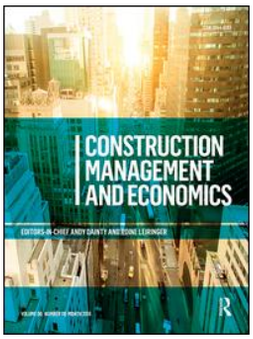

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Challenges when implementing BIM for industry change

Susanna Vass and Tina Karrbom Gustavsson

Department of Real Estate and Construction Management, KTH Royal Institute of Technology, Stockholm, Sweden

ABSTRACT

Public clients have been identified as drivers of architectural, engineering and construction (AEC) industry change through their implementation of building information modelling (BIM). Yet, little is known of this implementation process and the associated challenges. This study aims to increase the understanding of what intra- and inter-organizational challenges that arise when a large Swedish public infrastructure client implements BIM to change the work practices of the actors in the Swedish AEC industry. The IT business value model allows for understanding the public client's implementation of BIM as an IT-supported change process and for understanding the associated intra- and inter-organizational challenges. The findings show nine categories of intra- and inter-organizational challenges related to, for example, demanding BIM in procurement and creating incentives for BIM implementation. The findings show that intra-organizational challenges related to a top-down implementation of BIM, while inter-organizational challenges related to a bottom-up implementation. The impact of these challenges on the public client's ability to drive AEC industry change by implementing BIM is discussed. The findings contribute with the client perspective to studies on BIM implementation and with an increased understanding of the challenges associated with implementing IT-supported change processes.

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Building information modelling; organizational change; challenges; public client

1. Introduction

The architectural, engineering and construction (AEC) industry is changing and adopting new ways of working which include an increased digitalization and implementation of building information modelling (BIM) (Crotty 2013, Bryde *et al*. 2013), supply chain integration (Briscoe and Dainty 2005) and productivity enhancement (Dubois and Gadde 2002). In this change process, public clients have been promoted as change agents via their ability to make demands on the AEC industry actors' work practices in procurement (Linderoth 2010, Wong *et al*. 2011, Porwal and Hewage 2013, Bosch-Sijtsema *et al*. 2017). Public clients worldwide are implementing BIM with the specific aim of driving industry change (GSA 2007, UK Cabinet Office 2011, HKCIC 2014). However, the implementation of BIM is challenging (Fox and Hietanen 2007, Hartmann *et al*. 2012).

Although public clients are being promoted as drivers of AEC industry change via their BIM implementation (Linderoth 2010, Wong *et al*. 2011, Porwal and Hewage 2013, Bosch-Sijtsema *et al*. 2017), there is still limited understanding of how this implementation process is pursued and of the associated challenges. This study aims to fill this gap. A large Swedish public infrastructure client recently implemented BIM with the aim of driving change, innovation and productivity in the Swedish AEC industry (SOU 2012:39, Trafikanalys 2015). This study aims to increase the understanding of the intra- and inter-organizational challenges that arise when a public client implements BIM as a means for changing the work practices of the actors in the AEC industry. As the largest procurer of infrastructure in Sweden and via its ability to make demands in procurement, the public client can influence the work practices of and competition among the actors in the Swedish AEC industry (Trafikanalys 2015). Thus, it is important to understand the challenges that arise from this implementation and how they impact the public client's ability to change the work practices of their suppliers.

The IT business value model (Melville *et al*. 2004) allows for such understanding. The model accounts for the large influence of the public client on the work practices of and competition among the actors in the Swedish AEC industry and understands IT-supported change processes in a multi-layered context using multiple levels of analysis (Melville *et al*. 2004). The model allows for understanding the public client's implementation of BIM as an IT-supported change process and for understanding the associated intra- and inter-organizational challenges.

CONTACT Susanna Vass susanna.vass@abe.kth.se

2. Challenges in BIM implementation

BIM can be understood as "a set of interacting policies, processes and technologies generating a methodology to manage the essential building design and project data in digital format throughout the building life cycle" (Succar 2009). Proponents of BIM argue that BIM can alleviate the AEC industry's challenges (Rezgui *et al*. 2009, Succar 2009). However, implementing BIM is challenging and the high expectations have not always been met (Fox 2014, Dainty *et al*. 2015). Challenges relate to variations in competences and skills in BIM (Mäki and Kerosuo 2015), different roles, responsibilities and decision-making power (Gu and London 2010, Mäki and Kerosuo 2015), different attitudes and beliefs (Davies and Harty 2013), cultural resistance (Smith and Tardiff 2009) and lack of client demand (Eadie *et al*. 2013).

2.1. Different implementation approaches

Hartmann *et al*. (2012) argued that much of the BIM implementation is conducted at an operational level (i.e. bottom-up approach) and that the challenges associated with this implementation are important to understand. Arayici *et al*. (2011) showed that while architects implementing BIM bottom-up had been able to engage more project actors and managed resistance towards change, the implementation was dependent on the engagement and support from a few BIM knowledgeable top managers. Mäki and Kerosuo (2015) showed that BIM implementation was dependent on project managers as early adopters. A lack of implementation guidelines left the implementation dependent on the tasks, roles and the responsibilities of individual project managers. Dossick and Neff (2010) showed that that collaboration is limited when project teams are organizationally separated, have different access to information and have different decision-making power.

2.2. Conflicting expectations

Conflicting expectations seem to pose a particular challenge in BIM implementation. At the same time as there are expectations on BIM to be aligned with the current and preferred ways of working, there are also expectations on BIM to transform and change the industry's ways of working (Jacobsson and Linderoth 2012, Davies and Harty 2013). Contractors, for example, perceived BIM as beneficial only when BIM was perceived to be aligned with their existing work practices (Hartmann *et al*. 2012, Jacobsson and Linderoth 2012). Consequently, managers need to create conditions for the implementation by providing motives that are in line with the user's expectations (which often relate to the gaining of immediate benefits) (Jacobsson and Linderoth 2010). Project actors may also have competing interests and obligations to scope, project and company (Dossick and Neff 2010).

