Exploring the paradox of low BIM adoption in the built environment

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Abstract. Building Information Modelling (BIM) is an ICT application of tools and processes. There is a limited understanding of the real root causes of challenges in implementation among practitioners. As part of an ongoing action research project in a Norwegian municipality, we held a series of focus group sessions with technology users. We explored the reasons for the slow uptake of BIM in the context of the need for information management. We find limited engagement in information management processes necessary for successful application of BIM. However, we find great interest in achieving more sustainable outcomes in the municipality. We argue a possible re-alignment of the purported benefits of BIM towards emerging sustainable development goals in the municipality. The relevancy of this article is to find leads to actionable solutions to the slow digital transformation in the built environment. We find it paradoxical that increased BIM adoption might be achieved by not focusing on BIM at all, but by focusing on achieving sustainable outcomes, for which both BIM and information management is necessary.

Keywords: BIM; Sustainability; information management; resistance to change; digital transformation; construction; action research.

1 Introduction

Building Information Modelling (BIM) is digitalization in the built environment embodied. BIM is related to Computer Aided Design (CAD). But where a CAD model is a 2D/3D model representing geometric information, BIM adds an extra "dimension" that describes the elements in the model. BIM is seen as an integral part of the digital transformation of the built environment. The largest actors in the Architecture, Engineering and Construction (AEC) show considerable technical BIM capabilities in flagship projects. The technology is mature, but the transition from technology to process is lacking – hence also widespread adoption. Considering the economic size of the sector, and with 39% of global energy-related CO_2 emissions [1], substantial economic and environmental gains can be achieved with percentage wise small improvements.

Using BIM results in new ways of doing things, or new processes. And it is from these processes that the benefits are thought to arise. It is related to and part of several

trends in the digital transformation of the Built Environment, which is a term being increasingly used to emphasize a more holistic perspective of "the construction industry." In terms of roles, the construction industry is the Architecture, Engineering and Construction (AEC) sector. But the project execution phase of constructing a building is a fraction of its lifecycle. A holistic perspective includes the perspectives of the Owner, Operators and Facility Management (OO/FM) as they use the data throughout the building's operation. Fundamentally, the AECOO/FM roles supply the users with an environment in which they generate value. And the users operate in an environment with many built assets, hence a built environment.

The most cited adoption barrier to BIM is "resistance to change" [2]. BIM is often understood as being a technological artefact, a software [3, 4]. And the focus and incentives for BIM use have been biased towards the AEC roles, not the OO/FM roles. The efforts of the research program center on the OO/FM roles - to find solutions to resistance in the digital transformation, using BIM as an example. BIM implies significantly improved information management and organizational changes to that effect. With an OO/FM perspective, and an approach that assumes that if there is resistance to change, there likely is a will also, we just don't know for what yet.

Engaging with a Norwegian municipality and their department and units concerned with the OO/FM of municipal built assets, we conducted focus groups with expert technology users. Their commonality is the use of ICTs in which BIM adoption or integration would be beneficial to achieving the benefits BIM is purported to have. In other words, they are potential users of BIM software or, most importantly, the information content and flow that BIM enables.

In an earlier study of the same municipality's department and units concerned with the built environment, we found BIM was primarily understood as a software. And that BIM adoption was slow because the right software was not yet made available [3]. This was contrasted with comments from the software community stating the clients usually do not know what they need. To us, as well as leading industry organizations, the starting point for BIM adoption into the owner organizations must start with properly procuring BIM [5]. But this leads back onto the problem of owner organizations not knowing what their information requirements are [6]. Our research efforts therefore started with the focus on understanding the perspectives of potential BIM users in the organization. And to have them contribute to finding solutions to establishing a set of information requirements the organization could use. This approach was informed by the newly published ISO standard for information management using BIM. The following research question was formulated:

RQ: How to increase the use of digital information through BIM for Owner-Operators?

