

The BIM Impact on Stakeholder Management in Airport Construction Projects

by

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This study is a result of a great restlessness lived on my professional experience about what could be done to improve the efficiency of construction projects regarding the management of stakeholders since any construction project exists just to attend the needs of people. I hope my efforts may contribute with the searching for improvement on construction industry.

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L'impact du BIM sur la gestion des parties prenantes impliquées dans les projets de construction aéroportuaires

Tais SCHERER

RÉSUMÉ

Les aéroports sont complexes et dynamiques et représentent un environnement impliquant de multiples acteurs, ce qui demande un effort important de la part des parties prenantes du projet lors de la mise en œuvre d'une intervention d'infrastructure. Développer des stratégies pour gérer les parties prenantes au sein des activités du projet est fondamental pour atteindre les objectifs du projet, en particulier en ce qui concerne le processus de prise de décision qui, dans les aéroports, devrait être aussi dynamique que possible en raison des nombreuses interférences qu'un projet peut avoir dans leurs opérations. C'est là que les nouvelles technologies, telles que la modélisation des données du bâtiment (BIM), jouent un rôle stratégique, en contribuant au projet en fournissant des informations de bonne qualité qui aident les décideurs. L'hypothèse de cette étude est que, avec des informations de meilleure qualité, le processus de communication sera amélioré, ce qui permettra de gérer efficacement les parties prenantes pendant le projet. Afin de vérifier cet impact sur la gestion des parties prenantes lors de la gestion de projets avec BIM, une étude de cas a été choisie et une série d'entretiens semi-structurés ont été réalisés avec les principales parties prenantes de l'aéroport, internes et externes au projet. Les résultats des entretiens ont été combinés à des concepts basés sur des recherches antérieures sur l'industrie aéroportuaire, l'industrie de la construction et la gestion de projet, axées sur la gestion des parties prenantes, pour aboutir aux résultats de cette étude. Le résultat final suggère une amélioration de la gestion des parties prenantes obtenue par: une amélioration significative de la compréhension du projet, car le BIM pourrait créer un langage commun qui aligne la perception de toutes les parties prenantes sur le projet; la création d'un environnement collaboratif permettant d'établir des relations de confiance entre les acteurs impliqués dans le projet; la création d'un sentiment d'appartenance à un projet, favorisé par la création d'une communauté de projets aéroportuaires; un engagement accru grâce à l'environnement de collaboration, au sens de la communauté et grâce à une meilleure compréhension du projet. Ces résultats ont été validés par deux spécialistes du domaine des aéroports. Les recherches futures pourraient englober les aspects du comportement organisationnel et individuel et de la résistance au changement, afin de tirer pleinement parti des technologies BIM en ce qui concerne la gestion des parties prenantes.

Mots-clés: BIM, visualisation 3D, compréhension, gestion des parties prenantes, engagement

The BIM Impact on Stakeholder Management in Airport Construction Projects

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ABSTRACT

Airports are complex and dynamic, a multiple stakeholder environment which demands a great effort from the project actors when running an infrastructure intervention. Developing strategies to manage stakeholders within the project activities is fundamental to achieve project goals, especially concerning to the decision-making process, which in airports should be as assertive as possible due to the numerous interferences a project can have on their operations. This is where new technologies like Building Information Modeling (BIM) assume its strategic role, contributing to the project providing good quality information that helps the decision makers. The assumption of this study is that, with better-quality information, the communication process will be improved, helping to efficiently manage stakeholders during the project. To verify this impact on stakeholder management when running projects with BIM, a case study was chosen, and a series of semi-structured interviews were made with the main airport stakeholders, internal and external to the project. The findings from the interviews were combined with concepts from previous research on the airport industry, construction industry and project management, focused on stakeholder management, to come up with the results of this study. The final result suggests an improvement of stakeholder management achieved by: a significant improvement on understanding, since BIM might create a common language that align all stakeholders' perception about the project; a creating of a collaborative environment that allows trustful relationships be built; a creating of a sense of project ownership, promoted by a creating of an airport project community; an improved engagement due to the better understanding, the collaborative environment, the community sense. These findings were validated with two specialists in airports domain. Future research could embrace the aspect of organizational and individual behavior and resistance to change impacting to achieve the full benefits of BIM technologies concerning stakeholders' management.

Keywords: BIM, 3D visualization, understanding, stakeholder management, engagement

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INTRODUCTION

Airports deal with countless elements that impact on their efficiency. This industry changes constantly and 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 client requirements, regulatory laws and financial goals all together to get the best response to every distinct situation. Amongst all these issues could arise different interests between the large number of stakeholders involved into the decision-making process regarding operational activities.

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 the stakeholders and project team, as each other, so important. Thus, stakeholder management might be considered strategic to aim project objectives, engaging all different individuals, groups or institutions impacted by the project activities or with the power to impact them.

