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# Aligning building information model tools and construction management methods

Timo Hartmann [a,*], Hendrik van Meerveld [b], Niels Vossebeld [b], Arjen Adriaanse [c]

[a] VISICO Center, Department of Construction Engineering and Management, Twente University, P.O. Box 217, 7500AE Enschede, The Netherlands
[b] Department of Construction Engineering and Management, Twente University, P.O. Box 217, 7500AE Enschede, The Netherlands
[c] BIM Center, Ballast Nedam, The Netherlands

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ABSTRACT

Few empirical studies exist that can explain how different Building Information Model (BIM) based tool implementation strategies work in practical contexts. To help overcoming this gap, this paper describes the implementation of two BIM based tools, the first, to support the activities at an estimating department of a construction company and the second, to support risk management activities on a large infrastructure project. Using the cases, we illustrate that it is possible to closely align the functionality of existing BIM based tools with specific and well established construction management work processes. In this way, we illustrate that it is possible to implement BIM based tools in construction organizations in a "technology pull" manner. With these findings, we complement existing implementation theories in construction management that advocate "technology push" implementations during which existing work processes need to be radically changed to align with the functionality of the BIM based tools.



## 1. Introduction

The introduction of building information model (BIM) based tools to support the work of construction management organizations is still a problematic task in practice. It is not surprising, that many researchers have tried to address the problem by trying to explain why and how implementations were successful or unsuccessful. Influenced by Rogers' [1] diffusion of innovation theory this existing work mainly analyzes technology implementations from a technology push view. These views mainly proliferate the vision to use BIM to best support as many business processes as possible across all different organizations that are involved throughout the life-cycle of a building project [2,3]. It is not surprising that most of the prior work has identified the loosely coupled structure of the construction industry [4,5] as the main barrier for implementation. As a solution, these authors suggest that project teams need to align their work processes to the new "collaborative and integrated ways of working" that BIM based tools require [2]. The argument that follows from these assumptions is then that a top-down technology-push implementation is necessary to successfully change construction organizations and, in turn, to allow for the meaningful use of BIM based technologies [2].

Within practical BIM based tool implementation settings this top-down view is limited as it is seldom feasible to significantly change existing work processes to enable the implementation of new technologies. This is mainly because the working practice of construction project management teams are already well structured around generally accepted construction project management practices. For example, projects all over the world, whether they are small or large, use formal critical path scheduling techniques to estimate project duration or structure cost estimates into cost categories using generally accepted work breakdown structures of the physical project work. Hence, in practical settings, technology pull implementation perspectives that focus on the possibility to align existing BIM based tools with current work practices might be complementary to the prevailing technology push implementation perspectives.

To further the above notion, this paper provides case based evidence for the benefits of a technology pull view and for its practical feasibility in "real world" BIM based tool implementation settings. To do so, it describes the BIM based tool implementation effort of two construction organizations. The first case focuses on the support of cost estimating activities with BIM based automated quantity take-offs. The second case focuses on the support of project risk management activities with BIM based 4D models — a BIM based technology that allows the visual simulation of planned construction activities over time. Both cases illustrate well that it is possible to align organization and technology by gaining an in depth understanding of the underlying project management methods that guide the operation of a project team and by aligning the existing functionality of BIM based tools with these methods. In this way, the paper's findings

* Corresponding author.
*E-mail addresses:* t.hartmann@utwente.nl (T. Hartmann), h.vanmeerveld@student.utwente.nl (H. van Meerveld), nielsvossebeld@gmail.com (N. Vossebeld), a.adriaanse@ballast-nedam.nl (A. Adriaanse).
*URL:* http://www.utwente.nl/visico (T. Hartmann).

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not only show that it is possible to align the functionality of BIM based software applications with generally established project management based working methods, but also that implementations from a technology pull perspective can be successful.

The paper is structured as follows: it starts with a review of the existing BIM literature with respect to technology implementation and theory in construction settings. After this review, the paper then describes the action research methodology that we applied during the case studies and how we supported, but also traced the implementation of the technologies on the two cases. The paper then continues with an in depth comparison of the technology pull based implementations on the two cases. We then discuss these findings in light of the existing theories and develop a number of practical recommendations for practitioners that want to implement BIM based technologies. The paper concludes with a number of limitations of the here presented work and with a brief outlook.