2 Literature review

2.1 History and development of BIM

The principle of a Building Information Model, which is object-based design with parametric manipulation together with a relational database was conceptualized as early as

1962 [7]. The concepts for software to create a building element database were the Building Description System (BDS) created in 1974, and the first software example in 1975. Both were the result of U.S. military agency research [8, 9]. The first use of the word Building Information Model came in 1992. Recent developments, such as the ISO 19650: 2018 standard for information management using BIM further specifies the phase which the model is used, by specifying a Project Information Model (PIM) used during the project execution phase. And the Asset Information Model (AIM) used during the operation phase.

Today Building Information Modelling is the most common meaning of the abbreviation BIM. It was first used in 1986 and started to be popularized in 2002. The purpose being to distinguish BIM from CAD, as well emphasizing the processual, informational and information management aspects using Building Information Models [8, 10]. "BIM is not a thing or a type of software but a human activity that ultimately involves broad process changes in construction" [8].

There is an increasing interest in the socio-technical dimensions of enabling BIM adoption [2]. It has been known for a long time that BIM adoption is slow, with a multitude of barriers to BIM adoption being identified [11]. Implementing BIM will require significant changes to social practices, norms as well as technological change. In this context, Building Information *Management* has seen some use as an alternative abbreviation for BIM [12]. In this paper we use the term Building Information Modelling, though we use it as a broad concept: "BIM-as-process", which also includes the information management activity [8].

2.2 **Research on BIM**

Research on BIM started in 2004 and took off in 2010, reaching about a thousand articles in 2020[1]. [13] identified 60 key research topics as the knowledge base on BIM. [14], grouped the topics into distinct stages. From the formulating topics on establishing frameworks, concepts, standards, technological bases, towards the transformative, which is the integration of BIM into new developments and additional use cases (see figure 1). Using newer sources, we can see the trend of for example "green building" or sustainable building increasing. 90% of articles within on this topic were published in 2014-2019 [15].

[1] TITLE-ABS-KEY ("building information model*" AND construction OR facilit*)

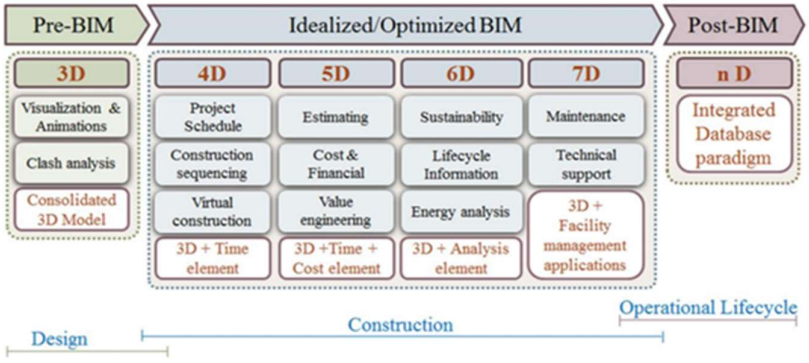
Fig. 1. Development of BIM literature

Year	(Li et al. 2017) Scientometric analysis
2006-2012	3D design
2007-2012	nD BIM
2007-2012	IFCs
2008-2012	Modeling
2009-2011	3D models for implementation and adoption
2012-2013	Universal interoperability
2011-2013	Green building
2011-2015	Quality inspection

	(Liu et al. 2019) Bibliometric analysis
Formulating stage (2006-2012)	Establishment of a theoretical, conceptual BIM framework for BIM application and curriculum structure around BIM use-cases
Accelerating stage (2008-2015)	BIM application incorporated with other technologies such as energy calculation, GIS and rule-based checking
Transformating stage (2014-2015)	BIM application integrate with emerging ICT and facilities management, etc.

It is outside the scope of this paper to give a summary of the 60 research topics of BIM. But the concept of nD BIM (see figure 2) is an effective way of understanding both the capabilities and interest area of BIM and BIM research, as well as the direction of the development. "nD" refers to the number of "dimensions" of information in the BIM model. And where additional "dimensions" of information added to the BIM model, enables an increasing amount of use cases [16].

Fig. 2. nD terminology, copied from [16]



There is an awareness the initial push of implementing BIM has been towards the design and construction stages [17]. However, the greatest benefits of BIM will be for the owners and operators [18]. The problem is the lack of understanding asset owners have for their information needs [19, 20]. And in general, the BIM competency and awareness ("BIM maturity") of the organization. The cost of loss of information during the lifecycle of a building is estimated at $15.8 billion in the US alone [21]. This cost

stems from a lack of useful information at the Facilities Management phase. At the handover of a new building, information provided by the contractor has a limited shelf life until it becomes outdated. The task of updating the quality of the information, previously paper based, now often based on electronic documentation, is significant.