2.3. Managing change

Changing the current and preferred ways of working is a major challenge. Taylor (2007) showed that designers and contractors had managed to change their current work practices and roles by redistributing work among firms and developing a system for interaction and understanding of project scope. Change is also challenging when contractors, consultants and software suppliers have different understandings and uses of BIM (Fox and Hietanen 2007). Aligning current business models to BIM implementation is also challenging (Howard and Björk 2008). BIM implementation also involves creating new roles, such as BIM coordinators, which redistributes power and decision-making (Bosch-Sijtsema 2014). Change management challenges often relate to creating a sense of urgency for change and communicating throughout the change process (Kotter 1996). Although public organizations are key change agents, resistance towards change often arise when the change initiative is isolated to certain units and challenges current job positions (Fernandez and Rainey 2006).

3. Framework for IT-supported change processes

The IT business value model has been used to understand IT-supported change processes (Melville *et al*. 2004, Kohli and Grover 2008, Wiengarten *et al*. 2013).

3.1. The IT business value model

The IT business value model (Melville *et al*. 2004) describes how IT-supported change processes are inter-organizational and are co-created in a multi-layered context that encompasses the firm, competitive and macro level (Melville *et al*. 2004).

The model focuses on interactions between an organization (focal firm) and the actors in its competitive and macro environment. These interactions are viewed as intra- and inter-organizational change processes and are prerequisites for the creation of IT-supported change processes and the subsequent creation of business value (Melville *et al*. 2004). Managing intra- and inter-organizational change is also challenging and the model supports an understanding of the intra- and inter-organizational challenges associated with IT-supported change processes (Melville *et al*. 2004) (see Section 3.1.1).

IT-supported change processes take place on three levels: the firm level (focal firm), the industry level

(competitive environment) and macro level (macro environment). Analysis of such multi-layered contexts is important for understanding the impact of information technology and its impact on change in the individual, organizational and societal context (Walsham 1992, Pettigrew *et al*. 2001).

3.1.1. The focal firm

The focal firm makes use of IT resources and human IT resources (Melville *et al*. 2004). The implementation of IT-supported change processes requires the focal firm to manage intra- and inter-organizational change (complementary organizational resources). These must be managed both within the focal firm (intra-organizational level) and in relation to the actors in the competitive and macro environment (inter-organizational level). By coordinating and integrating their business processes (e.g. order taking, manufacturing, logistics, sales, procurement), the focal firm and the actors in its competitive and macro environment co-create intra- and inter-organizational change and IT-supported change processes (Melville *et al*. 2004). Examples of intra- and inter-organizational change processes include changes in workplace practices, policies, rules, contracts, business models, organizational structures, roles, decision-making and culture. These changes may also pose as challenges (Melville *et al*. 2004). The public client organization may be viewed as a focal firm when regarding its major influence on the work practices of and competition among the actors in the Swedish AEC industry via its ability to make demands in procurement and its role as the largest procurer of infrastructure.

3.1.2. The competitive environment

The focal firm and the actors in the competitive environment co-create intra- and inter-organizational change and the creation of IT-supported change processes. The competitive environment consists of industry characteristics, such as regulations, competitiveness and technological change and consists of industry actors (trading partners), such as buyers and suppliers (Melville *et al*. 2004). In the case of the public client, the competitive environment consists of the actors of the Swedish AEC industry (suppliers such as contractors, consultants, material and machinery suppliers, software developers) and is characterized by fragmentation, complexity and heterogeneous project teams (Dubois and Gadde 2002) and a reluctance to increase the use of new IT for innovation and change (Jacobsson and Linderoth 2012). Most of the public client's maintenance of infrastructure has been outsourced and opened for competition (Eriksson *et al*. 2013). The competitive also consists of other public organizations competing for government funds.

3.1.3. The macro environment

The macro environment also impacts the focal firms' ability to implement IT-supported change processes. It includes governmental regulations, government initiatives and country-specific factors (education system, residents' maturity of IT) (Melville *et al*. 2004). As a government agency, the Swedish public client's macro environment is regulated by the Swedish Government and EU regulations. The initiative to implement BIM was a response to a government directive that aimed to encourage industry change, innovation and productivity (SOU 2012:39).

4. Method

This section presents the case study, the public client's initiative to implement BIM and the methods used to understand this implementation process and the associated intra- and inter-organizational challenges.

4.1. The case study

The public infrastructure client is the largest procurer of infrastructure in Sweden and has large influence on the work practices of and competition among the actors in the Swedish AEC industry (Trafikanalys 2015, SOU 2012:39). The public client's BIM implementation process was studied during a three-year period starting in 2014. It was followed from the perspective of a BIM implementation group conducting a top-down implementation and from the perspective of BIM pilot project managers conducting a bottom-up implementation. The BIM implementation project group was studied by an ethnographical field study approach including observations of meetings, conferences, workshops, regular workdays, etc., while the BIM pilot project managers were studied using semi-structured interviews. The case study also includes document studies, email correspondence and informal talks. The interpretation was thus based on empirical material that was created from a variety of empirical viewpoints (Merriam 1998). The case study consists of a total of 40-h interviews (20 h with BIM pilot project managers) and 330 h of observations. One researcher had access to the office premises, the Intranet, various databases and was also invited to join reoccurring meetings and conferences. The case study is an example of a qualitative longitudinal case study that aims at contributing to both the theory and practice of IT-supported change processes from a public client perspective (Yin 1994, Eisenhardt 1989).

