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BIM IMPLEMENTATION IN DESIGN FIRMS. RISK-RESPONSE STRATEGIES TO SUPPORT CHANGE MANAGEMENT

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Keywords: Building Information Modelling (BIM) implementation, change management, supply chain management, risk assessment

Abstract *This paper presents a research project which is being carried out at Politecnico di Milano about the topic of BIM implementation in design firms.*

The overall construction sector is facing a revolution about knowledge and process management. Building Information Modelling (BIM) is both the technology and methodology enabling this change. Although benefits derived from an efficient knowledge and process management by using BIM are increasingly recognized and the technology is rapidly growing, the pace of BIM adoption in the Italian context is still slow.

The change process involves numerous challenges and many risks factors, interrelated to barriers to overcome, have to be managed: 1) Managerial: inefficient processes and fragmented supply chains; 2) Social/cultural: people's resistance and high percentage of Small and Medium Enterprises (SMEs); 3) Technical: scarce interoperability between software and tools; 4) Institutional: lack of government involvement, thus of national standards and guidelines; 5) Economical: high investment requirements.

Until now, many research efforts have been concentrated on benefits, thus process outputs, deriving from BIM adoption - instead, little interest has been placed in mapping BIM inputs. Not considering BIM as a process made up of both inputs and outputs may lead to create more and more barriers to its implementation.

The research project aims to fill up this gap by managing BIM implementation in design firms through the development of risk-response strategies. This research project, which is still ongoing, is being conducted in two phases. The first one in which the traditional design process has been broken down in phases and activities, identifying, for each of them, outputs and involved stakeholders. The second one is mapping a BIM implementation process tested on a pilot project, assessing where BIM mitigates risk factors related to a traditional design process and where it adds new ones.

1. INTRODUCTION

The overall construction industry is more and more asked to boost innovation in knowledge and process management to improve both process inefficiency and sector productivity [1]. The way is to develop digital and integrated environments, driven by a knowledge-based economy. Building Information Modelling (BIM) is the new technology and way of working being adopted by construction sector to improve both product quality and process efficiency [2].

In accordance with the definition given by the National Institute of Building Sciences, BIM is “an improved planning, design, construction, operation, and maintenance process using a standardized machine readable information model for each facility, new or old, which contains all appropriate information, created or gathered about that facility in a format useable by all throughout its lifecycle” [3].

However, even if benefits derived from an efficient knowledge and process management by using BIM are increasingly recognized and technologies are rapidly growing, the pace of BIM adoption, above all in the Italian construction sector, is still slow [4, 5,6].

Since this digital transition involves numerous challenges interrelated to barriers to overcome, risks related to this change process should be first assessed and then managed. These different risk factors may be classified as it follows:

− Managerial: fragmented processes and atomized supply chains characterizing the construction sector;

− Social/cultural: high percentage of Small and Medium Enterprises (SMEs), above all in the Italian construction sector, as well as people resistance to change (conservative approach);

− Technical: still scarce interoperability between many software and tools used by the different actors involved in the whole construction process;

− Economical: high investment requirements to purchase software and hardware, as well as for training and hiring BIM-capable people;

− Institutional: lack of government involvement, thus of national BIM standards and guidelines.

These risks might well be assessed, thus managed, in order to get a successful BIM implementation. In fact, for example, given the immaturity of the Italian context about digitalization and BIM, and consequently the aforementioned barriers to change, Italian design firms should develop transition strategies according to risks related to this change and mapped within the construction process.

Until now, benefits deriving from BIM implementation have been widely investigated; many research efforts have been concentrated on BIM outputs [7, 8, 9]. Instead, little interest has been placed in mapping BIM inputs. Not considering BIM as a process made up of both inputs and outputs may lead to create more and more barriers to its implementation and to underestimate risks related to this change [10, 11].