BIM is a vehicle for information management and exchange. Information is retained, structured, and gathered in one place. It is, however, still static information. Updating and analysis require manual action. Taking BIM further is the concept of the "Digital Twin" (DT). It originated in the aerospace industry, is thought to be able to achieve a dynamically, real-time, digital representation of a building – enabling simulations, analysis and prediction [22]. It integrates several of the AEC digital "hype technologies" such as sensors, cloud computing, Artificial Intelligence (AI) and Machine Learning (ML) [23]. The effect is improved ability to achieve nD use cases discussed above. And maybe to achieve the "BIM utopia" goals, or rhetorical-promotional promises that were promulgated as part of the initial push for BIM adoption [24].

With reference to literature on BIM, our approach centers on the problem of BIM adoption and Sustainable Construction. The most cited adoption barrier to BIM is *resistance to change* [2]. In this paper we therefore focus on the socio-technical informed concept to BIM adoption, which has been used before [25, 26], and increasingly in the later years [2, 27].

3 Methodology

The methods comprise of Canonical Action Research (CAR) [28] at a Norwegian municipality. With the overall research question being "how to get more BIM use". It is a qualitative approach, organized and managed through research by immersion, which helps in creating thick descriptions associated with phenomena of digitalization [29]. The whole project is over three years during which the lead researcher engages with the organization and its strategy towards digitalization. The point of departure of the methods described in this paper are in longitudinal relation to the semi structured interviews conducted to inform the diagnosis stage [3] of CAR. In this paper we use reflections from focus group findings conducted with technology users in the organization to inform the planning stage of CAR.

A component of the CAR is to create or otherwise enable change. The diagnosis was that the municipality saw BIM primarily as a technical artefact. This was exemplified by an explanation for why BIM was not more widely adopted:" We need better software." We found this contrasted itself with comments we heard from the software community stating something to the effect of "the clients do not know what they need".
The action planning would therefore be directed towards getting the technology users (who are potential BIM users) to explore BIM in the context of which information management processes would support the municipal BIM adoption. Our approach was informed by a newly arrived ISO (International Standards Organization) and NS (Norwegian Standard) called "Organization and digitalization of information about buildings and civil engineering works, including Building Information Modelling (BIM) –

Information management using BIM" [30]. The needs for integrating BIM with information management is acknowledged by the standard organizations. We aim to identify sources of agency, motivation, and engagement on the part of technology users. This is hypothesized to provide a source of bottom-up change in the organization.

In total, there were four participants to our focus groups. They held current roles in the municipal departments for maps and geodata; water and sewage; computer aided facility management (CAFM); and planning and regulation. While the diagnosis stage utilized semi-structured interviews which were in-depth on the individual level, focus groups extended on this data with a focus on group level. The multiple focus group sessions over the course of 7 months, with the same participants, were intended to create dynamic dialogue between researcher and researcher participants. In this sense, the use of focus groups fit what [31] lists as desirable criteria to choose focus groups for data collection.

At the time of designing the research, we saw no sign that would indicate focus groups should be avoided. The one reservation was whether the participants would be uneasy with each other. The topic at hand did not suggest deep personal feelings would be shared, though it was the stated intention to understand and discuss opinions. Some of the opinions could be overly critical of other groups in the organization, or of specific third persons. Though the professional setting, lessened this worry for us. We interpreted the situation as if any criticism would be well founded, and possible for participants to identify with. Still, it set the stage for a strategy to keep the group small.

The focus groups ended up being with 4 employees in the municipality. This is towards the smaller size of the recommended number of people participating in a focus group, which typically range between 5-12. And it could be interpreted as a limitation of the paper. The fact that we nevertheless chose to continue with this few, can be summarized by 1) we conducted 7 focus groups over a length of time (September 2020-March 2021); 2) we had the option of adding people, should there be a need – and if we found new participants; 3) the covid-19 pandemic presented several issues (closed municipality, home offices, ongoing reorganization facilitating remote working, such as implementing MS Office 365 and Teams) that made access to people difficult; and 4) the potential participants that fit the criteria of being technology users was limited.