When dealing with large and complex endeavors as airport engineering projects, the communication problems amongst stakeholders are one of the main causes for the performance issues of those projects (Azouz et al., 2014; Egan & Williams, 1998). Collaboration on projects requires stakeholder engagement, which is based on the communication process and its information quality (Egan & Williams, 1998). Poor data flowing through project actors leads to a distrusted environment and all effort made by the project team in engaging stakeholders might fail (Pryke & Smyth, 2006). To maintain the commitment, all main stakeholders should be confident in the project decisions (Bourne, 2005). Inserted in the airport environment, the project is susceptible to many interferences and under the influence of several actors with different motivations. The negative impacts of an airport engineering project may represent significant financial losses for the entire related community, which adds yet another complicating element in this already complex context.

To deal with engineering project performance issues, new technologies had been developed, improving the quality of construction and its process and modifying the way projects are managed, like Building Information Modeling - BIM. The new work environment that comes with BIM demands skills and behavior that goes beyond the abilities project teams traditionally used to run projects successfully. Concepts like trust, engagement and sharing have been added, creating a positive atmosphere where the collaborative work can arise (Crotty, 2013), promoting the working culture of high performance (Kumaraswamy & Rahman, 2012) needed by airport projects.

The good quality and trustworthy information generated by BIM technologies 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 an efficient manner. This virtuous circle helps to improve construction projects productivity and predictability (Crotty, 2013), conditions required by airport construction projects due to their complex and uncertainty nature.

Thus, an engineering project inserted in this panorama shows a fertile field to observe the influence of BIM technologies implementation on the effectiveness of the stakeholders' management. 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.

Thus, considering the airport engineering project context, this study aims to assess how the use of BIM technologies, here translated into 3D visualization¹, can impact the efficiency in managing stakeholders.

¹ For the purpose of simplification and considering that the sample profiles include airport stakeholders that may not have the knowledge of BIM and its technologies, this study decided to use the term "3D visualization" as a format for any information in opposition to those traditional forms of presenting engineering project

The objectives of this research are:

- 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;
- to expand the comprehension about how stakeholder engagement is affected by project information quality;
- to enlarge the knowledge about the effects of BIM in the decision-making process, highlighting its impact on project efficiency.

A single case study will be used to investigate the impact of BIM technologies in stakeholders' management: the terminal area enlargement of the Québec City International Airport, where the whole project was run using BIM technologies.

This report is organized in five main parts. Based on the referenced authors, Chapter 1 starts studying and critiquing structured knowledge upon three different technical domains: Airport Industry, Project Management, and Construction Industry. The literature review aims to highlight the connections between these three domains, especially those concerning to stakeholders. Chapter 2 details the methodology used to answer the research question based mainly on long interviews. After that, Chapter 3 describes how the data gathered on the interviews was analyzed. Chapter 4 follows linking the analysis results to the concepts extracted on the literature review. At last, the Conclusion summarizes this study and suggests topics for further research.

information, as 2D drawings, spreadsheets, Gantt graphics, specification texts. Doing so were included on the term "3D visualization" for example, the virtual model, virtual reality, 3D/4D, etc.

CONCLUSION

Airports deal with countless elements that impact on their efficiency, starting with its multiple stakeholders' environment with not so rarely, divergent objectives. This industry is complex and dynamic, demanding the same rigor from any intervention to its infrastructure. Then, construction projects facing this challenge with a strategy that includes stakeholder management could raise the chances of project success by implementing communication processes that help those stakeholders on the decision-making process.

An engineering project inserted in this complex scenario is fruitful to observe the influence of BIM technologies on the effectiveness of the stakeholders' management. Our assumption was that, by refining the information quality used, the communication process will gradually improve, producing a positive effect the decision-making process. Thus, the research question was how the use of 3D visualization, the aspect of BIM technologies being focused on, can impact the efficiency of stakeholders' management. The study objectives were: to verify the impact of good quality information on stakeholder management, how it affects the decision-making process and the stakeholder engagement.

A single case study - the terminal area enlargement of the Québec City International Airport - was chosen to answer the research question. The data was gathered mainly by interviews made with the stakeholders, internal and external to the project. The data was codified using concepts extracted from the literature review and the interviews. Those most cited ones were used on the data analysis and the results were a combination of the interviews and the literature review content. The findings were demonstrated through the conceptual maps in which the concepts on the map were the categories used to codify the data, and the links between them were the connections among categories.

Running projects in a complex environment where multiple stakeholders might have divergent opinions about the project outcomes is a challenging task. The research findings suggest that the use of 3D visualization can break the barriers of understanding, creating a common language that all stakeholders can speak, impacting on their engagement to the project activities.

Considering the data analysis results, combined with concepts based on the literature review, this research can contribute progressing the understanding of the 3D visualization impact on stakeholder management. The findings answer the research question – how the 3D visualization impact stakeholder management – with 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;
- with fewer conflicts and an improved understanding, it creates engagement, reinforcing the sense of community within airport stakeholders that increase the efficiency of the stakeholder management process.

Other contributions from this research are:

- the new concepts extracted from the interviews and not encountered on the literature review, namely hierarchy/authority, community and experience;
- the framework used to structure this research 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 present on this research;
- the management implications when working in a collaborative work environment, including how to organize a collective effort to take the best advantage of new technologies like BIM, as the needed organizational and personal behavior changes.

