The use of HBIM and scanning in cultural heritage projects

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ABSTRACT: The adaptation of HBIM, (Historic Building Information Modelling), in cultural heritage has been a challenge since such buildings are unique. Historic buildings are known to be some of the more challenging structures to rehabilitate. This has led to a backlog of digital tools in rehabilitation projects. This paper has, therefore, chosen to take a closer look at digitization and how it affects work in historic buildings. The purpose is to see to what extent HBIM has an impact on productivity in a construction process and whether this simplifies or complicates the work. A case study of the ongoing rehabilitation work at the old hospital building in Drøbak, Norway, was chosen. The shape of the building was collected by 3D laser scanning technology. The study also included qualitative in-depth interviews with a selection of involved actors. The interviewees had different roles in the rehabilitation project, which gave informative results and a broader perspective. In addition to this, a search in scientific literature was carried out in which relevant research and theories were analyzed. This method of triangulation meant that the findings could be examined and prepared further, in a methodical way.

1 INTRODUCTION

In Norway, BIM-implementation has been in progress for many years, much due to Statsbygg, one of the largest construction developers in Norway, demanding BIM since 2010 (BuildingSMART Australasia, 2012). Therefore, many of the large architecture, engineering and construction (AEC) firms operating in Norway have hands-on experience in working with BIM (Merschbrock & Nordahl-Rolfsen 2016). In Norway there is a national standard, NS 8360:2015 for BIM-objects (Standard Norge 2022) that has been important for the implementation of BIM in new buildings. Although the use of BIM in older historic buildings has lagged behind, there has also been an evolution there.

1.1 Historic Building Information Modelling (HBIM)

Historic buildings are known to be some of the more challenging structures to rehabilitate. Traditionally Historic Building Information Modelling has consisted of individual measurement, fieldnotes, 2D drawings and pictures taken at sites (Murphy, McGovern & Pavia 2009). According to Murphy: "Traditional methods used for surveying and recording historic structures are based on: manual measurement systems (using tapes, levels), instrument based (theodolite and level) and image-based using rectified photography or photogrammetry" (Murphy, McGover & Pavia 2009). An example of this is the documentation of the old, protected hunting lodges at Prins Karls Forland, Svalbard, Norway (Planke & Wammen 2008), where lists of photos, rewritten fieldnotes and drawings were used. And it was very difficult to see and understand the small details of the drawings.

The adaptation of Historic Building Information Modelling (HBIM), in cultural heritage has been a challenge since such buildings are unique. The requirement for HBIM knowledge increases with the complexity of the project (Namork & Nordahl-Rolfsen 2018). "The HBIM process begins with remote collection of survey data using a terrestrial laser scanner combined with digital cameras. A range of software programs is then used to combine the image and scan data" (Murphy, McGovern & Pavia 2009).

In a paper written by Ma, Hsu & Lin (2017), the use of HBIM in a rehabilitation project is considered. This concludes that there still are challenges that have to be overcome to create a useful HBIM tool. The paper underlines that there is much detailed information that could not be standardized. This makes the work with the creation of an HBIM-model difficult and time-consuming. The key to useful use of HBIM is the use of the 3D scanning and creation of the point

cloud, which gives the documentation of irregularities in the building.

Norway has used 3D scanning in many projects. The Cathedral of Nidaros in Trondheim has often been focussed. Tylden & Langø (2006) executed a project with a 3D scan of the cathedral and the point cloud was converted into a 3D -model with more than 19 million points. This visualizes how much detail this technology can capture be able to preserve.

There had been a fire in the Nidaros cathedral in 1531. In 2013 Theoharis, Papaioannaou, Bjørlykke, Ekroll, Rieke-Zapp, Lein & Andreadis tried to reconstruct some of the damaged parts from the fire of 1531 by using scanning. "The first step required in order to use such tools is the 3D digitization of the objects of interest. Much research effort has been directed to this problem in computer science and related fields and several 3D digitization's attempts have been made. Although huge steps have been taken, the general feeling still remains that 3D digitization is a difficult and costly process." (Theoharis et al. 2013).

