avoid them; including a feedback mechanism to enable the evaluation of the progress of the implementation through a comparison between planning and execution. Subsequently, the plan should be validated by different management levels. Finally, having the plan ready, the pilot projects in which the implementation will be rolled-out have to be determined.

In the assessment of documentation, the information found in the contract's governance, SCO, and communications was considered to be the operational process because it described the proposed planning to roll-out BIM 360. Therefore, based on the aforementioned elements, the operational process was characterized and presented according to the setup described in subchapter 4.1.3.3. Figure 21 shows the different definitions that were made rendering the governance guidelines.

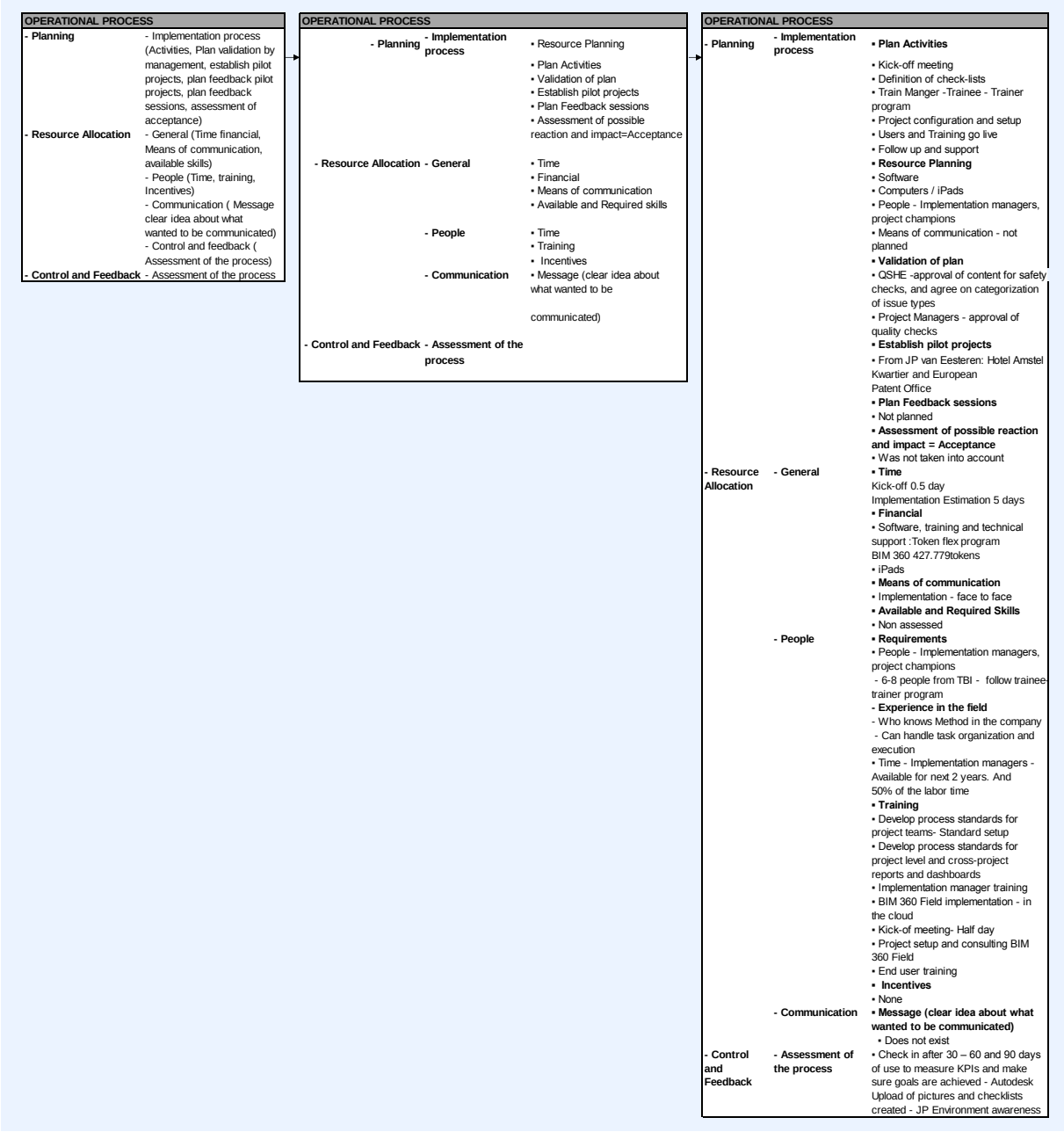

Figure 21. Definition of operational process. Fourth category of the implementation strategy - Appendix E

As can be seen in the strategy (Figure 21), a sequence of activities were found to be planned (Kick-off meeting, definition of check-lists, trainee-trainer program, project configuration and set up, users training and follow up and support). Additionally, the needed resources such as software, iPads, and implementation managers (project champions) were defined, as well as the validation of checklists and parameters by HSEQ and other departments. Then two pilot projects were chosen: Hotel Amstel Kwartier, that needed support with the handover and the European Patent Office which needed implementation for its complete execution.

Next the general resource allocation and people allocation were discovered. The general allocation described the time that the kick-off meeting and the implementation was going to take, the financial implications based on a token flex program contemplated in the EBA and the investment needed for the iPads. The allocation of people defined the number of implementation managers that were planned to be involved and the time they should invest,

additional to the skills and knowledge they should have. Finally, the training for the implementation managers to develop process standards for project teams and for the project level, including cross-project reports and dashboards, was described, including the setup of the aforementioned processes. Furthermore, the end user training was designed. Lastly, the feedback and control were proposed as control sessions after 30, 60 and 90 days to measure the KPIs.

Nevertheless, it was not found the definition of all the elements established in the ISF. The elements that were not found in the documentation that outline this operational process are feedback sessions, assessment of reaction and impact on the organizational culture, assessment of existent and needed skills in employees, and incentives. Furthermore, in the documentation the only evidence of communication was the kick-off meetings, but not a real plan including a clear message and means of communication.

Outcome

According to what was learned from the ISF, the outcomes are derived after the deployment of the implementation. The outcomes come from assessing whether what was planned was followed. The assessment focuses on the compliance of the rolled-out process compared to the established implementation strategy. Additionally, the assessment looks whether the proposed objectives were achieved. Table 3 describes the parameters with which the results are assessed.

Table 3. Definition of outcome. Fifth category of the implementation strategy - Appendix E

Outcome	
Comparison	Planning vs Execution
Conclusions	Where the objectives achieved?
Satisfaction	Were involved parties satisfied?
Lessons learned	Lessons learned from the implementation process

For this research project, this last part is going to be developed with the analysis of the interviews and observation session. They will give evidence of the experiences during the implementation and will identify if the execution went according to plan, the satisfaction of the parties and the compliance of objectives. The results from the analysis of the interviews and the observation session will be compared with the implementation strategy developed and described in this chapter searching for matches and mismatches between proposed and rolled-out process. Additionally, the elements that were not planned from the beginning and that should have been considered in order to fully assess the whole process will be taken into account.

4.2.1 Validation

The resulting strategy, as was mentioned, was based on the study of the documentation and the internal information of the company. Nevertheless, since it was built based on the understanding and interpretation of the researcher it was important to validate it with the intention of proving its veracity. To do this, a meeting was held with the person considered as the main driving force of this implementation. The draft of the implementation strategy

diagram with its respective explanation was presented to him to which he added and clarified the information and finally agreed with its validity.

4.3 Data collection

The data collection will be based on qualitative methods as defined in subchapter 2.2.2. Once the background of the case was established and the implementation strategy was developed through literature review, and acquisition of better insight from the company and the rolled-out implementation, the process of data collection was organized and carry out. To be able to study this case, and in order to define the identified objectives, the real-life process carried out during the implementation of BIM 360 and how the tool is being used, the chosen methods for data collection were interviews and direct observation as justified in subchapter 2.2.2. Additionally, informal inside meetings to understand and get a better overview of TBI were carried out.

The selection of the participants for the interviews and for the observation session was based on the participant's involvement during the development of the implementation process. As stated in subchapter 2.2.2 there are three parties considered: the cloud-based tool provider, the team of implementation inside JPvE and the users, correspondingly recognized as TP, TT and TC. The participants considered were suggested by a member of TBI Kennislab who has the knowledge about the people that have been involved in the implementation process.

During the selection of TP and TT participants from the suggested options, it was found that the process was not carried out by the same people, but that it had some changes and people walked outside and new people walked inside. Therefore, there are four interviews carried out, the first set of 2 interviews were done to the initial participants in the implementation process from TT and TC, and the second set were carried out with the participants that followed the initial implementation, and that currently are working with the further implementation and deployment of BIM 360. On the other hand the observation session was conducted with the accessible and available participant. The selection of the participants of the additional meetings came with the development of the process to complement it and as a research of the implementation of BIM 360 in other of the subsidiary companies of TBI.

4.3.1 Interviews

The determined interview type was semi-structured based on its characteristics of giving guidance without losing flexibility as stated in subchapter 2.2.2. The development of the interviews was held in one round with each selected participant. The guideline used for the interviews and the interviews' transcriptions are found in Appendix B and Appendix C correspondingly. The names and other personal information of the interviews were left out due to anonymity purposes.

The round of interviews were held in at the working place of the interviewees. The interviews were taped and supported with notes taken parallel. After the interviews, the recordings and notes were transcribed within 24 hours to avoid losing the essence of the meetings. Even though for clarification some of the interviewees were approached there was not received an answer back, therefore the tapes were listened and studied again to make sure all the information was being considered.

The interviewees were asked about their background and position in the company, the aim of implementing BIM 360/BIM 360 Field, the type of information and knowledge that can be produced during the execution phase of construction projects and its use, the used methods and tools to collect the produced information and knowledge, the process of implementation and deployment of BIM 360, and future use development of the tools. These topics were determined based on the elements defined in the implementation strategy, and further sought information regarding knowledge, its documentation, and its use to review the process of KM and more specifically knowledge capture.

The analysis of the interviews was done taking into account Roulston's (2014) statement in which she expresses that *"although there is no right way to analyze interviews, researchers can forward qualitative research by doing informed thorough, and rigorous analysis situated in particular theoretical traditions."* Additionally, she states that in general de data collected from interviews can be analyzed applying the following three phases: data reduction, data reorganization, and data representation.

Data Reduction

The function of data reduction is to narrow down the gathered information in order to abstract the information of interest (Roulston, 2014). For this case, the data reduction will be based on the narrative influence, which points towards the edited representation of the story tell by the interviewees focusing on the main discussed concepts (Roulston, 2014).

The data reduction of this project was carried per interviewee. Based on the interview's guideline and the broad content of the interviews were defined recognized topics. The defined topics were BIM 360 aim, information produced, used methods and tools, implementation and deployment and others. Afterwards, the interviews were thoroughly analyzed and the main ideas per topic were summarized in order to obtain patterns and relevant information from every team. This information was organized in a summarized text retrieved from the gathered data, and as a result the ideas of every team member could be easily identified.

Data reorganization and Data representation

These phases can be merged, the process start with the reorganization and restructuring of data, categories, and stories among others. This process is carried out through an iterative process of reorganization in which the association of categories led to a revision of concepts and understanding of information contributing to the development of key concepts. Generally the interpretation of these ideas is organized and represented in diagrams and other schemas that helps identify the resulting outcomes (Roulston, 2014).

The data reorganization of this project was carried out per teams in the implementation process. Based on the thorough analysis and findings, three of the categories were broaden to understand better their content and to ease the comparison of results between the parties. These categories were: information produced, implementation and deployment and others. The category information produced was broaden into information produced, analytics, and future use of gathered information. To continue with the category of implementation and deployment, it was expanded to implementation and deployment, results, feedback and acceptance. Finally the category of others was punctually defined as future tools and improvements.

In regards with the data reorganization, the summarized main ideas of both interviews from TP were gathered and organized according to defined categories. The gathering of ideas was mainly done taking into account the relevant information from both parties that would contribute with the analysis of the developed implementation strategy. The same process was followed to reorganized TT interviews. The resulting information was organized in a table diagram divided in the different found topics and its results. The results of this analysis can be seen in Appendix E and following a summary will be presented

TP Summary Results

BIM 360 Adoption Aim

The implementation of BIM 360 was established after TBI entered into an EBA with Autodesk. The main goal of TBI was getting BIM on the construction site, in order to get better quality of work thanks to quality checks that could be done on site. JPvE wanted to standardize the use of their tools, because everybody had a different solution. Now BIM 360 is JPvE's standard. BIM 360 has a wide range of different applications and it was developed for coordination purposes. It is a cloud-based application used to connect the team members, the different parties with which the project is carried out, and also to connect site to office. Specifically, BIM 360 Field and BIM 360 Glue are the connection between office and site. BIM 360 Glue is a coordination tool used during the design process, it supports the preparation of the models for clash detection and collaboration in the cloud. BIM 360 Field is a site management tool with different features. It is used as an administration tool on an iPad, where all the checklists, all the drawings, and all the models that are required can be found.

Information Produced on site and its use

The main information that BIM 360 wants to gather are quality checklists and clash controls. The information that can be gathered on site with BIM 360 Field are: issue management (pictures, description, responsibilities, etc.), checklists (review based on quality and safety parameters), drawings and models (brought to site and will give the same data to everyone), commissioning and handover (information about entries giving insight on elements and their current state), and reporting (based on issue and information entries). The use, as well as the organization of this information, is determined by the needs of the company and the setup developed for BIM 360 Field. Therefore, a good organization is required and a definition of the information desired or required. At this moment the information that is being used is for the follow up of projects.

The information can be retrieved and delivered once a week or as often as it is necessary in order to analyze the gathered data. BIM 360 also works with dashboards, where project overviews on the issues that are created can be seen. If an analysis at a higher level is wanted dashboards can be customized. However, if something fails or something else is wanted the company should go back to the programmer to submit new requirements and/or have him fix the issues. The recommendation is to retrieve the information and manage it with power BI which has a general purpose and can support further analytics. Indirectly, the analytics will be done based on the defined setup because the information that is retrieved from BIM 360 is based on this, so if there is standardized/general setup the exported files could be merged to achieve better insight. However, a general setup for TBI can be generated only up to a certain

level. Finally, the analytics are not based on string analysis, this is why it is recommended to define the types and issues well.

For using information in future projects the dashboard can be found in the environment of the projects, where statistics can be found on how many issues are still open and how many have been closed, how long does it take subcontractors to close an issue, and similar. It is also possible to create a report on all the projects that have a link to the type of issue; this can help gain a broader insight of what is going on in the projects. With these reports a complete overview on different projects can be delivered, so it is possible to create a cross-project analysis. So, it can all be related to the business intelligence, if preferred. For a better development and use of the information, a complete standardization of the database has to take place. At this moment everyone is using it in a different way, so this will be the next step to take. Another topic is the current pushpin in a 2D location that can be push pinned in 3D.

Used methods and tools

Part of BIM 360, namely BIM 360 Glue, in charge of clash detection is used, and BIM 360 Field is used, in charge of the issues and quality, for instance checks. When using BIM 360 Field and producing issues and checklists, these can be related to the model or to objects in 2D drawings or objects in the data base. Once the use of BIM 360 Field is expanded to 3D models the different issues and checklists are related to BIM objects that need to be adjusted; this entry is supported by presenting drawings, comments and other issues related to that element or object. In order to define and use BIM 360 Field appropriately the definition and setup should be defined according to the company's requirements. The case of TBI is special due to the different disciplines of the various companies.

The implementation of 3D models and the support from the tools can be done in two ways. In the first one the model can be uploaded directly to BIM 360 Field, but this model will not have properties. If properties are required, there is an option to split the model and create sections. This mode uses BIM 360 Glue as a mediator between Revit and BIM 360 Field allowing the extraction of data. Nevertheless, from the information mentioned by the interviewee it seems that the models should be split because Revit cannot accept certain amounts of information and it also depends on the device it runs on. It is also common knowledge that an iPad has less capacity, so the easiest way to cope with this is by splitting the model. Therefore a well-implemented process in design will lead to a good design that will contribute with correct information, making it possible to use the models at a later stage.

Implementation and Deployment

The implementation is done through a trainee-trainer process where small groups are trained and they will become the trainers, to repeat this process and share what they learned with the rest of the projects. These trainees and future trainers stay in contact with the consultant to solve any pain points. At TBI the deployment was carried out with teams of approximately 7 members, with whom there are regular meetings (it is difficult to get them all together). In TBI it is difficult to generate a master setup due to the different specialties within the companies. The implementation on site is done to show the users how to approach the issues that exist in real-life and how to report them as issues.

At JPvE, in the project of interest for this research, the kick-off was held twice, once as a pilot project and afterward as an official implementation. After the kick-off meeting schedules were set, and the training was carried out with the team it continued in a similar vein. Almost every month talks were held with the implementation manager, when issues that couldn't be solved were raised. The implementation probably lasted three days, explaining how a checklist can be used, how to fill the checklist, how issues can be created, and how to do the commissioning. Afterward, different groups participated in a training, people who were going to use the iPad, and after that it was in the hands of the implementation manager.

The expected results of this implementation were to get BIM to the construction site and a high rate of adoption, the adoption being measured in terms of willingness and actual use and implementation by the site managers. This goal was achieved because after 3 months there were more than 200 iPads in the TBI companies. Additionally, the usage in terms of product adoption and usage have been measured and are positive.

In terms of feedback, when Cad & Company was responsible they tried to reply to feedback immediately and give help with follow-up steps. And at the beginning monthly meetings were scheduled with the person in charge from the Kennislab; however, we just had one meeting and afterwards the person in charge left and the communication stopped. The current state with Autodesk depends on the feedback and solutions, it depends on the content, usability, setup, and layout. Regarding content it is not that easily changeable but if it is about setup then the collection of data can be revised and it can be assessed what can be improved. And in terms of layout, there was a big problem with the language, which now has been solved. Furthermore, at the moment there is a program called insider program in which different organizations are collaborating with their feedback to improve the tools.

Others
The following updates of BIM 360 will require users to follow training, since the tool is being developed from scratch, taking into account feedback coming from the companies (insider programs). The suitability and communication with other types of software/programs is and will be based on Forge software that is supported by API (application programming interface) which defines ways of communication between different software allowing an easier development of programs. The use of Forge allows the use of functionalities of products without disrupting them, this open platform is suitable for tools such as Relatics, and Share Point among others.

TT Summary Results
BIM 360 Adoption Aim
The aim to adopt BIM 360 was to fulfil the need for quality checks. Its main objective was to collect the information by assigning issues to specific elements in the model which could be approached at a later moment. BIM 360 was seen as a quick win: it was the way to gather information from different sources in just one place. The drawings, documentation and others could be summarized by having just one document in BIM 360, which contained the required documentation, pictures and references to a specific element in the model. Additionally, BIM 360 was an easy solution to the issue of poor feedback to engineering. Since the communication is just in one direction, from engineering to construction, some information and feedback gets lost. Furthermore, the adoption of BIM 360 sought to make life of the

construction managers easier, ensure a good verification file of the execution, and to communicate better and easier. Finally, even though there are other application such as Snagit and ED controls, ultimately BIM 360 was chosen because it has the advantage of the BIM model.

Information Produced on site and its use

The information that can be produced consists of checklists for verification, issue-management during execution, photo management, and punch lists for the handover of the building. The checklists that are included in BIM 360 Field are based on system break down structure and work break down structure (developed in Excel and then in Relatics) to prove that things are being executed according the agreements, and quality and requirements are being complied with. Furthermore, information regarding project success can be documented.

The produced information can be gathered so it can be used in the creation of a verification file for the project, providing tracking to the municipality for permits, and providing information for maintenance and guarantees. Additionally, it can be used for project analysis and prevent issues in the future. If the tools were implemented in projects of the same type the gathered information could be used in future projects. It just needed the standardization of the forms, and if the standardization is done correctly the gathered data is always the same. Then an analysis and comparison between projects can easily be made to spot trends and things that always go wrong in order to improve them. This information and these lessons are very valuable to prevent failure in the future, leading to better contracts with suppliers and subcontractors because trends and the ability to work with a certain quality could be demonstrated for tenders. However, this information is not being used at the moment, because the company is in the starting phase of the implementation (first 2 years). Once information coming from various projects can be gathered it can be used in new projects. This information is expected to be used in the near future. First the time is needed to analyze information and good reporting from project managers and then from construction managers. BIM 360 is able to give a lot of information and a description is required on how exactly it works.

In terms of the reuse of knowledge: what is used and what is very common are information sessions in which a group of 5 people share their experiences, best practices, and lessons learned. These meetings are scheduled monthly by the site managers who assign distinct topics.

Used Methods and Tools

Currently the used methods are BIM, BIM 360, Relatics, and Chapoo. The information of the project-site is downloaded from the BIM 360 Field environment in PDF format and it is uploaded to Chapoo which is linked with Relatics. It cannot be analyzed there, because it is not fit for exchanging information, it is just PDF. Chapoo is just a document management program. For now, BIM software is being considered, in the near future it will be possible to get the model on the iPad. Then, linking the checklist with the BIM model will give a better scope of the project. It will be connected with BIM Glue using BIM software. BIM 360 is suitable, however, connecting BIM 360 with the BIM model has not been possible because it is too large and it is not usable on the iPad.

Regarding the gathering of issues: standard issues are not reliable, because every issue is different. When people are offered standard issues they are not alert and fill in exactly what happened. Therefore, in order to gather information, it is require to approach the structure of the issues. This is planned by creating a code for the System Breakdown Structure (SBS) and then assign issues to one of the codes. Those issues are connected to the drawings and the codes and in that way it is easy to identify an issue with an element.

Implementation and Deployment
It started with the TBI Kennislab, they had a business agreement with Autodesk, an enterprise agreement, and BIM 360 tools, BIM 360 Glue, and BIM 360 Field were included in their package. We can use BIM 360 Field to filter the knowledge from TBI's companies.

TBI Kennislab started to implement it in various projects as a pilot but it was not arranged on a company level. To adopt BIM 360, a construction work inspection plan (checklists) was developed according to the requirements that should be supervised, and this was included in the program. We started with two people that work on site; they received some training on how to use it and an iPad, and they responded positively. Then we got two people from installation that could implement it.

In general, when a project starts the implementation manager arranges the iPads, creates a project in the digital environment, sets up the project, and trains the project administrator and the project team. The setup is created according to the Project manager's and the construction manager's requirements and support. Additionally, the implementation manager acts as a service desk for the projects. The main goal is that project teams learn and find out themselves, with a decent kick start.

