



THE BIM IMPACT ON STAKEHOLDER MANAGEMENT IN AIRPORT CONSTRUCTION PROJECTS

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Abstract: Airports are complex and dynamic, an intricate multiple stakeholders' environment. Developing strategies to manage stakeholders within the project activities is fundamental to achieve project goals, especially concerning the decision-making process, which in airports should be as efficient as possible due to the numerous interferences to their operations any intervention on its infrastructure can present. Core to these strategies are means to communicate and exchange accurate project information for all stakeholders to assess design solutions and make decisions. This research assumption is that Building Information Modeling (BIM) can improve the communication process, helping to efficiently manage stakeholders, with better-quality information. The case study is a Canadian airport for which BIM was used both for supporting the management of a major project extension and its future operation. A series of interviews were conducted with the main airport stakeholders, internal and external to the project. Findings are: significant improvement on understanding, since BIM helps to create a common language that aligns all stakeholders' perception about the project; a collaborative environment that generates trustful relationships; a sense of project ownership with the creating of a project community; improved engagement to the project. These findings were validated with two specialists in airports domain.

1 INTRODUCTION

Airports deal with countless elements that impact on their efficiency. This industry changes constantly: it must be able to adjust itself quickly and efficiently to respond to those demands. To do so, it is mandatory to combine the airport requirements, regulatory laws and financial goals all together in a multiple stakeholders' environment to get the best response to every distinct situation. In airport projects, the concept of stakeholders may be understood as everyone that uses the infrastructure, i.e. passengers, services offered, governmental authorities, air companies, even the public in general, the city where the airport is located, or the country. With such huge different kinds of stakeholders, it is not difficult to realize that this type of venture is affected by many conflicting situations, which make the relations between project team and the airport stakeholders so important. Thus, stakeholder management might be considered strategic to engaging all different individuals, groups or institutions impacted by the project activities or with the power to impact them.

Inserted in the airport environment, influence of various actors with different motivations may interfere with the conduct the project has a negative impact on an airport engineering project that may translate into significant financial losses for the entire community. Communication problems amongst stakeholders are one of the main causes for the performance issues on those projects, requiring a collaborative approach to deal with those issues. Collaboration on projects requires stakeholders' engagement, which is based on the communication process and its information quality (Egan and Williams 1998). Poor data flowing through

this process leads to a distrusted environment and all effort made by the project team in engaging stakeholders might fail (Pryke and Smyth 2006).

New technologies had been developed, like Building Information Modeling - BIM that may help to deal with these issues. The new work environment that comes with BIM demands skills that go beyond the abilities project teams traditionally have to run projects successfully. Trust, engagement and sharing are then required to create a positive context in which BIM collaborative work can arise (Crotty 2013), and to promote the working culture of high performance (Kumaraswamy and Rahman 2012) needed for airport projects. The good quality and trustworthy information generated by BIM technologies can help improve communication flow, which, in airports, means that decision-making process might run quickly and assertively as demanded. All the conflicts generated by misunderstanding technical documents may be reduced and stakeholders should be able to communicate with each other in a more efficient manner. Therefore, BIM technologies implementation could contribute on the effectiveness of the stakeholders' management in this context. Our assumption is that, by refining the way technical teams produce and manage information, moving from document-centric to information-centric management, communication between internal and external stakeholders will gradually improve, producing a positive effect on stakeholder management. This research aims to assess how the use of BIM technologies, especially 3D visualization¹, can impact the efficiency in managing stakeholders.

The objective of this research is to establish the relationship between the improvement on the quality of information flow that BIM can add to projects and its impact on the stakeholders' project engagement. The contribution to knowledge is a conceptual mapping of the effects of BIM in the decision-making process, highlighting its impact on project efficiency. The case study is the terminal area enlargement of the Québec City International Airport, one of the first in Canada to use BIM technologies in airports in a whole facility lifecycle perspective. The project counted with two main phases: the first phase consisted on the construction of the new terminal area, that was isolated from the operational area, delivered on late 2017; and the second phase, which is currently running, consisted on the connection between the two terminal areas. It is worthy notice that the project team was able to deliver the first phase respecting the project parameters and is perceived as a success for the airport stakeholders and project team.