Shabani, Hosamo, Plevris & Kioumarsi (2021) tested a methodology for structural vulnerability assessment of heritage timber buildings in Tønsberg, Norway. They experienced that "3D laser scanning is much more precise than traditional 2D geometrical surveys, especially for structures with more complicated 3D geometry. The method can be effectively used for the conservation of heritage structures against potential risks." Furthermore, they found that "Point clouds not only can be used as an input for 3D documentation of the case studies but also can be utilized in order to model precise automatically models of the components to detect any deflection or settlements in structural elements or foundations." (Shabani et al. 2021)

Namork & Nordahl-Rolfsen (2018) did a study of HBIM acceptance amongst carpenters working with heritage buildings. The project was based on the preservation and relocation of three historic buildings from Northern Norway to The Folk Museum in Oslo. Since the buildings had already been disassembled at the time when the BIM-model was created, the 3D model was created in Autodesk Revit based on 2D drawings, measurements, notes, and photos. Photos and notes were then linked to the 3D model using Dalux snagging tool, enabling mobile and easy on-site access to all available information. The carpenters were introduced to the tool and model before being interviewed, and they were quite positive to the new HBIM invention.

This paper has, therefore, chosen to take a step further and look at digitization with the help of laser scanning, to see how it is expected to affect work in historic buildings. The research question is: *How could HBIM influence the productivity and ease the rehabilitation of historical buildings?* The purpose is to see to what extent today's HBIM technology is expected to have an impact on productivity in a rehabilitation process, and whether this might simplify or complicate the work. This research aims to explore the perceived usefulness and ease of use of point cloud enhanced HBIM at the operative end of the process. While the process of creating the HBIM model is briefly outlined, this paper does not focus on the usefulness and ease of use of the process.

2 THEORETICAL LENS

For an organization to be willing to change, the perceived benefits must outdo the cost of changing the organization. For successful BIM implementation the perceived benefits must be assessed. There is a wide range of different information system (IS) theory models which aim to predict and explain technology adoption.

2.1 Technology Acceptance model

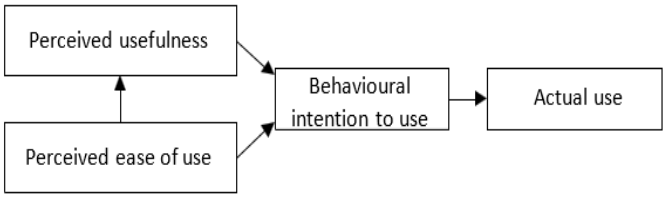

Figure 1: Technology acceptance model (Davis 1989)

This research is based on the Technology Acceptance Model (TAM), which posits to predict individuals' intention to use new information technology (Fig. 1). The TAM-theory is based on the Theory of Reasoned Action (TRA) developed by Fishbein & Ajzen (1975). The TRA aims to explain a persons' decisions and acceptance in a general manner. The TAM is an IS theory which suggests that the perceived ease of use and perceived usefulness of a new technology will influence the system acceptance, behavioral intention of use, and actual system use (Davis 1989). According to Davis the usefulness can be defined to the "…extent they believe it will help them perform their job better." (Davis 1989, p. 320). Even though the user finds the new system to be useful they may "[…] believe that the system is too hard to use and that the performance benefits of usage are outweighed by the effort of using the application" (Davis 1989, p. 320), hence the assessment of ease of use. By analyzing data on individuals' stated perception of ease of use and usefulness, the likelihood of continued use can be elucidated.

Davis focussed on certain items, such as accomplishing tasks more quickly, increasing job performance, enhancing productivity and effectiveness and making jobs easier, as indicators of perceived usefulness; while finding the system easy to learn and use as well as flexible, clear and understandable, were indicators of perceived ease of use. Namork & Nordahl-

Rolfsen (2018) narrowed this down to specific properties relevant to the task of preservation and relocation of historic buildings (Table 1).