The explanation of the tool is given to the administrator and deals with what is the basis of the tool, what can the tool do, how the tool can be used. Once the administrators knows everything, then they go on site and they set up the new projects. So the users learn the basics and can experiment, they can learn it themselves, they need to be self-sufficient and learn with the use of the application. When they do not know or understand something they can ask the administrator and escalate until they reach the implementation manager. Thus, the implementation manager worked as the help desk. The application is practical and it is not very difficult to learn.

The expected result was first of all quality checks but the expectation was also that it would be easy to document issues going to site and whenever something wrong is noticed a photo can be taken and uploaded to BIM 360 Field, but that is not being used right now. So that is a point for improvement. Nevertheless, the results of the implementation so far are good because every project within the new large projects by JPvE is using BIM 360 Field, and maintenance as well.

Now the main result that is expected is the management of information. For the near future an evaluation is wanted, implementation in projects issue information, but that requires patience and the pressing of the right buttons. Furthermore, the monitoring of performance is not formally developed, it is carried out by talking to people, but that is not enough, and it must be developed. Additionally, feedback now is being done through word of mouth but not

documented; the goal is to plan evaluation sessions with projects so they can give feedback on the process of implementation, and on their requirements so the quality of the implementation can be increased. Also, another goal is to create a form to report with which will be included in the plan for the coming 2 years.

The feedback received from the parties involved in the pilot projects started by the Kennislab was plentiful and people have a lot of requests; these issues were communicated to Autodesk. Additionally, the feedback of the users is used to enhance the training of other users. The biggest issue communicated to Autodesk was regarding the use of 3D models because they were too big for Glue and this is why it did not match with the project that is being studied in this research project. The consultants of the implementation recommended splitting the model, but it has already been split in parts and it cannot be split any further. The idea is that the model will give a better insight of the project, or at least that is the goal, taking into account that the model is of a good type.

Some notes regarding the acceptance: this is a conservative company and it has defined standards and working methods, and everything new is not easily accepted. However once you know the precise people with whom to speak it is easier to present new concepts. It is important to attract these people to test the tool and show it to them and to let them discover the success of the application, then they will help with disseminating the tool. In general the users were satisfied with the wins that BIM 360 offers them.

Others
The new application will be simplified so it is not necessary to have plans for those updates. To manage that change, the old projects will continue to be executed in the old version and new projects in the new version. So for new versions the new workflow will be given and it starts all over again. The new app is easier. The implementation is not going to be hard and it is better than the old version.

To improve the use of the tool and make it available for everyone standardization is necessary, which could be completed with feedback on missing elements every time one is identified. The set of proposed questions should be more or less generic for the different projects. Yet the company has 1 setting per project, instead of an integral setting which can be used in different settings. Additionally, different ways of working were noticed between companies (specialties), thus misunderstandings occur. This should be part of the standardization for everything to work the way it should.

4.3.2 Observation Session

The second part of the data collection, namely the observation session, was carried out on site approaching TC in order to understand better the reality in which the cloud-based tools is being used, and the perception of the users regarding the implementation process.

The observation session took place on the construction site with one of the users. This session was held in two parts. The first part was held in the office on site where the user showed the use of BIM 360 in the browser and explained all the concepts of the check-lists, issues, drawings, pushpins and communication. Additionally, he explained the process that is carried out with the subcontractors and checks that they do. The second part was held by means of a

walk-around on site, where the use of the application on the iPad was shown and the process that is carried out through the documentation of some issues. Additional to the explanation on the use of the tool a conversation was held regarding the implementation of the tool, his experience with tools and his understanding about the aim of implementing the tool. The collection of data of this session was mainly gathered in the field. Immediately after the session was finished the notes and remarks were put down in writing. With the written information retrieved from the observation session the same process of data organization and representation was carried out. These outcomes can be seen in Appendix E; below a summary will be presented.

TC summary results

BIM 360 Adoption Aim

The main objective of adopting BIM 360 is the quality check using established checklists. Additionally, it improves communication, including connection between disciplines.

Information Produced on site and its use

The information that is produced on site is the quality controls through checklists and identification of issues. Afterwards, issues will be followed-up until they have been fixed and their status is changed to close. The issues can be documented from the checklists filled in by subcontractors and from information also gathered onsite during visits by the responsible person.

Used methods and tools

In this moment the method that is being used is the location on 2D maps through the pushpins. It cannot be linked to 3D model because of the capacity of the tool.

Implementation and Deployment

A comprehensive explanation of the tool and its functions was given for the implementation of the tool. BIM 360 was given for experimental purposes so it was not clear what the objective was or what was expected from the use of the tool. The results from using the tool are the documentation and follow up of issues, and faster communication with other parties. It makes submitting reports easier and faster, additionally other parties can immediately reply to the issues with a comment.

The perceived acceptance from the user was positive. Additionally the tool is being used according to the purpose that the user understood it to have.

Others

Furthermore, some comments were given. The process of uploading plans was described; sometimes if the notification for new plans is not timely the result is a lack of coordination and the plans are uploaded late. In terms of logistics the tool loads slowly and sometimes does not work correctly.

The results from the interviews and the observation session were gathered in a table containing the results showed above. These tables can be seen Appendix E.

4.3.3 Other meetings

The five meetings held outside the schedule of the interviews had three different reasons. Firstly, two meetings were held to better understand the process of implementation across TBI. These two meetings were held with the manager interested in improving performance and a better connection between office and site, and the implementation manager of BIM 360 in Comfort Partners, another subsidiary from TBI. This company was chosen since it is the process that is considered the most successful within the different subsidiaries that adopted BIM 360. Secondly, a meeting was held with the head of the EBA adoption and the main promoter of BIM 360's implementation in order to validate the proposed implementation strategy in subchapter 4.2. Finally, the third reason was to gather further information of the current process in terms of HSEQ and communication in JPvE. The responses during these meetings helped complete the overviews of the implementation process of BIM 360.

4.4 Results Analysis and Recommendations

The built implementation strategy (BIS) presented in subchapter 4.2 will be the basis for the following analysis and recommendations. A comparative analysis will be done between the BIS and the ISF described in subchapter 3.5, to assess whether the BIS contains all the elements described in the ISF, which will determine the BIS theoretical gaps. Additionally, the BIS will be compared with the outcomes discussed in subchapter 4.3, resulting from the rolled-out implementation (RI) and concluded from the interviews and the observation session, to evaluate if what was planned was also implemented.

The results were organized according to the elements defined in the ISF to be able to compare the theory and the practice, as can be seen in Appendix G. In the first comparison, the theoretical concepts from the ISF are studied vs. the identified concepts in the BIS; all the elements will be taken into account from external context until operational processes. In the second comparison the assessment will consider BIS vs. RI. Nevertheless, not all the elements will be assessed in the second comparison because two of the elements, internal and external context, are fixed for the complete implementation, because they are the basis to propose the implementation. The two elements that are studied are the understanding of the implementation content and the execution of the operational process.

In the previous explanation the evaluation of the implementation's outcomes is not mentioned because no evidence was found that it has been done, thus this analysis will serve as an evaluation of the outcomes. Additionally, further topics and remarks are taken into account for the analysis and recommendations. After the results were organized and compared, conclusions were drawn, and served as the starting point to put into words the recommendations presented in subchapters 4.4.3.1 and 4.4.3.2.

4.4.1 Results Analysis - Comparison

The comparison between theory and practice is based on the implementation framework, the implementation strategy built on documentation, and the perception of the real-life situation. The following analysis will be divided into two parts. The first part will consist of the assessment of the internal and external context. The second part will contain the evaluation of the implementation content and the operational process from which the evaluation of outcomes will be developed.

Internal and External context

The internal and external context are the background or independent components and the internal settings that affect an organization. In this case, it was found within the BIS that both are taken into account.

AEC was determined as external field because TBI and therefore JPvE are developing in this field. Furthermore, the considered elements were based on the risks that are taken into account according to the governance of the organization. In the internal context the organizational structure and culture are also defined. The assessment of the completeness of the external and internal context was based on Table 4 that is part of the BIS defined in subchapter 4.2.

Table 4. Assessment of complete definition of external and internal context

EXTERNAL CONTEXT				
AEC INDUSTRY		**INTERNAL CONTEXT**		
		TBI - JP VAN EESTEREN		
- Strategic/ Market	**▪ Changes in market conditions** - Change in type of contracts DBM - Client's higher demands **▪ Increased competition** - Increase in BIM implementation	**- Organizational Structure**	**- Within TBI holding**	▪ Private company governed by two separate boards of directors ▪ Compliance with Dutch corporate governance code ▪ Group council advise - cross-company issues ▪ Achieve company's strategies and goals ▪ Compliance with laws and regulations ▪ Management of Risk
			- Within JP van Eesteren	· Executive Chairman · Director · Finance Director · Project Director · Integral Projects Director · Building, Maintenance and Renovation Director
- Compliance	**▪ Law and regulations** - EU- Change of the public procurement directive - Netherlands - change of the Quality Assurance Act for the building process	**- Organizational Culture**	**- Spoken - Documented**	**▪ Defined standards and working methods** **▪ Project Management and Execution** ▪ Standard layout work folders and archiving ▪ Inspection Plan, Inspection execution ▪ Purchase requests ▪ Content VGM dossier ▪ Project Specifications, Drawings, Models ▪ Legal Requirements **▪ Insurable risks and liability risks** ▪ Risk Inventory and Assessment ▪ Risk overview **▪ Safety of employees and subcontractors and** Environment awareness ▪ Health, Safety, Environment and Quality (HSEQ) Plan
			- Unspoken	▪ Conservative company ▪ Old Fashion

Nevertheless, it is important to understand how the company responds to the external context based on its internal context. In terms of type of contract and client's demands the company was found to be client-driven. This characteristic is approached by changing processes in projects to comply with clients' requirements. However, if these changes are successful and in line with the company's development, they should be adopted and standardized in the company, to homogenize the internal processes to comply with the requirements of different clients and to avoid having to adapt specifically per client. Furthermore, changing processes without realizing that new working procedures can work better is losing a competitive advantage in terms of process improvement and innovation. This shortcoming results in waste of time and waste of learning. This is another evidence of the lack of KM and KM awareness in the company.

In terms of adaption to new regulations and changes there is a legal department which is responsible for determining the impact of changes and presenting those changes and impacts

to the project managers, who will adopt the adequate measures. Even though these elements are proposed as motivation to implement BIM 360, it is important to emphasize the fact that they should in general be considered for the development of the business.

Implementation Content and Operational Process

The assessment of the implementation content and the operational process will be done separately. First the implementation content is studied and subsequently the operational process is evaluated.

The assessment of the **implementation content** started with the comparison between BIS and ISF. In this comparison no evidence of managerial participation and involvement was found. Also, no assessment of the impact of the implementation of BIM 360 on ongoing and future project was found. The only reference found regarding ongoing projects was the initiative of using BIM 360 in a closing project, which needed handover; and the reference regarding future projects pointed out new projects and their urgency to start. Finally, the goals found all referred to long-term goals and short-term goals were not found.

The aforementioned shortcomings were validated by the head of the implementation in that moment. Also some of this problems were characterized by him throughout the description of a bottom-up implementation in which the expected managerial interest and support was not received. The situation described before, led to an adoption dependent on the willingness of every company to adopt BIM 360 instead of a standardized adoption, which inside JPvE translated into the same. Better said the adoption of BIM 360 in every project at JPvE also depended on the interest of the project manager. This independent adoption of BIM 360 also resulted in a lack of short term goals because unlike long term goals that were formulated within a general perspective, short term goals needed to be aligned with the specific practices of each company. To wrap up, this way of implementation can partially explain the quality and quantity of information found and studied at the beginning of this project. As the adoption of BIM 360 depends on the project managers, its implementation has varied in extent across different projects, which has led to produced information that faces issues in fulfilling the quality expectations.

To continue the assessment of the **implementation content**, the comparison between the BIS and RI focused on the understanding of the objectives of the implementation of BIM 360 by the different participants (TP,TC, and TT). The definition of the established objectives in the BIS and their corresponding characteristics were used as a basis for the assessment. These characteristics were previously explained in subchapter 4.1.3.3 and will be summarized below. The characteristics that outlined the first goal, **improvement in project performance**, were improvement of working times, efficiency, quality, documentation of processes, and handover. The characteristics that outlined the second goal, **improvement in cross company integration**, were standardization of ways of working, reuse of gathered information about quality, commissioning and safety, sharing of best practices, and facilitate future implementation.

The comparison between the aforementioned characteristics that outlined the established objectives and the understanding of the objectives by TP, TC and TT, led to the identification of the objective of improvement in project performance.

The identification of the objective **improvement in project performance** was implied based on the main understood objectives by TP, TT, and TC namely, quality checks, and coordination and connection between team members / disciplines / office and construction site. The first understood objective by TP,TT, and TC namely, improvement via the use of quality checks, evidenced a convergence with some of the characteristics of improvement in project performance; specifically, quality improvement and documentation of processes. The relation with quality improvement is evident. In regards to the latter, the relation to the documentation of processes was identified because to do quality checks, processes control and decision making are needed, and should be well documented. The second understood objective, as in coordination and connection between team members / disciplines / office and construction site, led to infer improvement in collaboration between parties. The improvement in collaboration between parties enhances ways of working that can decrease problems and rework implying improvement in working times, efficiency, and quality, which are characteristics of the objective of improvement in project performance.

Finally, the second objective, **improvement in cross company integration** was only identified by TC who recognizes the need for information, and that information can be useful when reusing it in future projects; however, the other teams did not seem to have this in mind. Following, the comparison of the implementation strategy content between BIS and RI is presented in Table 5.

Table 5. Implementation Strategy Content. – BIS vs RI

IMPLEMENTATION STARTEGY CONTENT				
- Why? - Need / Implementation (EBA - specifically BIM 360) AIM	EBA ▪ Transformation Business- BIM implementation ▪ Widen scope of contracts BIM 360 ▪ Improve and enhance collaboration ▪ Field management and logisic optimization			
- How? - Management Participation	▪ No participation found			
- Impact on ongoing and future projects	▪ Only was consider its use on the handover of one project ▪ Assessed urgency to start with new projects			
	Plan	**Provider - TP**	**Implementation Team - TT**	**Users - TC**
- How? - Objectives	Long term goals TBI - JP VAN EESTEREN ▪ Improve cross company integration JP VAN EESTEREN ▪ Improve project performance ▪ Improve cross company integration future performance No Short term goals	▪ Improve project performance ▪ Get BIM into construction site ▪ Improving through quality checks ▪ Coordination purpose ▪ Connect project team members ▪ Connect Office and construction site	▪ Improve project performance ▪ Coordination purpose - all documents and required information in one place ▪ Fulfill need to do Quality check ▪ Ease construction managers tasks ▪ Improve in communication - better and easier ▪ Improve in future projects / future performance ▪ Feedback - Collect information - assigning issues to a specific element in the model ▪ Ensure good file of the infromation of the execution	▪ Improve project performance ▪ Quality Checks ▪ Improve communication ▪ Connection and communiciation between disciplines

The outcomes resulting from the assessment of the established goals in the BIS and the understood goals from the RI are recorded in Table 6.

Table 6. Comparison's Outcome - Implementation Strategy Content.

IMPLEMENTATION STARTEGY CONTENT	
Outcome	
	Notes ▪ The aim of widening scope of contracts appears to be only to satisfy clients ▪ General objectives that should be achieved by the implementation in the different companies should be defined in order to match with each other in the execution path. ▪ Management Participation is one of the most important requirements in a successful implementation and deployment
Comparison Planning vs execution - Understanding	
	All of the parties understood as an objective the improvement of project performance, even though it is expressed in different terms it can be evidenced that the objectives mentioned make reference to performance and the actions taken to improve it. Nevertheless, not all the parties contemplate the same improvements -Similar Objective Improvement ▪ Improve through the use of quality checks ▪ Coordination Purpose - Improve connection and communication between the parties, and between office and site. Gather all the information just in one place -Single/Different Objective Improvement ▪ Take BIM into construction site ▪ Ease construction managers tasks In terms of improve for the future nor the provider nor the users have it present. The only party that contemplates the part of future improvement is the implementation team, who considers collection of feedback based on issues assigned to specific elements in the model and ensure a good documentation of the execution process.

To continue, the **operational process** from the BIS is assessed first in terms of its completeness and subsequently through the comparison between the BIS and the RI.

The evaluation of completeness of the BIS through the comparison with the ISF showed that there is a gap in the definition of the following components: means of communication and definition of clear message, planning of feedback sessions, assessment of acceptance (possible reactions and impact), evaluation of available and required skills, and proposed incentives (recognition, economical, etc.), as described in subchapter 4.2. These components were also recognized by the head of the implementation but no further explanation was given.

The second part of the evaluation of the operational process was also divided into two parts: first the planning and resources allocation were assessed and afterwards the control and feedback were evaluated. The planning and resource allocation were based on what was intended to be rolled-out and through which means. In the RI the following elements were found to be deployed: kick-off meeting, trainee-trainer program, project configuration and setup, users training and go live, follow and support. Furthermore, during the deployment the check-list were developed, and according to TC there is a plan for future development. Nevertheless, the workflows were not found in the provided documentation. Even though the checklists were developed and implemented, the standardization cannot be easily developed because, as it was already explained, every project has the freedom to adopt the implementation and to which extent to adopt it, so standardized workflows can be only planned to some extent. Finally, the validation by HSEQ and the project manager were not found or mentioned and according to the validation done by the main implementer this validation did not take place. The compared information can be found in Table 7 and Table 8.

Table 7. Implementation Operational Process – BIS vs RI - Planning and Resources Allocation.

OPERATIONAL PROCESS			
		Plan	Provider - TP
- Planning and Resource Allocation	- Implementation process and resources (general, time, people and communication)	▪ Plan Activities and Implementation (5 days) in defined pilot projects ▪ Kick-off meeting (0,5 day) ▪ Definition of workflows and check-lists ▪ Develop process standards for project teams- Standard setup ▪ Develop process standards for project level and cross-project reports and dashboards ▪ Validation of plan (QSHE -approval of quality checks, content for safety checks, and agree on categorization of issue types ▪ Train Manger -Trainee - Trainer program (6-8 people Available for nex 2 years and 50% of labor time - knowledge/skills needed : Experience in the field, acknowledges methods in the company, can handle task organization and execution) ▪ Implementation manager training ▪ Project configuration and setup ▪ BIM 360 Field implementation - in the cloud ▪ Users and Training go live (employees and subcontractors) ▪ End user training ▪ Follow up and support ▪ Feedback Sessions - not completely established Financial and Resource Planning ▪ Software, training and technical support :Token flex program BIM 360 427.779tokens ▪ iPads ▪ People - Implementation managers, project champions ▪ Means of communication and clear message to be communicated ▪ Implementation - face to face ▪ Lack of definition of other means and clear message ▪ Available and Required Skills (Assessment before implementation) ▪ Assessment of possible reaction and impact = Acceptance ▪ Incentives ▪ None	▪ Start ▪ Adoption of an Enterprise Business Agreement as a standard to be implemented in all the companies ▪ Processes of implementation and deployment - continuous process that is fed by the feedback received in the projects, and is adapted according to that feedback, unless faults are too big. ▪ Trainee-trainer process - Small groups are trained and they will become the trainers - champions team 6-8 with whom there are regular meetings ▪ Carried Out Activities / Resources ▪ Kick-off meeting ▪ Set schedules and check-lists ▪ Training and setup with the project's team ▪ Training with users ▪ Regular meetings to raise unresolved doubts and situations Implementation Manager (1 every month) and Kennislab (only was held one) ▪ Champions from the different companies

Table 8 Implementation Operational Process – BIS vs RI - Planning and Resources Allocation. (Continued…)

OPERATIONAL PROCESS			
		Implementation Team - TT	Users - TC
- Planning and Resource Allocation	- Implementation process and resources (general, time, people and communication)	▪ Start ▪ Implementation by TBI Kennislab and an Enterprise Business Agreement(EBA) with Autdesk. TBI Kennislab started to implement it in various projects as a pilot but it was not arranged on a company level. ▪ First pilot displayed success and needed guidance ▪ Carried Out Activities / Resources ▪ First short course in which was discovered that the tool was a quality control item ▪ Meeting with the parties involved in the pilot projects started by the Kennislab, it was explained what was the situation, and they were asked for feedback ▪ Construction work inspection plan ▪ Training ▪ Implementation manager arranges the iPads, creates a project in the digital environment ▪ Created setup according to the Project manager and the construction manager needs ▪ Implementation manager trains the administrators (full kick start - what are the basis, what the tool can do and how is used) ▪ Administrators do the setup on site (users learn the basics and can experiment, self-sufficient and learn with the use of the application) ▪ Feedback and doubts escalate from user, to administrator, to the Implementation manager who serves as a service desk	▪ Carried Out Activities ▪ Broad explanation of the tool and its functions. ▪ Tool given for its experimentation

To continue, the elements that were not considered in the operational process are: assessment of required skills, assessment of acceptance, and incentives. These elements were validated by the head of the implementation who clarified that there were surveys to assess the required skills and acceptance, but they were not applied. Additionally, he confirmed that the incentives were not considered.

Finally, the elements that were defined or partially defined in the operational process but did not comply are: message (explicit message), validation, and feedback sessions. This elements were found when studying the different results, in which means of communication and validation were not mentioned in the meetings or found in the documentation. Furthermore, during the validation the head of the implementation made clear that means of communication or message could be found on the presentations. However, they were not found and the presentations cannot be considered as a communication plan. Additionally, the

head of the implementation confirmed that the validation did not take place. Lastly, the feedback sessions were found to take place by means of phone calls but a regulated process does not exist and there is no formal register from this feedback.

Based on the compliances and gaps found in the aforementioned comparison Table 9 shows the outcomes from these findings.

Table 9. Comparison's Outcome - Implementation Operational Process – Planning and Resources Allocation.