Rival Explanations and Limitations

Considering the specific case study of this research, some rival explanations for the findings, especially concerning the stakeholders' engagement to the projects, could be the small number of actors involved that could have allowed the team to engage stakeholders in more productive ways. Besides, the project environment generated by this specific airport size and business model could have influenced the level of engagement, impacting more on the stakeholders'

management than the exposure to the 3D visualization, subject of this study. These two characteristics, combined with the fact that this was the first project with BIM in airports in Canada, could have propitiated a positive environment to the project, which may have influenced the overall success of the stakeholder management results.

The limitations to this study are based on the single case being studied and the lack of the researcher participation during the project execution for direct observations. Despite the interviewee's profile had covered all types of the project participants, given to the findings some heterogeneity, the findings are based on the speech of twelve key actors and may not represent the truth for the majority of stakeholders. Also, despite the methodology applied to the data gathering and analysis, both processes were carried out by one researcher. Then, to exclude such bias on the findings, the research should be applied to different airports and with a larger sample to confirm the results.

Recommendations for further research

The literature review for this study focused just on researches made specifically to the related domains, airport industry, construction industry and project management. From this context where identified some gaps on the literature that could be further explored:

- The influence of the lack of previous experience of the project team in airport context and the lack of previous experience of airport stakeholders on construction processes to the achievement of project objectives;
- The level of the hierarchy of those involved in the project activities, especially the authority to make decisions and its impact on the project activities;
- The sense of belonging to the project as part of its team through the concept of community and its impact on the community engagement to the project objectives and activities.

On the other hand, the analysis of the data gathered by the interviews considered just the more representative ideas. However, some perceptions, despite coming from fewer interviewees, are interesting insights to future researches concerning the changes on the organizational culture and professional behavior:

- **The resistance to new technologies:** being BIM a new technology, it could not be totally comprehended by the majority of technical professionals, as it is also true for the airport community. As mentioned by one interviewee, *“pour le moment il y a des gens qui ne sont pas super habitués à la technologie donc ils sont très réfractaires à cette idée de technologie”*¹⁹³ [Delivery level]. It will take some time to vulgarize this way-running engineering projects to truly see its benefits. *“On n'est pas là à 100 % encore, je dirais que la société, du moins le secteur (ou le domaine) aéroportuaire, ne maîtrise pas encore ça à 100%”*¹⁹⁴ [Delivery level], which means that the way people interact with this kind of technology might interfere on the positive impacts that its implementation can offer.
- **Organizational changes:** running a construction project with BIM technologies brings numerous benefits. However, as stated by an interviewee, *“le BIM ne règle pas tout, parce que c'est une boîte noire que tu dois nourrir pour avoir l'information pertinente. Si les gens ne sont pas conscients qu'il faut mettre la maquette à jour, selon moi on va arriver au même constat que lorsqu'on utilisait du papier. Pour moi, le BIM ce n'est pas la clé pour tout”*¹⁹⁵ [Director level]. Concomitant with BIM technologies implementation should come organizational changes that propitiate fully utilization of its benefits.
- **Personal behavior changes:** another aspect is related more to the effects of the utilization of BIM and the organizational culture. With BIM stakeholders are much more involved in the decision-making process, but sometimes, *“les gens n'aiment pas être imputables de leur décision, parce que souvent, la facilité n'est pas de répondre ou de ne pas se positionner”*¹⁹⁶ [Director level]. Thus, new technologies like BIM, or even more integrated delivery methods, require a different behavior of its players and might impact the overall project success.

¹⁹³ *“For the moment there are people who are not super used to technology and are very reluctant to this idea of technology.”* [Delivery level]

¹⁹⁴ *“We are not 100% there, I will say that the airport community does not master it yet to 100%.”* [Delivery level]

¹⁹⁵ *“BIM does not solve everything, because it's a black box that you have to fulfill to have the relevant information. If people are not aware of keeping the model actualized, we will come to the same conclusion by the time when we used paper. For me, BIM is not the key to all.”* [Director level]

¹⁹⁶ *“People do not like to be imputable to their decision, because often the easiest way does not respond or do not position yourself.”* [Director level]

APPENDIX I

SEMI-STRUCTURED INTERVIEW PROTOCOL (English first version)

INTRODUCTION

- Interviewer presentation
- Research presentation
- Permission to record the interview
- Interview structure presentation

RESPONDENT'S IDENTIFICATION

Title:

Name:

Last name:

Current position:

Working experience in the airport industry:

LAST EXPERIENCE RELATED TO AIRPORT PROJECTS

- What was the most recent engineering airport project you participated in? What was your role and your level of involvement?
- Considering this last experience on airports, what was the most challenging aspect about this project? And the most rewarding aspect about it?

DIMENSION #1: STAKEHOLDER MANAGEMENT

The activities that have their place on airports involve not only passengers and air companies. To be operational, an airport demands a variety of services to process passengers and luggage, providing security and comfort, which require diverse professionals as those directly related to the airport administration, air companies, governmental and regulatory institutions, as commercial services, like restaurants, stores and other convenience services, which, joined to other occasional airport infrastructure users, from what can be called the airport community, the airport stakeholders.

