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BIM AND PUBLIC ADMINISTRATION

The Brazilian Case

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Abstract. Brazilian construction industry's efficiency level is very low. Within the public administration sectors responsible for the construction of public facilities, this fact is amplified by the very nature of the laws regulating the public expenditures. Transparency and active public accountability are in its initial stages, creating misinformation and opportunities to corruption. Some public initiatives of adopting BIM (Building Information Model) for public construction projects are however taking place, seeking to revert this scenario. Corruption is one of the particular problems that are to be addressed for a efficient adoption of BIM in the public sectors. In addition to the traditional corruption-fighting tools, if we comprehend all the actors and processes that lead to the construction and operation of a public building as a whole complex system, where BIM is responsible for transparent flux of information, it can provide another layer of transparency, accountability and social control over the process.

Keywords. BIM; Public administration; Brazil.

1. Introduction

This article is a result of a research work currently undergoing at Nomads.usp Center for Interactive Living Studies at the Institute of Architecture and Urbanism of the University of Sao Paulo (IAU-USP), a Brazilian public university, and aims at establishing the theoretical and conceptual basis for the study of the possible impact of the introduction of BIM (Building Information Model) within the Brazilian context of public works, exploring the necessary changes in the workflow, new

information inputs and the limits associated with such new design processes.To illustrate this, this article is divided in three sections: The first section will paint a broad picture of the actual processes of public contracting in Brazil, dealing with the legal and practical aspects that guide public expenditure in buildings projects, and the role that is played by corruption in the processes. The second section deals with BIM itself, its concepts, its reach and shortcomings. We will present BIM as part of a complex system, capable of maintaining a coherent and transparent flow of information. The third section will deal with recent BIM implementation initiatives in Brazil in some sectors of the State' structures, establishing relations among proposed implementations exploring their limits and roles in changing the building process, concluding with some directions to new research works being developed by the Nomads.usp group aiming to verify and validate the possibly impacts and methods of BIM implementation on the given context.

2. Brazilian Public Works Context

Brazilian construction industry in general has a very poor historic of efficiency. Resources and materials waste due to deficient planning, low standardization level and non-rationalized construction techniques lead to overpriced buildings and recurring schedule delays (Baldry 1998). Within the public administration sectors, this figure is amplified by the very nature of the laws regulating public expenditures. Brazil's public contracts are mostly ruled by two legal frameworks: the 8.666/93 act, which deals with "Rules for public biddings and contracts", and 10.520/02 act, dealing with public auctions for more common expenditures, such as consumables and easily quantified objects.

The former is responsible for the majority of the public buildings bidding processes. In its text, the law defines what is called "the basic project": an intermediate phase between what is defined by the American Institute of Architects (AIA) as the "design development" phase and the "construction document" phase (AIA 2007). The law adopts a loose definition to the term:

"IX- Basic Project: a set of necessary and sufficient elements, with an adequate level of precision, to characterize the work or service or complex of works or services that are the object of the bid, based on the indications of the preliminary technical studies, that ensure technical feasibility and adequate treatment of the environmental impact of the undertaking, and that allows the evaluation of the cost of the work and the definition of the methods and the execution period, and should contain the following elements: (...)" (Brasil 1993, our translation)

In the text of the law, this definition is not tied to the Brazilian Association of Technical Normatives (ABNT in portuguese) committee definition of building design phases, and is open to interpretation of what is "sufficient" or "adequate".

One of the practical result of that lack of normative enforcement is that little time and few specialized human resources (architects, engineers, technicians) are allocated to the planning phase by public services, generating a great deal of improvisation and modifications during the construction phase. It is not unusual that either the initial cost arises without adding quality to the project scope or this latter is reduced for the same initial price (Rasmussen 2013).