OPERATIONAL PROCESS - Planning and Resources Allocation	
Outcome	
Comparison	Planning vs execution When comparing the plan versus what was executed and experienced by the different parties it is found that some of the planned actions are carried out while others not, and some others were partially carried out. Comply **Kick-off meeting** - half a day with everyone, specific one for the project. **trainee-trainer program** - it was carry out with the selected implementation managers (champion) from the companies. The time might be probably less than 50%. Still the same after 1 years of roll-out **project configuration and setup**- it was explained and supervised the project configurations and setup on the cloud according to defined parameters **users and training go live**- there was a deployment on site to the direct users, however it is expressed that it was a broad explanation **follow and support** - regular communication with implementation managers and measurement of adoption and usage, as well as raised inquiries. Partially comply **Definition of workflows and check-lists** - they were developed, however the standardization regarding process standards for project teams, and project level and cross project is difficult to carry out because the implementation is different per project and is dependent on the manager of the project Did not comply **Message -** No clear or explicit message found **Validation-** was not carried put, the process between office and site is still disconnected. **Assessment of required skills -** Existing basic surveys regarding holding and use of tablets. However, they were not used **Assessment acceptance** - There was awareness of the conservativeness of the company. However no acceptance assessment was done. **Incentives** - Not considered **Feedback Sessions** - Not completely established

To finish with the operational process, the elements of control and feedback were studied. The documentation showed that checkups, and measuring the established KPIs after the first, second, and third month of the deployment were proposed as control mechanisms. However, well-defined KPIs were not found and the found checkups were related to adoption and usage of the tools. Additionally, to complement these results the perception of the different parties regarding expected results and evidenced results, and feedback and acceptance of the tool were evaluated. This comparison will be presented in Table 10 and Table 11

Table 10 Implementation Operational Process – BIS vs RI – Control and Feedback.

OPERATIONAL PROCESS			
		Plan	**Provider - TP**
- Control and Feedback	- Assessment of the process	▪ Check in after 30 – 60 and 90 days of use to measure KPIs and make sure goals are achieved - Autodesk	▪ Results & Feedback ▪ Expected Results ▪ The main goal of TBI was to get BIM on the job site and get the use of the ipads on site ▪ High rate of adoption, this adoption is measured in terms of willingness, use and implementation by the site managers ▪ Results ▪ The goal was managed because after 3 months we already had more than 200 iPads into the TBI company ▪ This adoption can be checked and monitored through the cloud base usage of devices. ▪ Feedback ▪ The feedback is received in the meetings with the Implementation Manager ▪ Solution will depend on the content ▪ Usability - content it is not that easily changeable ▪ Setup - the collection of data can be revised and can be assessed what can be improved ▪ Layout - there was a big problem with the language and it has been already solved. ▪ Insider program - different organizations are collaborating with their feedback to improve the tools

Table 11. Implementation Operational Process – BIS vs RI – Control and Feedback. (Continued…)

OPERATIONAL PROCESS			
		Implementation Team - TT	**Users - TC**
- Control and Feedback	- Assessment of the process	▪ Results & Feedback ▪ Expected Results ▪ Quality Check ▪ Go on site and report issues (wrong things) on BIM 360 field use and implementation by the site managers ▪ Expected results for future - work with the app and reach information management. ▪ Results ▪ The results of the implementation so far are good because every project within the new big projects from JP van Eesteren are using BIM 360 field ▪ Monitoring of performance is not formally developed, it is carry out by talking to people, but that is not enough, and it must be developed. ▪ Feedback ▪ From Users ▪ Feedback of users is used to enhance the training of the users. ▪ The feedback is received in with people but it isn't documented ▪ Goal - plan evaluation sessions with projects' teams to increase quality of implementation ▪ Create awareness in construction managers of the needed knowledge according to the evinced missing information. ▪ To Autodesk ▪ Requests emerged from the meeting with the members of the pilot projects, they were given to Autodesk, however the response comes slow ▪ Feedback was given regarding the use shortcoming of using 3D models and the lack of support from BIM 360 Glue. This was a big problem that did not allow implementation of the model ▪ Consultants of the implementation recommended splitting the model, but the model is already split ▪ Acceptance ▪ Transition ▪ There was not a transition between BIM 360 and other projects, it was just started BIM 360 and said this is what we're going to work with and the other things are not going to be used anymore onsite. Nevertheless we did got concerned ▪ Acceptance ▪ This is a conservative company and it has defined standards and working methods, and everything new is not easily acceptable, but once you know the precise people with whom to speak about this, and they test the tool and show them and let them discover the success of the application, then they will help with broadening of the setup. ▪ The document manager and the quality controllers, they were very enthusiastic because with BIM 360 all the information is in one place ▪ The guys on site, they were positive about not having to bring all kinds of documents to the site when they have to check something. ▪ The negatives were, all in English. It is being worked on it - the check-lists were made double, both in English and Dutch. They were really open, or at least is what they say to me.	▪ Results & Feedback ▪ Results ▪ Documentation and follow up of issues ▪ Communication - It is a faster mean of communication with other parties, and it saves time by sending the report, the location and the picture. The other parties get an immediate notification and can reply with a comment ▪ Acceptance ▪ The acceptance is good. The users think it is useful. ▪ They are using it according to their understanding and to their benefit

As a result it was found that every TP and TT had a different perspective on the expected results and therefore their definition of results and success was also different. In these terms

TP's expectations are linked with taking BIM to site and tools adoption rate, while TT are linked to quality checks and issues.

Regarding the results, TP found that the implementation was successful based on the increasing rate of adoption. Nevertheless, one of the main aims was taking BIM to site, and this has not been accomplished, and this should be identified by TP. TT's perception concerning results is also positive, based on the adoption by large projects and taking into account that this is a process that takes time to settle completely. However, as discovered at the beginning of this project, even though some projects adopted the tool the information they produce has a low quality. Additionally, the adoption of the tool is not completely enforced. The aforementioned elements are important when determining the success of the implementation. Finally TC's results show that TT's goal of bringing check-list and use of issues to site was accomplished.

Furthermore, BIM 360 is used as a communication tool, this use explains the resulting information from the tool. The users communicate directly with the person that is executing the tasks; if they make a mistake the solution of taking a picture and making a basic comment, complemented with a location in 2D or even without a location, is enough to give the required information and get it revised and fixed. This shows that the TT use the tool as they think it is useful for them because they do not have the knowledge of what is wanted from it.

Even though all the parties considered the process a success their reasoning is not in line with each other and with the objectives established at the beginning. Every party considers the success of the implementation in terms of their own understanding and perception, which shows that there is a clear lack of communication and that the current situation can be improved by synchronizing the parties. Then they will all seek for the same outcome.

Moving on to the feedback, it is established from the information that meetings exist from which TT gives feedback to TP. It is said that the response to some problems is not very fast, which is explained by TP as being dependent on the nature of the problem. The problems are classified by TP as usability, setup or layout. The problems regarding usability and setup can be solved faster because they are based on the use and internal setup of BIM 360 in the company, which makes easier to identify the issue. However layout problems take more time since matters have to be adjusted from the root. Furthermore, Autodesk has an insider program on feedback with which the tool is developed from scratch, and TBI Kennislab participates in this program. Direct feedback from TC is used to enhance and improve the implementation and this is done in an escalation setup. This means that the users report the problems to a nominated administrator on site, who takes away doubts or escalates to the implementation manager who solves problems or hands them on to TP.

Continuing with acceptance and its lack of assessment, the process was carried out through an instruction in which the use of BIM 360 in the field was determined, and the other tools should be dismissed. In the places where the project managers made the use of BIM 360 compulsory the personnel received the tool well and they think it is useful, however, as explained before, the usefulness is seen according to their understanding. In other projects they just kept using the familiar (old) tools. Table 12 displays the outcomes from the analysis of control and feedback.

Table 12. Comparison's Outcome - Implementation Operational Process – Control and Feedback

OPERATIONAL PROCESS - Control and Feedback	
Outcome	
Comparison	**Results expected vs reality** According to the information, in summary some of the expected results were acieved meanwhile others were not. It is important to clarify the perception of the different parties to what was or not achieved Achieved **Quality Checks** - were developed, implemented, and used and based on them there is reporting of issues **Go on site and report of issues** - partially - it was possible to bring the tools on site and report issues. As an outcome are found documentation and follow up of issues. Nevertheless, the expectations of the use of the model are missing. **Communication-**Users considered this as an achievement, faster and clear way of communication. **Increase rate of adoption-** Measured in use of iPads, use of tools, issues, photos, documents, check-lists. Not Achieved **BIM to site -** The use of BIM on site has not been implemented because the tool did not support the model, and the program even though receive pinning in 2D and 3D only displayed one so when changing there is a discontinuity. Is expected for future projects the implementation with 3D pinning. Awareness The implementation manager is aware of short comings and consider the them for the future development of the process by taking it into account in the development plan.
Satisfaction	**Feedback** In general parties show a positive answer regarding the results of the implementation Implementer There are regular meetings between implementer and implementation manager where the different questions are raised, they get reply even thoug this one is slow in some cases User The questions are in a escalation method were users approach the administrator (trained by the implementation manager) this one gives answers or take the doubts to further levels (implementation manager) when there is not a clear answer. **Acceptance** Even though the transition was drastic and the company is conservative it was received positive reactions and feedback regarding the implementation and usefulness of the tool. Nevertheless, the users use it according to their understanding

To conclude: good definitions and gaps were found, as well good practices and limited practices as described in the assessment of completeness and comparison tables. To follow this analysis of results, other topics from the interviews and the observation session were studied.

4.4.2 Results Analysis – Others

The results that will be analyzed below are based on the comparison between perspectives of TP, TT and TC regarding implemented and used tools, the production of knowledge and its use, including analytics and future use. Finally the future of the tools is considered. The comparison table between the perceptions of TP, TT, and TC can be found in Appendix H.

The description of the used tools referred to the basis that supports the use and setup of BIM 360, and the storage of documentation. This comparison showed a complementary relationship between the different parties. In short, the implemented tools mentioned were BIM, Relatics, Chapoo, and BIM 360 which included BIM 360 Field and BIM 360 Glue. The process is described below.

First, for the design and execution of projects BIM is used to model and check clashes and Relatics is used for the establishment of requirements. These requirements and other well-defined elements have been set up as checklists for quality control on site. The control on site and application of checklists is supported by BIM 360 Field. From the checklists different quality and safety issues can be defined that are communicated to the person in charge by means of a message, containing the notification with the information in the cloud, namely picture, location pinned on the 2D map and basic description/basic inquiry of the issue among others. These issues can be also created based on discoveries made on site during inspections

or rounds. As a response to the notifications the person responsible gives an answer and the issue is followed up until its status is changed to close, going through the phases of open, work completed, ready to inspect, not approved or in dispute.

The issue report and follow up help show the correct execution of the project and the compliance with requirements. The follow up of quality is done on site and the follow up of safety is done by the HSEQ department. From the checklists and the reported issues different reports can be retrieved that are used to analyze the information. In addition to BIM, BIM 360 and Relatics, Chapoo is used, this is a document management program.

BIM 360 Glue as a mediator has a low rate of use because it does not support big models, however, it was found that in smaller projects it can be used. To use the aforementioned information and lessons learned, a monthly information session is held between groups of people from the projects to share experiences, best practices, and lessons learned. To conclude, the fact that not all the features have been used should be acknowledged and it should be considered for the near future, in order to exploit the tool to its maximum.

Continuing with the analytics that can be derived from the information retrieved, all the parties agreed to some extent on the way that this analysis can be done or is being done according to their scope. The setup of checklists and the other parameters for controlling the project were identified as the basis for analytics, since that is the foundation for the gathering of information. This information can be analyzed in different ways. BIM 360 shows the behaviors in a standard dash board. Furthermore, reports in Excel or PDF can be retrieved to assess different information. These reports can be translated into general overviews that give insight in the projects behavior and state. Nevertheless, none of the aforementioned is standardized.

It can be said that it is clear what can be done with the information. Therefore, it should be standardized in order to produce meaningful information. The standardized well-structured information that is gathered from different projects could be used to reach lessons learned from experience that will help to prevent future failures. Additionally, with the information of projects with similar characteristics a cross-project report can be delivered linking types of issues to analyze trends in processes to improve them. Additionally, the use of 3D is recognized as a mean to improve the process of gathering data that can improve its use in the future. In conclusion: the value of the information and importance of standardization is recognized which is a good starting point for awareness of KM.

Next, regarding future tools a discrepancy was noticed in perception between the parties. According to TP the changes in the tools are going to be big and further training will be needed. At the same time TC considers that new changes are going to improve the tool, but they would not require further training or re-learning. This is important to be recognized by everyone, overall for the implementation manager to be able to plan further implementation based on the changes and avoid future intricacies. Additionally, it is important to pay attention to the suitability between software as well as to future requirements of law.

Finally, suggestions of improvements and other comments were given that will be summarized here for the sake of completeness. The current implementation is considered to be scattered

in projects, in terms of different settings per project. Additionally, the importance of implementation in every company striving towards the same point was mentioned. Finally, the comments referred to improvements in performance of the tool, the importance of exploring and settling the 3D option, and problems regarding the present shortcomings in terms of logistics when uploading new plans. These last comments form part of the need of standardization of processes through workflows into organized process.

In conclusion positive outcomes were discovered from the implementation and also some shortcomings. Below, recommendations are proposed that seek to approach the big picture in the company, as well as to tackle the found shortcomings and improve the implementation that has been carried out so far.

4.4.3 Recommendations

The implementation of the tool aimed to enforce KM by a number of means as shown in the background given in subchapter 4.1, the implementation strategy described in subchapter 4.2 and the results and analysis listed in subchapter 4.3. This enforcement was attempted through the organized gathering of explicit knowledge from the execution of projects to find valuable lessons to improve. However, KM is a process that exists only to some extent in the company, mainly in an unspoken language. CoP were discovered inside the company, but most of those CoP stay at a project level and do not cross to a company level, leading to the socialization of the knowledge but not the completion and scaling of the knowledge spiral. Additionally, dossiers used only for follow up of projects were found. Therefore, without a clear process a successful implementation is difficult to achieve. Moreover, if BIM 360 was intended to support another process within the company it was not clearly defined in the implementation strategy. Finally, it can be said that a lack of awareness was unveiled regarding the need of KM and the value of knowledge, coming from a lack of understanding of what can be done with knowledge gathering and how it can be used.

In this specific case, through the process of implementation and deployment of BIM 360, different people played a part, joining and leaving, taking part in different parts of the process and leaving some gaps and doubts about the process and responsibility. These gaps imply a lack of continuity in the process that has affected it. Furthermore, no evidence of interest was found by senior members which could result in an incomplete synergy between them and the initial implementation teams. To tackle the problems and gaps found in this implementation, the corresponding explanation and recommendations will be generated.

For the recommendations that are proposed, it is important whether to define and implement a KM process or determine how to manage knowledge through the different existing processes inside the company. Additionally it is essential to define which of these processes BIM 360 will support and how. For practical purposes it is also necessary that the implementation team has the possibility to invest full time in the completion and further development of the process of implementation and post-implementation. Bearing in mind that this will not be a pilot project where it is fair to demand half time from implementers of the process. Additionally, it is important to understand that the complete implementation of the process will take time and will include taking steps that will allow it to go beyond. Finally, the implementation should involve parties from the office and on site to develop it parallel in both environments.

Based on the analysis and comparison between the defined implementation strategy and the information retrieved from the interviews and the session of observation, the shortcomings were classified into two types: one is **lack of definition** and the second is **objectives not achieved**. Within the lack of definition can be found lack of management involvement and support, lack of planning of means of communication, lack of a clear and defined message to be delivered, lack of definition of short term goals, and finally lack of assessment regarding acceptance and required skills. The objectives not achieved involve definition of workflows, taking BIM to site, validation of check-lists and conduct surveys to determine KPIs. Additionally, certain extra information included in comments and feedback that was given should be considered. These features are: standardization of process on a company and project level, update of basic documents such as plans, tool's features, future use of the information and future changes of the tool.

For the following recommendations the process that BIM 360 will support, is assumed to be defined.

4.4.3.1 Recommendations to solve Lack of definition

Shortcomings defined as lack of definition need immediate solutions since they are the basis of the implementation process. If this implementation strategy is the one that is going to be used in future projects, the time for these solutions will be defined by the start of the next project in which the process will be implemented.

To approach the shortcomings classified as lack of definition some steps are taken that were defined by Kotter (2007) to assure that change can happen, as explained in subchapter 3.6. These steps are in line with the ISF and can help strengthen it. It is favorable to take the 8 steps into account, nevertheless according to Pandey (2016) *"even if these steps are not taken, there are forces which imbibe change in organizations in due course of time."* The steps that are used for the recommendations are: establish sense of urgency, create a vision, communicate the vision, plan for and create short-term wins, form a powerful guiding coalition and empower others to act on the vision.

Establish a sense of urgency

The creation of a sense of urgency is the step that can generate the awareness necessary for **managers to get involved** and be supportive of the implementation. A well-established and presented situation can boost the interest towards the implementation and will allow the different parties to see the need for it. In this specific case there is a very clear situation that will affect the appropriate development of the organization, this is the change of the Wkb as defined in the external context of the strategy and further explained in subchapter 4.1. The need for quality and processes control and improvement through KM is demonstrably evident; this can be supported with the implementation of a cloud-based management tool and its full setup for the appropriate documentation of the whole project life- cycle.

According to the law, the builder is required to prove quality compliance through the documentation of checks and corrections carried out in every phase of the execution. Furthermore, changes in the law have established that the execution of a project cannot be allowed to start without having an authorized instrument to document the quality tracking

and control. Therefore it is possible to comply with the requirement that demands that the builder proves quality compliance through the documentation of checks and corrections carried out in every phase of the execution by means of the tool. These checks will be verified by an inspector who will confirm the quality level and conformity. Also, it applies to checkups in every phase of the life-cycle of the project from tender to hand-over.

The new requirements and conditions coming from the enforcement of the WKb have to be reinforced and strengthened, supported with the exact information that needs to be delivered. This should be reflected in the work break down structure and system break down structure containing the different requirements to be handed over that will support the setup of BIM 360. Additionally, form and content should be defined complying with the law's requests.

Form a powerful guiding coalition and Empower others to act on the vision
From all the members involved early in the project, the person in charge at JPvE is now the implementation manager who followed the trainee- trainer program. In light of the different interviews the implementer manager is the main guiding coalition member, he understands the process and its path, and has a future plan to follow. Additionally, he has a strong involvement with key members within the on-site community that can enhance the adoption of the tool. Finally, he is completely supportive of the process and knows that it has to be driven step by step which will take time. Nevertheless, a number of these guiding coalition members are not yet there.

One of those main members required is someone in a managerial position with the power to make decisions, this is one of the people that is targeted from the first step, to establish a sense of urgency. Additionally, it will be also important to add a person from the office that believes in and promotes the implementation there, which will also help to connect the site with the office. Moreover, it will be required to connect with the IT department in order to get their support and also that the final communication between Kennislab and other departments improve. Finally, it is important to define which department is in charge of tracking and controlling the progress and performance according to the contract's agreements.

Added to the members already mentioned, it is important to carry out the **assessment regarding acceptance, and existing and required skills** to be able to join key members, and to execute a good implementation. Through evaluations of existing and required skills, guidance can be given to members to boost and enlarge their knowledge and confidence. This will lead to an empowerment in terms of giving knowledge to produce knowledge. Furthermore, through the evaluation of acceptance, the obstacles of the implementation can be acknowledged, and mechanisms can be developed to eliminate these obstacles or to clarify discontent. In short with both assessments, acceptance and skills, a powerful coalition can be created that can provide ideas for present and future development.

Plan for and create short-term wins
Based on the established sense of urgency and aim of the implementation, it is possible to **define short-term goals** setting criteria to measure performance according to what is needed together with the format in which it is needed inside the JPvE. An example is the measurement

of the adoption and use of tools and features through the quantitative review of users, uploaded photos and created checklists. This adoption rate and what has been measured can be set as a goal defining the increase that is expected in a determined period of time depending on the control, it can be monthly, quarterly, etc. At the same time in line with the long-term goals, if the plan is to improve performance some partial goals can be set. By measuring the performance in the current projects in execution and setting them as a baseline, a point of reference will be set to measure performance improvement against in future projects.

The goal should define what has to be measured and what is the expected rate of change in terms of time, percentage or otherwise. Another example that could be useful in this specific implementation is the aim to bring BIM to the construction site, so far it has not been accomplished. In these terms a goal of roll-out can be developed and predictions on its use with which its adoption will be measured. It is important that this type of adoption is measured not only in quantity but also in quality, depending on the information that is needed. Therefore establishing quality measurements is also of use. This quality measurement should be aligned with the compliance not only with the company's needs but also with the Wkb requirements.

Finally, the importance of these short-term objectives are the short-term wins with which the process can be boosted, not only by knowing how it flows, but also by recognizing and sharing progress achieved. It is important that these short-term wins empower the process without letting them interfere with attention paid to further development and growth.

Create a vision and Communicate the vision

Having defined sense of urgency and goals a better vision of what was rolled-out can be created, and of what is expected from it in the short and long-term. Additionally, consequences can be defined that might affect the organization if the process is not adopted. Consequently, the vision can be created and put in place and then be communicated. It is important to make out of it a **clear message** that can be understand by everyone. It is also essential that the message is delivered by every possible mean of communication, making sure that it reaches everyone. Based on these communication needs, it is evident that it is necessary to plan and define the **means and strategies of communication** that will be used and how are they going to be used. Because even though the concepts and goals are clear for the implementers, for the future users they are not and it is important to deliver a message that attracts them and makes them curious and willing to try the implementation. It should be considered approaching communication department to get ideas and recommendation regarding who can help developing this plan.

Through word of mouth can be checked if the message is clear or if it needs some sort of improvement. If this implementation is based on the change required by the Wkb the outcome of such a plan should for example communicate the importance of quality, because it turned out to be part of the liabilities of the company and due to this implementation quality can be proven by reviewing of checklists and issues. If the organization does not comply with this requirement it will have its drawbacks on the projects as well as on procurement and contracting with the different entities, and since an organization works like a gear this will affect everyone. This is an example for a higher level, for lower levels it should be planned also

a message explaining the quality important and its implications in the company in an easy and understandable way. Furthermore, the positive side of the new implementation can be incorporated in the message and how it will lead to the accomplishment of improvements and ease the communication processes at work.