1. Considering this multiple stakeholder environment, running engineering projects can be pretty challenging. Could you tell how the airport community is managed and what are the challenges to engage them on the project objectives?

DIMENSION #2: COMMUNICATION PROCESS

To gain and maintain the airport community engagement to the project objectives, an efficient communication with them and the project team is fundamental, especially considering the complexity of the airport environment and its multiple actors. For example, when reporting the pace of execution of project activities or presenting a design solution for some construction issue, everyone involved should get the same understanding about the information being communicated to be able to align ideas and solutions.

2. Considering this aspect, what is the relevance of the quality of the communication amongst the airport community and the project team about the execution of the project activities?

DIMENSION #3: DECISION-MAKING PROCESS

Airports need to get an efficient and effective decision-making process. For example, if it is necessary to interrupt the operation of some sector of the departure area to get a job done, the decision including how to maintain this area operational with the required level of comfort, how to isolate it to permit access to the work team maintaining the security conditions. Then, the project team presents to operational, commercial and security teams the possible scenarios to involve them in the decision about what would be the best strategy and they are invited to contribute and required to give their approval.

3. Considering this scenario and your current experience on involving the airport community or being involved by the project team on decisions like that, what are the challenges presented?

FINAL DEBATE

4. Considering your experience, what is your overall perception about the impacts that the use of 3D visualization can cause to stakeholders' management at airport industry?

APPENDIX II

SEMI-STRUCTURED INTERVIEW PROTOCOL (English final version)

INTRODUCTION

- Interviewer presentation
- Research presentation
- Permission to record the interview
- Interview structure presentation

RESPONDENT'S IDENTIFICATION

Title:

Name:

Last name:

Current position:

Working experience in the airport industry:

LAST EXPERIENCE RELATED TO AIRPORT PROJECTS

- What was the most recent engineering airport project you participated in? What was your role and your level of involvement?
- Considering this last experience on airports, what was the most challenging aspect about this project? And the most rewarding aspect about it?

DIMENSION #1: STAKEHOLDER MANAGEMENT

The activities that have their place on airports involve not only passengers and air companies. To be operational, an airport demands a variety of services to process passengers and luggage, providing security and comfort, which require diverse professionals as those directly related to the airport administration, air companies, governmental and regulatory institutions, as commercial services, like restaurants, stores and other convenience services, which, joined to other occasional airport infrastructure users, from what can be called the airport community, the airport stakeholders.

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3. Considering this scenario and your current experience on involving the airport community or being involved by the project team on decisions like that, what are the challenges presented?

FINAL DEBATE

4. Considering your experience, what is your overall perception about the impacts that the use of 3D visualization can cause to stakeholders' management at airport industry?

5. If the project was to be redone, how would you like to be involved?

APPENDIX III

SEMI-STRUCTURED INTERVIEW PROTOCOL (French final version)

INTRODUCTION

- Présentation de l'intervieweur
- Présentation de la recherche
- Permission d'enregistrer l'interview
- Présentation de la structure d'entrevue

IDENTIFICATION DU RÉPONDANT

Titre:

Nom:

Position actuelle:

Expérience de travail dans l'industrie aéroportuaire:

DERNIÈRE EXPÉRIENCE LIÉE AUX PROJETS AÉROPORTUAIRES

- Quel a été le plus récent projet d'aéroport d'ingénierie auquel vous avez participé? Quel était votre rôle et quel était votre niveau d'implication dans ce projet?
- Compte tenu de cette dernière expérience sur les aéroports, quel était l'aspect le plus difficile de ce projet? Et l'aspect le plus gratifiant à ce sujet?

DIMENSION # 1: GESTION DES PARTIES PRENANTES

Les activités qui se déroulant dans les aéroports n'impliquent pas seulement les passagers et les compagnies aériennes. Pour assurer le confort et la sécurité des usagers et la gestion des bagages, l'aéroport fait appel à divers intervenants, notamment l'administration aéroportuaire, les compagnies aériennes, les institutions gouvernementales et réglementaires, les restaurants, les magasins et autres services qui forment la communauté aéroportuaire, etc. Les questions suivantes portent sur les relations entre l'équipe de projet et la communauté aéroportuaire.

1. Compte tenu de cet environnement où il y a de multiples acteurs, les projets d'ingénierie en cours peuvent être assez difficiles. Pourriez-vous nous dire comment la communauté aéroportuaire est gérée et quels sont les défis pour les impliquer dans les objectifs du projet?

DIMENSION 2: PROCESSUS DE COMMUNICATION

Pour obtenir et maintenir l'engagement de la communauté aéroportuaire envers les objectifs du projet, une communication efficace avec eux et l'équipe de projet est fondamentale, surtout si l'on considère la complexité de l'environnement aéroportuaire et de ses multiples acteurs. Par

exemple, lorsque vous signalez le rythme d'exécution des activités du projet ou que vous présentez une solution de conception pour un problème de construction, tous les participants doivent avoir la même compréhension de l'information communiquée pour pouvoir aligner les idées et les solutions.

2. Considérant cet aspect, quelle est la pertinence de la qualité de la communication (entre la communauté aéroportuaire et l'équipe de projet) sur l'exécution des activités du projet?