4.2. The public client's implementation of BIM

The public client organization consists of five departments: major projects, investment projects, maintenance,

planning and traffic management. The public client initiated a BIM implementation in 2012. This initiative came as a response to a government directive which stipulated that the public client ought to implement BIM to encourage industry change, innovation and productivity (SOU 2012:39). The aim of the public client's implementation of BIM implementation was twofold: (1) to change internal work practices by increasing the use of BIM-based work practices within the public client organization in order to increase internal efficiency, innovation, productivity and life cycle management, and (2) to change the work practices of the actors in the Swedish AEC industry by increasing suppliers' use of BIM-based work practices and therein increasing the efficiency, innovation and productivity in the industry as a whole, (i.e. drive AEC industry change) (SOU 2012:39, Trafikanalys 2015).

A BIM implementation project group was formed which consisted of 12 members (of which the majority worked at major projects). They appointed 25 BIM pilot projects. The majority were from major projects and a handful from investment projects. They were managed by BIM pilot project managers who were assisted by BIM coordinators. These were major, complex and unique and were already using BIM either on the initiative of individual project managers or their suppliers.

The BIM implementation project group conducted a top-down implementation of BIM. Its task was to govern and steer the implementation so that the public client could increase the use of BIM-based work practices among their internal project managers and their suppliers) (i.e. drive AEC industry change). To achieve this, the BIM implementation project group revised the steering documents that govern the work practices of internal project managers to include BIM-based work practices (e.g. require project managers to provide descriptions for how to work with BIM in their early project phases) and the procurement contracts that govern the work practices of their supplier (making detailed requirements to suppliers on how to work with BIM including demanding coordination activities and deliveries to be in models instead of drawings). The project managers were to implement the revised steering documents and procurement contracts and thereby change their internal work practices and those of their suppliers. This process describes the IT-supported change process intended by the public client when implementing BIM. Thus, the challenges examined relate to the challenges encountered by the BIM implementation project group and BIM pilot project managers when trying to implement such IT-supported change processes in their internal organization and among their suppliers. Due to their autonomy and available resources for experimenting with new ideas, the BIM pilot project managers could also conduct a bottom-up implementation of BIM.

4.3. Observations of the BIM implementation project group

The members of the BIM implementation project group were studied through observations. The observations took place both formally and informally, for example at BIM kick-off conferences, internal and external BIM meetings, regular meetings, workshops, project meetings, phone conferences and various seminars. The researcher was partaking mainly as a listener except during brakes and social events when the researcher also engaged in informal discussions. The interactions of the BIM implementation project group were observed at two-day BIM kick-off conferences held in 2014 and 2015. The BIM implementation project group's interactions with BIM coordinators and implementation managers from major projects and investment projects were observed at a two-day BIM kick-off conference in 2016. Observations also included internal BIM meetings arranged by the BIM implementation project group and phone conferences among BIM coordinators. All observations were documented by hand written notes and transcribed directly after each observation.

4.4. Interviews with BIM pilot project managers

The BIM pilot project managers were studied through open-ended and semi-structured interviews. There were a total of 18 BIM pilot project managers managing the 25 BIM pilot projects. All 18 were contacted and 10 agreed on an interview (Table 1). Those who declined had not yet started their projects. Each interview lasted an average of two hours and was documented by hand written notes that were transcribed directly after each interview. The interview questions focused on the perceived business value of BIM. During the interviews, the respondents briefly discussed perceived business values and instead choose to focus on describing difficulties, obstacles and challenges of implementing BIM.

4.5. Lens and interpretation process

To understand intra- and inter-organizational challenges of the public client's implementation of BIM and their impact on the public client's ability to drive AEC industry change, the IT business value model (Melville *et al*. 2004) was applied as analytical lens. The model accounts for the large influence of the public client on the work practices of and competition among the actors in the Swedish AEC industry and understands IT-supported change processes in a multi-layered context using multiple levels of analysis (Melville *et al*. 2004). The model allows for understanding the public client's implementation of BIM as an IT-supported change process and for understanding the associated intra- and

Table 1. Respondent profile of BIM pilot project managers.

Respondent	BIM pilot project	Project phase	Use of BIM	Experience in BIM (years)
Respondent A	Road expansion and interchange	Planning/ construction	Extensive	1–2
Respondent B	Road expansion and complex pipeline work	Maintenance	Little	0–1
Respondent C	New railway yard	Planning	Little	0–1
Respondent D	Major new high-speed railway	Early planning	Extensive	5–10
Respondent E	Traffic junction	Planning/ construction	Some	0–1
Respondent F	Major traffic junction and road stretching	Planning	Extensive	2–5
Respondent G	Major new road stretch	Construction	Extensive	5–10
Respondent H	Major new railway	Planning	Extensive	5–10
Respondent I	Major stretching of railway	Planning	Extensive	1–2
Respondent J	New road expansion	Construction	None	1–2

intra-organizational challenges. The interpretation process of the empirical material followed three interconnected steps (where the IT business value model was applied in steps 1 and 3):

4.5.1. Applying the focal firm level to identify organizational challenges

In the first step, the focal firm level of the IT business value model was applied. When interpreting the interview transcripts and the field study notes, the examples of organizational changes described in Melville *et al*. (2004) (see Section 3.1.1) emerged, but in terms of challenges rather than changes. For example, "challenges in changing project managers' work practices". The model allowed for identifying the challenges perceived by the BIM implementation project group and the BIM pilot project managers when trying to implement BIM in order to change the work practices of the internal public client organization and those of their suppliers.

4.5.2. Using thematic analysis to categorize different challenges

In the second step, the organizational challenges were categorized using thematic analysis (Braun and Clarke 2006). The thematic analysis was based on terms such as "barriers", "challenges" and "problems" in the empirical material and resulted in nine categories of organizational challenges.