In this case it can be shown how BIM 360 will help accomplish the requirements stated in the changes of the law; in addition to the benefits that it will bring to the whole project life cycle it can help in giving feedback from on-site to office and vice-versa, and facilitating documentation of issues and corrective processes on site. Moreover, users should be shown the benefits that they will get, such as documenting and adding input to the actions taken during the solution of a problem, which can be shared with peers and can give recognition. Additionally, time saving can be identified because the issues' information will be summarized in just one place and it can ease inspections where only a tablet is needed which with training will be easy to use.

4.4.3.2 Objectives not Achieved

The shortcomings that come from objectives not achieved should be tackled and the aim has to be to achieve them in a mid-term period of time. The definitions given in the previous subchapter 4.4.3.1, and some of the strategies and definitions given in the literature review will likely help increase the chance that objectives will be achieved.

Definition of workflows

The definition of workflows will help improve **coordination and communication** and will contribute to achieving connection between site and office, and as required by the Wkb a further connection with the stakeholders. To define the workflows, it is necessary to understand the process that BIM 360 will support, how the process of knowledge gathering is taking place in this moment, after the implementation of the tool in order to have a base point for further explanations and solutions. To complete this workflow, as stated in subchapter 3.1, it is necessary to define the knowledge that is contained in the company and that can enrich the organization, additional to the information that is being currently produced including its quality. This means the knowledge that is needed and in which form it is needed. The study of this knowledge should be done parallel with the study of the environment elements that will determine the sense of urgency and short term objectives.

The needs of content and form can be based on the definition and requirements of the Wkb, this definition will help clarify the workflows. In addition, these workflows will help **standardize the procedure at an organizational level, and therefore at a project level**. It will also establish procedures that should be followed to **keep the basic information running and up to date**, information used to work on site and that can be verified at the office and by the control entity required by the Wkb, such as models and plans. Also, it will help plan the roll-out of the different **features that the tool has** in order to exploit it to the maximum, taking into account its **future changes**, which according to the provider are extensive. Additionally, the standardization will help reduce and eliminate the different tools in use that have to be discontinued. These workflows have to follow the same route of other processes and workflows in the company, defining the input, responsible party, output and how it belongs to more general processes. In this part, it is very important to define the responsible party and

if the stated information and format is suitable with the way in which the information is revised and evaluated. This leads us to validation of the check-lists.

Validation of check-lists

A validation of the check-lists is required to assure that the correct information will be gathered. This validation will also determine the suitability of the gathered information with the different requirements within the company and with the law. In the proposed roll-out, the HSEQ team and the project managers had been expected to revise the checklists but due to company constraints these assessments were not found.

To accomplish this objective, the first thing to evaluate is the current check-lists to define if they intend to gather the required information, or if it is necessary to further develop them. The definition of workflows will give an idea of the information that should be gathered. In case the Wkb is established to create the sense of urgency and, consequently the basis for information that is needed the setup of the check-lists should be according to the Wkb. And the validation should be done by professionals that have knowledge about the Wkb requirements as well as the company's and clients' requirements. Once the validation is performed, it is also necessary to make sure that the implemented check-lists and the issues derived from them are being filled correctly, and if the produced information is useful and readable. In addition to the definition of the content needed, it is important to explain to the users, who are the main source of information, the importance of filling the required spaces in a specific way. Furthermore, it is necessary to explain to them which information is expected from them otherwise they will use it for the purpose convenient for them, as they do at the moment because they do not know the real purpose. If this is not explained they might even not always see the usefulness of the information. In other words, it is important to get the users closely involved in order to get information with good quality.

Conduct surveys to determine performance improvements

Once the implementation has been rolled-out it is very important, as stated in the ISF in subchapter 3.5, to measure and compare outcomes with what was planned. Since one of the objectives is to improve performance, in order to evaluate it is important to measure it. One of the proposals found in the contracts is to conduct surveys to determine performance improvements. Taking into account that these surveys have not been done or at least they were not found in the received information, they could be held and taken as a starting point. After the re-implementation a new measurement can be carried and this will result in a more accurate outcome. A revision of the information produced and determined could be added to these surveys whether it fulfills expectations or not.

In addition to the conduction of surveys, it is important to determine what a successful implementation means. In the current case, the different parties found the current implementation successful, however, this success was measured with different parameters and they were not completely in line with what was proposed initially. This was evidenced by the measure of success in the adoption of software, and its use in projects; however, quality or usefulness of the information was not mentioned. Thus, based on the definitions of the workflows a way of measuring the success of the implementation should be established.

Taking BIM to site

In bringing BIM to site the first revision should guarantee that the models with which the project will work are of the quality needed. Following this, bringing BIM to site must be done within the defined workflow. However, it has to be done together with the provider of the tool who is the responsible for its deployment. It has been established that the adoption of BIM 360 is the more suitable, in part due to its advantage of using BIM, which up to now has not been used. It is important to get this feature to work with the help of the provider to completely seize the implementation of the tool and its use. Likewise, it will really enhance the development of the change in Wkb, where the controller will be able to verify and understand the reviewed check-lists and issues better by using all the material from the project.

4.4.4 Conclusions

To conclude this chapter, it can be said that there is no clear KM process defined at JPvE. However, the existence of knowledge sharing and application can be seen in knowledge externalization in development of dossiers, and socialization through CoP. These communities were found to be closed groups or only active at a project level, which narrows the flow of knowledge inside the company. These factors lead to a barrier which truncates the current informal process of KM. Therefore, the development of KM as a process or its implicit application inside the company could be done to improve the company's performance. As long as the chosen process to be supported by the cloud-based tool allows the cycle of identification and capture of knowledge, knowledge sharing and dissemination, and knowledge application, KM and its benefits would be implicitly applied. Once the importance of KM and its adoption explicitly or implicitly has been established, the matter of IT tools to support KM can be addressed closely taking into account the users.

Regarding the adopted cloud-based tool it is concluded that it cannot be evaluated on its usefulness due to the lack of definition of which process it attempted to support and the undefined content that was expected from the explicit data. Nevertheless, some conclusions can be drawn about the implementation of the cloud-based tool. As already established, the strategy of implementation of the cloud-based tool at JPvE can be improved by defining the process that it is meant to support. Furthermore, the implementation should complement its guiding team with supportive and engaged members at every level. Once these definitions are given, the correct planning of the implementation strategy will bring with it the definition of the required knowledge, which will include the necessary content and form taking into account the preservation of knowledge's background After the implementation strategy has been planned it will be easier to explain to the users what is expected from them and the content of information that they should capture; the result will be clear communication and data with the desired quality. It is very important to involve training, and gather users' perceptions and feedback in order to get successful results of the implementation. For this specific case, since the process was already rolled-out, the found gaps can be supported by the recommendations presented in subchapter 4.4.3. As explicitly described, the recommendations have a direct link with the elements that were not defined at the beginning and the proposed objectives that were not achieved. These recommendations straightforwardly identify the gaps and give a theoretical basis to cover them, including suggestions on how to approach them based on the current situation.

4.5 Results Discussion and Limitations

The discussion and limitations regarding the present research project will be presented next.

4.5.1 Discussion

It has been shown that change is needed within construction organizations to comply with regulations, clients, and the surrounding environment. Moreover, change is needed for organizations to improve and become more competitive. The need for change has evidenced the helpfulness that KM can provide to address this need and to further strengthen the organizations capabilities and performance. Additionally, and more important is that the organization realize the need for change. Once this happens, addressing this need is possible with the different required implementations of processes and tools. Subsequently, having the acknowledgement of the needs is fundamental to plan an implementations strategy well-structured and coordinated to achieve the objectives. The way to succeed will be through the involvement of people to reach balance between technology and human capital, striving for people's full acceptance. This can be enhanced by embracing and enlarging working practices such us CoP and remembering the power of defined and clear communication at every level.

4.5.2 Limitations

The limitations regarding the development of the implementation strategy and its filling are given by the reliance on the researcher's interpretation and understanding of the framework, and the studied documentation and processes.

The shortcoming that the methodologies chosen can bring are based on its nature. The interviews can have some shortcomings since they are based on personal perception, and may not reproduce the situation precisely. Continuing with the observation session, it may lack detail, since this process depends on the memory of the researcher. Finally, for the aforementioned methodologies it must be said that the language and cultural difference are possible limitation, because when speaking in a third language, not being the native language of either the researcher or the interviewees, some information could be lost or misunderstood. In the same way, the cultural differences in the construction industry in various countries may serve as a limitation in the understanding and interpretation of the information.

Furthermore, this project was developed based on processes and information documented by JPvE, one of the construction companies of TBI. Therefore, the resulting outcome is directed at practices inside this company. For its use in other companies, it is necessary to analyze whether it is or is not compatible with their practices. Additionally, this project was confined by time constraints.

Having developed the relevant recommendations according to the findings of this thesis, the corresponding conclusions, and the faced limitations following are drawn the conclusions and recommendations for further research.

5 Conclusions

The nature of this thesis led to draw conclusions pointing towards a practical and a theoretical approach. The practical conclusions were presented in subchapter 4.4.4 as a conclusion of the results and analysis of results. In these conclusions were considered the findings of the case study and its implications. Furthermore, the found practices of KM within the company and how KM implementation could lead to improvement in the company was established. Finally, in the practical conclusions are tackled the found shortcomings and gaps of the implementation of the cloud-based tool to support knowledge capture, and the proposed correspondent recommendations. Following, the theoretical approach will focus on the ISF and the development of the implementation strategy on which this research project was based.

The ISF provided the basis to develop the implementation strategy as described throughout this report. The ISF, as well as the background in which it was based were thoroughly studied. This study led to an understanding of the different categories that substantiate the development of the implementation strategy. The implementation strategy was developed seeking to reach a holistic view of the process. To understand the implications of the process an integrated analysis of the established content and the definitions, as well as the people involved in the process and the implemented tool was carried out. This assessment and the fit between the gathered information, the strategy schema and the latent gaps in the process led to the following conclusions.

It was seen that the studied ISF offers easy guidance to develop an implementation strategy based on the clear description of the different categories and elements that it contains. Additionally, it was found that this framework is suitable with the studied implementation since the different definitions of the implementation can be clearly matched with the given guidelines. Nevertheless, the ISF does not contain guidance or references regarding behavioral aspects. In this order of ideas, it could include a parameter of assessment of readiness for change in the organizations, to measure the openness to coming change, as only the implementation planning may not assure success. Additionally, the dynamism and complexity of real-life environments and the interaction with ongoing strategic developments can be involved through the planning of possible adaption.

Following, further acknowledgements will be presented by answering the research question (RQ) and the sub-research questions (SQ1, and SQ2).

RQ: How can an implementation strategy help strengthen the processes of implementation in organizations?

An implementation process is deployed inside organizations to tackle an arising need. This process can be strengthen by an implementation strategy throughout the thorough planning of guidelines to reach people that will need to accept, adopt, and enhance the implementation and the change that the implementation will bring. The planning of guidelines will be based on the roots from where the need is arising, the existing governance inside the organization, and how the coordination in the organization will permit facing the arising need. Therefore, to plan the process the external and internal conditions will be studied to understand the need and what is required to tackle it. The assessment of the conditions will help define the objectives and goals of the implementation, and how to measure their achievement. Finally,

the planning will take into account the required assets and means to roll-out the process, assuring that every person is reached and that everyone understands the need for the implementation, its objectives, and its benefits. The careful and comprehensive assessment, and the planning of the process will lead to strengthen the implementation's deployment.

SQ1: How can the development of an implementation strategy be guided by an ISF?
The development of an implementation strategy can be guided by an ISF by giving it a solid basis of the elements that it should consider and the explanation of their importance. In the case of the ISF defined by Okumus (2003), the main four categories that should be evaluated are defined and explained, including the minimum content that each one of them should contain, leading to avoid forgetting essential definitions.

SQ2: How can a rolled-out implementation be assessed with the development of an implementation strategy?
A rolled-out implementation for this project is a deployed process that had some initial criterion and proposals. Nevertheless, the rolled-out process does not have an established plan behind it. The existing proposed parameters and governance will give the guidelines with which the implementation strategy will be developed. The rolled-out implementation can be recreated from the perception of the people that was involved in it. Both scenarios, the developed implementation strategy based on theory and the understanding of the deployed process explained by the beholders will allow their comparison leading to the assessment of the process. Furthermore, the developed implementation strategy can be compared with an ISF to evaluate its completeness. The assessment of the completeness of criterion and proposals, and the rolled-out process can lead to improve and bridge existing gaps through the creation of awareness of their existence, and the generation of recommendations to bridge the found gaps.

5.1 Possible Future Research

The results and analysis of this research project lead to a series of recommendations and conclusions that could be further developed with the following suggestions for further research.

- Assessment of readiness for change at every level in an organization and how to include it in an implementation strategy
-How to define an implementation strategy taking into account dynamism and complexity of real-life environment.
-During the development of the implementation strategy, how to define the operational process taking into account that the message and content should be delivered at different levels in an organization.
- The importance of taking into account the users were mentioned in the recommendations. Resulting from this idea a topic of research can be based on how technology acceptance by the workers can help gather quality data.
- For this specific case, suggestions from JPvE are to study the current processes, how a cloud-based tool can support those processes, and how to seize CoP.

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Appendices

Appendix A Organigram JP van Eesteren

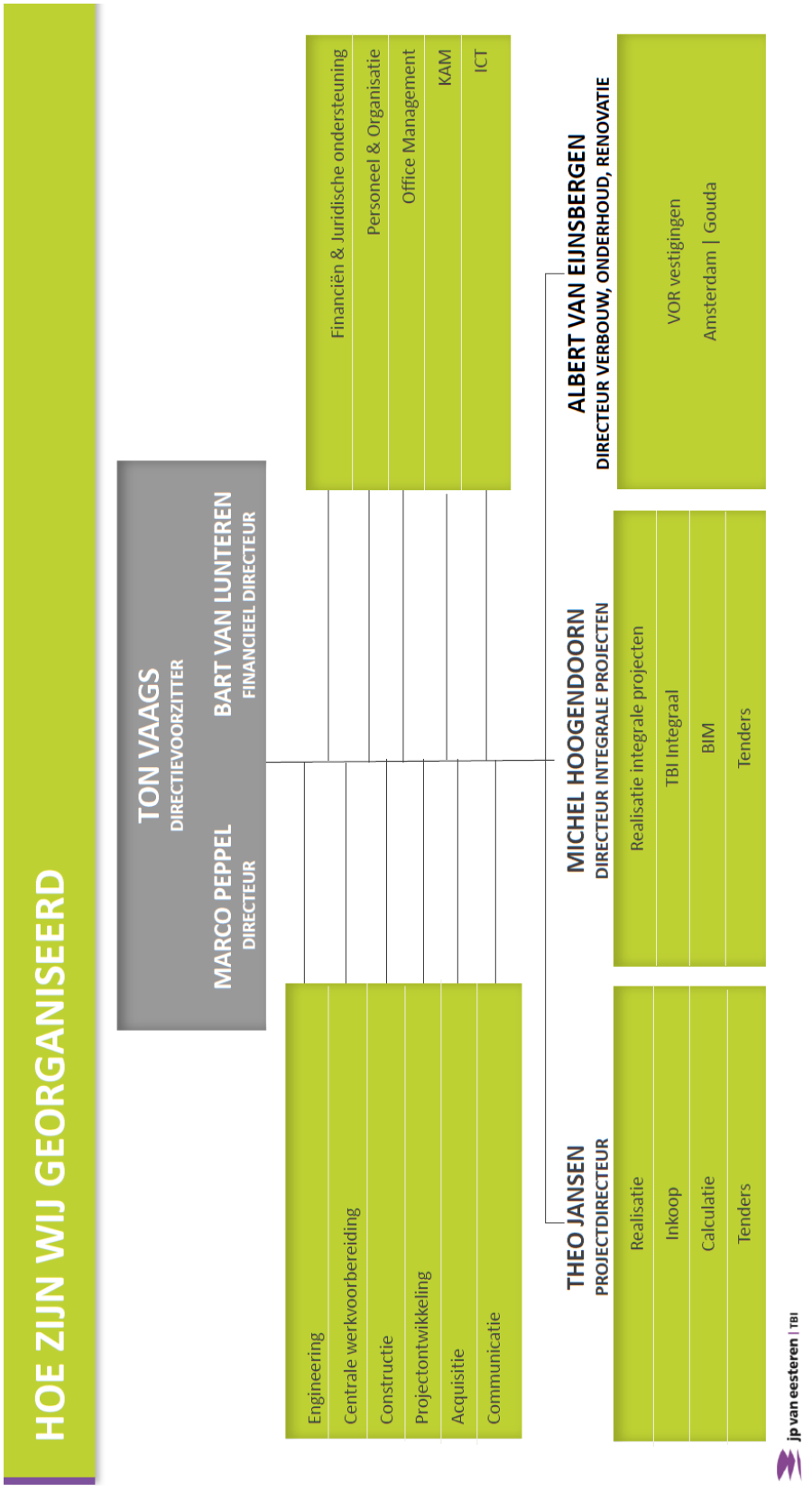


Figure 22. Organigram JPvE - Provided by JP van Eesteren (2016)

Appendix B Interview Guideline

Interview subjects - Autodesk
Personal information
Name
Company
Current position in the company
Education & working experience
Current function and types of project that have been managed
1. What aim do Autodesk tools seek to fulfil?
Type of information and knowledge that is produced during the execution phase of construction projects and their use
1. Can you tell me about the type of information and knowledge that is expected to be produced during the execution phase of construction projects?
2. How can this information be used? Prompt – and its use in future projects?
3. How do you think that this information should be organized so it can be used?
Used methods and tools to collect this information and knowledge
1. What should the methods and tools be to collect the information and knowledge?
2. Which of these methods and tools do you provide?
3. How are these methods suitable for the collection and use of information and knowledge?
Process of implementation and deployment of the used tools.
1. How was the process of implementation carried out?
2. What was the expected result of the implementation of this method/tool?
3. What was the actual result of this implementation phase?
4. How were the performance of the tool and the achieved objectives monitored after the implementation? Prompt – Did you receive feedback from the company? / How did you approach it?
Others
1. Is there a better tool in the near future?
2. Will there be big updates which require that the users follow training?
3. Do you have suggestions regarding this topic?

Interview subjects – TBI – implementation team
Personal information
Name
Company
Current position in the company
Education & working experience
Current function and types of project that have been managed
1. What is the aim of implementing BIM 360 and the other tools you use?
Type of information and knowledge that is produced during the execution phase of construction projects and their use
1. Can you tell me about the type of information and knowledge that is expected to be produced during the execution phase of construction projects?
2. How can this information be used? Prompt – and its use in future projects?
3. How do you think that this information should be organized so it can be used?
Used methods and tools to collect this information and knowledge
1. What are the methods and tools used in the company to collect information and knowledge?
2. Why do you think these methods and tools are suitable/unsuitable for the collection and use of information and knowledge?
Process of implementation and deployment of the used tools.
1. How was the process of implementation carried out?
2. What was the expected result of the implementation of this method/tool?
3. What was the actual result of this implementation phase?
4. After the implementation was there a “help desk” to solve doubts and problems of the users?
5. How were the performance of the tool and the achieved objectives monitored after the implementation? Prompt – Did you receive feedback from the users? / How did you approach it?
Others
1. Do you have a plan in case there are new versions and updates of the tools?
2. Do you have suggestions regarding this topic?

Appendix C Interviews' Transcription

Interview subject 1 - TP

Personal information

Current position in the company: Implementation Consultant BIM 360 Construction
Education & working experience: Construction Engineer. Worked on construction projects in different roles for several years; currently consultant at Autodesk

1. What aim of BIM 360 does Autodesk tools seek to fulfil?

Specifically works with BIM 360 Field and Glue. These two tools are developed for coordination.
Glue- cloud base coordination tool – use in design process – model data for clashes detection between the different design parties. It allows communication in the projects through markups. It is comparable to Navisworks in the cloud.
Field - site management tool – it is to be used on construction sites and it approaches issue management, checklists. Additionally it is used for commissioning and handover. And lastly, based on the aforementioned points it can create reports in order to learn from the different entries.

Information produced on site

Type of information and knowledge that is produced during the execution phase of construction projects and its use

1. Can you tell me about the type of information and knowledge that is expected to be produced during the execution phase of construction projects?

BIM 360 can gather information of five main points:
Issue management - pictures, description, responsible, etc.;
Checklists - review based on quality and safety parameters;
Drawings and models - That are brought to site and will give the same data to everyone;
Commissioning and handover- information about entries giving insight about elements and their current state. Additionally, specific elements include QR code with which information such as provider, date of delivery, etc. can be retrieved;
Reporting- Based on entries information, gives a base to learn from the issues and complement the initial setup aiming to get the required information.

2. How can this information be used?

The use of this information will depend on the need of the company and the set-up (options that can be selected in the tool while using it) developed for BIM Field. Thus, a good organization is required as well as a definition of the information desired or required.

Prompt – Is the information that is produced, used in future projects?

The information produced at this moment is for the follow-up of projects; at the moment it cannot be used in future projects.

3. How do you think that this information should be organized so it can be used?

The organization of the information for use in future projects depends on the requirements of the company. These requirements will determine the established setup.

Used methods and tools

1. What should be the methods and tools to collect this information and knowledge?

The methods described refer to the setup of the tool and the company's needs. TBI has a wide range of projects that it can choose from, due to the specific specialties of their subsidiaries. Working with an installation company is different from working with a building company.

Prompt – did you support this process?
The support was given in the phase when questions were defined.
2. Which of these methods and tools do you provide?
His expertise is based on BIM 360. However, there are other existing cloud-based tools.
3. How are these methods suitable for the collection and use of information and knowledge?
This method will make work easier compared to old school techniques, and the site manager can confirm that the time it takes to do the tasks is reduced. This way of work will save time based on the decrease of manual processes.
Prompt – How were the users involved?
Even though I can prove the usefulness of the tool and that it works, and I try to show with facts why the technology should be adopted, sometimes they cannot be convinced.