2 LITERATURE REVIEW

The aim of the literature review was to establish the links between the three domains that compound airport engineering projects: construction industry, project management and airport industry: identifying the concepts from these three domains related to airport stakeholders' management strategies.

2.1 Construction Industry

The increased specialization and the large number of specialist firms involved on projects worsened the inner construction industry complexity, being this fragmentation the critical factor of poor performance and low productivity of this industry (Crotty 2013). Other factors that corroborate to the industry low achievement might be the misinterpretation of client needs, poor communication between designers, and incorrect or out-of-date information used to produce inadequate specifications (Rounce 1998). As a result of those elements, the generic issue among project participants that lead to low performance on engineering projects can be summarized on the communication process and the quality of the information flowing into its process (Crotty 2013).

The industry involves multidisciplinary teams producing many documents in a very high flow, but very little of the information generated in construction is structured, systematic or trustworthy (Crotty 2013). Clients spend a lot of time searching for the needed information, because it is not provided in the right way and format, and accessible to the right person. The poor understanding of the information generation and

¹ For the purpose of vulgarization, this study reduced BIM context to the term "3D visualization" in opposition to those traditional forms of engineering project information, as 2D drawings, spreadsheets, Gantt graphics, specification texts. Thus, the term "3D visualization" includes the virtual model, virtual reality, 3D/4D, etc.

storage leads to low levels of trust amongst users of the available data (Bew and Underwood 2010). To interpret all the drawings and conventional design, a very high level of human judgment is required, mainly because the client and his team might not have the ability to read the drawings and, by not understanding the technical documents, causes an uncertainty that introduces delays and revisions which reverberate throughout the entire project life-cycle (Crotty 2013).

2.1.1 BIM solutions

The industry fragmentation is one of the causes for the decreased client satisfaction due to the loss of their voices during the dissolved process that their requirements pass through, generating conflict and frustration. The most important recommendation to face this challenge is to reduce confrontational attitudes amongst its players – stakeholders – and instead embrace collaborative methods of working (Egan and Williams 1998), reducing waste, cutting cost, rationalizing processes and promoting a working culture of trust and high performance (Kumaraswamy and Rahman 2012). Building information modeling (BIM) is a new approach to design, construction and facility management, a human activity that involves broad process changes in the construction industry (Eastman et al. 2011), demanding a collaborative environment that includes all actors. Through collaboration, the information is generated by BIM models in a higher quality and its exchange protocols improve significantly communications between organizations, by enabling the well-structured information to be used directly by participants (Crotty 2013). Consequently, due to its centralization, BIM allows users to be more efficient in exchanging information during all facility's lifecycle, reducing its loss (Eastman et al. 2011).

Furthermore, the interactive 3D models are much more understandable than the paper documents, which are very often difficult to read for many stakeholders (Kunz and Fischer 2012). The visual aspect provided by BIM makes the information more easily understood by a wider range of stakeholders. By improving the way ideas can be shared with the rest of the team and offering enormous benefits to all stakeholders, the concept of 'what you see is what you get' model is the biggest benefit of using BIM for clients. This method of representation enables them to fully understand the design and allows early decision with more certainty. By growing the client's confidence and making possible to them to interact with the alternatives, the BIM visualization tools can lower the changes during the execution and the impacts on the relationship between client and contractors (Crotty 2013).

2.2 Project Management

PMI (2017) defines project as a temporary endeavor undertaken to create a unique product, service, or result, being a solution for a social or organizational problem, a policy or a strategy, or part of a program. With specified duration, cost and performance, projects lead to uncertainty and complexity, which requires balancing all relations between the project and its parts, other projects, even with the organization. Furthermore, a project only can exist with the consent of its stakeholder community and their relationships are essential for the project success (Bourne 2005). While some definitions of stakeholders are very broad, others may be relatively narrow. However, most of them categorize stakeholder as external or internal to the project, depending on their relation to it, as someone that has an impact or is impacted by the project activities or has an expectation on project objectives. Also important is the understanding that the group of stakeholders does not include just the project team and the clients, but may involve the whole community where the project is located (Newcombe 2003).