4.5.3. Applying the competitive and macro environment levels to distinguish between intra- and inter-organizational challenges

In the third step, the competitive environment and macro environment levels were applied to distinguish between the nine categories as intra- or inter-organizational challenges. Melville *et al*. (2004) argue that IT-supported change processes are inter-organizational and require the focal firm to manage intra- and inter-organizational change together with the actors in its competitive and macro environment. These changes may, however, also pose as challenges (Melville *et al*. 2004). In differentiating between the challenges, intra-organizational challenges were such challenges that were described as internal challenges, while inter-organizational challenges were such challenges that were perceived to impact inter-organizational collaboration with suppliers. A distinction was also made between which challenges that the BIM implementation project group and the BIM pilot project managers perceived as intra- or inter-organizational when trying to implement BIM in order to change the internal work practices of the public client (via the revised steering documents) and the work practices of suppliers (via the revised procurement contracts) (i.e. when trying to create AEC industry change).

The findings from the three steps of interpretation (identifying perceived challenges, categorizing challenges into categories and distinguishing between intra- and inter-organizational challenges) are presented in Sections 5.1–5.9. Each section represents one type of challenge. The challenges presented in Sections 5.1–5.9 include the BIM implementation project groups' efforts to change the public clients' internal work practices (by revising the steering documents) and their suppliers' work practices (by demanding BIM in procurement) and the BIM pilot project managers and their suppliers' reactions to these changes. The findings are used to assess and discuss the public client's ability to implement BIM as a means for driving AEC industry change (see Sections 6.2 and 6.3.2).

5. Intra- and inter-organizational challenges

The following nine categories of intra- and inter-organizational challenges are related to the public client's implementation of BIM for driving AEC industry change.

5.1. Changing work practices

The BIM implementation project group perceived intra-organizational challenges in changing the steering

documents that govern the work practices of internal project managers. They found it difficult to make explicit formulations and to follow-up that the requirements were actually used by the project managers. Changing the work practices of major projects was also challenging due to their size, complexity and autonomy.

The BIM pilot project managers found these changes to cause both intra- and inter-organizational challenges. Respondents F and I found the changes fuzzy and incomplete which caused confusion and in that they disregarded them. Respondents B, C and I also found that implementing BIM (making detailed demands on suppliers) clashed with the parallel change effort of becoming a more professional client (using less detailed contracts), making collaboration with suppliers difficult.

5.2. Providing education and learning

Three members of the BIM implementation project group perceived intra-organizational challenges related to education and learning. They had assigned BIM pilot project with BIM coordinators as additional support. As there was an initial lack of BIM competent and available in-house staff, some projects were assigned external BIM coordinators (consultants). In 2016, they procured education in BIM for internal staff and assigned more internal BIM coordinators. They also argued that many BIM pilot project managers had not done the required experience feedback reports.

Some BIM pilot project managers (F, G, I and J), on the other hand, argued that there were no instructions for how to create these reports. BIM pilot project managers also perceived inter-organizational challenges. Respondents A, C and I argued for a need for the public client to develop an internal BIM competence instead of relying on consultants to educate them on BIM.

5.3. Developing a mutual BIM definition

The BIM implementation project group worked via seminars and discussions to develop a joint and accepted definition of BIM to communicate internally. Still, Respondents B and C argued that management needed to develop a better understanding of what extent that BIM was being used at the public client. One member of the BIM implementation project group described this as an intra-organizational challenge. There were also different definitions of BIM being developed in different parts of the organization. Those in the group belonging to major projects promoted more extensive and holistic definitions of BIM. In 2016, the BIM implementation project group developed a set of criteria for defining BIM.

The BIM pilot project managers found the development of a mutual BIM definition, to cause both intra- and inter-organizational challenges. The lack of a joint and mutually accepted definition of BIM was, according to Respondents B and C, contributing to projects not using BIM. Different definitions and expectations on BIM also created misunderstandings and extra costs both internally and for their suppliers, Respondent G argued, for example, for suppliers making bids on contracts.

5.4. Evaluating the business value of BIM

In early 2013, the BIM implementation project group perceived a need for justifying the BIM implementation by demonstrating the business value of BIM. However, it was difficult to evaluate any economic effects of BIM. Two members of the BIM implementation project group viewed it as an intra-organizational challenge to demonstrate the business value of BIM to sceptical project managers. They argued that this was used as arguments by sceptical project managers for why not to implement BIM together with a lack of time, resources and heavy workload.

Most BIM pilot project managers (A, B, C, F, H and G) found it difficult to actually measure any economic effects of BIM and argued that evaluations were based on experiences and perceptions of individual project managers. They also found BIM to disrupt their day-to-day project management, adding extra costs but no clear benefits. Respondents A, B, C, D and E also perceived that any possible business values of BIM fell to the contractors who then passed on their internal costs for experimenting with BIM onto the public client by charging extra in their bids.

5.5. Demanding BIM in procurement

Demanding BIM in procurement was perceived as a major intra- and inter-organizational challenge by both the BIM implementation project group and BIM pilot project managers. One member of the BIM implementation project group described it difficult to formulate the requirements demanding BIM-based work practices in the procurement contracts. Inter-organizational challenges also arose as it was difficult to verify that suppliers had followed the requirements.