Process of implementation and deployment of the used tools.
1. How was the process of implementation carried out?
In the case of TBI, this participant was not involved; he took over after the deployment of the tool.
Prompt-Not specifically at TBI, but generally speaking: describe the implementation and deployment of the tool.
The first part of the implementation is based on the setup of BIM 360 Field, which is one of the more important ones and requires more effort, since it is the basis of the process which will set the guidelines for the deployment. The implementation and deployment of the tools is an ongoing process which is fed by the feedback received in the projects, and is adapted according to that feedback, unless faults are too big. For this implementation, a trainee-trainer process is used in which the provider trains small groups (champions' team) of the organization who will become themselves the trainers of the tool. Besides, one project will be deployed on site which could be replicated in the rest of the projects. And during the adoption and deployment the consultant stays on top of the champions' team, checking and helping with the pain points.
At TBI, the deployment was intended for JPvE, Comfort Partners, Hazenberg, Era Contour and Koopmans Bouwgroep. The group of the champions' team is composed of approximately 7 members with whom regular meetings should be held, although it is difficult to assemble them all together. These champions are from different companies in TBI. This is why, in this case, it is difficult to generate a master setup because the different companies have different specialties.
Implementation on site is carried out to show the users how the tool approaches the issues that they have in real-life and it teaches them how to implement the tool. In the end it became clear that the tool allows simple issue management.
2. What was the expected result of the implementation of this method/tool?
The expected result is a high rate of adoption. This adoption will be measured in terms of willingness and actual use and implementation by the site managers. Success of implementation depends for 80% on whether end users will use it.
3. What was the actual result of this implementation phase?
He rated the implementation as a 7 on a scale from 1-10; it could be better but it is not bad.
4. How were the performance of the tool and the achieved objectives monitored after the implementation?
The adoption can be checked and monitored through the cloud-based usage

Prompt – Did you receive feedback from the company?
Yes, there was feedback from the company and actually there is a current program going on called 'insider program' in which different organizations are collaborating with their feedback to improve the tools.
Prompt –How did you approach feedback?
The approach towards the feedback depends on the content, usability, setup, and layout. For example with content: if they say there are too many buttons this is something that cannot be changed easily. On the other hand, if it is about setup then the collection of data can be revised and assessed what can be improved. And in terms of layout, there was a big problem with the language and this has already been solved.
Prompt- Regarding the connection between BIM 360 Field and Glue. I understand that the model cannot be fully opened. How have you coped with this?
This is a misunderstanding. There are two possibilities: if one wants to study drawings they can be uploaded directly in BIM 360 Field, however, drawings do not include properties but they can be used. The second option is to split the building into sections. If the properties of the model are required BIM 360 Glue acts as mediator between Revit and BIM 360 Field, and it allows the extraction of data. It is common knowledge that Revit cannot bear larger amounts of information (around 150 MB) and this also depends on the type of device that is used. Another thing is that an iPad has a small capacity, so the easiest way to cope with this is by splitting the model. My question to site managers is: why do you need the whole model? During the old times, if you were going to do an inspection on the second floor you just took plans of the second floor, not of the whole building; so why is it required now. This is a mindset of the users that should change.
The use of Revit in the field is mainly for commissioning. A well-implemented process in design will create a good design that will contribute correct information to models in order to withdraw it at a later stage.
Prompt- And regarding the analytics of the data, what can you say?
The analytics are really useful, they can be scheduled to be delivered once a week or as often as necessary. BIM 360 has standard dashboards; if information is wanted on a higher level be dashboards can be custom-made, however, if something is missing or something else is required the company should go back to the programmer and ask him to include new requirements and/or fix their issues. The recommendation is to retrieve the information and manage it with power BI, which has a general purpose and can support further analytics.
Prompt- The analytics will be done based on the setup?
Indirectly yes, because the information that is retrieved from BIM 360 is based on the setup, so if there is general setup the exported files could be merged to reach a better insight. However, for TBI a general setup can be generated only up to a certain level.
Prompt- So the analytics are based on string analysis?
No, it is not that advanced yet, it is based on the setup and the predefined issues types, this is in order to avoid mismatches. That is why it is recommended to define the types and issues well because otherwise users would not take the time to think about it and they will fill it with random options; even though this part influences the reports with real-life data.

Others

1. Is there a better tool in the near future?

Yes, every day work takes place on the development of new tools and improving the existing ones, but it is true that many applications or tools have different characteristics, otherwise everyone would be using just BIM 360.

2. Will there be big updates which require that the users follow training?

Yes, currently there is a parallel track seeking to develop the next generation of BIM 360, this development started from scratch using the knowledge and lessons learned from the implementation in the different companies and projects. In this process the ideas and the feedback are also considered that come from the insider program. However, this will be a completely new solution, it won't be possible to merge it with the old technology. So its implementation will be for new projects but not for projects in execution.

Prompt- Then, how can it suit other tools and technologies, not only Autodesk (for example Relatics)?

The suitability and communication with other types of software/programs are based on Forge software that is supported by API (application programming interface) which defines ways of communication between software and allows an easier development of programs. The use of Forge allows the use of functionalities of products without disrupting them, this open platform is suitable with tools such as Relatics, and Share Point among others.

3. Do you have further input or suggestions?

No

Interview subject 2 - TP

Personal information

Current position in the company: BIM 360 consultant

Education & working experience: Master in Architecture. Worked as architect for 12 years – expert in BIM – Consultant of BIM360

1. What aim of BIM 360 does Autodesk tools seek to fulfil?

BIM 360 portfolio has a wide range of different applications. But specifically BIM 360 Field and Glue are the connection between office and site. They will support having all the checklists you want on site, all the drawings, all the models. It is the administration on the building site all on an iPad. BIM 360 Glue preparation of the models is for clash detection and collaboration in the cloud, so the whole portfolio with the different applications is cloud-based and connects everybody in the team, and also the construction site to the office, and with other parties you are working with.

Type of information and knowledge that is produced during the execution phase of construction projects and its use

1. Can you tell me about the type of information and knowledge that is expected to be produced during the execution phase of construction projects?

The main part of information expected to be gathered is quality checklists and clash control

Prompt- How is the report of incidents resulting from the quality checks and other inspections included in the information?

In Glue this is clash detection and in Field these are the issues, so you have different issues and quality checks and the formal checklist. The thing with Field is that all the check issues are related, at best to a model or to objects in the drawings or the database. Therefore, if you expand BIM 360 Field to its full extension you will have all your issues and checklists related to BIM objects that you can just select and modify on the iPad. For instance, when you select a door on the iPad, and it has been installed correctly you see all the details of the door but you can also see all the checklists of the doors, all the drawings, and all the photographs that were taken during the construction period, and you can see all the issues that are related to that one object.

2. How can this information be used and retrieved from the system?

The whole cloud experience of BIM 360 is connected to Revit or Navisworks, so once you have an issue in the model on the iPad it will sync to the cloud, and you are able to download those issues, incidents, checklists, etc., into Revit or Navisworks. For example, when you have a door that is on the building site: once it has been delivered you can say that the status is no longer being engineered but that it is on site. In Navisworks you can have those updates shown in the model, but you can also see how many issues are still open or what data has changed for this door; this is all related in Navisworks so you can get a new file or you can even retrieve it to your Revit model. For drawings and checklists you can do a download, you can make a report, you can do a raw download if you like. It is cloud-based, so it would be best to keep it in the cloud, but if you like you can just get a csv file exported or create a report on anything. Because you still want to communicate with subcontractors, the type of workflow remains where subcontractors do not have an iPad or are not able to get internet connection on the building site. This means, like the Boston and Seattle project the manager still want the reports as a PDF or as an email. And even though the tool is cloud-based and it would be better if all subcontractors used it on iPad we are still able to just create a report and hand it over to the subcontractors.

Prompt – If they want to use this information for coming projects, how can they retrieve and analyze the information?

You can see the environment for Boston and Seattle and there is a dash board, where I can see how many issues are still open and how many have been closed, and see how long it takes the subcontractors to close the issues. You can see that we managed to create different reports almost every day, so they can get the reports that they want almost every day. I can create reports from all different kind of things: the checklists or the daily updates, and different objects. I am also able to create reports in the total account, so because I am the account manager for this environment, I can create a report that is not only for this project but that has an overview of all the projects. So, with the standardization of the implementation of BIM 360 Field JPvE decided to have all the different types of issues standardized. Each project has issues, and you can see the different characteristics including the type; this type should be the same in all projects. If they find an issue on the iPad they have a specific list they can choose from which is a small list of only seven or eight issues. But because we have this same list in all the projects we are able to get a report on an issue from all the projects, which means we can analyze and have insight in what is going wrong in projects. If something caused by the same subcontractor all the time, or maybe you do not see the contractor mentioned often or at all in the reports of an issue. This gives you a complete overview of all the projects, it is possible to make a cross project analysis.

Prompt – Based on the standardized lists that you mentioned, Is it possible to implement a specific specialty field, such as A/C or concrete?

Yes, that is possible, we can create extra parameters which can be filled in. I can choose and I can change what things I want to see, like for example when is it uploaded, the method and route course among others, thus, now I have a lot or at least some more information. You can see that 'he, just use a push pin', that it was a normal issue, and that it was created based on the template of the issues. I can just add the parameter if I want. That would be an extra parameter to analyze. We also did a complete report of different projects, what we wanted was a complete download, a csv download, from this account and put it into Microsoft BI,

And it was very nice to see how many different issues they have, how many different subcontractors they have. So, you can relate everything to the business intelligence if you like.

3. How do you think that this information should be organized to be able to use it/have a better feedback?

Yes, what I just saw, the complete data base, has not been completely standardized yet. Everybody is doing it in a different way, so I think that is one of the next steps they have to take. A better standardization in the organization, and it will be much more structured than it is even now. For pushpins, I have to open the issue, because the information in the report does not tell me enough. But in the iPad the interface is cleaner than in the computer. If it is just an Excel you miss information such as pictures and pushpin.

Mainly to improve it is necessary to complete the standardization.

Prompt – For high management, that receive issues with pictures, but they don't know exactly the problem or the location. Do you think there is a way to improve that?

Yes, that can be improved, must probably with the necessary training. Because as you can see, when you create an incident you can place the pushpin but it is missing in different files. So is the way they hand over the information to the managers, that they do not relate it to a specific location or specific floor, and then they miss this information, even though the information is available. It is a matter on how the information is handed over to the manager because the information is there.

That is a lack of training. The way the report is created and presented to the managers, can be standardized or customized in every report.

Prompt – Right now the pushpin is located in 2D. What is lacking for the implementation of the 3D model?

You are able to use the pushpin in 3D models, but Boston and Seattle were not ready yet. We saw that in almost all of the projects. Also we saw it with EPO, it was only used for clarification on the job site. We did Amstel Kwartier, they didn't have the 3D model yet. I thinks that's the next step they have to take, to have the 3D model. You are able to extract all the information from the 3D model and in Field you can put the pushpins in the 3D model, but it is the question: you have to decide whether you want to use the pushpins in 2D or 3D. They don't show in 2D once you add it to 3D. It is just the workflow now. It is easy to use in 2D but it is also easy to use in 3D. But it is not yet a tool that does both and I think they're taking the next steps now that you can extract 2D drawing from the 3D file, once that's possible, then they will have the capability to push in a 3D model and get a 2D drawings out of it. And when you have an object, you can push both file types. At this moment it is not there yet.

Prompt – What can you tell me about the support of a 3D model, because when it is too big, it cannot be opened and it should be divided. How are you coping with this?

Well, it is the first time I hear this, but I think just for the work that you can do with it, it is better if it is divided in different sections or floors. It will just be easier to use if you do it like that. You don't have the problem that people cannot open the model. No, I have a point cloud in my BIM 360 Field with a model of a whole football stadium and I'm able to go to the 3D point cloud. So, it is more dependent on the iPad you have and its capabilities.

Process of implementation and deployment of the used tools.

1. How was the process of implementation carried out?

We started with two pilots almost 2 years ago. We started with EPO and Amstel Kwartier pilot, and before we knew it we were starting more projects with the tool, before JPvE saw its potential. After a year they decided, well this is clearly very good for us, so why not do the standardization of BIM 360 Field for all of the TBI organizations. We started it with different contractors, Era Contour, JPvE, Hazenberg, also Croonwolter&dros, so all the different companies from TBI were involved and we tried to set up a standard, and after that, after 3 days of training, we tried to get the implementation started. The idea was to have utility companies and housing companies together. It started with just one project, to do the implementation for all the different projects in just the same way, so they know from each other how they did it and why they did it and all that kind of stuff. Well, that didn't work. It lacked TBI organization; they just waited for projects to come by and then called us. 'OK, we have a project now and we can start with the implementation'. Instead of getting one project with all the different companies or maybe two projects with all the different companies, we started as CAD & company and as Autodesk, we started with just one pilot project for all the different companies and we made it successful. But, JPvE already had an advantage the moment we started. This was because of the implementation manager, he was part of the implementation team, but I had already done three projects with him. So, the standardized implementation for him was already completed and maybe that is something that wasn't clear then, but it is clear now how they evolved in this kind of process; the implementation manager is very advanced with BIM360. I wish it was a completely clear process, we really tried but when you're working with such different companies; they are always waiting for projects to come along where they can use BIM 360 Field. It just went different than it was supposed to.

Prompt-What was the process of implementation specifically in JPvE?
We had a kick-off. Or rather we had two kick-offs with JPvE, because JPvE was the pilot project with EPO and Hotel Kwartier. And a year later we did it again, but that was much easier because the current implementation manager had already joined them, and he knew a lot of things. After the kick-off meeting we set schedules, we did some training with them and they just went off. I communicated with the implementation manager almost every month, he raised the issues that he couldn't resolve. So, the implementation was probably three days for EPO, explaining how do you use the checklist, how to complete the checklist, how can you raise issues, how to do the commissioning, and after that we did the training with some different groups who were going to use the iPad and after that it was in the hands of the implementation manager who was the BIM 360 engineer over there.
Prompt- You mentioned that they had the same vision. Then, what was their vision, what were they aiming at with the implementation of BIM 360.
They all implemented it because the TBI organization told them to do so. TBI has an enterprise business agreement (EBA) and they thought, when we have the tools everyone has to use them. It was right because everybody has another solution for this kind of work on the job site. They already had a Dutch competitor in the system, so I had to convince all the different companies to get started with BIM 360 because it was TBI standard, or it is TBI standard at this moment, and they were supported by Autodesk and Cad & Company to get it into their systems.
Prompt- TBI had a specific aim to contract this EBA? Which problem they were aiming to solve?
The main goal for TBI when we started was getting BIM onto the job site, with the other systems that are in the Netherlands, the other competitors, such as Snagstream or ED controls; they are all 2D based and not BIM based, and that was the main goal for TBI to start with BIM 360 Field. Because it really works with BIM, and you can really get better quality models, building is better because you have the quality checks on the work site.
2. What was the expected result of the implementation of this method/tool? 3. What was the actual result of this implementation phase?
The main goal of TBI was to get BIM on the job site and get the use of the iPads on site. We managed this goal because after 3 months we already placed more than 200 iPads in the TBI company. That was the main goal really for the first implementation.
Did you receive feedback from the company?
Constant communication with the implementation manager
4. How were the performance of the tool and the achieved objectives monitored after the implementation?
It was out of my hands because Autodesk now has the Dutch Autodesk BIM 360 consultant. He is the guy that monitors the usage now, and he is the one that can say if it is going to be a success or not. Nevertheless, I still communicate and have formal meetings with the different implementation engineers in the TBI's companies
Prompt- How do you approach the feedback and requests that they raise?
Most of the time I give them the answer at once and help them with the next steps. And if it is something that is not in the system I will get it into BIM 360 Field, see whether they can resolve it or not. Now, that is also more the responsibility of the Autodesk consultant. With the initiator from Kennislab we tried to setup a monthly meeting to set up those issues raised in the team, and to see when Autodesk can resolve it. But we only had one meeting and after

that there was a lack of communication because the initiator from Kennislab left the company, so now it is in the hands of someone else, to start up those meeting again.

Others

1. Is there a better tool or an improvement of this tool in the near future?

In the coming years the tool will be better and better, they are working now in the 2.0 version, with JPvE we are still working with the first version on the environment. At the end of this year or maybe next summer we are expecting the first 2.0 version of BIM 360 Field and it will have a much better connection with all those different kind of applications. So I was talking about BIM 360 Glue, BIM 360 Field, BIM 360 docs, but by the end of the year it will be just one application. It will have all of these different things in it. So they are now working with a system that is more user based. Now, the role and permissions you'll have, they will make it into more of an experience where the user just walks around the building site and he will get the information that he needs at that moment, immediately and automatically, so if he needs to fill a checklist in a specific room the iPad will notify him: you are near this room, why don't you use this check-list. That is what I saw but I don't know if that will all be part of the system. But it is the idea of the future

2. Will there be big updates which require that the users follow training?

No, I think it will be a much more friendly way to use this application. At the moment it could be a struggle to use it, because it has a lot of functionality with a lot of buttons, and a lot of checks or things you have to fill in. I think the future might be friendlier to use.

3. Do you have suggestions regarding this topic?

He showed the example of a 3D model and everything that can be seen. This is something that is not yet in use at JPvE.

Prompt – This could give feedback to engineering or architecture – design?

Yes. This is more BIM related that they are using it now. Right now they are just using 2D Base, maybe they put the mode in just to view it, but this is the next step. How can I use the model, how can I record/report this, how can I map this information to my model and back again.

Prompt – What type of requirements are needed in the model?

It doesn't need anything specific. It would be the best if it has classification or categorization for the Dutch code related to the different objects, because the model should be prepared and have a mapping. I have the database of the model and I'm going to divide the database into different subjects, so I can easily filter it.

Prompt – In what should the mapping be based?

It should be Dutch standards or directives. We are able to do it in IFC but it is better in Revit. It would be awesome if it's right from the start of the design but I know this is not the way it will be in practice; but that would be the best way to do it.

Prompt - Integration between BIM 360 and other programs. How is that migration from other programs to BIM 360?

You can compare it to Share Point, to the BI environment of Microsoft. It depends on what the client wants. I think it should be compatible with everything.

Do you have further input or suggestions?

You have quite a clear understanding about how we did this, the implementation was not 100% clear also due to the size of TBI and how we manage to do it. I think is time for the next step with JPvE to start the implementation of the real BIM objects.

Interview subject 3 - TT

*In this interview it is important to clarify that it was held in two sessions: one was an informal meeting which brought important information and the second was an appointed interview. Below the summary of the first meeting will be presented and the transcription of the interview in that order.

Personal information

Current position in the company: BIM Director
Education & working experience: Building Engineering – HTS (HBO) – / Architecture – TU Delft

Meeting

The adoption of BIM 360 was inspired by the need to do quality checks. Its main aim was to collect the information by assigning issues to specific elements in the model which could later be approached. To adopt BIM 360, a construction work inspection plan (checklists) was developed according to the requirements that should be supervised, and it was included in the program. It was considered a quick win in BIM 360, it was the summary of the gathering of information from different sources in just one place, therefore, the drawings, documentation and others could be summarized by having just one document in BIM 360, which contained the required documentation, pictures and reference to a specific element in the model. Additionally, BIM 360 was an easy solution to solve the issue of poor feedback to engineering. Since communication is just in one direction, from engineering to construction, some information and feedback tends to get lost. The process takes place based on the owner's requirements that are known by the engineering department. These requirements are materialized in the technical design and are sent to the construction site. On the construction site, the drawings are received nevertheless, the requirements are unknown, and in this way is not clear on site whether or not they are complying with the requirements. This issue could be approached by pinning issues in the model where engineering could see the problems, in other words, it can be a way of giving feedback to engineering. However, BIM Glue, the tool which supports the incorporation of BIM models to complement BIM 360 allowing the use of models, did not have enough capacity to handle the model, it was considered to be "too big". Due to this limitation, the use of the tool has been scaled down to gathering required documentation, pictures and references to 2D drawings, which narrowed its usefulness.

To improve the use of the tool and make it available for everyone there should be a standardization, which could be completed with feedback of missing elements every time they are identified. The set of proposed questions should be more or less generic for the different projects. The way the process works in terms of design, is: first sketch, secondly create preliminary design and lastly create final design. To reach this point there is a set of requirements with which a functional design and an architectural design are created. In this process the requirements are above of everything. The process is: Requirements-Design-Engineer-Build. In this process the contractor is accountable for any problem. Yet the company has 1 setting per project, instead of an integral setting which can be used in different settings

In terms of reuse of knowledge: what is used and is very common are information sessions in which a group of 5 people share their experiences, best practices, and lessons learned. These gatherings are done monthly by the planning engineers[6] who approach defined topics.

Specifics Case of study.
Different ways of working between companies (specialties), thus misunderstandings occur. On the one hand a building company methodology is never to assume, hence, once the drawings are received (architecture and providers) a comparison is made and adjustments are requested from the relevant party. On the other hand installation companies hire an advisor who make the drawings and delivers them to the supplier who draws and builds; however, they do not check the initial drawings and compare them with those of the suppliers. A specific case took place in which the suppliers adjusted the drawings (ventilation ducts) to qualify for certification. This lack of revision caused clashes that could have been detected. This should be part of the standardization.

Interview

1. What is the aim of implementing BIM 360 and the other tools you use?

BIM- We shouldn't make models as a contractor but we should direct the people who do and combine them. Make sure that every piece of information is provided in the same way.
Aim of BIM – Tool: to be able to coordinate in a better way that we used to, because it is an integral project. It is very difficult with the steel construction and steel form and it should be integrally coordinated, and the easiest way is to use BIM.
BIM 360 – To use it for the construction work inspection plan. We created a plan to be able to prove to the owner of the building that what we have done is right according to the agreements and the requirements. And as we said earlier this week, we probably do have new contracts for this project according to new standards, in which we are not checked by the owner or another institution, but we should be able to prove that what we do is good and according to plan. So that's why we implemented BIM Field, because we have to prove that we are doing the right things.

Type of information and knowledge that is produced during the execution phase of construction projects and its use

1. Can you tell me about the type of information and knowledge that is expected to be produced during the execution phase of construction projects?

We have checklists for every part, we made a System Breakdown Structure (SBS) and a Work Breakdown Structure (WBS), to divide the project in smaller pieces and for every piece we made a checklist; these checklists are placed in BIM 360 Field and for each part we can prove that we have done the things that we have agreed on.
The SBS were set up first in Excel and then in Relatics.

2. How can this information be used?

The information can be used to prove that the quality and requirements are accomplished.

[6] Werkvoorbereider was the word used. It is Dutch word that can be translated as planning engineer, work preparator engineer, job preparator or manufacturing engineer.