DIMENSION 3: PROCESSUS DE PRISE DE DÉCISION

Les aéroports ont besoin d'un processus décisionnel efficace et efficient. Par exemple, s'il est nécessaire d'interrompre l'exploitation d'un secteur de la zone de départ pour effectuer un travail, la décision comprend comment maintenir cette zone opérationnelle avec le niveau de confort requis et comment l'isoler pour permettre l'accès à l'équipe de travail et maintenir des conditions de sécurité. Ensuite, l'équipe de projet présente aux équipes opérationnelles, commerciales et de sécurité les scénarios possibles, pour les impliquer dans le processus de décision.

3. Compte tenu de ce scénario et de votre expérience actuelle d'implication de la communauté aéroportuaire ou d'implication de l'équipe de projet dans des décisions de ce type, quels sont les défis présentés?

FINAL DEBATE

4. Compte tenu de votre expérience, quelle est votre perception générale des impacts que l'utilisation de la visualisation 3D peut avoir sur la gestion des parties prenantes dans l'industrie aéroportuaire?

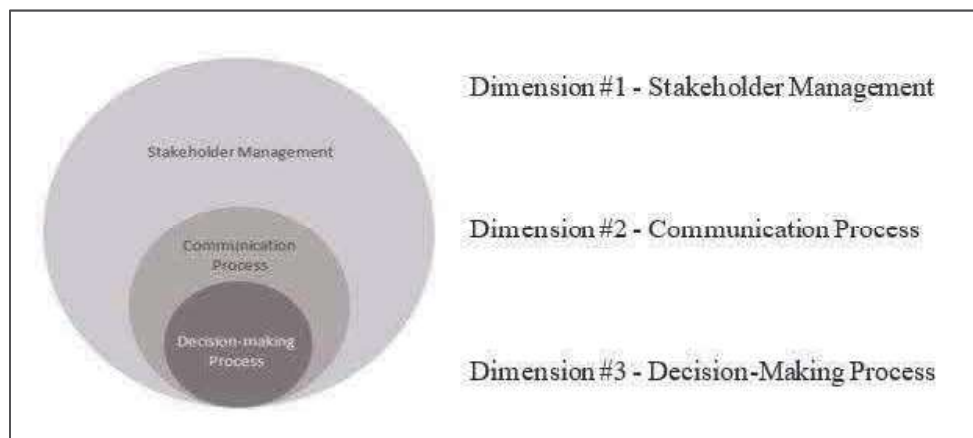
5. Si le projet était à refaire, comment aimeriez-vous être impliqué?

APPENDIX IV

VALIDATION PROTOCOL

1. THE DIMENSIONS

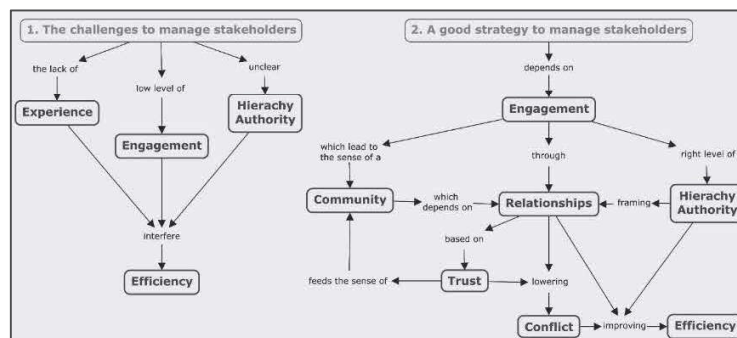
To verify the impact on stakeholder management when informing through 3D visualization, the interviews were framed using the dimensions described below:



1.1. The research focus was to verify whether the 3D visualization exposition can impact on stakeholder management. Considering this focus, do you agree that the decision-making process will demonstrate that impact?

2. THE CATEGORIES

DIMENSION #1 – Stakeholder Management: on this dimension, the interviewees were asked what were the challenges to manage stakeholders and what a good strategy would be.



From the interviewees' perspectives, the main challenges to manage stakeholders through the project activities (Question 01) include the project team lack of experience in the airport industry, and the lack of experience of construction industry and project management by those airport stakeholders involved on the project. Also, the wrong level of hierarchy/authority to

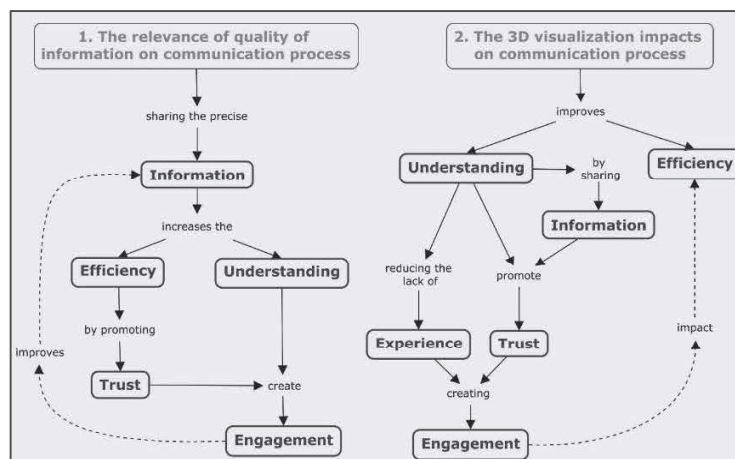
make decisions of those involved on the decision-making process, and the airport stakeholders' lower level of engagement, especially on the early stages of the project.