Extrapolating the idea of delivering the project within the original time, budget and scope, for a project to be successful, it needs to be regarded as a success by its stakeholders (Bourne 2005). To do so, the project should meet stakeholders needs and expectations through trustee relationships, combining their interest with those of the project to ensure its survival (Newcombe 2003). The strategy should distribute both benefits and harms between different groups of stakeholders, developing actions to ensure the long-term support of all them (Freeman and McVea 2001). In doing so, these strategies might cope with the conflict between the project and its stakeholders smoothly, since conflict can occur on projects when decisions are made without taking into account the consequences it will have on different stakeholders (Olander and Landin 2008). In this context, conflict can be broadly defined as perceived incompatibility or discrepant

views between stakeholders and its management should include mutual respect and willingness to compromise, promoting cooperation and harmony within the group (Lepine et al. 2008).

Failing to properly engage the project stakeholders might have significant impact over the project outcomes, since stakeholders know when their voices are not heard, which increase frustration and can invoke greater reactions in order to be heard, understood and considered, mobilizing power in their favor (Smyth 2008). Besides avoiding those negative impacts over the project activities, meaningful stakeholder engagement strategy can improve decision-making and promote equity (Mathur, Price, and Austin 2008).

However, to engage stakeholders, relationships must be built. When considering relationships as strategic for managing projects, the human relations between project actors assume their important role on effective and efficient delivering of a project. Furthermore, relationships can be managed, and their quality is a key element in the success of a project, as both behavior and attitude of actors can affect project performance (Pryke and Smyth 2006). Finally, the relationship management can be linked to several tenets, including the improvement of long-term relationships to engender loyalty, repeated business and/or increased referral business, as also maintaining and increasing market reputation (Smyth 2008). To built and maintain long-term relationships, the generation of trust is important as it can be linked to satisfaction and commitment (Costa 2003). Trust is also linked to respect in relationship development, and when developed on early project phases, trust will create harmony within stakeholder group that will continue into project phases (Davis and Walker 2007).

2.3 Airport Industry

Aviation and airports have a wide ranging of impacts. By stimulating business, creating employment, promoting tourism and trade, airports might support economically their regions, which make the decisions on their infrastructure the most strategic ones a country or region can make, promoting economic, environmental and social development. As complicated business they are, airports combine different elements and activities to serve passengers and flight airlines through organizations with their own business particularities concerned with commercial, logistical, security and safety aspects (Fernandes and Pacheco 2010). This diverse and heterogeneous industry presents high degree of quality differentiation, diverse ownership and regulatory structures, divergent mixes of services and operating models, as well as external restrictions such as location and environmental factors (Oum, Yu, and Fu 2003), elements that make each airport unique in its specificities.

As complex systems with interdependent parts, airports are composed of various categories of stakeholders having different requirements, being essential to consider how these relationships affect the behavior of the whole to establish a balance amongst them. Furthermore, as their context is subject to changes in terms of aviation demand, technological developments, demography, and regulations, it is fundamental to adopt an integrated approach to analyse how all these elements affect each other, mainly because they might impact airport performance and affect stakeholders objectives in different ways (Wijnen, Walker, and Kwakkel 2008).

Thus, in order to plan, to design and to operate an airport, decision-makers must face complex decision-making problems involving many processes (i.e. strategic planning, operations management), entities processed (i. e., passengers, baggage, cargo, aircraft.) through the system, various different elements (i. e., runway system, taxiway system, apron area, terminal), and a large number of stakeholders with divergent and sometimes conflicting objectives concerning the airport performance (Zografos and Madas 2006). Then the challenge consists in building a common understanding within the numerous actors both from inside and outside of the organization (Wijnen, Walker, and Kwakkel 2008) to align the decision-making in technical solutions. Because the involvement of the airport stakeholders on the decision-making process might affect the airport operation (Pastor and Benavides 2011), having them engaged and working together on solving problems is crucial to improve understanding about the airport systems, its problems and potential solutions (Wijnen, Walker, and Kwakkel 2008).