Table 1: Usefulness and ease of use of HBIM on-site

Usefulness	Ease of use
•	•
• Easy access register for information • Full on-site access to detailed information • Better visual understanding of the building • Information flow to project participants • More detailed information • Time savings	• Software is intuitive to use • Interaction with the system is clear and understandable • Easy to find the information you want

3 METHOD

A case study of the ongoing rehabilitation work at the old hospital building in Drøbak, Norway, was chosen, and the study took place between February and May of 2021. The building had been exposed to climatic exposure for more than 200 years. A new process of restoring it started in 2020 with a consultant company involved.

Figure 2 The old hospital building in Drøbak, Norway.

They carried out a condition analysis of the building which revealed much to be remediated. Hence, among other things extensive rot damage to load-bearing outer walls of 'laft' (log construction), backlog of window maintenance, problems with flaky paint on panels, moisture and drainage problems, and flaky plaster on basement walls. At this time, a description had been prepared for hiring a contractor. The building gave a unique insight in various materials and building techniques that had been used during its lifetime.

The case was chosen since the project was at the rehabilitation phase, and an HBIM could be tested on-site. The shape of the building was collected by 3D laser scanning technology (see Figure 3) and the scan was transferred into Autodesk Revit 2021. The point cloud was made in RCP-format, which was subsequently converted to IFC-format, which could be used by many different programs. This ensured that other software were able to read/adopt the model correctly (ISO 16739, 2013). The point cloud also makes it possible to compare reference lines with reality and measure skews and construction damage in relation to set axes and levels.

Figure 3 Point cloud of the old hospital building

For the building elements of the model, the point cloud was used for reference lines and as a source of geometric information. Using the "In-Place Mass" function in Revit, tailor made walls were constructed (see Figure 4.) This is a necessity if you want a drawing basis that represents the exact shape of the building.

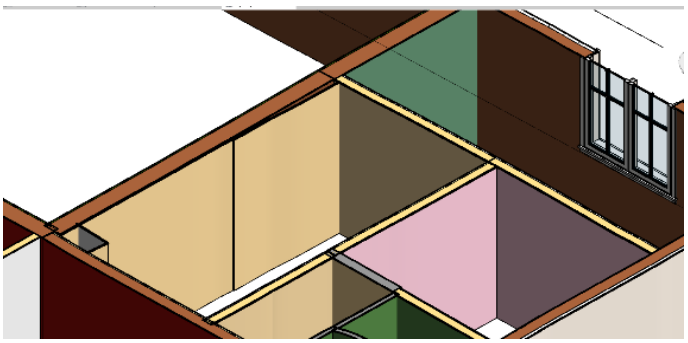

Figure 4 Detail from the 3D-model

Pictures, condition reports and other documentation were used in the work with the model. In walls, for example, information was posted about the various layers and associated descriptions. This includes the type of material present, dimensions and element-specific condition analyzes. Autodesk Recap 2021 was used to complete the details that were either not included in the information sent, or that were not clear

enough in Revit, with precise geometry from the scan. In the modelling, it was found that there was a double layer of beams in one part of the building. This turned out to agree with later findings during disassembly. The purpose of making this BIM was to give the project leaders easy and understandable access to the building information, with plans, sections, elevations, and information. An easy link from the model to photos was important for the presentation.

The study went on to include qualitative in-depth interviews conducted and structured according to Technology Acceptance Model (TAM), with a selection of involved actors. The interviewees had different roles in the rehabilitation project, which gave informative results and a broader perspective (see Table 2). They were the project leaders of the designer / consultant, the contractor and the client, and all had a background as carpenters. Along with our search carried out in scientific literature, this method of triangulation meant that the findings could be examined and prepared further, in a methodical way.