We proceeded with the participants we had. Since the focus groups were recurring over an undefined period, we could add to the number of participants if needed. The condition was if the conversation and dialogue started to abate. This did indeed happen during the second meeting, and as a step in the process evaluating what to do, a second researcher joined in on the next meeting to give the lead researcher an outside perspective of the status of our dialogue. This stage turned out to be a turning point that led to the topic of this research paper, and which will be discussed in the next section.

4 Results

This is a preliminary high-level analysis of the focus group sessions, focusing on how the discussions evolved based on the participants' perspectives. The preliminary

analysis will inform further direction for activities within the action research project this paper is a part of, as well as relate results to relevant literature.

The focus is on the evolution of the main topic in each session, and the main turning points in the process of the project. The starting point for topics of discussion was informed by the previous study, which showed BIM understanding to be directed towards software [3]. Our experience as practitioners informed us that attentiveness to information management was lacking. And the application of the relevant information standards, such as ISO 19650, were recent developments that had not been applied yet. Literature informed us Owner-Operators struggle with defining information requirements [19]. The intention was therefore to make the participants reflect and, if possible, engage in describing information management strategies and solutions which would improve their respective functions in the organization.

The topics of the sessions evolved as shown in the table below. The first sessions (45min) are characterized by questioning the practices of the participants' information management routines, as well as their understanding of what BIM is, and what it could be. The intention was to allow the practitioners themselves room to define how BIM would work for them, and not to be limited by a pre-existing perception of what the "original intentions and goals" of BIM was. Since the introduction of BIM, as with other ICTs, into the organizational context would invariably change the original goal with BIM, by anyone's pre-existing definition [25].

Table 1. Focus group session general themes and reflection

	Date	General themes	General reflection
1	25.09.20	Establishing knowledge of each other's roles and activities	Presentation of backgrounds and roles and perceptions of BIM
2	09.10.20	Problematization of digital information needs; information management and BIM	User regards BIM and information management is important. Conversation starting to abate
3	23.10.20	Problematization of digital information needs; information management and BIM	Second researcher joined and observed lead researcher was pushing the subject of information management and BIM
4	12.11.20	The possibilities of data for the built environment. Data as a resource "data is the new oil" [32, 33]	Tried to spur discussion on the possibilities of data and what it might lead to, with an example from "Smart-Bodø" creating a marketplace for municipal information of and on built assets

5	03.12.20	Higher utilization leads to sustainability	Conducted a Menti questionnaire on sustainability to initiate reflection. Led to several examples noted in the next table.
6	14.02.21	Higher utilization leads to sustainability	Sharing perspective on the examples brought up by the participants in the former meeting, and the commonalities between them (increased utilization)
7	04.03.21	Increasing the utilization of the underlying object	Lead researcher presented an abstract for a possible paper outlining the participants view of increasing the utilization of the underlying asset

Although we kept the focus on information management, the discussion started to abate after focus group session #2. Participants expressed doubts as to what they could do. In their view it was an activity for management. And efforts, questions or otherwise engaging management was seen as an increasing risk of getting a task or action in return. BIM was accepted as a useful tool, or information container, in which information management could be achieved in an effective manner. The existence of an ISO standard on the topic was also seen as something denoting it a management action to commence. We reflect on the abated discussion and hypothesize that this was due to the low number of focus group participants, or that the discussion theme had run its course. As part of the process to determine the next steps, a second researcher joined a session. She had prior experience with running focus groups, but no prior knowledge of this focus group project. Her function was "a new set of eyes", and to externally validate the next steps form an outside perspective.

Her observation was the lead author was too fixated on directing the conversation to problematizing the need for Information Management systems and new processes. And where BIM and the desired information inputs of the participants would then be helped. She noted the participants did not show much interest in these topics. She suggested to the lead author allow the participants themselves to discuss solutions to what they perceived as the relevant problems in the municipality. And to which they wanted to make changes towards. Her advice was implemented in the subsequent session, and the conversation can be characterized as more active and fluid. The next session saw the participants mentioning sustainability as the key matter they felt the municipality could improve on. This was followed up with a Menti questionnaire in the following session. The linkage to BIM and Information Management was that better information flow in the municipality was needed to achieve this. The specific example of desired improvements is shown in the table below.