2.1. Do you agree with the interviewees' perspective of the challenges managing stakeholders?

The strategy to manage stakeholders (Question 02), from the interviewees' perspectives, depends on the engagement of those with the right level of hierarchy/authority to make decisions, which will create a sense of community based on trustworthy relationships, decreasing the conflicts amongst them.

2.2. Do you agree with the interviewees' strategy to manage stakeholders?

DIMENSION #2 – Communication process: on this dimension, the interviewees were asked to state the relevance of the information quality being communicated to the relationships amongst the stakeholders and the project team, and what would be the impacts when providing that information on 3D format.



The interviewees stated that the relevance of the information quality (Question 1) is on sharing a precise information to the stakeholders, considering the one that will receive it, its content, format and time. This sharing will increase the efficiency of the communication process as the information understanding, establishing trustworthy relationships among all involved, that lead to increased levels of engagement.

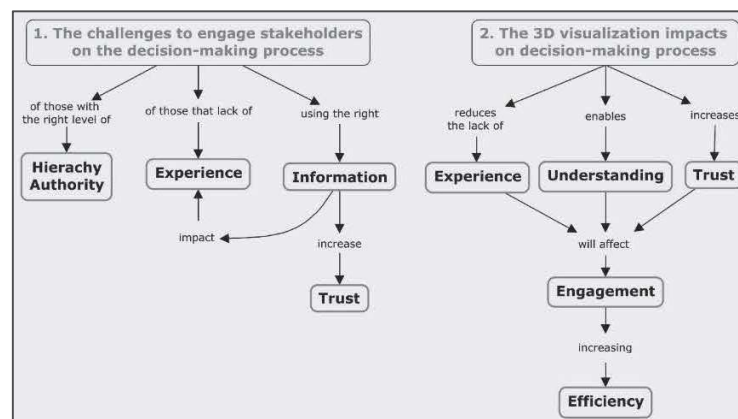
2.3. Do you agree with the interviewees' perspective of the relevance of the information quality?

When asked what would be the impacts on this process by providing the 3D visualization of the information being communicated (Question 2), the interviewees argued that it will improve the efficiency of the communication process by promoting a better understanding. This better comprehension will reduce the lack of experience on construction process and it will allow to increase the quality of the information by promoting trustful documents. With alignment of

understanding and increased trust, their level of engagement will improve, which impact the efficiency of project process.

2.4. Do you agree with the interviewees' 3D visualization impacts on the communication process?

DIMENSION #3 – Decision-making process: on this dimension, the interviewees were asked what the challenges to engage stakeholders on the decision-making process were and what would be the impacts when using the 3D visualization on the process.



The interviewees stated that the challenges to engage stakeholders on the decision-making process (Question 1) were the level of hierarchy/authority of those involved on the process, their lack of experience on the domains (mainly construction) and the use of the right information, which impact the level of experience, as also can increase trustful relationships among all involved and to the documents being generated.

2.5. Do you agree with the challenges stated by the interviewees?

From the interviewees' perspective for the 3D visualization impact on decision-making process (Question 2) include the reduction of the lack of experience on the domains (airport and construction), it enables a better understanding of the subject being discussed, and it increases the level of trust on the information being given. Those three concepts will affect the stakeholders' engagement, which can increase the efficiency of the decision-making process.

2.6. Do you agree with the interviewee's perception of 3D visualization impact on the decision-making process?

APPENDIX V

CATEGORIES THEORETICAL REFERENCES

| Categories | Theoretical references | | Literature related to |
|------------|----------------------------|--|-----------------------|
| Engagement | (El-Gohary et al., 2006) | “A positive involvement with stakeholders can be a decisive factor that can ‘make or break’ a project.” (p.604) | Construction Industry |
| | (Shindler & Cheek, 1999) | “Open and inclusive public processes enjoy increased support” (p.03). “Early and continuous involvement improves public understanding of the issues and managers understanding of participant perspectives.” (p.05) | Construction Industry |
| | (Widén et al., 2014) | “Structured process of engagement with stakeholders should form an integral part of the innovation process and that doing so will raise the prospects of successful innovation diffusion.” (p.06) | Construction Industry |
| | (Olander & Landin, 2008) | A proactive strategy to stakeholders’ management is more likely to gain their support to the project. | Construction Industry |
| | (Chinyio & Akintoye, 2008) | Engage stakeholders demands a combination of approaches and skills, since stakeholders influence project in different ways. | Construction Industry |
| | (Thomson et al., 2003) | There is a need for a common value language amongst construction project participants to engage stakeholders. “This language must be usable by people with different knowledge, expectations and objectives so they can articulate their values.” (p.14) | Construction Industry |
| | (Schade et al., 2011) | “From a client’s perspective the AEC sector needs to be involved earlier in the building process. On the other hand, the AEC sector also needs to involve the client more in the design process to ensure the business and project goals as expressed by the client are met by the proposed design.” (p.375) | Construction Industry |
| | (Wijnen et al., 2008) | “Inconsistencies in data, assumptions, models, and results, the current approach does not facilitate easy and comprehensive collaboration among stakeholders, resulting in excluding some of them altogether, or involving them too late.” (p.17) | Airport Industry |