2. PROJECT OBJECTIVES

Starting from these considerations, the research project, which is presented in this paper, aims to achieve a critical understanding of this transition process by mapping the related risk factors within the construction process. In fact, if on the one hand, the growing need for innovation in both products and processes calls for digital environments enabled by the BIM methodology, on the other hand there may be conditions in which BIM is still not convenient.

Therefore, the research project aims to propose to design firms an interpretation map of the construction process in which risks related to this change have been identified. In this way, design firms could develop digital transition strategies calibrated according to peculiarity of their own organizational structures, readiness level of supply chain, as well as maturity of national contexts within which they work.
International standards and best practices, as well as case studies with different maturity and knowledge levels, will be assumed to benchmark and calibrate project results.

3. WORKING PROCESS

In relation to the aforementioned objectives, the research project is being developed through consequential steps, each of them associated to the achievement of specific targets. Some of these tasks (from point 1 to point 12) have been already performed; others are still planned (from point 13 to point 15).

Performed tasks:

1. Assessing the state-of-the-art at both national and international level;
2. Selecting a BIM pilot project as case-study;
3. Breaking down a traditional Design-Bid-Build (DBB) process (managed with CAD technologies) in codified phases and related activities;
4. Identifying and codifying outputs and involved stakeholders for each phase and activity of the traditional DBB process;
5. Designing the related workflow;
6. Mapping the process of the selected BIM pilot project;
7. Highlighting changes in the aforementioned traditional process in comparison to the BIM pilot process;
8. Assuming international BIM standards and guidelines as benchmark;
9. Pointing out differences by comparing the BIM pilot process with the BIM process as drawn by international standards and guidelines;
10. Implementing the BIM pilot process, taking into consideration both the aforementioned DBB process and the BIM process as proposed by the analysed international standards and guidelines;
11. Determining strengths and weaknesses of the BIM pilot process (quality of data

exchange among project stakeholders, level of consultants' BIM capabilities, time managed with a BIM methodology or a traditional approach, process efficiency in terms of effective time/delay time, etc.);

12. Developing an implementation framework, taking into consideration the aforementioned analyses on process strengths and weaknesses, to support the design firm in successfully adopting BIM.

Planned tasks:

13. Selecting other national and international BIM-based projects as case-studies;
14. Analysing the related workflows, taking into consideration organizational structures, supply chains and national contexts within which these projects are managed;
15. Developing an interpretation map of the construction process which identifies risks involved in this change to support design firms in creating their own digital transition strategies calibrated according to the different organizational structures, supply chains, as well as national contexts.

4. ACTION RESEARCH

As outlined above, the research project has selected a BIM pilot project as case study. This task has been carried out in collaboration with an Italian architecture and engineering company, which is transitioning its business structure and supply chain towards a digital environment supported by the BIM methodology.

The organizational structure of this firm can be described as an integrated and multi-disciplinary model. In particular, internal working areas which have been involved in this BIM pilot project are: space planning, architecture, rendering, engineering, fire safety, health & safety, as well as quantity survey. Instead, services outsourced through consultancies are: building survey, structural and illuminating engineering, and acoustics.

Although the high-level integration of this working team, not all the involved stakeholders have been able to manage the project within a digitalized environment. In particular, the architecture, engineering and rendering departments have been able to work with a BIM methodology, even if with different levels of knowledge competencies. Instead, all the other internal working areas, as well as external consultants, have not yet developed sufficient skills to work within a digitalized environment (see Figure1).

By observing day-by-day the development of this BIM pilot project, it has been possible to map the related workflow. Moreover, by comparing it with the previously designed DBB process, some changes have been highlighted in both activities and supply chain relations (see Table 1).