Table 2. Focus group increased utilization suggestions

#	Desired action	Desired effect	"Dimensions" of utilization

1	Public recreation spaces such as football fields should be designed and constructed such that they are permeable to water and can function as deposits for draining surface water into the ground from the football field itself, but also the neighboring environment.	If this was done, it would lessen the need for additional infrastructure for surface water handling – and water cleaning facilities. And alleviate damage done by heavy rainfall	Function & area: Multiple functionalities per asset. And increased utilization of areas.
2	Roads can be designed and constructed to function both as roads, and spillways for water in heavy rainfall events	This would increase the utilization rate of existing assets - which alleviates the need for additional or new facilities.	Function & area: Multiple functionalities per asset. And increased utilization of areas.
3	Municipal assets should be available for use by citizens and other organizations when it is not in use by the municipality, or organizations under the municipality (schools for example).	The investment budget for interior for new assets is lessened. Materials are reused instead of sold at a discount or recycled.	Time: Assets used over longer time periods
4	Rented and temporary head office facilities for municipal workers are refurbished with furniture, ICT technologies, and equipment. At the same time, the design of new permanent facilities is being constructed. Effort should be made at the time of design and purchase to establish material suitability and fitting to the new permanent office building.	The investment budget for interior for new assets is lessened. Materials are reused instead of sold at a discount or recycled.	Time: Materials used for longer.
5	Resources are spent on establishing various datasets. Such as maps of the municipality. But they are often only used for a select few processes.	Datasets should be used more extensively, and for multiple purposes	Data & function Increased value from using datasets for multiple purposes

5 Discussion

RQ: How to increase the use of digital information through BIM for Owner-Operators?

Significant research efforts have been dedicated to understanding the barriers to BIM adoption. And BIM adoption is portrayed as a key part of the process of digital transformation [34, 35]. Most of the focus has been on the use of BIM in the project execution phase. Yet the real effects of BIM will be achieved in operations phase. The premier barrier to BIM is *resistance to change* [2]. How can resistance to change within BIM for operations be overcome? Top-down efforts have their drawbacks. Managers are distanced from the technological and processual knowledge of the practitioners. By focusing on the will to change and competency of technology users in solving problems, we have attempted to identify actions to overcome resistance to change.

Our findings indicate the technology users have limited interest in information management and BIM. They do, however, have a good understanding of the meaning and practical importance of both. But they do not see it as "their" task. This is not ideal, because of the tacit knowledge and competencies of the technology user the organization could utilize for the digital transformation. A relevant question is to what extent the digital transformation process is expected to be initiated top-down. And whether the significant changes to existing tasks, roles and processes is efficiently achieved in a top-down implementation.

Potential BIM users desire for change is not aligned with efforts focusing on implementing BIM and information management. But when allowed to define the problems and solutions they wanted to commit to, they were very aligned in organizational efforts to achieving better sustainability. This alignment amongst technology users from different departments and roles within the organization should be seen as a resource. A resource that could complement top-down strategies and managerial actions, should they be structured and formulated in a way that caters to it.

The examples given by the technology users will need significantly more and higher quality information to come to fruition. Information for decision making purposes needs to span a larger cross-section of the organization. As well as information about users and their usage patterns. But also, about needs and requirements. This is like the current understanding of what is needed to implement BIM [6]. But the emphasis is different. That is why reconceptualizing information management as a requirement for sustainability might be a better means to an end. The result will be the same, BIM will be needed as an integral part of the information management strategy. But the strategy itself is for the purpose of achieving sustainable outcomes, not with BIM as the ultimate result.