Prompt – and its use in future projects?
I hope that this information could be used in the future but we got a very specific project (referring to EPO) and specific requirements, and it is the first project, so I doubt it, but I do hope so because it is valuable information.
Prompt – If these tools were implemented in projects of the same type, like Hotel Amstel Kwatier and Amstel Tower, do you think it could be useful for coming projects of the same type?
Yes, I do believe you have to standardize the forms, and if we do it in a correct way, the data provided is always the same and you can easily compare it throughout the projects and you can easily spot trends and things that always go wrong and improve them. That is very valuable information and if we do it correctly we can even show in future tenders that we are able to work with a certain quality because we got the numbers from BIM field
3. How do you think that this information should be organized to be able to use it?
This information should be standardized in the forms to it can be retrieved and compared.

Used methods and tools to collect this information and knowledge
1. What are the methods and tools used in the company to collect these information and knowledge? - Why do you think these methods and tools are suitable/unsuitable for the collection and use of this information and knowledge?
Currently BIM, BIM 360, Relatics. For the quality checks we started with programs that are comparable with BIM 360, such as Snagit and Ed controls, which everybody thought were easier to use, but we do believe that BIM 360 field has a better future, it is better for all projects and data management, it is better to implement
Prompt – Was it easy the transition between tools (Snagit/Ed controls and BIM 360).
No. We just started BIM 360 and said: this is what we're going to work with and the other things have to be eliminated from site; but we were concerned about the change, it is always scary. We got resistance from people saying 'it is not easier to use, it is more difficult to use' and they have to learn a new program again. The upside for a lot of people was that they got an iPad to work with, so they were happy anyway, but the document manager and the quality controllers were very enthusiastic because they use to collect all types of information and make one document out of it, so they have to rearrange the information they collect. But with BIM 360 it was already in one place, and that makes things a lot easier.

Process of implementation and deployment of the used tools.
1. How was the process of implementation carried out?
We started with the Kennislab, they recommended the use of BIM 360 Field for this project, and we spoke with CAD & Company (organization that provided us with the software and gave some support on using the software) and we got a small training on how to use it and we realized that it's not per se a BIM item but more a quality control item. So we got the current implementation manager on board, who was very positive about implementing BIM 360 Field, he made all the checklists, and then we started with, I think, two guys that work on site to use it. So they got a small training and an iPad, and they were positive about it. Then we got from the installation two guys that could implement it.

2. What was the expected result of the implementation of this method/tool? / 3. What was the actual result of this implementation phase?
We expected first of all quality checks but we also thought that it was easy that if you go on site and you see something that is wrong you can make a photo and upload it to BIM 360 Field, but I think that is not being used right now. So that's a point for improvement I think
4. After the implementation was there a "help desk" to solve doubts and problems of the users?
The implementation manager took it from there because we couldn't upload the model (inside BIM 360), so for me that was basically it. Because it couldn't provide anything from the drawings.
5. During the implementation did you monitor the performance of the tool and the achieved objectives after the implementation?
Well, that was about the point that I stopped working with it. That was the time were the model couldn't be implemented. So that's a question for the implementation manager.
Prompt – Based on this problem did you give any feedback to Autodesk?
Yes, because the models we make were too big for Glue. The way to implement a model in BIM 360 Field is through Glue. We work with Revit and you need to make an export to BIM360 Glue, and then make those exports re-available on BIM 360 Field, but the models were too big to be used in Glue. That was a really big problem and that's why we couldn't get it to work in the project. To implement the model into the BIM 360 field we have notified Autodesk and I do believe they improved Glue in a way that makes it possible to upload bigger projects but I haven't tested it yet.
Prompt – For further issues at the beginning of the implementation, when you received feedback, did you give any feedback to Autodesk or TBI Kennislab?
Yes, we did come together sometimes with Autodesk and CAD & Company, but not the Kennislab, because they were like always too busy with new stuff.
Prompt – Did they give partial solutions, such as split the model?
Yes, but we already did it, we already split the model in parts, but we couldn't split it any further.
Prompt – Taking into account that part of the success of the implementation are the users, what was their reaction besides aversion of learning new tool?
The document manager was very positive, because she got one document every time to check and not several documents with attachments. So for her, it was a step in the right direction. And the guys on site, they were positive about not having to bring all kinds of documents to the site when they have to check something. They didn't have to carry any drawings anymore and they didn't have to have several checklists and fill in them by hand, so that was also positive. The negatives were, all of it is in English (referring to BIM 360 interface), but we just said: it is an international job that we're doing, it is the European Patent Office, so a lot of things have to be in English, but we also made the questions bilingual, both in English and Dutch, to make it easier on them, and basically people got used to it. They were really open, or at least that is what they say to me. That is always the question, what they are saying and what they are really thinking.

Others
1. Do you have a plan to follow in case there are new versions and updates of the tools?
I don't think that there are any plans right now, but I do think it is something we should explore more. But it's just another thing in the list.

2. Do you have suggestions regarding this topic?

No, I don't have anything to add I think. Maybe that we manage to get someone from Autodesk, Marc Moran, he was really good, he had the knowledge and he could explain how things work and what it would mean for us.

Interview subject 4 - TT[7]

Personal information

Education & working experience	14yr – Business Administration
Current function	Engineer integral building processes Implementation manager BIM 360 Field

1. What is the aim of implementing BIM 360 and the other tools you use?

The main goals for implementing Field are:
- *To make life of the construction managers easier*
- *To ensure a good file of the verification of the realization*
- *To communicate better and easier*

We started with the TBI Kennislab, they had a business agreement with Autodesk, an enterprise agreement, and in their package the BIM 360 tools, BIM 360 Glue, and BIM 360 Field were included, and we can use Field to filter the knowledge from TBI's companies. They started to implement it in various projects as a pilot but it was not arranged on a company level, they just provided some iPads to several of the projects and said to work with it, without a real structured plan. So, EPO was one of those projects, and after a while we saw that the implementation was successful, but it needed some guidance. So they asked me for the implementation in the whole company, to be the implementation manager. Alongside with the implementation in TBI and the departments inside the companies.

What I heard is that the main goal was to make the life of the construction managers [8]easier, make the workflow simpler. They have to complete the verification in the organization, by filling in the checklist in a good and structured manner in order to provide reliable information and to communicate better and easier. There were more sub-goals but those are the main three goals.

Prompt – Within this communication is included the circulation of the information back to the office, including engineering and design?

Yes, that is the new goal, you need to define new workflows for that, because the implementation has levels in the application, we started with one or two functionalities and you start to grow, we are not beginners anymore, we are medium users, on an organizational level we know we can collect information from project processes and installations, we need to gather information from various projects. I think maybe next year we will have information that comes from various projects and can be use in new projects, so one step at a time.

Type of information and knowledge that is produced during the execution phase of construction projects and its use

1. Can you tell me about the type of information and knowledge that is expected to be produced during the execution phase of construction projects?

Type of information:

[7] The text that is found in cursive letter was given by the interviewee. He used it as a preparation.

[8] Uitvoerders was the word used. It is a Dutch word that can be translated dependent on the context in this case construction manager was used according to the written answers of the interviewee. Nevertheless, in this context it can be better translated as general foreman

- Checklists for verification,
- Issue-management during the Work (Worklist)
- Photo management
- Punch list for handover of the building
Knowledge:
- Project succeeding quality information
- To create a more and better quality sense for construction managers (Construction managers)

2. How can this information be used?

- To create a verification file for the project
- To provide the municipality with data necessary for permits (Wet kwaliteitsborging)
- To provide information for maintenance and guarantee
- To provide information for structural issues of the organization, necessary for the future

3. What can you tell me regarding the use of the aforementioned information in future projects?

This information is very valuable for future projects. However, we are not using this information just yet. Because we are in the starting phase of the implementation (2yr). We expect to use this information in the near future.

You can use it to prevent failure in the future so you can have better contracts with suppliers and subcontractors. Based on the functionalities you can learn how to perform and how to manage projects. And you can identify trends from the information that is being collected in the checklists. I think it is useful, but if you want to do it in a very professional way we have to collect reliable information in various projects. There are many projects now starting and using it and now we can collect this type of information. So that is something for the future for me.

4. How do you think that this information should be organized to be able to use it?

On a company level, at first by the engineering, then project management and then construction managers.

Well I think you should do it on a company level and give time to analyze information and good reporting for managers and then the construction managers. And the BIM 360 gives you a lot of information if you want to, it is possible. And how exactly it works should be put in a plan.

Used methods and tools to collect this information and knowledge

1. What are the methods and tools used in the company to collect these information and knowledge?

For now we are using the project information. We use and download the information of the project-site within BIM 360 Field environment.

BIM 360 Field and Relatics, and Chapoo are the document management programs. Those are all the programs that we are using right now.

Prompt – And you how are you linking them with BM 360 Field?

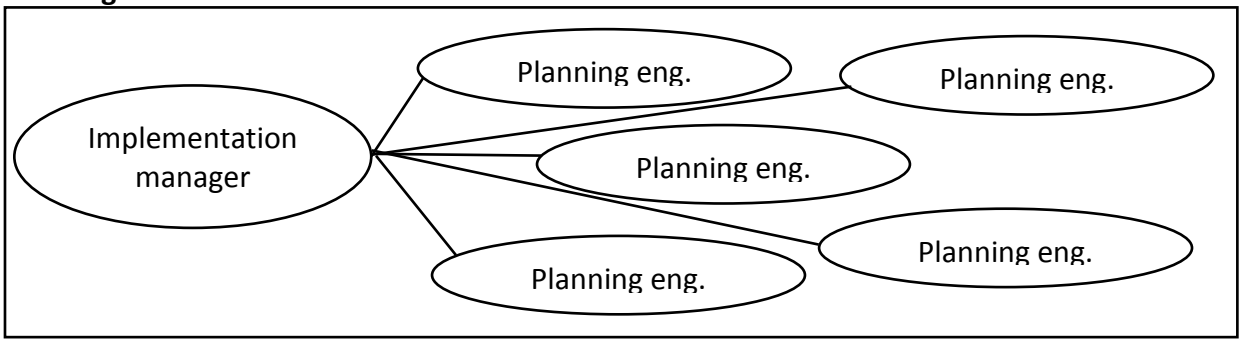
We retrieve the information in PDF from BIM360 Field and we move it into Chapoo. And Chapoo and Relatics are linked. It cannot be analyzed, there is not exchange of information, it is just pdf. Chapoo is just a document management program. What we are looking at is BIM software, I think in the near future we will get the model on the iPad, and link the checklist to the BIM model, to have a better range with the BIM model. BIM software will be connected with BIM Glue.

2. Why do you think these methods and tools are suitable/unsuitable for the collection and use of these information and knowledge?
Yes. BIM 360 is suitable, however, we haven't been able to connect it with the BIM model because it is too large; it cannot be used on the iPad. We tried it but, you have seen the building it is quite big. But there are more possibilities so it is fine. For example I'm on the terminal project, Lelystad Airport terminal, and the project team can use the model with the iPads. Once the design is done, in December when the execution starts the documentation of issues can be done. Within JPvE all the projects work with BIM 360. So the connection to the model is pretty mature, it is the next step.

Process of implementation and deployment of the used tools.
1. How was the process of implementation carried out?
At first TBI Kennislab carried out a number of pilot projects without a company manager. After a while it was clear that the projects needed guidance and structure. I was asked for the position of implementation manager for JPvE.
When a project starts elaborate with the Project manager and the construction manager for implementing the project:
- Arrange iPads
- Create a project in the digital environment
- Help set up the project
- Train the project team
- Train the project administrator
- Be a service desk for projects

The main goal is that project teams learn and find out themselves, with a decent kick start.

So there is an organization where they can learn it themselves and when they don't know or understand something they can come to me, through the administrators (planning engineer).
Prompt – So the planning engineers are the ones in charge of explaining the people on construction site, the final users, how to use it?
Drawing.



Yes, I'm in charge of explaining to the tools, what is the basis, what can it do, how you can use it, and then the administrators knows everything and then they go on site and they set up the new projects. This application is not that difficult to use, it is practical, it is not very difficult to learn it yourself. That is our main strategy so we don't have to train one by one, but you just say 'work with it and if there is something you don't understand then come and ask me.' You find it out yourself.

Prompt-And how was the acceptance?
It is a conservative company, with defined standards and working methods, and everything new is not easily acceptable, but I know a lot of people with whom I can speak about this, and they have influence. And if I can make them test and I can show them and let them discover the success of the application, then they will help with broadening of the setup.
Prompt - Back to the checklists of the issues you are the one on doing the checklists? What are they based on?
I make sure that the database of the enterprise environment for JPvE is filled with standard checklists. So all the checklists are in the quality management systems and BIM 360, for the projects that need to use them can put it in the specific project environment, and then they can use those checklists. At the end the construction managers generate the selection of the checklists they need.
I arrange the database for the whole company and then I together with the administrator of the projects we set up their project and then they can arrange further the project. My main goal is for them to use it on a professional level and produce valuable information but they choose what they need during the execution.
Prompt - Regarding the issues that you say you want to start gathering. Are you planning on implementing standard issues?
No, I don't believe in standard issues. Standard issues are not reliable, because every issue is different, if you give people standard issues, they are not thinking and filling exactly what it was. If you want a project to gather information, you have to manage the structure in the issues and that is a thing that we want to create, create a System Breakdown Structure (SBS) coding in Open Source Meets Business (OSMB) and then assign an issues to one of the codes. For example you have foundation piles and you have issues, that issue you connect to the drawings and the codes. It is easy to identify an issue with an element.
2. What was the expected result of the implementation of this method/tool?
See question 1
I didn't expect much really. Information knowledge, support of information and verification. My main expected result is the management of information.
Main goal to work with the app is to reach information management. Once you know this, the knowledge that you need from this quality information allows you to create more sense regarding quality to construction managers, and what knowledge is required. Because a construction manager focuses on planning and organization, but now their role is changing and now their involvement in quality management is also increasing.
3. What was the actual result of this implementation phase? / Are you satisfied with the results you have had so far?
We are now at +/- 50% of the goals
Well, yes, I think so, because every project within the new big projects from JPvE is using BIM 360 Field, and also the maintenance projects. It is really successful, and I have accomplished the goals I wanted, which were ambitious so I'm satisfied. I want evaluation, I want implementation in projects issue information, but I have to be patient because if I want to change it I have to be patient and press the right buttons.
4. How were the users involved in the process?
They need to be self-sufficient and learning with the use of the application. The feedback of the users is used to enhance the training of the users. I'm planning evaluation with frequent users sessions this year.

I brought together in a meeting all the pilot projects started by the Kennislab, and I explained what was the situation, and I asked them what the experience was with the tool. I got a lot of feedback and then I started the implementation of a few projects and what sort of questions they have, so they can be as ready as possible for other projects. But it was a critical crowd, because once they start they have a lot of requests as users and Autodesk is a big company. If you give your wishes to them, they are not the fastest company to implement your wishes in the application. That is what has been difficult but there are other application such as Snagit and Ed controls, and they have given presentations about what they can do, and ultimately we have chosen BIM field because it has the advantage of the BIM model, and the other two are not yet there. The idea is that the model will give you a better insight of your project, or at least that is the goal based on the fact that your model has to be on a good level and there is where we find problems, because of the level of development of the BIM model is not always in the level of development that you need on the construction site.

Prompt - How do you manage with the other stakeholders (contractors, subcontractors)?

Here (referring to EPO) it went fine because we are with installation of TBI, Croonwolter&dros. We have a few other project leaders who weren't very enthusiastic. They are not at TBI level, there are not many implementations; I think there are two projects. I created one. I know that in Croonwolter&dros a couple of people have implemented it, but not on a company level, the company is quite big so it is difficult to influence it. They have offices in the whole country, so is harder to do it on a company level; JPvE is just 2 offices so it is easier

5. After the implementation was there a "help desk" to solve doubts and problems of the users?

Yes, I performed this helpdesk. The first person to go to for help is within the project team (administrator)

6. How were the performance of the tool and the achieved objectives monitored after the implementation?

We aren't there yet, we have to develop this in the future

By talking to people, but that is not enough, my goal is to plan evaluation sessions with projects, so they can give feedback on the process of implementation, on their needs so I can increase quality of the implementation. But I have other projects and this BIM 360 is in addition to that, so that's all the time I have to do this.

7. Did you receive feedback from the users? / How did you approach it?

See question 4

I did spoke with people a lot, and I received feedback but it isn't imported in a document/ form report. And is another goal, to create a form to report and include it in the plan for the coming 2 years.

Others

1. Do you have a plan to follow in case there are new versions and updates of the tools?

No, this isn't necessary in my opinion. The application will be simplified.

The way we are going to manage that, is that old projects keep being executed in the old version and new projects in the new version, we give them the whole flow and it starts all over again. The new app, I have seen it and it is easier, I don't think it is going to be hard to implement it, it is better than the old version I think.

2. Do you have suggestions regarding this topic?
Other projects within JPvE
Those two projects (Amstel Tower and Boston & Seattle) where implemented by the Kennislab so they feel they don't have the time to try the tool and start its use. And perhaps the construction manager says ok I'm going to use it, but there is no structure, no instructions. They use it as far as they feel is useful for them, but in those terms they just fill it for the standard, and then they don't have the level of maturity for using this information. It is difficult for them to fill out all the issues. It is a pity but that's the way it goes. It has to be done gradually.
But I think JPvE we're getting there and then it comes the re-treatment and analysis of data
Prompt – From what I have understood it is a good tool but it needs to be developed.
Yes, you have to create workflows for the projects, you have to set up rules, management. But first you have to start with the users using the iPad, and take it outside otherwise they just put it in the desk. You have to let them use it.
Prompt – Are you experimenting with the tool?
No, we already passed the experimenting phase, we are using it in all of our projects, only we let them find it out for themselves and then you have people that adopt it at once and others that need more time to convince themselves. The construction managers are asking for the implementation of BIM 360.

I have a booklet with implementation plan of BIM 360 within JPvE.
You have to think what works to get them engaged, and this is a group that is hard to convince. And I know because I grew up in it, and now I know how they think, and I had to think how to convince them. Then you have to let them experiment it. Just give it and tell them go play with it and then they will discover 'if I do this I find it there. This is a successful method because they are coming to me for the implementation.

The users on site have given good feedback. But we are still not there yet, with a professional structure with processes, schemes in system, so we can't still get data from them.
Prompt - How do you connect subcontractors apart from TBI with this tool?
We are asking it in the contracts, so they have to use it. But this still is a learning phase, and the subcontractors also have to learn. Is a continuously developing story, and it is growing.
Prompt - You are also giving the support to them?
Yes, but I don't receive many questions, because my connections are the administrators then they train them and when they don't know something, then they come and ask me. And if I don't know something I go to Autodesk or CAD&Co.

Appendix D Observation Session notes

Explanation and insight of the tool
The tool is used to document and show quality control through the identification of issues, and follow up until the issues are closed. One of the main uses of the tool is communication. The tool provides connection and communication between disciplines.

The use of checklists is a mechanism used with the involvement of subcontractors. These checklists are filled in by the subcontractors in a specific format. After this documentation is revised it is used to fill the different checks and requirements in BIM 360 Field. Furthermore, the documentation of issues can be done from the checklists filled by the subcontractors, or can be made from site visits undertaken by the responsible people.

Regarding issues, BIM 360 Field is a tool that helps documenting and communicating issues taking place on site. Information can be retrieved from the tool from which a general overview is generated of the state of the issues and it can be shown to the subcontractors (He showed the excel files, with which the information is analyzed and presented to the subcontractors, exposing the state of the issues). Once the user can access the platform and has access to more than one project revision about a current problem can be accessed to see how it was addressed (He has no access to other projects, so he could not show me). Finally, the idea of using information in future projects would be helpful, that is a good idea.

The implementation of the tool for the users was based on a broad explanation of the tool and its functions, however, it wasn't clearly explained what was the aim of the tool, what was expected from their "testing" of the tool and experience. The tool was given for experimentation.

In terms of usability the image of BIM 360 is not nice, for some of the users it is too much, not organized and a lot of small print. ED controls is more organized. Additionally it takes a lot of time to load. Furthermore the computer layout is not user friendly and could be improved.

Observation
In this observation session the use of the tool was shown by documenting issues found on site. The following issues were documented

Issue 1 - Void below ceiling height.
A void for a pipe in a wall is found to be lower than the ceiling, it is reported by the person responsible that notices it. He chose as specialty mechanical. This mistake could happen because of coordination and drawings. This is supposed to be discovered in the clash detection session. Another mechanism to check the correctness is through the person that signs the drawings. Once an issue has been uploaded it can be checked in the database of the project (filtered), and it could be related with other similar issues. Afterwards, the issue is closed, either because it will be redesigned or because it has been fixed. Only the administrator or commissioning person or the person responsible for checking the state of the issues is allowed to "close" them. Regarding coordination, sometimes it also happens that new plans arrive, but if he doesn't see them or get notified he cannot upload them in the tool, thus he does not have the latest version.

Issue 2 Low placement of fire safety piping in basement.
The case is filed as an issue, description “laag juist?” making reference to whether the height of the piping is correct and according to designs. Additionally a picture is taken, and the location is defined as basement (it is not a specific point but a whole room). Furthermore, the contractor defines it as a revision. Most of the things are already present, only the first three things should be filled. It was noticed by the observer that the description is very simple because it is sent directly to the contractor and asked whether the installation is according to the drawings or not. After this, the state of the issue is open and has to go through the process of revision by the different parties and the corrective actions or reply with justification until the state is changed to close.

The app did not load the complete list of issues and check-lists. The comment that was made by the user referred to the loading of the app that is not always appropriately. Later that day all the issues were seen in the browser at the office. Additionally it was mentioned that the app is slow and that the pinning of issues is not that sensitive. In terms of further development it was mentioned that the 3D model cannot be linked because of the capacity.

Finally it was described that for installations there is a “gadget”- QR code that can be scanned and then automatically shows the location on drawings and information regarding it.

Below pictures will be presented of the instructions for using BIM 360 made by this user for the workers.