In this second phase, the model was introduced to the project leaders. In this way, they were familiarized with what the model contained and how to navigate between different information sources (e.g., 3D model, details from the 3D-model, sketches and photos). This was followed up by interviews by using Zoom. The purpose was to uncover the interviewees' initial and personal perception of the usefulness and ease of use of this method of registration of heritage buildings.

All interviews were voice recorded and later transcribed. The reason for this was to keep the interviews anonymous, as their perceptions as users are what is interesting to the research.

Table 2: Interviews conducted

Interviewees	Role in project
Interviewee 1 (I#1)	Designer's project leader
Interviewee 2 (I#2)	Contractor's project leader
Interviewee 3 (I#3)	Client's project leader

3.1 Validity

HBIM is complicated and difficult, therefore it is important to be critical to the information collected, and how it can answer the research question. This has been essential in the forming of the interviews in the interview guide, the analysis of the interviews and the source and information in the literature study. By letting the interview objects talk freely without interruption to the well-structured interviews, the validity is increased. The importance of the interviews is to collect the opinions and attitudes to HBIM. Subjectivity is important in the analysis. It is important to emphasize on the main parts of the interviews. Qualitative interviews give complex information, with great amounts of data input.

3.2 Reliability

Qualitative interviews give detailed and justified answers. By reproducing the findings, one will always find inequalities, because it takes into account the participants' reality which will vary because of situation, individual factors and external variables. Before the interviews all the interviewees were given identical information about the HBIM model. All the interviewees answered the same questions, which increases the reliability. The method triangulation with the combination of the case study, qualitative interviews and literature study increases the reliability of the study.

3.3 Objectivity

Trust and objectivity are important achievements in research, but it is difficult to fulfill (Andersson 2018). It is important to use high objectivity in research papers. This research paper has a continuous critical focus on the scientific findings. Interview effect, question effect and context effect is emphasized. Individually conducted interviews eliminate the possibility of participants' influence on each other. The answers were anonymized which allowed the interviewees confidence. They were given the opportunity to talk and answer freely without interruption and comments from the researchers. The questions were also made objectively, not claiming a special answer.

3.4 Generalizability

A case study concerning the Old Hospital in Drøbak is done, and naturally all old buildings are unique. It is important to see if the results from this could be generalized and reused to other projects. Work with heritage buildings follows the same practice and laws, and it gives the opportunity that the results of this project could be reused in other projects. On the other hand, in the case study there are many involved parties. One of the negative aspects with a small number of interviewees is that this will reduce the generalized effect of the study.

4 ANALYSIS

The analysis of the results follows the structure suggested by the Technology Acceptance Model (TAM). First, the *perceived usefulness* of the technology by project leaders is discussed. Second, the *perceived ease of use* of the BIM software and hardware in the context of HBIM is presented. Third, the project leaders' *behavioral intention* to continue using HBIM for reconstruction projects as an indicator for actual system use in future projects is predicted. The findings showed that the technological impact on productivity

is strongly linked to the perceived user-friendliness and usefulness a user sees in the technology.

4.1 Perceived usefulness

4.1.1 Easy access

In general, the project leaders stated that they perceived the BIM technology to be useful. All the interviewed project leaders had positive expectations prior to the on-site testing of the technology. I#1 said that "it is important to have a place to store information, and especially visual information about how a project locked like before, during and after the rehabilitation. And it is important to store the information of the history of a building in a place where it is easy to find." I#2 also agreed that it would have been useful to use a 3D model, but he is not very enthusiastic.

4.1.2 Full on-site access to detailed information

All the information can be accessed on-site via handheld hardware such as a pad let or a mobile phone. I#1: "File sizes are of course a challenge. So, you have to consider whether you need to have the point cloud available at all times." I#1 points out another challenge - HBIM is nice to use in a warm office, but when it is freezing outside and it rains, then this is not so easy to use.