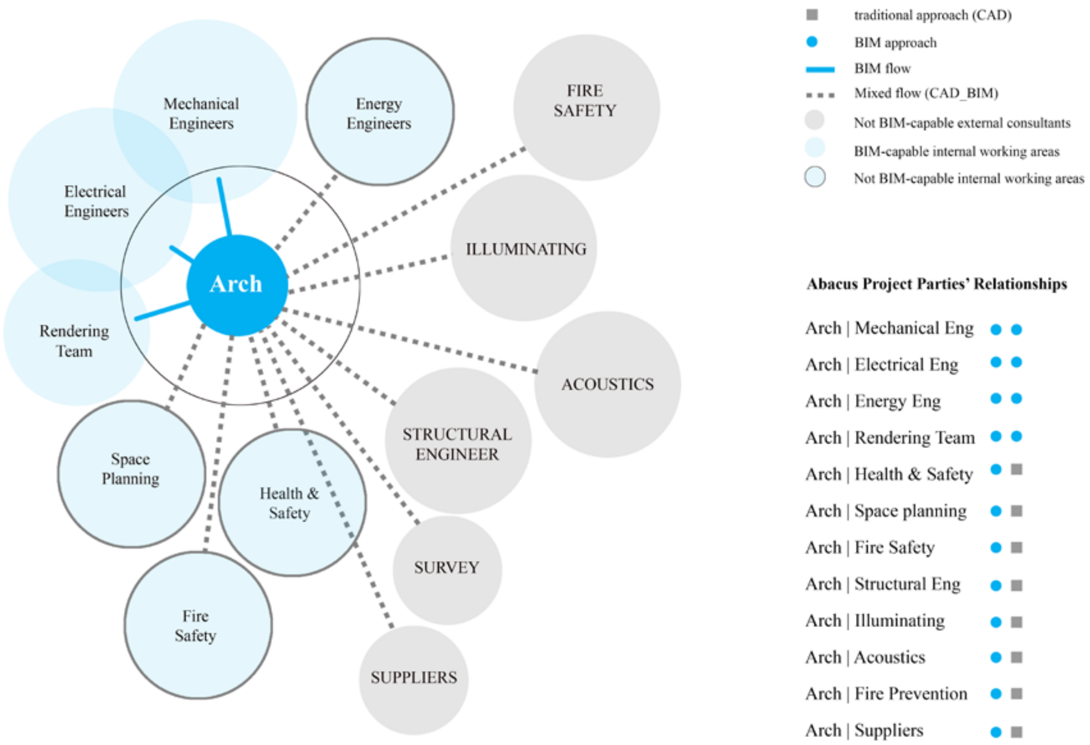

Figure 1. Infographic describing stakeholders' BIM competencies (or not) and project parties' relationships

Table 2. Changes highlighted in the BIM-pilot process in relation to a traditional approach

Managerial	**Social/Cultural**	**Technical**	**Economical**
Integrated digital workflow between the architecture and engineering areas	BIM training offered to the architecture and engineering areas	Reduced file exchange between the architecture and rendering areas	Hardware & Software implementation (R&D investment)
Integrated digital workflow between the architecture and rendering areas	Improved synergy and collaboration between the architectural and engineering teams	Improved consistency and accuracy of architectural and engineering drawings	
Enlarged marketing opportunities	New roles and responsibilities within the working team	Reduced file production by the architecture and engineering areas	
	Improved design consciousness of the architectural and engineering areas		

This BIM pilot process has been analysed not only in comparison to the traditional approach (DBB process), but also in relation to international BIM standards and guidelines [12, 13, 14, 15] assumed as benchmark by the research project.

Comparing the BIM pilot workflow with the BIM process as outlined by international standards and guidelines has been useful to identify some differences (see Table 2).

Table 2. Differences highlighted in the BIM pilot process in comparison to the BIM process as proposed by international standards and guidelines

Managerial	Social/Cultural	Technical	Economical
Lacking preliminary agreement with the Client about management, technical and commercial issues of the BIM process (Employer's Information Requirements-EIR, BIM Execution Plan-BEP)	BIM training not offered to all the internal working areas involved in the pilot project	Lacking preliminary standardization of the BIM environment according to business process and procedures	Design process with time delay
BIM not implemented throughout all the phases of the construction process	Lacking preliminary definition of stakeholders' roles and responsibilities		
BIM not implemented by all the working areas involved in the BIM pilot project	Lacking preliminary evaluation of consultants' BIM-competencies		

5. METHOD FINDINGS AND ARGUMENT

In order to understand how these differences between the pilot process and the BIM workflow, as drawn by international standards and guidelines, have influenced process efficiency, some other analyses have been carried out by the research project.