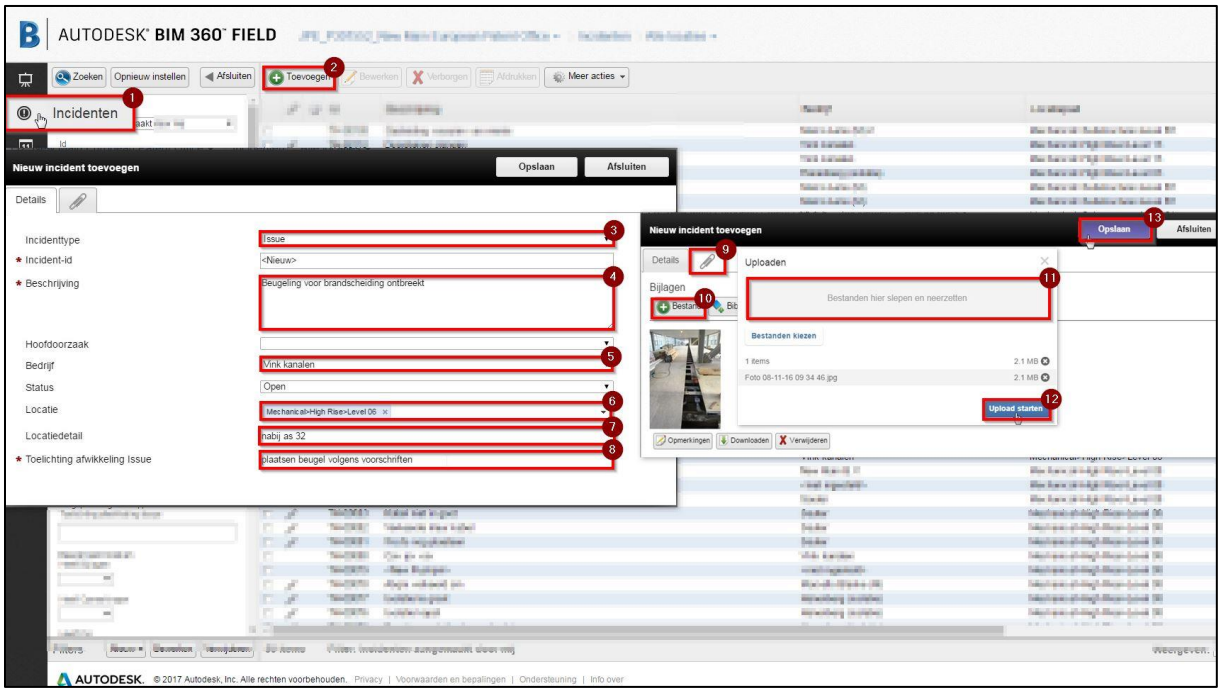


Figure 23. Instructions for entering issues. – Provided by TT (2017)

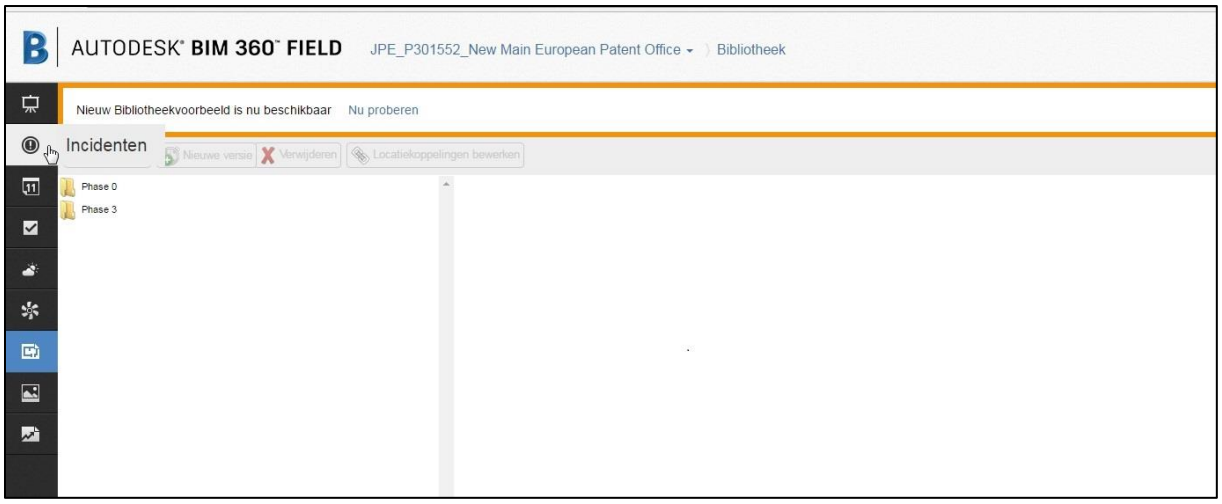


Figure 24. Instructions for entering issues. – Step 1 - Provided by TT (2017)

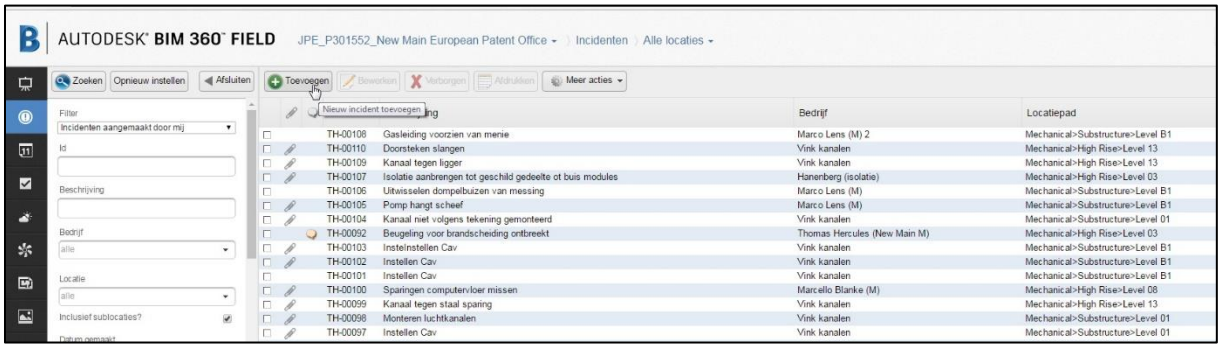


Figure 25. Instructions for entering issues. – Step 2 - Provided by TT (2017)

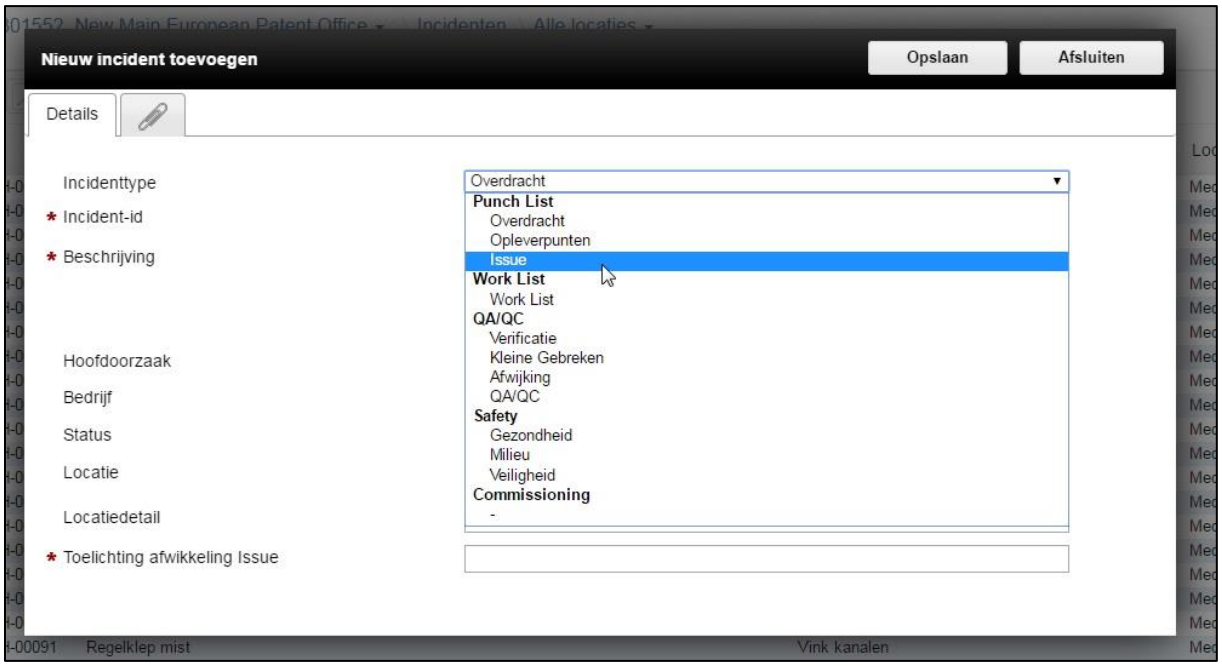


Figure 26. Instructions for entering issues. – Step 3 - Provided by TT (2017)

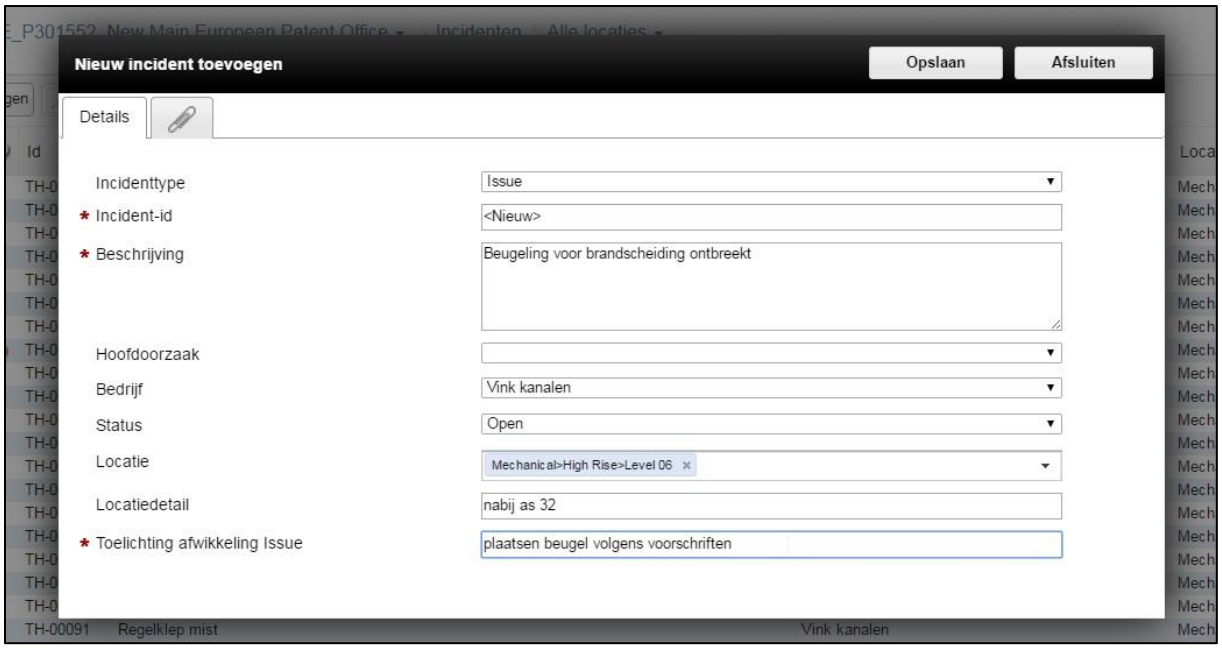


Figure 27. Instructions for entering issues. – Step 4 - Provided by TT (2017)

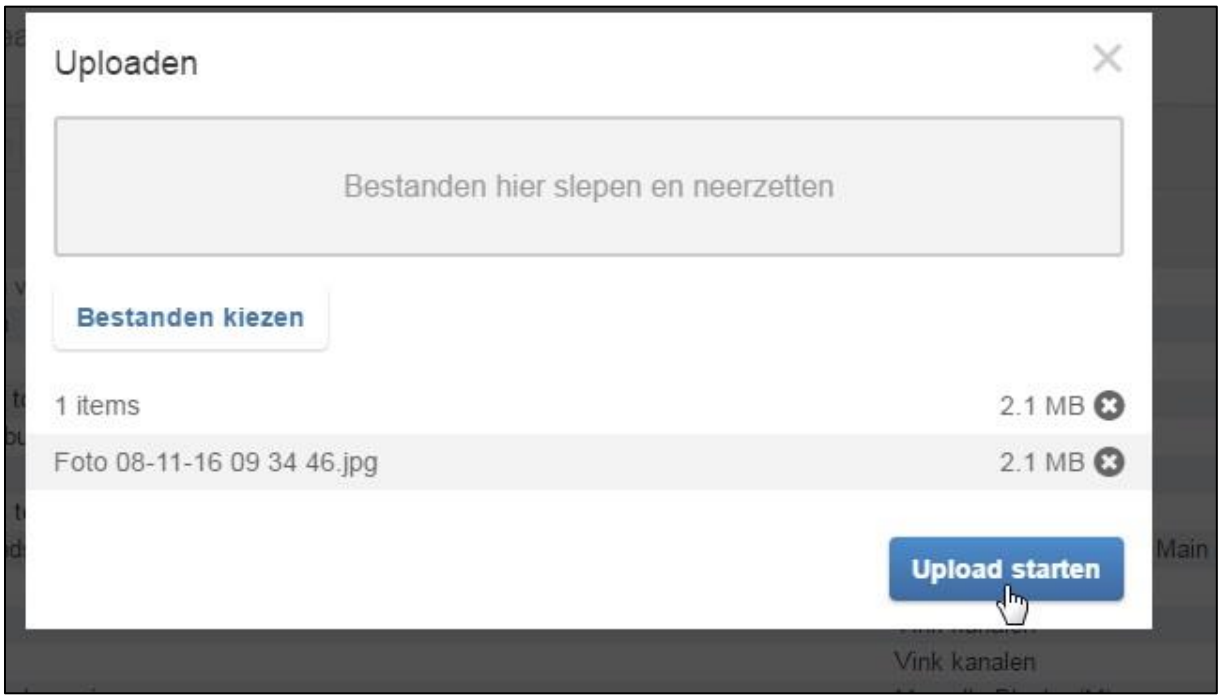


Figure 28. Instructions for entering issues. – Step 5 - Provided by TT (2017)

Figure 29. Instructions for entering issues. – Step 6 - Provided by TT (2017)

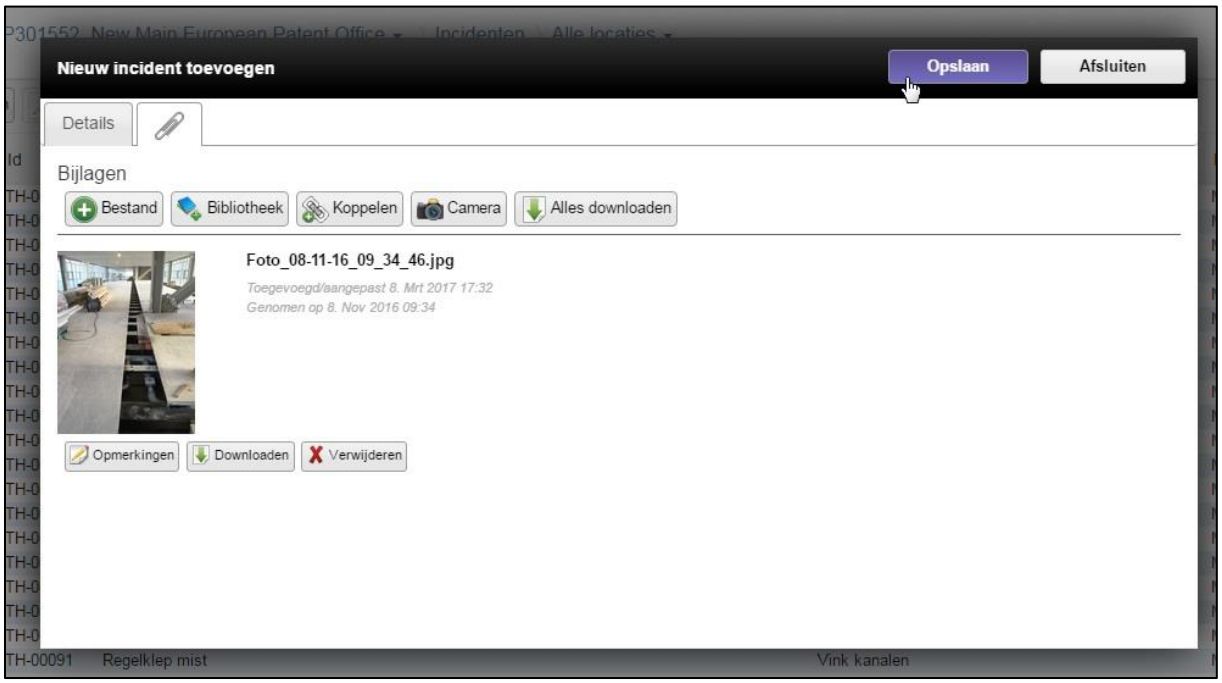


Figure 30. Instructions for entering issues. – Step 7 - Provided by TT (2017)

Appendix E Interviews and Observation – Data Representation

TP Results

Table 13. TP – Data Representation

Topic	TP
Autodesk BIM 360 aim and aim of its adoption	**BIM 360 AIM** - Coordination purpose. - Cloud-based applications to connect everybody in the team - Cloud-based applications to connect construction site to the office, and other stakeholders - BIM 360 Field and Glue are the connection between the office and the site. - BIM 360 Glue - Coordination tool used during the design process - Clash detection - BIM 360 Field - Site management tool - Administration on an iPad (checklists, drawings, models etc.)
	TBI AIM - BIM 360 ADOPTION -Enterprise business agreement (EBA) to set a standard -As an organization – Goal - get BIM into the construction site. - improve building through quality checks on site
Knowledge/ Information Produced on construction site- execution phase	**KNOWLEGE / INFORMATION** - BIM 360 Field based on a determined and organized initial setup - BIM 360 can be used for - issue management - pictures, description, location, responsibilities, etc. - check-lists - review based on quality and safety parameters - drawings and models - put them on site and will give the same data to everyone - commissioning and handover - information about entries, giving insight about elements and their current state - reporting - Reports based on the setup and different entries. - Gives a basis to learn from the issues and complement the initial setup aiming to get the required information
	ANALYTICS - The analytics are based on the initial setup of BIM 360 - In TBI a general setup can be generated until a certain level - BIM 360 - dashboards that can be used. In this interface it can be seen a project overview regarding the issues that are created. - Custom made dashboards - analysis at a higher level (the programmer is needed if new requirements need to be included and/or fix issues) - Recommendation - retrieve the information and manage it with power Business Intelligence (BI) that can support further analytics.
	FUTURE USE -BIM 360 dash board can be used to check statistics. - Create overall projects report - cross-project analysis - Evaluation of performance based on the linkage of projects by type of issue - broader insight of what happened with a project. -Needed for a better development and use of the information - Complete standardization of the database and lists created in the

	setup. - It is possible to use push pin in 3D instead of 2D
Current used methods and tools for Knowledge capture	**BIM 360** -BIM 360 Glue -Mediator between Revit and BIM 360 Field -BIM 360 Field - Issue and quality checks related to a model or objects in the drawings contained in the database. -The setup of the tool is important so people can work with it in line with the company's requirements -2 ways of using BIM 360 Field - Upload the model directly to BIM 360 Field without properties - Use BIM 360 Glue allowing the extraction of data. However, 3D models should be split due to the capacity of Revit and device. A well-implemented process in design will contribute for this use, with models with correct information for later stages. - Method mainly used in commissioning
Implementation and deployment	**GENERAL PROCESS** -Processes of implementation and deployment - iterative process that is fed by the feedback received in the projects, and is adapted according to that feedback, unless faults are too big. -First part of the implementation - based on the setup of BIM 360 Field, setup of guidelines for deployment. - Trainee-trainer process - training of small groups who will themselves become trainers. -The groups stay in contact with the consultant to solve pain points
	TBI -In TBI it is difficult to generate a master setup due to the different specialties within the companies. -Deployment carried out with teams of more or less 7 members with whom there are regular meetings - The implementation on site is done to show the users how to approach the issues that exist in real-life and how to report them as issues.
	TBI JPvE Pilot Project -Kick off - Set schedules - Carry out the training with the project's team. 3 days - Regular meetings to raise unresolved doubts and situations- Implementation Manager (1 every month) and Kennislab (only 1 meeting was held)
	RESULTS **Expected results** - The main goal of TBI was to get BIM on the job site and get the use of the iPads on site - The expected result from this implementation was a high rate of adoption, this adoption is measured in terms of willingness and actual use and implementation by the site managers **Results**

	-The goal was managed because after 3 months already 200 iPads were in use -This adoption can be checked and monitored through the cloud-base usage of devices.
	Feedback - The feedback is received in the meetings with the Implementation Manager -Solution will depend on the content Usability - content it is not that easily changeable Setup - the collection of data can be revised and what can be improved can be assessed Layout - there was a big problem with the language; this has been solved. Insider program - different organizations are collaborating with their feedback to improve the tools
Others	**FUTURE TOOLS AND IMPROVEMENTS** -The following updates of BIM 360 will require users to follow training, since the tool is being developed from scratch, taking into account feedback coming from the companies (insider program). - Suitability and communication with other types of software/programs is and will be based on Forge software that is supported by API (application programming interface) which defines ways of communication between different software, allowing an easier development of programs.