4.1.3 Better visual understanding of the building

I#1: "The detailing of the walls… Especially when picking off the wallpaper, for example to find out that there is a hard fibre wall panel behind…. and then there is timber paneling…. This is important to document. But also pictures of detailed profiles, or damages. Such documentation is very important in heritage projects. Because much is dealing with the documentation of what is done and the history of the building…" I#2: "In heritage buildings, all the layers - all the historic layers, when changes are done - it is important to document this"

A key to succeed in projects concerning historic buildings is to have a comprehensive understanding of the building. Not only the surfaces, but the whole building's life needs to be examined.

4.1.4 Information flow to project participants

All projects have a list of stakeholders and the information flows between these are crucial. I#1: "It would be easier to send information back and forth…The traditional method of using a folder with drawings on site is a challenge." The importance of supplying everyone with the latest updates is crucial, this is possible with HBIM". I#3 said: "One can be at separate places, therefore a model is very important."

4.1.5 More detailed information

I#1: "There is a difference between a model and a point cloud. A point cloud tells you more accurately about the condition when the point cloud is established, compared to a model. It is the detailing of the model that decides how much information is included. But is it important to include every bump on every log in a model? Usually not." I#2 says that the model should contain important information like product number, CE-marking etc.…and he is not so confident with the model. I#3: The accuracy of the model is important because it will be used to rebuild the building. "The building is a heritage building and it should be rebuilt in the same way as it was built, then the accuracy of the model with all the details is seriously important."

4.1.6 Time savings

While time may be saved on-site by eliminating frequent trips back to the office to fetch more drawings, creating the BIM model from the point cloud in the first place is a time-consuming job. I#1 believes it will be time saving in the long run, but on the other hand, I#2 believes it will require increased use of resources.

4.2 Perceived ease of use

4.2.1 Software is intuitive to use

Creating the BIM model from the point cloud naturally requires certain skills which not many craftsmen have. But maneuvering in the finished model can also be a challenge to many.

The project leaders answer differently to this question. I#1 has worked with the programs previously and is quite positive to using them. But for persons not used to this it could be complicated, he said. I#2 is not so positive to the use of the HBIM-model, but he can see the benefits of it. He points out that the skills of the user using HBIM is important. An ordinary carpenter does not have these skills and would not be able to use it. "The craftsman down there is doing what he always does, independent of what you are drawing."

4.2.2 Interaction with the system is clear and understandable

I#1: "As long as you can use the model to find information and not a folder system, then yes. It requires that you have some common guidelines on how to build a model." I#2 is skeptical to the use of the HBIM because he is not confident with the programs. I#3: "As you showed me, it looks simple. But I had not fixed it myself. But I think it looks good to zoom into the visual room, if you only know what you are doing. It`s easy once you know it."

4.2.3 Easy to find the information you want

I#3 said: "It is very confusing when drawings, revisions and O&M documentation are not stored at the same place. When I need to find drawings, I have to look both digitally and in different places, various

folders and also paper archives of things that have not been scanned. So yes, there are only advantages with having everything stored in one place."