As a consequence of this grade of uncertainty, the law permits, in its text, that new buildings are allowed to a 25% cost increase or decrease, and in the case of a refurbishment, this amount goes up to 50% of the original cost. In fact, the contractor cannot even object to this amendments to the original contracts. As the laws says:

"§ 1o The contractor is obliged to accept, in the same contractual conditions, the additions or suppressions made in the works, services or purchases, up to 25% (twenty five percent) of the updated initial value of the contract, and, in the particular case of building or equipment renovation, up to the limit of 50% (fifty percent) for their additions." (Brazil 1993, our translation)

This grade of uncertainty create improvisations on the construction site and costs and deadlines overruns. Santos et al. (2015), after an extensive comparative study of public buildings' construction process, ascertain that in the majority of cases these flaws are not there by mere chance, but are an intentional part of the bidding and building processes. The authors also note in their study that the responsibility for these uncertainty is the lack of well defined and precise preliminary studies and projects. This leads to another important facet of public contracts in Brazil: they are notoriously plagued by corruption schemes. Corruption isn't a mere question of enforcing a legislation or punishing the involved parts; it is a social problem as well as legal one (Filgueiras 2011). Corruption on public buildings contracts is an important factor in the Brazilian context, and some discussion of its concepts are necessary.

The very concept of corruption is based upon a shared secret between the involved parts (Abramo 2005). Another important concept about corruption, and specially important for this study, is that corruption is a wicked problem, one that is not easily delimited and is amorphous by nature, adapting itself to the attempts to curb it (Sabet 2012). It means that not only it is very difficult to identify and understand the actual mechanisms of corruption on a given context, but also that while attempting to combat it one cannot do so by half measures or with palliative efforts, as it will adapt itself to the new parameters (Sabet 2012).

Thus, it is not possible to discount official measures to deal with corruption; in fact, in the very core of these efforts, the strengthening of the State's structures and regulations are paramount, granting transparency of its acts (thus attacking the very concept of "secret" common to all corrupt acts) and accountability of public officials (dealing with the sequester of the State's structure by them).

In short, the perception of corruption is more attained to a shroud of secrecy in the State's acts and to the lack of access to the State's services and goods, as corruption acts in the border of the public and private, blurring and mixing this two concepts which are structural for the democratic States. In this context, corruption can be understood as a lack of inclusion of the population on the democracy system (Warren 2015).

Public services are intimately linked to public buildings or places. In Brazil, a series of nationwide spontaneous protests in 2013 had no clear agenda besides the dissatisfaction with the public services and officials. These demands lead to a "positive agenda" by the politicians at the moment, but those proved, about a

year later, to be insufficient to deal with "alarming levels of corruption in Brazil" (DeSanctis 2015, p. 394). The ongoing so called "Lava-Jato" (Car Wash) investigation that began in 2014 (leaving aside all its internal contradictions and doubts about its political uses), exposed a network of inappropriate relationships between Brazil's biggest construction companies and high-ranking political officials, all the way to the top of the government. The "Lava Jato" generated other investigations branched from the first, based on the successive leniency accords made by the involved companies and individuals.

Although the newspapers stamp the corruption linked to bigger projects, the problem is pervasive on all scale of public buildings construction (Santos 2015). Add to this scenario a characteristic lack of transparency in the government acts that only recently is being addressed by means of initiatives of electronic governance and accountability laws and processes (Article 19 2014) and we can infer that these two factors - the gaps in the legislation and the lack of transparency on the government acts - although aren't the only issues that contribute to the actual state of the public construction projects in Brazil, are in the root of the perception of lack of accountability and incapability of a broader social control that would otherwise contribute to minimize the problems detected.

Some public initiatives of adopting BIM for public construction projects are taking place, seeking to revert this scenario of waste and corruption. It is important however to conceptualize some points about BIM and its implementation on other contexts to compare with the Brazilian scenario.