3 METHODOLOGY

To answer the research question of how being exposed to 3D visualization has influenced stakeholders' management in airport projects, an exploratory case study is used. This qualitative research studies the interactions between the project team and the airport stakeholders to identify how the implementation of BIM technologies can facilitate stakeholders' management, reinforcing their engagement to the project activities. The airport stakeholders will be the unit of analysis of this study.

3.1 Data collection

Data is captured and analyzed from the project documents provided by the airport project team and from the semi-structured interviews with airport stakeholders and airport specialists, from inside and outside the airport organization. The interviews focused on the information format provided by BIM technologies – 3D visualization – as a counterpoint of the traditional engineering information format. Thus, in the interview protocol sense, the 3D visualization englobes the 3D model and all the information it contains. The interviews' sampling focused on airport stakeholders, including the engineering professionals with work experience on the airport industry. There were three main groups of interests: the director level from Quebec City International Airport - YQB, Los Angeles International Airport - LAX, and Montreal–Pierre Elliott Trudeau International Airport - YUL, all of them with experience in BIM projects; the project delivery team, that had worked with BIM; and the clients from YQB, airport stakeholders that were exposed to BIM during the project activities. The intention with the sampling was gather the point of view of all levels of involvement on the project activities, having achieved a consistent balance between levels: 4 interviewees from the Project Director level, 5 from the Project Delivery level, and 4 from the Client side. The relevance of this proportion lies on the contributions' heterogeneity, providing an overall perception of BIM technologies impact to the management of airport project stakeholders.

3.2 Coding

Previously to the data gathering, seven categories were identified from the literature review to code the interviewee's contributions – engagement, conflict, trust, efficiency, understanding, information, and relationships. To those categories, another three categories were added extracted from the interviewees' answers, using the method inspired by the grounded theory (Strauss and Corbin 1990). These three categories – community, hierarchy/authority and experience - were not configured as research focus in any of the three domains reviewed on the literature: airport industry, construction industry and project management theory. The final categories list helped to understand the impacts of 3D visualization BIM's tools on the stakeholder management and the technique of the conceptual map was used to better visualize their connections. On the conceptual map, the categories assumed the place of the concepts and the links between them summarize through the verbs (actions) how those concepts (categories) might be connected. This technique was chosen due to its strong visual aspects that helps to visualise its connections in a more easily manner.

3.3 Validation

The conceptual framework and map were validated with two airport domain specialists through semi-structured interviews, focusing on the adoption of the three domains and dimensions. The categories were validated through the finding's presentation. The first validator is a Ph.D. on airport design with international experience working on airport industry, dealing with infrastructure development. The second validator is a professional with over 25 years of work experience on the airport industry developing projects to airports all over the world. Each element of this framework is detailed in the following subsections.

4 Results and discussion

4.1 Conceptual Framework

To answer the research question – how the use of 3D visualization impact on the stakeholder management - the following framework was built, divided in three elements that are called: domains, dimensions and categories, as summarized by Table 1 below.

Table 1: Framework

DOMAINS	Airport Industry	DIMENSIONS	Stakeholder Management
	Project Management		Communication process
	Construction Industry		Decision-making process
CATEGORIES	Engagement	Community	
	Conflict	Information	
	Efficiency	Experience	
	Hierarchy / Authority	Trust	
	Understanding	Relationships	

Domains are the technical domains related to the case being studied. They were the base on which the theoretical framework was built. Dimensions are the processes to manage stakeholders where it is possible to verify the ultimate impact of the 3D visualization usage of BIM. They were used on the semi-structured interview protocol to guide the interviewee. Categories are the concepts extracted from the literature review and from the interviews that explain the interactions between the stakeholders and the project team during the project execution. Those categories were used to codify the interviewee's answers.