First, it has been highlighted that the design process recorded a delay time which is around 30% of the initial estimated time. Then, the research project has tried to understand which issues have determined this delay time. A research question arises: have those differences previously identified by comparing the BIM pilot process with BIM international standards (see Table 2) influenced process efficiency? If yes, how?

Some analyses on the timesheet of the BIM pilot project (quantitative analysis), as well as interviews with BIM-capable management resources (qualitative analysis) have been useful to understand how these differences have influenced process efficiency. It turns out that some of these issues have negatively influenced process efficiency:

- Lacking preliminary evaluation of the consultants' BIM competencies has produced a +400 hrs. (4% of the total amount of hrs. dedicated to the project);
- Lacking of BIM capabilities and competencies within the supply chain (not BIM-capable, nor readable suppliers) has produced a +50 hrs. (0.5%).

Instead, some other issues, even if still generating a plus of hours in comparison to a traditional approach, have positively influenced the BIM process:

- Training people about BIM has produced a +600 hrs. (6.5%);
- Standardizing the BIM environment according to the business quality and procedures has produced a +100 hrs. (1%).

Therefore, summing up all these issues, it turns out that a +1150 hrs. (12,5%)has been determined by both inefficient process conditions and efficient pilot project activities. If we consider that delay time has been around2000hrs, it means that a reduction of 50% may be achieved, both by improving BIM process and experiencing BIM projects.

The research project is now selecting other national and international BIM-based projects as case-studies in order to analyse the related workflows, taking into consideration organizational structures, supply chains and national contexts within which these projects are managed. In this way, it could be possible to validate and calibrate project results in order to develop an interpretation map of the construction process which identifies risks involved in this change to support design firms in creating their own digital transition strategies.

6. CONCLUSIONS

A successful BIM implementation should be carried out through an incremental, integrated and risk-response change management. In this heterogeneous transitional context, design firms should develop their own implementation strategies taking into consideration not only international BIM standards and guidelines, but also peculiarity of their organizational structure, readiness level of supply chains, as well as maturity of national contexts within which they work.

For example, focusing on the aforementioned BIM pilot project, some key issues have been proposed to the design firm as supporting tool to develop their own transition strategy. Specific organizational structure, supply chain and national context have been considered to mitigate risks involved in this change process. Analyses about process inefficiencies of the BIM pilot project, as well as international BIM standards and guidelines, have been considered to develop these key-issues which involve three different action levels: Process-Product-People (3P) (see Table 3).

Table 3. Key-issues proposed to the design firm as supporting tool to successfully implement BIM

Process	Product	People
Involving other business working areas in this digital transition process	Standardising BIM environment according to business quality and procedures	Defining roles and responsibilities of all the stakeholders involved in the BIM process
Collaborating with BIM-capable consultants		Involving other business working areas in the BIM training
Preferring BIM-readable suppliers		Improving competencies of BIM-capable resources

These guidelines have been developed to mitigate endogenous risks related both to the specific organizational structure and supply chain of the design firm. Nevertheless, there are some others, such as risks related to immaturity level of the Italian construction sector or to the lack of institutional involvement, which cannot be directly managed by the design firm, but still they have to be identified in order to develop a successful BIM implementation strategy.

For these reasons, the research project aims to identify both endogenous and exogenous risks related to this digital transition, in order to support design firms in developing risk-response project management strategies. In this way, design firms could develop their own digital transition roadmaps by taking into consideration organizational structures, supply chains and national contexts within which they are working.

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