3. BIM Concepts and Adoption Cases

In the context of this research, BIM is understood as a complete and differentiated information system, capable of influencing not only the project design and execution cycle, but also allowing greater technical and social control over public spending. If the processes, actors and variables that dictates the conception, construction and lifecycle of a public building are by their very nature diverse and complex, the problems detected are of the same nature. BIM here is understood as a part of a complex system, as defined by Ludwig von Bertalanfy. The author writes that a system is "(...) a complex of interacting elements" (Bertalanffy 1977, p. 84). The system can not be studied from the reduction to its constituent parts, under the risk of what Edgar Morin (1977) calls "decomposition" of it. However, even if the constituents of the system are not isolated, they must not be ignored. It isn't a focus on the whole to the detriment of the parts. This concept is important as to put in perspective that BIM isn't just a technological increment over CAD; its implications are more profound and demand a more holistic understanding of the whole context.

Manzione (2013) identifies the concept of a project as a flux of information, able to reduce the waste of time spent on information management. This concept can be "adopted for the design process, (...) allowing flexibility and coordination of different information flows and the interaction of the design process with the supply process and the execution of the work" (Manzione 2013, p.22, our translation).

In this methodology, the driver of the design process is the information itself, not the individual product of each task, and for maximum efficiency, it must flow unimpeded and integrated, a task that BIM systems can perform. (Eckert et al. 2001 apud Manzione 2013, our translation).

BIM, therefore, allows people to virtually experience a building, in all its aspects (Underwood & Isikdag 2010). This includes the design and construction process as a whole. Sacks (2012) informs that BIM is more than a technical exercise: it is a social exercise, focused on collaboration and cooperation, helping the decision making of the professionals involved by aggregating the available data.

Eastman et al. (2008) emphasize the importance of BIM as a form of production, analysis and, important in the case of the present research, communication of building models. Thus, BIM assumes the facet of a tool of production, management and organization of the information about a building. It is more than simply using another project tool, it is about an information system that can integrate with other systems, generating and receiving information. These concepts tie in with the definition of a system in the aforementioned von Bartalanffy's text.

But even as this complex view allow for a holistic vision of the processes involved, it also results in a slow rate of adoption of this concept. There are several studies on the implementation of these systems, comparing the moment of transition from hand drawings to CAD (Computer Aided Design) platforms, and the difficult task of modifying processes and procedures that are already ingrained in design. Leonardo Manzione (2013) after a complete bibliographical review detects that still, within the construction industry:

"In general, (the) culture and the mentality of 'knowledge silos' prevail in AEC (Architecture, Engineering and Construction), and the exchanges based on documents between professionals and the production chain occur in an uncoordinated and low intelligence manner. Decisions are often taken autonomously and without multidisciplinary participation, and with the absence of accurate holistic understanding" (Manzione 2013, p. 9, our translation)

The author, in his thesis, points out that despite a relative profusion of works on the subject and a general interest in the technology, publications generally adopt a "messianic" tone, more interested in offering BIM as a "product" to be sold to the companies than a complete system that requires an overall restructuring of the design methods and concepts (Manzione 2013).

Therefore, an important role is played by the public sector. As Succar (2009) puts it, the public sector is a policy-maker actor, and thus helps to create the foundation, to regulate and to oversee this process. In Brazil it also overlaps, in a smaller scale, with the Process field actors (as defined by Succar 2009), demanding and sometimes producing projects and buildings. Thus, it is understandable that public building and contracting processes are important to define long-term policies and developments, and to implement BIM in a complete, and not fragmented, way.

For instance, Cheng and Lu (2015) in their very extensive study of worldwide BIM adoption identifies some countries or areas that are currently adopting and creating standards for BIM implementation. The authors also identifies six roles that the public sector play in the BIM adoption: Initiator and Driver, Regulator,

Educator, Funding Agency, Demonstrator, Researcher (Cheng & Lu 2015). Of special interest for this study, on all of them the role of Initiator and Driver was taken by the public sector, even if other roles were not attributed to it. According to the authors:

"Undoubtely the public sector plays a key role in initiating BIM. Public organizations in most countries has set their BIM goals and required the use of BIM in public construction projects when they first jumpstarted BIM technology (...)" (Cheng and Lu 2015, p. 466)

Wong et al. (2009), in their study of the role of major stakeholders in BIM implementation in various countries in the world, declare that:

"(...) It is observed that the support of the central government towards BIM implementation can be regarded as the driving force towards higher utilization of BIM in those countries. If the support is strong it would create a uniform environment for nation-wide acceptance of BIM. BIM requirement would then come under legal jurisdictions. (...)" (Wong et al. 2009, p. 6-7)

BIM implementation on virtually all aspects of the construction industry, as documented on the extensive works of Succar (2009) and Succar & Kassem (2015), is necessary to achieve its full potential, although that, by the relative novelty of the frameworks and technologies involved, there weren't enough time yet to a full implementation as preconized in these works. (Succar 2009)

One of the most successful cases of BIM implementations is the United Kingdom's, by the establishment of a "BIM Task Group" by the government, with a clear and objective roadmap and extensive interaction and collaboration with the private contractors and the academic community. Also in the works is the roadmap for BIM level 3 implementation, one that would fully realize the BIM framework in the entire lifecycle of an edification and and the "one-model" concept. The final objective is the called "Digital Built Britain", where the model acts as more than a one-way information repository, but allow that cloud computing, the internet of things and big data information to be used and incorporated to the model, reflecting the many levels of relationship beyond the pure physicality of the building. (BIS 2013)

This experience has the potential of expanding the BIM concept beyond the purely technological and industrial processes, opening up the possibility that information generated by external actors (physical, natural, social or otherwise) outside the building can be incorporated automatically to the model, helping the decision making progress in eventual refurbishments and expansions by providing and incorporating feedback in its entire life cycle. It can also generate a database of real-world scenarios to future buildings of that kind or placement, important in the case of public buildings that are, in the name of cost savings and lack of information, built in a serialized manner with a disregard of the local peculiarities. It can also expand the reach of the information about all processes involving a public contract to the public and professionals at large, who can then engage in a social control of the process.

4. Comparison and Guidelines

It is clear that the simple implementation of BIM isn't *per se* a solution for the construction issues of low quality, high cost, high uncertainty and associated corruption processes as described in the first section of this article. The literature about the concepts of BIM preview that the first phases of BIM adoption in a given context are fragmented by nature, and the full implementation of the system can only take places as a multi-actor driven effort. (Succar & Kassem 2015). As the international cases cited verifies, BIM adoption is generally driven by initiative of the government in conjunction with other sectors (Cheng and Lu 2015), even if in later stages of implementation and diffusion its role is diminished (Succar & Kassem 2015).

Brazil's adoption of BIM has been slow, with only private individuals and few fragmented public initiatives fully embracing it. As Kareem and Amorim (2015), in its comparison of the actual state of adoption of BIM in Brazil to six countries of the EU shows, some of these initiatives are very advanced, but with limited reach:

"In Brazil, although BIM is not mandated at any level, industry reports (...) shows that the use of BIM in Brazil is focussed more on cost control at the construction phase rather than on the collaboration with owners. This represents a reversed BIM usage pattern to the one witnessed in other countries (UK, France, US, Germany, etc.) where BIM entailed more collaboration with owners and other project stakeholders. This use of BIM and the maturity level of contractors in Brazil could trigger a middle-out type of implementation pressure across the supply chain. However, this effect could be limited or slow. Indeed, seminal research on innovation diffusion in construction industry demonstrated that coercive forces are more significant in influencing the extent of BIM adoption especially if they are mediated by the client or owner (Dimaggio & Powell 1983; Mitropoulos & Tatum 2000; Cao et al. 2014)" (Kareem 2016).

Worth mentioning is that the brazilian army's Diretoria de Obras Militares (Directorate of Military works) has implemented a system called OPUS. As Kareem reports:

"OPUS is an integrated system for the management of project delivery phases (e.g. procurement, design construction, demolition) that includes information about over 16.000 buildings making up the asset portfolio managed the Brazilian Army. OPUS is also a web-based system in which 2D and 3D models, from several sources and in several formats, can be overlaid on a Google map using a system of coordinates. Over the web, the system allows the switching over several levels of model details (3D, 2D, etc.) or by project delivery phase (e.g. construction, demolition, etc.)." (Kassem 2016)

The OPUS system represents an advanced technological infrastructure, which are in development in other countries. However, by its military nature, it is not publicly accessible, and by its limited reach, cannot be considered an extensive governmental policy.