4.2 Dimension 1 – Stakeholder Management

The aim of this dimension was to identify the challenges faced by project managers to manage stakeholders on this multiple actors' environment, and the strategies to address them. The results show that engaging stakeholders is the biggest challenge they face. This finding is consistent with the literature in which scholars point out that just involving as many stakeholders as possible on the decision-making process is not enough (Wijnen, Walker, and Kwakkel 2008). Even if they are involved, they do not engage because they have divergent interests (Zografos and Madas 2006), becoming very difficult to satisfy all of them.

This challenge gets its complexity increased due to the project team lack of experience in airport industry when they are not from the airport organization, and to the airport stakeholders lack of experience of construction process. These two aspects were significantly present on the interviewees' answers, where they argued that the visual tools of technologies such as BIM can fulfill this necessity for alignment between these two groups. As the understanding of the subject been discussed increase because the information is provided on visual forms, the lack of experience is decreased since they can be easily leveled.

Another aspect not present on the literature and referred by almost all interviewees is the failure in getting the right participants involved, especially with the power to make decisions. Despite the idea that having the ones empowered to make decisions joined on the decision-making process being common sense, the importance to this stakeholders' group is so evident that the lack of more profound studies of its impact to the project success is a gap that deserves more attention, especially because it can lead to project failure.

An interesting aspect not present on the findings, but largely present also on the literature referring to projects in general, is related to conflicts. Scholars state that conflicts among airport stakeholders are based on the disagreement about the parameters to planning and designing airports (Wijnen, Walker, and Kwakkel 2008), as to how would be a satisfactory performance of its operations (Zografos and Madas 2006). As airport stakeholders have very distinct business objectives, they may never agree with some project objectives causing a misalignment that might persist all over the project.

Concerning the strategies to better manage airport stakeholders, the findings suggest that building efficient communication process based on trustworthy relationships may decrease the conflicts between stakeholders, leading to the concept of community suggested by the interviewees as a strategy to truly get

the buy-in of stakeholders. Interestingly to notice that, accordingly to the interviewees, trust had a role on the strategy, but, similarly as conflict, does not figure among the challenges. A relevant aspect of trust that impacts the relationships on airport context is the willingness to be vulnerable, that is the primary obstacle to develop trustful relationships (Davis and Walker 2007). As trust is linked to commitment (Costa 2003), the concept of community used by the interviewees can be related to build trustful relationships.

4.3 Dimension 2 – Communication Process

The aim of this dimension was to identify the relevance of quality information to the communication process, and what the impacts to this process are when visualizing information on 3D format. The finding that good quality information can impact on stakeholder engagement is aligned with the literature. Also aligned is the idea that good information improve the communication among stakeholders and project team, increasing the efficiency of its process (Olander and Landin 2008).

The results go a little bit further, saying that an efficient communication process is based on the precise information needed by the stakeholders, which, combined with a better understanding of the subject being discussed, can promote trust within the process (Bew and Underwood 2010). At the end, better understanding through a more efficient and trustworthy process can create engagement. Furthermore, the findings suggest that this is a virtuous cycle: as sharing the precise information can create engagement, engaged actors contribute to the project by sharing ideas and knowledge, which in return improves the quality of information (Bourne 2005).

As per literature, when using the 3D visualization as a tool to inform stakeholders, it improves the understanding and the efficiency of the communication process. The better understanding gained through the 3D visualization of information provided by BIM technologies reduces the lack of experience by creating a common language that all actors can speak (Kunz and Fischer 2012). Scholars say that reading traditional technical documents as 2D drawings is a challenge, and on this point the research findings and the literature are aligned. However, the concept of experience used by the interviewees is not just the capacity of reading drawings, graphics and sheets. It goes deeper, involving the capacity of stakeholders (internal and external to the project) to collaborate using their own knowledge (airport or construction domains) in order to achieve the project outcomes. In this sense, the visualization of the project solutions in a 3D format levels all actors to be able to collaborate, improving their engagement. Along with a better understanding promoted by the 3D visualization, and the access of the precise information needed by the stakeholders, comes the trust on the information, that also corroborate to their engagement.