TT Results

Table 14. TT Data Representation

Topic	TT
Autodesk BIM 360 aim and aim of its adoption	**TBI AIM - BIM ADOPTION** - Coordination of delivered models in order to ensure its coherency and no clashes. **TBI AIM - BIM 360 ADOPTION** -Collect information by assigning issues to specific elements in the model which could later be approached - Fulfil the need to do quality check. -Gather all necessary information and documentation from different sources in just one place (drawings, documents, models, pictures, etc.) -It was an easy solution to solve the issue of poor feedback to engineering -Ease construction managers task (make the workflow simpler) -To ensure a good file of the verification of the realization -To communicate better and easier
Knowledge/ Information Produced on construction site- execution phase	**KNOWLEDGE / INFORMATION** - System break down and work break down structure based on requirements - Checklist for BIM 360 developed based on SBS and WBS -to prove that things have been according to requirements - Information and knowledge that can be produced: Checklists for verification, Issue-management during the Work (Worklist), Photo management, Punch list for handover of the building.
	ANALYTICS The produced information can be used to do a project analysis of succeeding processes and quality information - Create a verification file for the project to -provide permits to the municipality (Wkb) -information for maintenance and guarantee -information for structural issues of the organization, to prevent them in the future.
	FUTURE USE - For future use of information standardization is required to gather the same information in similar projects on an organizational level; first by engineering, then by the project management and construction management. This needs planning and time to be analyzed -Based on similar data cross-project analysis can be done in order to spot trends of wrong processes, actions, etc. to be able to improve - This information can be used for feedback to engineering, design and others. -The information is not being used because the implementation is still in the starting phase **Reuse of information/lessons learned**

	- Monthly information sessions for sharing their experiences, best practices, and lessons learned (groups of 5).
	OTHERS - Standardization of issues should be done through management of the structure in the issue with the creation codes based on a System Breakdown Structure and then assign the issues to one of the codes. Then the issues will be assigned to the drawing with the established code, therefore it will be easy to identify and issue with an element
Current methods and tools for Knowledge capture	**BIM** -Model and coordination tool The level of development of the BIM model should always be on the level of development that it is needed on the construction site **RELATICS** -Quality Control - list made in Excel and afterwards developed in Relatics **Chapoo** - Document management program **-Document Management** The information is retrieved in pdf from BIM360 Field and it is moved into Chapoo; Chapoo and Relatics are linked. **BIM 360 (Glue and Field)** -**BIM 360** has better future for all projects and data management compared to other software -**BIM 360** was chosen because it has the advantage of the **BIM** model. The idea of the model can give a better insight. Link check-list with 3Dmodel will give a better scope of the projects *However, **BIM 360 Glue**, the tool which supports the incorporation of **BIM** models to complement **BIM 360 Field** allowing the use of models did not have enough capacity to handle the model, due to this limitation, the use of the tool has been scaled down to gathered required documentation, pictures and reference to **2D** drawings, which narrowed its usefulness. -For smaller projects the project team should be able to\ use the model with the iPads
Implementation and deployment	**GENERAL - TBI** - The implementation of BIM 360 started with the implementation by TBI Kennislab and an Enterprise Business Agreement (EBA) with Autodesk. TBI Kennislab started to implement BIM 360 in various projects as a pilot but it was not arranged on a company level. **JP VAN EESTEREN** -In JPvE and EPO as Pilot projects the process also started with the Kennislab; they recommended the use of BIM 360 Field for this project. After speaking with CAD & Company and getting a small course on how to use BIM 360, the realization came that it is not so much a BIM item but more of a quality control item.

	- To adopt BIM 360, a construction work inspection plan was developed (checklists) according to the requirements that should be supervised, and this was included in the program **General Implementation** - Implementation when a project starts – the implementation manager arranges the iPads, creates a project in the digital environment, sets up the project, trains the project administrator and the project team - Setup - created around the needs of the Project manager and the Construction manager - Implementation manager - after implementation = service desk -Structure - Implementation manager - explains to "administrators". Then Administrators are in charge of the setup on site. - Development on site - users learn the basics and can experiment, they need to be self-sufficient and learn with the use of the application and when they do not know or understand something they can ask. **Implementation** -Meeting with the parties involved in the pilot projects started by the Kennislab, the situation was explained and they were asked about their experience with the tool. There was a lot of feedback. - The implementation began in a few projects to see what sort of questions they have, and to be as ready as possible for other projects
	RESULTS **Expected results** - Quality Check - Go on site and report issues (wrong things) about the use of BIM 360 Field and its implementation by the site managers -Expected results for future - work with the app and achieve information management. **Results** - The results of the implementation so far are good because every project part of the new large projects by JPvE are using BIM 360 Field - Monitoring of performance is not formally developed, it is carried out by talking to people, but that is not enough; this must be developed. **Feedback** **From Users** -The feedback from users is used to enhance the training of the users. -The feedback is received from the people but it is not documented in the form of reports. The goal is to plan evaluation sessions with projects, so they can give feedback on the process of implementation and on their needs so the quality of the implementation can be increased.

	-With the knowledge this creates more information can be given to construction managers and what knowledge is required. **To Autodesk** -After the meeting with the pilot projects a lot of requests were listed, it was found that Autodesk is the company that will implement your needs in the application fastest. -We gave feedback to Autodesk regarding the use of 3D models because they were too big for Glue. -Consultants of the implementation recommended splitting the model, but we already split the model in parts. It cannot be split it any further.
	ACCEPTANCE - There was no transition between BIM 360 and other projects. BIM 360 was just started as BIM 360 and it was said that this was what was going to be used and the other things had to be eliminated from site. This created concern because change is always scary - There was resistance from the people but the upside for a lot of people was that they got an iPad to work with - The document manager and the quality controllers were very enthusiastic because with BIM 360 all the information is in one place -JPvE is a conservative company and it has defined standards and working methods, and everything new is not easily acceptable, but once the precise people with whom to speak about this are identified, and they test the tool and discover the success of the application, then they will help with broadening the setup. -The guys on site were positive about not having to bring all kinds of documents to the site when they have to check something. - A downside is that everything is in English. They are working on this - the lists were made bilingual, both in English and Dutch. The users were really open about using BIM 360, or at least is what they said.
Others	**FUTURE TOOLS AND IMPROVEMENTS** -The implementation is not going to be hard and it is better than the old version. -The new application will be simplified so it is not necessary to have plans for updates. - The old projects continue to be in the old version and new projects will be executed in the new version.
	PROCESS IMPROVEMENT - The company has one setting per project, instead of an integral setting which can be used in different settings -Additionally different companies (specialties) use different work methods, thus misunderstandings occur.

TC results

Table 15. TC Data Representation

Topic	TC
Autodesk BIM 360 Aim and Aim of its adoption	**TBI AIM - BIM 360 ADOPTION - Field** - Quality checks - through checklists - Improve communication. - Connection and communication between disciplines.
Knowledge/ Information Produced on construction site-execution phase	**KNOWLEGE/INFORMATION GATHERING WITH THE TOOL** - Quality control through the identification of issues, and follow up until the status of issues is changed to close. - The documentation of issues can be done from the checklists filled by the subcontractors, or the information can be collected on site visits undertaken by the responsible ones
	ANALYTICS - Information can be retrieved from the tool from which a general overview of the status of issues is generated which can be shown to the subcontractors (open/close/in process etc.) - Other projects can be checked (provided you have access to them) if the problem found has happened before and perhaps information on how it was approached
Current used methods and tools for Knowledge capture	**BIM 360** -The issues are pinned in 2D maps because 3D model cannot be linked due to the capacity
Implementation and deployment	**JP VAN EESTEREN - EPO** – Broad explanation of the tool and its functions. - It was not clear what was the aim of the tool, what is expected from their "testing" of the tool and experience. -Tool given for experimenting.
	Results - Documentation and follow up of issues - Communication - It is a faster mean of communication with other parties, and it saves time when sending a report, location or a picture. The other parties get an immediate notification and can reply with a comment
	ACCEPTANCE - The acceptance is good. The users think it is useful. -They are using it according to their understanding and to their benefit
Others	**COMMENTS** - Upload of new plans - new plans should be uploaded, but if the notification for new plans is not timely they cannot be uploaded. -The app does not always load appropriately -It is very slow to load.

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Appendix F Implementation Strategy

Table 16. Implementation Strategy

IMPLEMENTATION STRATEGY

EXTERNAL CONTEXT		
AEC INDUSTRY		
- Strategic/ Market	**▪ Changes in market conditions**	- Change in type of contracts DBM - Client's higher demands
	▪ Increased competition	- Increase in BIM implementation
- Compliance	**▪ Law and regulations**	- EU- Change of the public procurement directive - Netherlands - change of the Quality Assurance Act for the building process

INTERNAL CONTEXT		
TBI - JP VAN EESTEREN		
- Organizational Structure	- Within TBI holding - Stichting	▪ Private company governed by two separate boards directors ▪ Compliance with Dutch corporate governance code ▪ Group council advise - cross-company issues ▪ Achieve company's strategies and goals ▪ Compliance with laws and regulations ▪ Management of Risk
	- Within JP van Eesteren	· Executive Chairman · Director · Finance Director · Project Director · Integral Projects Director · Building, Maintenance and Renovation Director
- Organizational Culture	- Spoken - Documented	**▪ Defined standards and working methods** **▪ Project Management and Execution** ▪ Standard layout work folders and archiving ▪ Inspection Plan, Inspection execution ▪ Purchase requests ▪ Content VGM dossier ▪ Project Specifications, Drawings, Models ▪ Legal Requirements **▪ Insurable risks and liability risks** ▪ Risk Inventory and Assessment ▪ Risk overview **▪ Safety of employees and subcontractors and** Environment awareness ▪ Health, Safety, Environment and Quality (HSEQ) plan
	- Unspoken	▪ Conservative company ▪ Old Fashion

STRATEGY CONTENT		
- Why?	- Need / Implementation (EBA - specifically BIM 360) AIM	**EBA** ▪ Transformation Business- BIM implementation ▪ Widen scope of contracts **BIM 360** ▪ Improve and enhance collaboration ▪ Field management and logistic optimization
- How?	- Objectives	**Long term** **TBI - JP VAN EESTEREN** ▪ Improve cross company integration **JP VAN EESTEREN** ▪ Improve project performance ▪ Improve in future projects No Short term goals
	- Management Participation	▪ No participation found
	- Impact on ongoing and future projects	▪ Only was consider its use on the handover of one project ▪ Assessed urgency to start with new projects

OPERATIONAL PROCESS		
- Planning	- Implementation process	**▪ Plan Activities** ▪ Kick-off meeting ▪ Definition of check-lists ▪ Train Manger -Trainee - Trainer program ▪ Project configuration and setup ▪ Users and Training go live ▪ Follow up and support **▪ Resource Planning** ▪ Software ▪ Computers / iPads ▪ People - Implementation managers, project champions ▪ Means of communication - not planned **▪ Validation of plan** ▪ QSHE -approval of content for safety checks, and agree on categorization of issue types ▪ Project Managers - approval of quality checks **▪ Establish pilot projects** ▪ From JP van Eesteren: Hotel Amstel Kwartier and European Patent Office **▪ Plan Feedback sessions** ▪ Not planned **▪ Assessment of possible reaction and impact = Acceptance** ▪ Was not taken into account
- Resource Allocation	- General	**▪ Time** Kick-off 0.5 day Implementation Estimation 5 days **▪ Financial** ▪ Software, training and technical support :Token flex program BIM 360 427.779tokens ▪ iPads **▪ Means of communication** ▪ Implementation - face to face **▪ Available and Required Skills** ▪ Non assessed
	- People	**▪ Requirements** ▪ People - Implementation managers, project champions - 6-8 people from TBI - follow trainee-trainer program **- Experience in the field** - Who knows Method in the company - Can handle task organization and execution ▪ Time - Implementation managers - Available for next 2 years. And 50% of the labor time **▪ Training** ▪ Develop process standards for project teams- Standard setup ▪ Develop process standards for project level and cross-project reports and dashboards ▪ Implementation manager training ▪ BIM 360 Field implementation - in the cloud ▪ Kick-of meeting- Half day ▪ Project setup and consulting BIM 360 Field ▪ End user training **▪ Incentives** ▪ None
	- Communication	**▪ Message (clear idea about what wanted to be communicated)** ▪ Does not exist
- Control and Feedback	- Assessment of the process	▪ Check in after 30 – 60 and 90 days of use to measure KPIs and make sure goals are achieved - Autodesk Upload of pictures and checklists created - JP Environment awareness

Outcome	
Comparison	Planning vs Execution
Conclusions	Where the objectives achieved?
Satisfaction	Were involved parties satisfied?
Lessons learned	Lessons learned from the implementation process

Appendix G BIS vs RI

Table 17 BS vs RI – Analysis and Outcomes

IMPLEMENTATION STARTEGY CONTENT					Outcome
- Why? - Need / Implementation (EBA - specifically BIM 360) AIM	EBA • Transformation Business- BIM implementation • Widen scope of contracts BIM 360 • Improve and enhance collaboration • Field management and logistic optimization				**Notes** • The aim of widening scope of contracts appears to be only to satisfy clients • General objectives that should be achieved by the implementation in the different companies should be defined in order to match • Management Participation is one of the most important requirements in a successful implementation and deployment
- How? - Management Participation	• No participation found				
- Impact on ongoing and future projects	• Only was consider Its use on the handover of one project • Assessed urgency to start with new projects				
	Plan	**Provider - TP**	**Implementation Team - TT**	**Users - TC**	Comparison Planning vs execution - Understanding All of the parties understood as an objective the improvement of project performance, even though it is expressed in different terms it can be evidenced that the objectives mentioned make reference to performance and the actions taken to improve it. Nevertheless, not all the parties contemplate the same improvements -Similar Objective Improvement • Improve through the use of quality checks • Coordination Purpose - Improve connection and communication between the parties, and between office and site. Gather all the information just in one place -Single/Different Objective Improvement • Take BIM into construction site • Ease construction managers tasks In terms of improve for the future nor the provider nor the users have it present. The only party that contemplates the part of future improvement is the implementation team, who considers collection of feedback based on issues assigned to specific elements in the model and ensure a good documentation of the execution process.
- How? - Objectives	Long term goals TBI - JP VAN EESTEREN • Improve cross company integration JP VAN EESTEREN • Improve project performance • Improve cross company integration future performance No Short term goals	• Improve project performance • Get BIM into construction site • Improving through quality checks • Coordination purpose • Connect project team members • Connect Office and construction site	• Improve project performance • Coordination purpose - all documents and required information in one place • Fulfil need to do Quality check • Ease construction managers tasks • Improve in communication - better and easier • Improve in future projects / future performance • Feedback - Collect information - assigning issues to a specific element in the model • Ensure good file of the information of the execution	• Improve project performance • Quality Checks • Improve communication • Connection and communication between disciplines	

Appendix H Other results TP vs TT vs TC

Table 18. TP vs TT vs TCI – Analysis and Outcomes

OTHERS				Outcome
Topic	**TP**	**TT**	**TC**	
BIM and BIM 360, and Other tools	**IMPLEMENTED TOOLS AND NEW TOOLS** -BIM 360 Glue -Mediator between Revit and BIM 360 Field -BIM 360 Field - Issue and quality checks related to a model or objects in the drawings contained in the database. -The setup of the tool is important so people can work with it in line with the company's requirements -2 ways of using BIM 360 Field - Upload the model directly to BIM 360 Field without properties - Use BIM 360 Glue allowing the extraction of data. However, 3D models should be split due to the capacity of Revit and device. - A well-implemented process in design will contribute for this use, with models with correct information for later stages. - Method mainly used in commissioning	**IMPLEMENTED TOOLS AND NEW TOOLS** BIM-Model and coordination tool The level of development of the BIM model should always be on the level of development that it is needed on the construction site **RELATICS** -Quality Control - list made in Excel and afterwards developed in Relatics **Chapoo** - Document management program **-Document Management** The information is retrieved in pdf from BIM360 Field and it is moved into Chapoo; Chapoo and Relatics are linked. **BIM 360 (Glue and Field)** -**BIM 360** has better future for all projects and data management compared to other software -**BIM 360** was chosen because it has the advantage of the **BIM** model. The idea of the model can give a better insight. Link check-list with 3Dmodel will give a better scope of the projects *However, **BIM 360 Glue**, the tool which supports the incorporation of **BIM** models to complement **BIM 360 Field** allowing the use of models did not have enough capacity to handle the model, due to this limitation, the use of the tool has been scaled down to gathered required documentation, pictures and reference to **2D** drawings, which narrowed its usefulness. -For smaller projects the project team should be able to use the model with the iPads	**IMPLEMENTED TOOLS AND NEW TOOLS** BIM 360 -The issues are pinned in 2D maps because 3D model cannot be linked due to the capacity	**Implemented tools- produced knowledge and its use** For the design and execution of projects it is being use BIM to model and check clashes and Relatics for the establishment of requirements. This requirements and other well defined elements have been setup as check-lists for quality control onsite. This control on site and application of checklists is done supported by BIM 360 Field. From this check-lists can be identified different quality and safety issues that are communicated to the person in charge by means of a message containing the notification with the information in the cloud, namely picture, location pinned on the 2D map and basic description/ basic inquiry of the issue among others. These issues can be also created based on discoveries made onsite during inspections or rounds. As a response to this notification the person responsible gives an answer and the issue is follow up until its state is closed, passing through the phases of open, worked completed, ready to inspect, not approved or in dispute. With this issue report and follow up can be showed the correct execution of the project and the compliance of requirements. The follow up of quality is done on site and the safety is done by the HSEQ department. From the check-lists and the reported issues it can be retrieved different reports that be used to analyze the information. Additional, to BIM, BIM 360 and Relatics it is being used Chapoo that is a document management program. BIM 360 Glue has a low use because it did not supported the big model, however it was evidenced that in smaller projects it can be used.
Produced knowledge and Information and its use	**Produced knowledge and Information, and its use** BIM 360 - BIM 360 Field based on a determined and organized initial setup - BIM 360 can be used for - issue management - pictures, description, location, responsibilities, etc. - check-lists - review based on quality and safety parameters - drawings and models - put them on site and will give the same data to everyone - commissioning and handover - information about entries, giving insight about elements and their current state - reporting - Reports based on the setup and different entries. - Gives a basis to learn from the issues and complement the initial setup aiming to get the required information	**Produced knowledge and Information, and its use** - Relatics System break down and work break down structure based on requirements BIM 360 - Checklist for BIM 360 developed based on SBS and WBS to prove that things have been according to requirements - Information and knowledge that can be produced: Checklists for verification, Issue-management during the Work (Worklist), Photo management, Punch list for handover of the building. Reuse of information/lessons learned - Monthly information sessions for sharing their experiences, best practices, and lessons learned (groups of 5).	**Produced knowledge and Information, and its use** BIM 360 - Quality control through the identification of issues, and follow up until the status of issues is changed to closed. - The documentation of issues can be done from the checklists filled by the subcontractors, or the information can be collected on site visits undertaken by the responsible ones	To use the information and lessons learned, a monthly information session is held between groups of people from the projects to share experiences, best practices, and lessons learned. Not all the features have been used, they should be consider in future steps of this development to exploit the tool to its maximum.
	ANALYTICS - The analytics are based on the initial setup of BIM 360 - In TBI a general setup can be generated until a certain level - BIM 360 - dashboards that can be used. In this interface it can be seen a project overview regarding the issues that are created. - Custom made dashboards - analysis at a higher level (the programmer is needed if new requirements need to be included and/or fix issues) - Recommendation - retrieve the information and manage it with power - Business Intelligence (BI) that can support further analytics.	**ANALYTICS** The produced information can be used to do a project analysis of succeeding processes and quality information - Create a verification file for the project to -provide permits to the municipality (Wkb) -information for maintenance and guarantee -information for structural issues of the organization, to prevent them in the future.	**ANALYTICS** - Information can be retrieved from the tool from which a general overview of the status of issues is generated which can be shown to the subcontractors (open/close/ in process etc.) - Other projects can be checked (provided you have access to them) if the problem found has happened before and perhaps information on how it was approached	**ANALYTICS** The setup of checklists and the other parameters for controlling the project were identified as the basis for analytics, since that is the foundation for the gathering of information. This information can be analyzed in different ways. BIM 360 shows the behaviors in a standard dash board. Furthermore, reports in Excel or PDF can be retrieved to assess different information. These reports can be translated into general overviews that give insight in the projects behavior and state. Agreement in perception up to some extent according to the scope of the party
	FUTURE USE -BIM 360 dash board can be used to check statistics. - Create overall projects report - cross-project analysis - Evaluation of performance based on the linkage of projects by type of issue - broader insight of what happened with a project. **STANDARDIZATION** -Needed for a better development and use of the information - Complete standardization of the database and lists created in the setup - It is possible to use push pin in 3D instead of 2D	**FUTURE USE** - For future use of information standardization is required to gather the same information in similar projects on an organizational level; first by engineering, then by the project management and construction management. This needs planning and time to be analyzed -Based on similar data cross-project analysis can be done in order to spot trends of wrong processes, actions, etc. to be able to improve - This information can be used for feedback to engineering, design and others. -The information is not being used because the implementation is still in the starting phase **STANDARDIZATION** - Standardization of issues should be done through management of the structure in the issue with the creation codes based on a System Breakdown Structure and then assign the issues to one of the codes. Then the issues will be assigned to the drawing with the established code, therefore it will be easy to identify and issue with an element		**FUTURE USE AND STANDARDIZATION** The standardized well-structured information that is gathered from different projects could be used to reach lessons learned from experience that will help to prevent future failures. Additionally, with the information of projects with similar characteristics a cross-project report can be delivered linking types of issues to analyze trends in processes to improve them. Additionally, the use of 3D is recognized as a mean to improve the process of gathering data that can improve its use in the future. Conclusion - The value of the information and importance of standardization is recognized which is a good starting point for awareness.
Future Tools and Improvements	**FUTURE TOOLS AND IMPROVEMENTS** -The following updates of BIM 360 will require users to follow training, since the tool is being developed from scratch, taking into account feedback coming from the companies (insider program). - Suitability and communication with other types of software/programs is and will be based on Forge software that is supported by API (application programming interface) which defines ways of communication between different software, allowing an easier development of programs.	**FUTURE TOOLS AND IMPROVEMENTS** -The implementation is not going to be hard and it is better than The old version. -The new application will be simplified so it is not necessary to have plans for updates. - The old projects continue to be in The old version and new projects will be executed in The new version. **IMPROVEMENT AND COMMENTS** - The company has one setting per project, instead of an integral setting which can be used in different settings -Additionally different companies (specialties) use different work methods, thus misunderstandings occur.	**IMPROVEMENT AND COMMENTS** - Upload of new plans - new plans should be uploaded, but if the notification for new plans is not timely they cannot be uploaded. -The app does not always load appropriately -It is very slow to load.	**FUTURE TOOLS** According to TP the changes in the tools are going to be big and further training will be needed. At the same time TC considers that new changes are going to improve the tool, but they would not require further training or re-learning. Discrepancy between the parties. Every party should recognize of this fact. Overall for the implementation manager who should plan further implementation based on the changes to avoid future intricacies. Additionally, it is important to pay attention to the suitability between software as well as to future requirements of law. **IMPROVEMENTS AND COMMENTS** The current implementation is considered to be scattered in projects, in terms of different settings per project. Additionally, the importance of implementation in every company striving towards the same point was mentioned. Finally, the comments referred to improvements in performance of the tool, the importance of exploring and settling the 3D option, and problems regarding the present shortcomings in terms of logistics when uploading new plans.