4.3 Behavioral intention to use

As the TAM-theory suggests, the 'behavioral intention to use' indicates how the new information technology is accepted by the users. Given that this research has been limited to a brief introduction of BIM-technology to the project leaders, the interview objects were asked about their thoughts on using it in future projects. The project leaders were positive to using BIM in future projects. I#1 points out that much depends on the economic aspects of implementing HBIM. I#1: "Everything is a modelling process, in the end the cost / usefulness is important for the intention to use. If it takes three days to make a point cloud and it saves many visits to the site for measuring a door, a window, a bench and that type of thing, then there is money to be saved just collecting information from the model." I#1 also believes that collecting information in a visual method like in an HBIM-model will simplify the visualization of the project to the client and other stakeholders. I#1 further points out that this project had to use drawings that were over 100 years old, and that a point cloud therefore would have great value for the project because one could collect accurate information: I#2 points out that it is important that the one who is creating HBIM has the necessary understanding. "For example, we want an overview of profiles and moldings and panels in the hospital". He is also concerned with noting down all the layers of paint in the HBIM-model. Although I#2 is more skeptical to the use of the HBIM-model, he could see the usefulness of it in the future - especially as the next time a heritage building is rehabilitated, crucial information stored in an HBIM model would be of great value. I#2 is sceptical to the BIM-knowledge of the craftsmen and emphasises that this could be a challenge when it comes to the productivity and efficiency in the work that is done. I#2 also mentions that the usefulness of the HBIM-system is not good enough for the craftsmen: "He (the craftsman) does as he is used to doing. No matter what you draw". It is important that the scanning and the model is detailed enough. "In this project, it is very important to be able to reproduce, we are not allowed to make any changes to the building. If a log is rotten, it must be replaced, but then that log must be exactly the same as the log that was taken out." I#1 also points out that it is important that everyone in the project must agree to use the tool (HBIM), so that everyone has the same platform to work around, and that this is an important aspect of HBIM being a successful and useful tool.

5 DISCUSSION

Although the findings showed that the technological impact on productivity is strongly linked to the perceived user-friendliness and usefulness, this in turn depends on the user`s experience and competence. However, an alternative could be to find a hybrid solution between the traditional documentation method and a full-scale HBIM project. In this way, small businesses can avoid the resource-intensive work behind it, but also be part of the innovation.

The concept of BIM was originally developed for designing new buildings, but in recent years it has been adopted for cultural heritage preservation and management. Earlier research on HBIM suggests that the use of BIM in projects concerning historic buildings and places can be a valuable tool for creating, conserving, documenting and managing digital drawings and information (Megahed 2015).

This research aimed to give a contribution to the rapidly increasing interest for HBIM-technology based on the use of the TAM-theory which illuminates how the HBIM-technology is perceived and used by the professionals working on-site with historic buildings. Based on the TAM-theory, the findings shown in Table 3 from interviews indicate that there is a relatively strong interest for further use of the technology in other projects. But it is important that there is one person responsible for the HBIM-model and that everyone has to participate in the use of the HBIM-model. When it comes to detailed information HBIM is very useful. Detailed information could be picked out of the 3D-modell. As I#1points out: "If I need information about a door, for instance if it is upgraded according to fire regulations, then I can find the product specification of the fire painting that is used in the HBIM-model instead of seeking information in a folder system." Also, for future rehabilitation projects crucial information stored in an HBIM model would be of great value. Some of the project leaders are skeptical to the BIM-knowledge of the craftsmen and emphasize that this could be a challenge when it comes to the productivity and efficiency in the work that is done. The usefulness of the HBIM-system may then not be good enough for the craftsmen. The answer to this could be to give the craftsmen better training in the use of snagging-software (such as Dalux, SiteWorks), which are user-friendly.

This research, as well as other research, (Bråthen & Moum 2016; Davies & Harty 2013; Merschbrock & Nordahl-Rolfsen 2016; Namork & Nordahl-Rolfsen 2018), points out several obvious advantages of using BIM on site. The results show that the professionals find the HBIM-technology to be useful and user friendly.

Table 3: Key findings

TAM theory	Findings in the interviews
Perceived usefulness	The usefulness of HBIM depends on the role in the construction project. Not all have the same needs. Common storage system for information increases efficiency / is time saving and increases productivity Simplifies collaboration by reducing the need for physical presence Most useful in the start and end phase, but not during the construction phase Sees the benefit of system storage in the future The reliability of information is questioned Time consuming
Perceived ease of use	Easy to retrieve information, but complicated and time consuming to enter The size of the file affects the speed of the software Important with high integrity of the HBIM Limited competence contributes to a reduction in use
Behavioral intention to use	Much depends on the economic aspects. Necessary that everyone involved participates. One person must be responsible for the 3D model. HBIM may be difficult to use for the craftsmen.