In Brazil, an isolated implementation of BIM would produce results below the desired ones. Thanks to the wicked nature of corruption, the risk of sequester of the system by the *status quo* to maintain its dominance over the processes of

public works' planning and building is real. A transformation of the entire legal framework is necessary, including the establishment of procedures and standards by the public government. These transformations, however, are beyond the scope of this paper, but suffice to say that in the actual Brazilian moment, measures to address some issues of transparency and accountability are slowly being discussed or taking place (accountability law bills in the congress, the information access bill, etc.), creating an ideal moment to the implementation of BIM guidelines and policies.

Comprehending BIM as a system and a framework for information flow and concentration, its vital that it is incorporated as a central piece of these policies, as Kaseem and Amorin (2015) diagnosis in their extensive report. They recommend the creation of a working group composed not only of government officials but also the society and stakeholders of the area (general public, contractors big and small, the academy) at large. It must, however, be driven as a public initiative, for its effects must be generalized over the entire market. A public forum involving all areas would be adequate to breaking the historical power concentration on the executive branch of Brazilian government, accustomed to deliver policies in a top-down manner (Ríos-Figueroa 2013).

5. Conclusions

Implementation of a system as revolutionary and complex as BIM in a context even more complex as any given society is a daunting task, one that cannot be taken lightly or in an isolated manner, with decisions taking place at closed doors. In the special Brazilian case, some issues that the BIM hopes to address are not pure processual flaws; one can argue that are built-in in the system to produce opportunities of mismanagement of public money in the fringes of the actual uncertainty and opaqueness of public acts.

However, international experiences shows that BIM is effective in dealing with this shortcomings, when adopted in a sensible and customized way, dealing with the particularities of each context.

BIM also can be approached as a complex system, on that the different actors exchange information between them, giving and receiving inputs and feedbacks. In this context, BIM is not the system per se, but the responsible for the coherent and unimpeded flow of information, generating a global comprehension of the object being projected or built in a more attuned way.

This characteristic also echoes in the very basic concepts of good governance and social control: unbiased and depersonalized information control and transparency in the public acts and decisions.

Ultimately, this framework can be used not only to permit a passive control by the civil society of the decision making and operationalization of public works, but also incorporate public-driven feedback on these actions, via active channels (ombudsman offices and prosecutory departments, surveys) or passive data collection (big data, remote sensing via internet of things).

This would, in one hand, empower and involve the civil society in the political and governance systems; in the other hand, would exert pressure over public offi-

cials to keep in mind the collective interest over the particular, effectively reducing the power of public officials and holding them accountable for any misdeeds.

The academy, in this initial stage, has an important role of identifying the common and disparate elements of another experiences and contexts and create guidelines for the successful adoption of BIM, aiming for a more quality, productivity and social control of the process. Its not a streamlined or easy process; interfering in a possibly corrupt system, which tends to close itself to new actors outside their sphere of influence is a difficult matter, but one that the academy is fit to deal with.

As the principles of the scientific work are its transparency, openness and systematic review, the very act of studying some aspects of the problem is bound to attract attention and a greater scrutinization of the bidding/construction process. Academy also can put forward new proposals and methods, and validate it independently thru the scientific community, thus helping to break the aforementioned wickedness of the corrupt system. Without the safeguard of transparency and social engagement, any new method or technology could be incorporated in the corruption schemes, mantaining the *status quo*. Therefore, the academy is fundamental by injecting rigour and transparency in the implementation of new public building processes.

With these points in mind, the Nomads.usp group is tackling the matter in the Urban Cartographies project. The project is in its initial phases of development, and in one of its lines of research, aims to explore the parameters to be used in BIM based parametric design programs, in a cycle that sees its results being available to the studied communities, thus generating greater transparency and enabling social control and engagement over potential public decisions.

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