| Categories | Theoretical references | | Literature related to |
|------------|------------------------------------|--|-----------------------|
| Efficiency | (Costa, 2003) | Relate trust to team performance, positively reflecting on the team outcomes and attitudes to the organization. | Project Management |
| | (Jehn & Bendersky, 2003) | “In order to have high performance and creativity, without too much loss of satisfaction or consensus-building ability, a group needs to have low levels of relationship conflict throughout its lifecycle, moderate levels of process conflict at the beginning, and moderate levels of task conflict starting in the middle of group’s project or life-cycle.” (p.228) | Project Management |
| | (Alper et al., 2000) | “The team performance will be affected by the way project teams deal with conflicts. ‘In a team setting, knowing that the group members tend to manage conflict cooperatively can strengthen conflict efficacy and team productivity.’” (p.637) | Project Management |
| | (Chiocchio et al., 2012) | “Together, communication, coordination, cooperation, synchronicity, are key to processes that influence team performance.” (p.08) | Project Management |
| | (Kozlowski & Bell, 2003) | Team effectiveness is influenced by three factors: coordination (manage interdependencies), cooperation (opposite of conflict) and communication (enable the other two factors). | Project Management |
| | (Gully et al., 2002) | Team-efficacy and potency are related positively to performance. Interdependence moderate the relationship between team-efficiency and performance but not between potency and performance. | Project Management |
| | (Chiocchio et al., 2011) | “Collaboration boosts the positive effect of trust and dampens the negative effect of task conflict, offering the opportunity to substantially improve performance.” (p.87) | Construction Industry |
| | (Pabedinskaitė & Akstinaitė, 2014) | “In the course of the development of airports, the improvement of their performance and service quality is a highly topical and challenging issue, which is widely considered from various angles and using different methods.” (p.408) | Airport Industry |
| | (Jehn & Bendersky, 2003) | “In order to have high performance and creativity, without too much loss of satisfaction or consensus-building ability, a group needs to have low levels of relationship conflict throughout its lifecycle, moderate levels of process conflict at the beginning, and moderate levels of task conflict starting in the middle of group’s project or life-cycle.” (p.228) | Project Management |

| Categories | Theoretical references | | Literature related to |
|---------------|--|--|-----------------------|
| Efficiency | (Jehn & Bendersky, 2003) | “In order to have high performance and creativity, without too much loss of satisfaction or consensus-building ability, a group needs to have low levels of relationship conflict throughout its lifecycle, moderate levels of process conflict at the beginning, and moderate levels of task conflict starting in the middle of group’s project or life-cycle.” (p.228) | Project Management |
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| | (Pabedinskaitė & Akstinaitė, 2014) | “In the course of the development of airports, the improvement of their performance and service quality is a highly topical and challenging issue, which is widely considered from various angles and using different methods.” (p.408) | Airport Industry |
| Understanding | (Kunz & Fischer, 2012) | “Only visual models have the power to support description to and evaluation by a broad class of stakeholders.” (p.37) | Construction Industry |
| | (Toledo, González, Villegas, & Mourgues, 2014) | “Using the 3D/4D model improve the understanding of both the project progress control information and the information shown to help visualize and manage the project constraints.” (p.976) | Construction Industry |

| Categories | Theoretical references | | Literature related to |
|---------------|------------------------|---|-----------------------|
| Understanding | (Wijnen et al., 2008) | “Information should be shared in such a way that an organization and its stakeholders gain an understanding of each other’s perspectives and objectives. Only when there is a mutual understanding is it possible to look for solutions that are satisfactory to all parties involved.” (p.18) | Airport Industry |
| | (Koch, 2004) | “Through the 3D visualization technology, an airport stakeholder can experience the visualization as though they were inside it, giving many more cues as to the desirability of a particular layout.” (p.28) | Airport Industry |
| | (Emmitt, 2010) | “It is the lack of common areas of understanding and a failure to develop a shared understanding that lead o ineffective communication” (p.30). “Clients unfamiliar with construction may be incapable of reading drawings and so virtual and physical models may be needed to communicate design intent and represent the proposed form of the building.” (p.40) | Construction Industry |
| Information | (Whyte et al., 2010) | “For clients, the value of data is derived from the operational expenditure and capital expenditure decisions. The big challenges at hand-over include the data accuracy and completeness.” (p.28) | Construction Industry |
| | (Pryke, 2004) | The author conceptualizes construction project as a “network of information exchange relationships.” (p.795) | Construction Industry |
| | (Wijnen et al., 2008) | Airport strategic planning involve “many resources, both inside and outside the organization: a lot of <i>data</i> are involved, requiring a significant number of <i>people</i> , possible using <i>tools</i> , to turn the data into <i>information</i> relevant for decision-making.” (p.14) | Airport Industry |
| | (Jordani, 2010) | “For the design/construction team, participation from one to several years is focused on a building project. For the owner, the focus is on the lifecycle of the facility. What was a project with fixed duration for the design/construction team is a long-term asset on the owner’s book. Digital information about a facility, its assets and systems, is essential to ongoing maintenance. Designs/construction teams have an opportunity to extend the value of their services by responding to this need with information needed for FM.” (p.16) | Construction Industry |