4.4 Dimension 3 – Decision-making Process

The aim of this dimension was to identify the challenges to engage stakeholders to the decision-making process and the impacts to this process when using information in 3D format provided by BIM technologies. The challenges stated by the interviewees for this dimension are very similar to those of the Dimension 1. Added to the lack of experience and hierarchy/authority, the findings show the importance of having the right information to make decisions as a challenge to get stakeholders engaged in the process. For the first two challenges, experience, and hierarchy/authority, both are not related to the concepts found in the literature review. However, the importance of having good information is aligned with the literature, as also is the trust that derives from this quality information (Schade, Olofsson, and Schreyer 2011).

It is worthy to notice that conflicting interests do not figure as challenges to engage stakeholders on the decision-making process listed by the interviewees. However, researchers agree that the existence of different objectives amongst stakeholders brings difficulties to this process, as alignment between actors objectives is not easily achieved (Schade, Olofsson, and Schreyer 2011). Also, the use of information in 3D format impacts the lack of experience by creating a common language that all actors can comprehend. It was already cited that as the 3D visualization improves the communication process by enabling understanding and increasing the trust on the information flowing through the process, it also improves the decision-making process by providing better information. This finding is aligned with the literature once trust on project environment has an important role that affects stakeholder engagement (Bourne 2005) and the

increased stakeholders' engagement improves the decision-making process efficiency (Mathur, Price, and Austin 2008).

4.5 The 3D visualisation impacts on stakeholder management

Based on the interviews' analysis, the overall perception of the impacts of BIM's 3D visualization tool on stakeholder management consists of two main elements: it provides good quality information, and it promotes better understanding. The project processes increased efficiency caused by these two elements is in accordance with the literature. The findings go further about the role that the level of project understanding has, bringing the idea that it can create engagement and the sense of community that is also reinforced by a better level of engagement on project activities. These two concepts – community and engagement, especially when engaged the ones with the right level of hierarchy and authority to make decisions, will impact the efficiency of project process themselves. Also, there are three absent concepts from the interviewee's speeches about the overall impact perception that deserves attention: conflict, collaboration, and relationships. These three concepts are intimately connected, and, intriguingly, they were not cited by any interviewee. The use of 3D visualization BIM tools demands a collaborative way of work to promote sharing information, what is gained through the relations between actors. This collaboration can attenuate possible conflicts amongst them and when these relationships are based on trust, they might impact the level of their engagement. Figure 1 below demonstrates the connections between concepts that summarizes the main impacts of 3D visualization on stakeholder management.