In 2016, BIM pilot project managers and various project managers of investment projects indicated difficulties with actually following the revised steering documents and implementing the revised procurement contracts. They were perceived as too complex and confusing for both the project managers and suppliers. Project managers had to put time and effort on directing the work of their suppliers. In many cases, the procurement contracts had

to be complemented with additional contracts or were simply put aside in favour of contracts versions that did not demand BIM. The new procurement contracts provided suppliers with detailed requirements and instructions on how to work with BIM. This was found to be in contradiction with the other change initiative at the department of investment projects of becoming a more professional client and making less detailed specifications and instructions in the contracts. They predicted that most project managers of investment projects would prioritize the professional client role. The BIM implementation manager of investment projects also perceived that the professional client role and mission implied making demands on function and quality and therein promoting and encouraging change, and not demanding change (as was done in the revised procurement contracts) (compare with Förordning med instruktion för Trafikverket 2010:185, 2 § line 10). The BIM implementation project group (working at major projects) and BIM pilot project managers of major projects had an opposite view. They interpreted that the public client role and mission was to demand BIM and thereby demand industry change. Consequently, there was confusion about the two change initiatives and whether they supported or counteracted each other. At an internal BIM meeting held in 2016 by the BIM implementation project group, the attending project managers expressed a need for more education in BIM to be able to better understand what they were expected to demand from the suppliers in the new procurement contracts. BIM pilot project managers A, B, D, F and H also discussed who it was that was actually driving the implementation of BIM in the industry. They argued that it was their suppliers who in fact had demanded to work with BIM.

5.6. Creating incentives

While many BIM pilot project managers perceived it as a challenge that they had not been assigned any extra resources for implementing BIM, no one from the BIM implementation project group mentioned this as a challenge. Instead, the BIM implementation project group created motivation by interacting with the industry and attending BIM networks, conferences and seminars both national and internationally.

A lack of resources and extra costs made it difficult to convince BIM sceptical project managers. Instead, the incentives for implementing BIM often came from individual BIM enthusiastic project managers, Respondent C argued, or from suppliers, Respondent B and J argued. Respondents E, F and H had created their own incentives for their suppliers to use BIM by creating additional contracts rewarding suppliers with bonuses for additional problem solving with BIM. The examples of best practice provided by the BIM implementation project group were, according to Respondents B, C and F, not applicable to their projects as they came from either housing projects or internal unique mega projects.

5.7. Including maintenance department

The Maintenance department did not partake in the BIM implementation process. This was because of resistance towards BIM and because they prioritized other ongoing change initiatives. Two members of the BIM implementation project group perceived this exclusion to hinder a long-term implementation of BIM. They tried to manage this intra-organizational challenge by inviting representatives from Maintenance to join their meetings and conferences. In 2016, there were two representatives from Maintenance taking part at the meetings and conferences.

BIM pilot project managers (D, H and I) who had implemented BIM on their own initiatives described the lack of Maintenance in the BIM implementation process to cause both intra- and inter-organizational challenges. They argued that the responsibility for including Maintenance had fallen to a few engaged project managers and that Maintenance struggled with their own changes and challenges.

5.8. Creating new roles

The BIM implementation project group developed a new role of the "BIM coordinator" who was to support the BIM pilot project managers. Initially, this was a new role and only a few in-house staff had the necessary knowledge in BIM. This resulted in a shortage of BIM coordinators and several BIM pilot projects did not initially have an assigned BIM coordinator. Instead, enthusiastic BIM pilot project managers had to fill the role of the BIM coordinators. In 2016, the situation had changed and the role of both internal and external (consultant) BIM coordinators was expanded to also support the BIM implementation project group with knowledge from the BIM pilot projects. They were also increasingly involved the BIM implementation project groups' meetings and seminars.

Intra-organizational challenges were also described by Respondents B and G who perceived that BIM challenged the traditional internal project roles, in particular the role of the project manager, a situation that could create a resistance towards BIM. Their arguments were that BIM enabled other project actors to visualize and understand the projects in ways that previously only the project managers had information to do.

5.9. Managing interoperability

The lack of interoperability was perceived to be a major inter-organizational challenge by the BIM implementation project group and they spent much time, resources and efforts by participating in BIM networks in trying to develop solutions such as common industry wide standards and formats. BIM pilot project managers D and H, who managed large and complex projects and had used BIM extensively, argued that BIM sceptical project managers used the lack of interoperability as an argument for not implementing BIM.

5.10. Nine interrelated challenges

The following nine interdependent organizational challenges were identified:

(1) Changing work practices
(2) Providing education and learning
(3) Developing a mutual BIM definition
(4) Evaluating the business value of BIM
(5) Demanding BIM in procurement
(6) Creating incentives
(7) Including maintenance department
(8) Creating new roles
(9) Managing interoperability

5.11. Different perspectives of different implementations

Table 2 illustrates how the BIM implementation project group (who conducted a top-down implementation) mainly perceived intra-organizational challenges, while the BIM pilot project managers (who conducted a bottom-up implementation) perceived both intra- and inter-organizational challenges with particular emphasis on inter-organizational challenges. The decentralized bottom-up strategy performed by the BIM pilot project managers enabled them to work more closely with their suppliers which provided them with a better understanding of inter-organizational challenges.

6. Discussion

This study aimed to increase the understanding of the intra- and inter-organizational challenges that arise when a public client implements BIM to change the work practices of the actors in the Swedish AEC industry. The public client in this case study is the largest procurer of infrastructure in Sweden and has major influence on the work practices of and competition among the actors in the industry. Thus, it is important to understand the challenges that arise from this implementation process and how they impact the public client's ability to drive AEC industry change.