## 2. Views on BIM based tool implementation efforts

"Building information modeling (BIM) is a digital representation of the building process to facilitate exchange and interoperability of information in digital format" [6]. In this way, the implementation of BIM in construction practice promises to improve the communication and collaboration between participants through higher interoperability of data [7]. However, to implement BIM on a construction project, practitioners need to configure and align BIM based tools, project work processes, and the business models of the companies that work together on a project [8,9]. Currently, there is little practical knowledge available to support practitioners with this necessary configuration.

To overcome these practical problems, several authors have developed different "views" on a BIM implementation with the intention to help practitioners to understand what BIM could mean within a specific implementation context. Some of the most widely suggested views are:

- BIM technology dimensions, i.e. categorizing a BIM implementation according to its soft- or hardware [10–12]
- industry level dimensions, i.e. whether a BIM implementation occurs at the industry, company, or project level [10],
- construction business functions, i.e. what function the BIM implementation should serve in the context of a construction project or for a construction firm [2,10,11]
- implementation maturity dimensions, i.e. how advanced and routine a BIM implementation is [13],
- and policy and regulative dimensions, i.e. what are the regulations and standards related to the implementation [13].

While these views certainly offer practitioners a guiding hand to manage a BIM based tool implementation, their developments, so far, have been purely theoretical endeavors with no or little empirical data that illustrated the application of these views in practical contexts. Another problem of these views is that they describe BIM based tool implementations from a top-down perspective focusing on technical and organizational dimensions at a very high level.

Such top-down views can help to strategically understand and draft large scale BIM implementation efforts with the goal to support as many business processes in and across organizations with the same set of underlying data structures and models as possible throughout the life-cycle of a building project [3]. While such strategic visions are appealing, BIM applications in current practice are rather characterized by the use of a multitude of models that are supported each by a different set of BIM based tools. Hence, the utility of the higher level frameworks is limited for the actual implementation of BIM based tools at the operational level [14]. After all practitioners have to understand how to best configure BIM based tools to support specific work processes [15]. Because of these reasons, the above summarized strategic level dimensions still are limited in guiding BIM based tool implementations in practice.

It is not surprising that several researchers have tried to complement the above described high level frameworks with concrete methods of how to support specific construction management work processes with BIM based technologies. Studies have, for example, developed processes that allow the use of BIM based tools to support specific construction management work processes. For example, researchers have developed BIM tool supported processes for constructability review [16], site management [17], scheduling, workflow-based or location-based planning [18], safety planning [19], or the identification and resolution of time-space conflicts [18].

Further, authors have derived more detailed and targeted BIM based tool implementation guidelines in close relation to empirical data collected in real organizational contexts. In this way, a number of studies have identified several drivers for BIM based tool implementations in practical contexts. Some of the more important identified drivers are

- the personal motivation of the implementing actors to use the tools [20],
- the availability of contractual frameworks to allow for the use of the tools, the availability of sufficient technical knowledge and skills [20],
- the availability of opportunities to apply the technologies [20],
- the existence of strong social networks to align goals and processes of an implementation [21],
- or the availability of high quality support from IT departments and top management support [22].

There is no doubt that these research efforts have significantly furthered empirical understanding about the meaning of the industry level, organizational, and regulative views summarized above. However, due to the underlying assumption of most of these studies that BIM technologies are not malleable, they only focus on how organizations and their work processes can be changed to adapt to specific technology characteristics. Little is still known about the possibilities to change BIM technologies and their functionality to existing organizational work processes.

To overcome this limitation of existing studies, this paper presents an empirical study with the main goal to increase the practical utility of the above "business function" views in relation to the technology related views. To do so, the paper empirically shows that existing construction management best practices are a good vehicle to understand and guide BIM based tool implementations. In particular, the paper describes two BIM based tool implementation efforts and uses generally accepted project management "business functions" as a post-priori view to describe and analyze the implementations. Before the paper describes and analyzes the two implementation cases in more detail, it will first summarize the research method that we applied to collect data from the cases in the next section.

## 3. Research method

We collected the empirical data for this study while supporting the implementation of BIM based technologies in two construction organizations. The goals of these two efforts were to explore bottom-up technology implementation efforts in relation to the context of the two organizations instead of observing technology implementations independent of their context. To allow for an in depth understanding of the existing contexts, the second and third authors of this paper, therefore, worked closely together with the members of the two organizations trying to get as deeply involved in the practical organizational work routines as possible. Hence, the research strategy we applied on the two case study projects can be best described as case based action research [8,23].