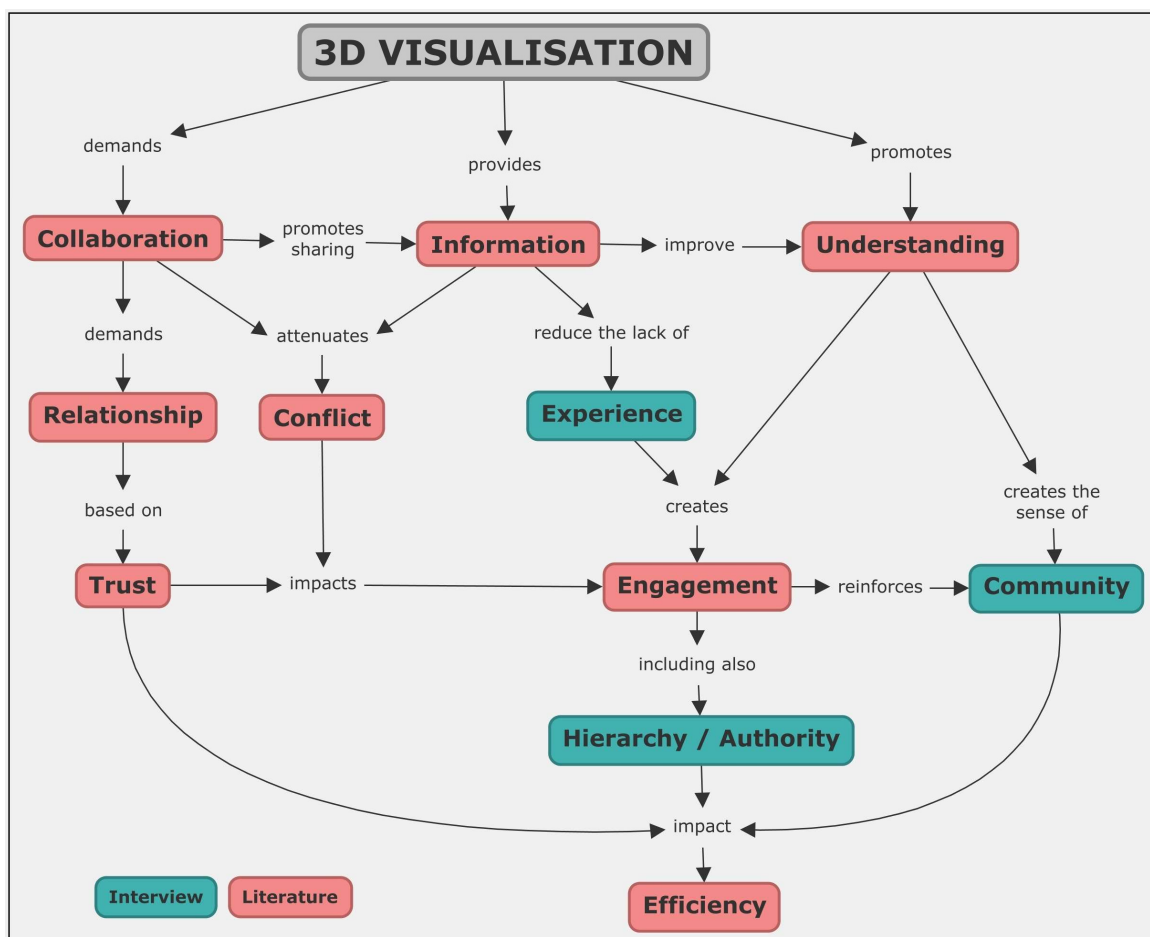


Figure 1: 3D visualization impact on stakeholder management

5 CONCLUSION

Airports are a complex and dynamic industry that deal with countless elements that impact on their efficiency, starting with the multiple stakeholders' environment, and not so rarely, divergent objectives. Since any intervention to its infrastructure must deal with this context, construction project managers should face this challenge with a strategy that includes stakeholder management, arising the chances of project success by implementing communication processes that help those stakeholders on the decision-making process.

The research findings suggest that the use of information on 3D visualization format provided by BIM technologies can break the barriers of understanding, creating a common language that all stakeholders can speak, impacting on their engagement to the project. Considering the data analysis results, this research contributes to the understanding of BIM impact on stakeholder management in the following aspects:

- it demands a more collaborative project environment for sharing information, which helps to develop trustworthy relationships that lower the conflicts between stakeholders and increase their engagement to the project activities;
- it provides information in a readable format that aligns understanding and lower the conflicts amongst stakeholders, internal and external to the project;
- with fewer conflicts and an improved understanding, it creates engagement, reinforcing the sense of community within airport stakeholders that increase the efficiency of stakeholder management.

Other research contributions are:

- the new concepts extracted from the interviews and not encountered on the literature review, namely here hierarchy/authority category, community category and experience category;
- the framework used to structure this study that could be tested on other cases to verify how strong it is answering the research question;
- the choice of using the conceptual map technique to visually demonstrate the abstract concepts presented on this research.

The findings limitations are based on the single case research and the participation of the same researcher on the data gathering and analysis. Some rival explanations for the findings concerning the level of stakeholders' engagement might be the case study airport size and business model, as the small number of actors involved on the project could have allowed the team to engage them in more productive ways. However, exploratory research provides new ground for future research that could include other airports to test the framework, mainly to verify the impacts on the stakeholders' response to the use of BIM technologies.

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