6.1. The client perspective in BIM implementation

The nine categories of challenges were not unexpected. Many of them have been acknowledged in previous research (e.g. challenges with different skills and competencies in Mäki and Kerosuo 2015, different roles and responsibilities in Gu and London 2010, changing work practices in Taylor 2007, and barriers and facilitators in Bosch-Sijtsema *et al*. 2017), but they have not been presented in a comprehensive way that acknowledges their interdependence and intra- or inter-organizational nature (Melville *et al*. 2004). Challenges of implementing BIM have also often been discussed from the perspectives of, for example, contractors (Hartmann *et al*. 2012, Bosch-Sijtsema *et al*. 2017), designers (Taylor 2007) and architects (Arayici *et al*. 2011), but not from the public client perspective. Contributing with the public client perspective to studies on challenges of BIM implementation is not only important because of the influence of public clients on the work practices of the actors in the AEC industry, via for example policies and strategies, but also because a lack of client demand for BIM has been identified as a barrier to BIM implementation (Eadie *et al*. 2013, Bosch-Sijtsema *et al*. 2017).

Recent studies have also pointed how BIM implementation must be understood from a multi-disciplinary context that regards the large integration and interrelations among the actors of the fragmented construction processes when they form in temporary inter-organizational arrangements and implement information technology (Linderoth 2010, Davies and Harty 2013, Sackey *et al*. 2014, Bosch-Sijtsema *et al*. 2017). In the Swedish AEC industry context, for example, recent studies show that contractors' expectations, interpretations and beliefs about the role of public clients for the industry's overall implementation of BIM seems to be of major significance for their choice whether to implement BIM (Bosch-Sijtsema *et al*. 2017). Lack of client demand for BIM seems is also a major challenge for many actors' adoption of BIM (Eadie *et al*. 2013). Contractors in the Swedish AEC industry, for example, look to public clients for incentives for implementing BIM and wait for clients to demand BIM-based work practices (Bosch-Sijtsema *et al*. 2017). This means that the challenges that arise when an influential public client tries to demand BIM in procurement and provide incentives for BIM implementation are particularly important to understand and their consequences for management in terms of, for example, decision-making, business development, strategizing among both the public clients and their suppliers. Thus, public clients play a large role in how the actors of the

Table 2. A comparison of how the intra- and inter-organizational challenges are perceived by the BIM implementation project group and BIM pilot project managers.

	Organizational challenges of the public client's BIM implementation					
	BIM pilot project managers			Members of the BIM implementation group		
Categories of challenges:	Described by respondents	Described as intra or inter organizational challenge		Described by members	Described as intra or inter organizational challenge	
1. Changing work practices	A, B, C, D, F, H, I, J	Intra	Inter	12 members	Intra	
2. Proving education and learning	A, C, F, G, I, J	Intra	Inter	3 members	Intra	
3. Developing a mutual BIM definition	B, C, G	Intra	Inter	1 member	Intra	
4. Evaluating the business value of BIM	A, B, C, D, E, F, G, H	Intra	Inter	2 members	Intra	
5. Demanding BIM in procurement	A, B, D, F, G, H	Intra	Inter	12 members	Intra	Inter
6. Creating incentives	B, C, E, F, H, J	Intra	Inter	0 members		
7. Including maintenance department	A, B, C, D, H, I, J	Intra	Inter	2 members	Intra	
8. Creating new roles	A, B, D, F, G, H	Intra		8 members	Intra	
9. Managing interoperability	D, H		Inter	12 members		Inter

AEC industry shape the design, use and adoption of BIM, both formally (e.g. procurement) and socially (e.g. through social interactions and networks).

The challenges of the public client's BIM implementation are also particularly important to understand at a time when much of the contemporary BIM research tends to promote rational and positivistic perspectives of BIM often focused on revolutionary promises of BIM for increased efficiency (see for example Fox 2014, Miettinen and Paavola 2014, Dainty *et al*. 2015, Yalcinkaya and Singh 2015). The hype and high expectations of BIM are being conveyed by both practitioners and researchers (see Fox 2014, Miettinen and Paavola 2014, Dainty *et al*. 2015). BIM needs to be studied as a multidimensional, historically evolving, complex phenomenon (Miettinen and Paavola 2014). Hence, there is a need to reflect on the impact of the challenges related to a large public client's implementation of BIM on the inter-organizational use and collaboration among the actors in the AEC industry. The multi-layered analysis used in this study is one way of making such reflections.

In order to discuss the public client's ability to implement BIM as a means for driving AEC industry change, the BIM implementation project groups' efforts to change the public clients' internal work practices (by revising the steering documents) and their suppliers' work practices (by demanding BIM in procurement) are compared with the BIM pilot project managers' and their suppliers' reactions to these changes and the implications of these challenges discussed (Sections 6.2–6.3).

6.2. Implications of intra-organizational challenges

The intra-organizational challenges encountered by the BIM implementation project group and the BIM pilot project managers when trying to implement BIM to change the internal work practices of the public client and the work practices of their suppliers have implications for the development of project governance, procurement strategies business development and reorganization.

6.2.1. Project governance

The BIM implementation project group was governing the BIM implementation process through a top-down approach of both enforcement and encouragement. They controlled the regulations (e.g. steering documents regulating contracts, work procedures, roles and responsibilities), the arenas (e.g. the BIM information meetings and seminars), the actors (e.g. BIM pilot project managers and BIM coordinators) and the actions (e.g. procurement). But, they also used more encouraging ways of controlling, promoting and legitimizing this process, such as communicating role models, examples of best practice and arranging for feedback-loops. However, the BIM pilot project managers targeted by this top-down approach had reacted adversely to many of these enforcing and encouraging governing actions. One concern about the enforcement was that they perceived that the resources and incentives for implementing BIM from the top-down approach were insufficient. Another concern was the need for more knowledge and education in BIM in order to be able to use the new procurement contracts and understand what was actually being demanded. A concern about encouragement was that the BIM implementation project group had not provided sufficient instructions on how to create the experience feedback reports and that the best practice examples were not applicable to their projects. These adverse reactions to the top-down approach suggest that there is a need to better understand the consequences of conducting both enforcement and encouragement when implementing BIM in a top-down manner.