In society we are inundated with messages pertaining to transforming to a "green society," recycling and sustainable development. A component of the motivation, is as per the 1987 of sustainable development, is the generational factor – leaving the earth habitable for our children. This is not the case with BIM - there are few far reaching personal motivational factors to further the development of BIM. As demonstrated by the responses from the focus group participants. However, achieving the more sustainable outcomes in the built environment is not possible without significantly improved information. On how assets are used, not used, the users themselves, and so on. If the result is the same (increased use of digital information), enabled by improved information management through the use of increased adoption of BIM; then why not realign the efforts with the organization's focus on achieving sustainability?

This was exactly how BIM first was portrayed when it started being promulgated in the beginning, but primarily focused on the AEC. The focus was on the return of investment of BIM, and other economic benefits [17, 36]. Margins in the AEC are understood to be thin. And any potential for efficiency gains or cost savings certainly creates interest. And this interest became a need for winning larger contracts for AEC firms when several European governments, and their real estate organizations, started demanding BIM [35, 37].

In general, the development needed to facilitate increased use of digital information suggesting the need for an increased awareness of the organization as an information organization. Not just an organization concerned with the management of physical assets. In our view, there is awareness, but not enough. Exemplified with the matters discussed in this paper. But also because of the sustainability goals the organization is subject to. The latter years has seen a movement of including the UN17 Sustainable Development Goals (SDG) into organizational strategies [38]. This introduces the issue of how to produce good KPIs to evaluate progress towards these goals. Which again is dependent on the availability of better information. Poor access to quality information to inform on decisions is well known in the early appraisal phase of new construction projects [39]. With the increased demand of SDGs, the digital information component is likely to become even more relevant.

In this respect, the motivation of technology users and the need of the organization is aligned. The organization needs to evidence more sustainable outcomes, and the technology users are motivated to work towards it. But both require better and more digital information. Where BIM and information management are enablers. This is a link to the argument of Hilty and Ruddy [40] that ICTs, like BIM, can only support SDG if they are applied as enablers of dematerialization. Where they define dematerialization as using less materials and energy in both production and consumption. The technology users agreed with this, though to them dematerialization was increasing the utilization rate of the underlying assets or objects.

An unavoidable factor that affected availability of participants was the reality that the municipality mainly procures their projects, the one that are large enough to warrant BIM deliverables, as Engineering, Procurement and Construction (EPC) projects. This means the municipality have little of the incentives (and capabilities) to use BIM in the capital expenditure (CAPEX) phase. There are limited benefits since the project risk is carried by the EPC contractor. This set up is unlikely to change. A transition to a project management organization is a significant reorganization with substantial costs and risks to the municipality.

The benefits of BIM to operating expenditure phase (OPEX) is known to be significant, and much larger than the Capital Expenditure (CAPEX) phase [18]. On top of this, for regulatory bodies, BIM has great potential for streamlining the planning application process. The use cases are much wider distributed; situated in operations phase; and not in the CAPEX phase, where the BIM maturity has come the furthest.

6 Summary remarks

Potential BIM users in a municipality do not see the immediate value of BIM. Even if they are active users of digital technology, but information management and BIM do not produce engagement. However, achieving sustainability objectives did. We argue the users' engagement on sustainability is a potential catalyst for change towards more BIM adoption. After years of rhetoric selling the "BIM Utopia" [26] as a means to increasing BIM uptake in the industry, it is a paradox BIM in OO/FM organizations might be achieved by not focusing on BIM at all. BIM is a means to an end. But where initially promulgated by government policy to "digitalizing" the built environment to increase productivity, perhaps sustainability is more effective.

The reason for the above statements, is that practitioners become more aware of the information content in the BIM. And therefore, also implementation of the process to which desired information for the BIM is specified. Specification of relevant information is required to achieve and document sustainability goals. This leads to greater understanding of the process of information management, and that information can be reused for multiple purposes in multiple scenarios. Connecting information is the real purpose of Building Information *Modelling*. The problem is that potential users may not understand BIM as a process, but as a product. It escapes them that the process will lead to the desired product – more sustainable outcomes – in this case. By analogy, currently everyone is screaming for more cake. But no one is thinking about the process of combining eggs, milk, and flour according to specification. If they were, it would be easier for them to reflect on issues such as the consumers' allergic status. Which would make information about allergens in the process very valuable. This implies sustainability specifications can be the driver for increased BIM adoption.

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