The HBIM allows for collecting all on-site necessary information in an easy access register. This reduces the unproductive time related to searching for and collecting detailed information from the site office. The digital platform also allows for easy handling of larger quantities of data. In the case studied this relates especially to the possibility to have full time access to high resolution photos, and the HBIM model on site at all times.

Despite the positive feedback from the professionals, they also illuminated several challenges. In line with what Bråthen & Moum (2016) point out in their research: "[…] there seems to be no appropriate tools to make use of BIM in rough environments in our part of the world". The interviewed project leaders in this research also find it potentially problematic with low temperatures and poor weather. This is also one of the findings in the research of Merschbrock & Nordahl-Rolfsen (2016) regarding the use of BIM on site for concrete reinforcement workers.

The findings indicate that there is still plenty potential in developing the HBIM software. As Megahed (2015) points out, there are a number of barriers between academic research on HBIM and practical applications that prevent this development (Megahed 2015). One of the main challenges found in this research during the preparation of the HBIM, just as Namork & Nordahl-Rolfsen (2018) pointed out, was that the BIM software was not compatible enough for adding qualitative documentation, and in particular photographs. Potentially, this could limit the attractiveness of implementing HBIM in heritage projects. However, snagging software such as Dalux opens new possibilities for adding such information.

Lastly, it is clear that the preparation of the HBIM model is time consuming. This is pointed out by Theoharis et al. (2013) in the paper "Multi-scale 3D Digitalization at Nidaros Cathedral". They conclude that although there has been done lots of research on developing HBIM, this still is a time consuming, difficult and costly process. This is also the conclusion of Ma, Hsu, Lin (2017), who point out that there are still challenges that need to be solved to make the work efficient. It is especially the handling of non-geometric and non-standard information which is time consuming.

6 CONCLUSION

BIM has for some time been optimized for industrialized buildings. HBIM has lagged behind, but in the recent years there has been an increasing interest in using BIM in the heritage sector. This research focusses on how the project leaders working with heritage buildings perceive this HBIM-technology as a substitute to printed drawings sketches and printed photos on site. Through the theoretical lens of the TAM-theory, this paper aims to give an answer to the question: *How could HBIM influence the productivity and ease the rehabilitation of historical buildings?*

As visualized in Table 3, the project leaders found the HBIM-technology to be useful and user friendly. However, this perception depends on the degree to which the engineers manage to prepare a satisfactory model with high level of credibility. Whether the cost of engineering hours to prepare the HBIM can answer to its benefits are still to be assessed, and it needs further research, preferably projects with full HBIM implementation. This could also illuminate how remote non-contact digital recording hardware and software would work towards making a HBIM suitable for on-site work. It is important to point out that the case considered in this research is just one of many potential usages of HBIM. One of the greatest challenges for implementing the use of HBIM in cultural heritage is to overcome the practical challenges of BIM software being optimized for industrialized building systems (Fai & Sydor 2013; Fai et al. 2015). Full on-site implementation of HBIM depends on useful and user friendly HBIM software. The full potential of

HBIM, in all stages, can only be shown by further research on HBIM in all phases of preservation of cultural heritage buildings and sites (Namork & Nordahl-Rolfsen 2018).

The findings indicate that today's BIM systems, handheld devices, and apps are sophisticated enough for providing project leaders and craftsmen with a good user experience. However, using scanners requires careful preparation by the engineers. Thus, despite the BIM-models' ease of use and apparent usefulness for the craftsmen, the costs of creating the models may outweigh their advantages. This article is important for several reasons. Firstly, it shows how very important storing of qualitative documentation of the building is. Secondly, heritage construction workers are likely to accept the new technology and find it to be beneficial for their work. Thirdly, it revealed some barriers for HBIM technology deployment. By learning from this, simpler HBIM models might be developed so that small businesses can avoid the resource-intensive work behind it, but also be part of the innovation.

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