Earlier research on BIM implementation has typically described bottom-up implementations of BIM and the associated challenges (e.g. Arayici *et al*. 2011, Hartmann *et al*. 2012, Mäki and Kerosuo 2015) while the top-down implementation often has been described as less effective (Hartmann *et al*. 2012). Yet, the top-down approach is often used by public clients as shown in this case study and in, for example, UK Cabinet Office (2011), HKCIC (2014) and Porwal and Hewage (2013). Thus, this study has not only contributed with the client perspective to research on BIM implementation but also increased the understanding of the challenges associated particularly with the top-down implementation process by, for example, problematizing the implications of using both enforcement and encouragement.

6.2.2. Procurement strategies

The public client is the largest procurer of infrastructure in Sweden. One major intra- and inter-organizational challenge was related to internal procurement strategies. There were two parallel change initiatives related to internal procurement strategies taking place at the public client at the time of the case study: one focusing on demanding BIM in procurement (detailed contracts requirements) and another focusing on becoming a professional client (using less detailed contracts requirements and increased use of design-build). Project managers and the implementation managers of investment projects found these two initiatives clashed. They viewed that demanding BIM in procurement, including providing suppliers with detailed instructions on how to use BIM, was in conflict with the requirements from management to also become a professional client by giving suppliers increased autonomy and responsibility. Moreover, they did not perceive that making detailed demands for BIM in procurement was in line with their interpretation of the public client's role and mission from the government (which was perceived to include encouraging and promoting change, not to demanding it).

6.2.3. Business development and reorganization

The intra-organizational challenges also have implications for other internal business development activities. For example, the challenge of not perceiving business values of BIM not only slowed down the implementation process in the departments that were assigned for pilot implementations, but also hampered the efforts to motivate and legitimatize the BIM implementation to other departments. When change initiatives are isolated to certain departments, resistance towards the change can arise in other parts of the organization (Fernandez and Rainey 2006). This was also the case at the public client. The majority of BIM pilot projects were pursued at major projects and the common view among them was that demanding BIM in procurement could change and improve current work practices of the actors in the industry. However, at the departments of investment projects and Maintenance, there where was little or no use of BIM. Here, the idea from the BIM implementation project group to have the public client act as change agent by demanding BIM in procurement was perceived as problematic. This finding problematizes the assumption in previous research of public clients acting as change agents by demanding BIM in procurement (e.g. Linderoth 2010, Wong *et al*. 2011, Bosch-Sijtsema *et al*. 2017) by illustrating the many difficulties and challenges in actually implementing such ideas in a public client organization. Although the findings show the importance of procurement in IT-supported change processes, they also problematize BIM implementation and procurement strategies.

Resistance may also arise when change initiatives challenges positions (Fernandez and Rainey 2006). Some BIM pilot project managers had perceived that BIM would challenge the role of the project manager. The new role of the BIM coordinator also gained increasing influence on strategies and decision-making of the BIM implementation project group. This is in line with the study by Bosch-Sijtsema (2014) who also found that the new role of the BIM coordinator had redistributed power and decision-making.

6.3. Implications of inter-organizational challenges

The inter-organizational challenges encountered by the BIM implementation project group and the BIM pilot project managers when trying to implement BIM to change the internal work practices of the public client and the work practices of their suppliers have implications for the development of practice and competence in the industry and for the public client's ability to act as change agent.

6.3.1. Developing practice and competence

As the public client is a government agency and a public procurer, the BIM implementation project group also procured much of the necessary knowledge, skills and competences needed for the implementation of BIM. External specialists (consultants) were hired to give education and training in BIM to the permanent staff and to fill the vacant roles of internal BIM coordinators. By procuring consultants to aid the BIM implementation process and by demanding BIM in procurement of suppliers, the public client contributed to the general development of practice and competence in BIM among the actors of the Swedish AEC industry. However, many BIM pilot project managers argued that the public client had relied too heavily on external actors for the BIM implementation and argued that there was a need for developing more internal practice and competence in BIM. This was especially important

for project managers in order to better understand what they were actually requiring from suppliers when using the revised procurement contracts. By relying on consultants to fill the role of internal BIM coordinators and provide BIM education to the public client staff, external actors could possibly gain influence over the public client's BIM implementation and thereby influence the extent and ways in which the public client can act as change agent (Rogers 2010, Bosch-Sijtsema 2014).

Thus, the paradox between, on one hand, expectations on BIM to be aligned with and improve existing ways of working, and on the other hand, to transform and change the industry's ways of working (Hartmann *et al*. 2012, Jacobsson and Linderoth 2012, Davies and Harty 2013), was also present at the public client. The new procurement contracts implied that project managers themselves were only to demand BIM from suppliers and make little changes to their own work practices. Yet, many BIM pilot project managers argued that in order to understand what they were actually demanding, they would in fact need more education in BIM. Thus, government control is not enough for becoming a change agent (Kotter 1996, Rogers 2010). Internal project managers need to be motivated to develop practices and competences in order to be able to understand how to demand suppliers to change their work practices.

6.3.2. The ability to act change agent

The inter-organizational challenges have particular implications for the public client's ability to drive AEC industry change. The findings in this study have problematized research promoting public clients as change agents through their ability to demand BIM in procurement (e.g. Linderoth 2010, Wong *et al*. 2011, Bosch-Sijtsema *et al*. 2017) by illustrating the many challenges in doing so. Project managers and the implementation manager of investment projects did not perceive that implementing BIM as a means to drive industry change was the public client's role and mission. Nor was it perceived to be in line with the professional client role. Demanding BIM in procurement meant increased control of suppliers work. The professional client role, in contrast, implied using less detailed requirements limited to demands on function and quality. These two conflicting initiatives hampered the ability to act as change agent by implementing BIM. The decentralized bottom-up implementation by BIM pilot project managers and their autonomy also enabled project managers to prioritize the professional client role. This reflects competing interests and obligations to scope, project and company (Dossick and Neff 2010).

In a recent study of Swedish contractors' adoption of BIM, contractors indicated that a demand for BIM from public clients was major driver in their implementation of BIM (Bosch-Sijtsema *et al*. 2017). This was also the main idea for the BIM implementation promoted by the BIM implementation project group (i.e. demanding BIM in procurement as a means to create AEC change). Yet, the professional client role (which implied more responsibility to suppliers and less demands from the public client) was in large parts of the public client organization prioritized over demanding BIM in procurement. Thus, comparing the contractor perspective in Bosch-Sijtsema *et al*. (2017) with the case study findings, there seems to be a mismatch between the contractors' expectations and beliefs about on the role of public clients in the AEC industry's overall implementation of BIM and between the public client's interpretation and belief about its role in the industry's implementation of BIM. This further illustrates the importance of understanding the impact of the inter-organizational challenges encountered by the public client when trying to implement BIM to change their suppliers' work practices.

In the case of the Swedish public client, there was no overall common view of the needs or benefits of implementing BIM, resulting in an uneven interest in BIM. While some departments, project managers and suppliers had high expectations on BIM, others did not. In addition, there was no overall sense of urgency to implement BIM. Neither the public client nor their suppliers seemed to face a critical urgency for change (compare with Bosch-Sijtsema *et al*. 2017). This situation can be understood as a kind of limbo where both clients and contractors are waiting for each other to make major changes. This situation is in contrast to the change management processes in, for example manufacturing industry, where change management initiatives were dependent on that organizations in collaboration with their suppliers were able to create a sense of urgency for change (Kotter 1996).

There were also project managers resisting BIM as BIM challenged their current roles, work practices, competences, responsibilities and power. Also, the change management initiative of implementing BIM became isolated to certain departments of the public client (major projects and investment projects). There were also insufficient incentives for project managers and suppliers to implement BIM, which also hinders change (Fernandez and Rainey 2006). Thus, comparing the case study to what been proposed in the change management literature (e.g. Kotter 1996, Fernandez and Rainey 2006, Rogers 2010), the public client still faces challenges in being able to act change agent. Also, several BIM pilot project managers argued that it was their suppliers that had convinced them to work with BIM and drove the implementation of BIM in the Swedish AEC industry, and not the other way around.

Finally, the IT business value model show that both intra- and inter-organizational change are prerequisites

for IT-supported change initiatives to have the intended impact. On the macro environment level, the BIM implementation project group members participated in various national and international networks and workshops arguing for increased interoperability. On the competitive environment level, there was the development of new procurement strategies and procurement contracts and competencies and skills, while on the focal firm level, new roles and responsibilities were developed and work practices, influence and power changed. However, the many interrelated categories of intra- and inter-organizational challenges suggest that there are barriers the public client must manage in order for their implementation of BIM implementation to serve as an IT-supported change process in the Swedish AEC industry.

7. Conclusion

A large Swedish public infrastructure client has initiated a BIM implementation to change the work practices of the actors in the Swedish AEC industry. This study aimed to increase the understanding of how this implementation process is pursued and of the associated intra- and inter-organizational challenges. These challenges are important to understand as public clients are influential actors in the AEC industry and as these challenges impact their ability to act as change agent.

Using the IT business value model (Melville *et al*. 2004), the public client's BIM implementation was understood as an IT-supported change process and nine categories of interdependent intra- and inter-organizational challenges were identified. The findings contribute with the client perspective to studies on challenges of BIM implementation from both the top-down perspective and the bottom-up perspective (Arayici *et al*. 2011, Hartmann *et al*. 2012, Mäki and Kerosuo 2015). The findings also problematize the assumption that public clients can act as change agents in the AEC industry by demanding BIM in procurement (e.g. Linderoth 2010, Wong *et al*. 2011, Bosch-Sijtsema *et al*. 2017). The study shows a mismatch between the expectations and beliefs about the role of public clients in the Swedish AEC industry's implementation of BIM among the public client suppliers (Bosch-Sijtsema *et al*. 2017) and the public client studied. This study concludes that there are several challenges that need to be better understood and managed before the public client's implementation of BIM can serve as an IT-supported change process and change the work practices of the actors in the Swedish AEC industry.

8. Limitations and suggestions for future research

The IT business value model was originally developed for analysing IT-supported change processes of firms (and not public organizations). Although being a public client and not a firm, the public client in this case study is the largest procurer of infrastructure in Sweden and is in the position of exerting large influence on both the work practices of and competition among the actors in the Swedish ARC industry via its ability to make demands in procurement. Due to its major influence and position of being able to impact competition and work practices, the IT business value model (Melville *et al*. 2004) is useful for understanding the interactions between the public client and the actors in the Swedish AEC industry and for understanding the challenges that arise when a large public client implements an IT-supported change process. Still, the IT business value model could be developed to be better adjusted for analysing public organizations. For example, the interface between the public organization (focal firm level) and its trading partners (competitive and macro level) could to be developed to acknowledge the two-way interaction. Future research could develop a tentative adjusted to the conditions of the AEC industry (project-based, fragmented) and to public organizations.

Suggestions for future research also include longitudinal studies that compare public client's intentions to implement BIM as a means for changing the work practices of the actors in the AEC industry by demanding BIM in procurement with the suppliers' reactions to and interpretations of the demands made in the procurement contracts. Studies that analyse the middle and long-term effects of implementations of IT-supported change processes by public clients are also encouraged. Studies combining procurement strategies and BIM development would also add important knowledge for the development of construction project management theory and practice.

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