| Categories | Theoretical references | | Literature related to |
|-------------|-----------------------------|--|-----------------------|
| Information | (Wijnen et al., 2008) | “A major fundamental cause of the problems in involve airport stakeholders into the strategic planning is the ‘dispersion of data, tools, information, and knowledge within the organization of the airport operator and those of its stakeholders.’” (p.17) | Airport Industry |
| | (Kleinschmidt et al., 2010) | “Having a detailed understanding of the physical structure of a building plays a fundamental role in initial building design and subsequent re-design, as well as managing the building throughout its life cycle. This information extends beyond a 3-dimensional representation of the building supporting information related to light and energy analysis, and properties of building materials.” (p.61) | Airport Industry |
| | (Crotty, 2013) | “There are two challenges to deal with the storm of information generated by the construction industry: ‘the quality of the information being generated and used on the project, and the means by which this information is communicated and shared amongst the project team.’” (p.01) | Construction Industry |
| | (Loosemore, 2012) | “Information provision is an issue not just of access and quantity, but of content.” (p.201) | Construction Industry |
| | (Emmitt, 2010) | “Information needs to be correct and available when needed by the user.” (p.89) | Construction Industry |
| Trust | (Tyler, 2003) | “Motive-based trust encourage people to commit themselves to their work and organization.” (p.564) | Project Management |
| | (Costa, 2003) | Trust is a manifestation of behaviour towards others and a multi-component construct, being trustworthiness and co-operative behaviours the strongest of those components. | Project Management |
| | (Davis & Walker, 2007) | “Early development of trust engendered harmony within the stakeholder group.” (p.386) | Project Management |
| | (Simons & Peterson, 2000) | “... trust moderates the connection between task conflict and relationship conflict’ (p.16), being ‘the intragroup trust the key to preventing task conflict from escalating into relationship conflict.’” (p.17) | Project Management |
| | (Smyth, 2012) | “Trust can be developed, and manager can develop trust proactively.” (p.115) | Project Management |

| Categories | Theoretical references | | Literature related to |
|------------|-----------------------------|---|-----------------------|
| Trust | (Emmitt, 2010) | “It is through interaction and communication that we are able to establish the trustworthiness of our fellow project participants” (p.45). “As individuals start interacting they begin to gather experiences and form opinions that may reinforce or challenge the anticipated stereotypical behaviour and hence the level of trust. The longer the relationship continues the greater the opportunity for trust to develop.” (p.51) | Construction Industry |
| | (Smyth & Pryke, 2009) | “One thing that trust is not all about is open communication. If there is complete transparency of communication, then there is no need for trust. Collaborative relationships need trust, and complete transparency is simply unaffordable. Therefore, trust is needed in the face of uncertainty, hence a lack of information and information asymmetry. To develop collaborative relationships requires the development of trust.” (p.129) | Construction Industry |
| Conflict | (Alper et al., 2000) | “Conflict management is a central task for members of teams.” (p.627) Cooperative and competitive approaches to conflict have different outcomes to the conflict efficacy. | Project Management |
| | (Simons & Peterson, 2000) | “Task conflict is usually associated with effective decisions, and relationship conflict is associated with poor decisions” (p.01). However, “teams that report task conflict also tend to report relationship conflict” (p.03). Then, “efforts to stimulate potentially beneficial task conflict run a substantial risk of triggering detrimental relational conflict” (p.03). | Project Management |
| | (Jehn & Bendersky, 2003) | Conflict is both detrimental and beneficial. “While task conflicts may improve groups’ productivity and creativity under some circumstances, it can also damage group members’ satisfaction and their ability to reach consensus decisions.” (p.225) | Project Management |
| | (Wijnen et al., 2008) | “One of the problems to engage airport stakeholders on the strategic planning process is the constant presence of conflicts amongst them.” (p.17) | Airport Industry |
| | (Kleinschmidt et al., 2010) | “Each stakeholder has a different perspective on airport operations, and places different criteria on which successful airport operation is measured. Often these criteria are in conflict, and so in order to resolve challenges and to derive solutions benefiting all stakeholders, a truly multi-disciplinary approach is required.” (p.58) | Airport Industry |

| Categories | Theoretical references | | Literature related to |
|---------------|---------------------------|--|-----------------------|
| Conflict | (Emmitt, 2010) | “The perception of conflict can result from differences of opinion, simple misunderstandings, mistakes and/or fundamental differences in requirements. Thus, conflict exists where there is an incompatibility of interests.” (p.132) | Construction Industry |
| Relationships | (Smyth & Edkins, 2007) | Value is added to the project through the people and its relationships, increasing the satisfaction of client end users and other stakeholders. | Project Management |
| | (Simons & Peterson, 2000) | “... relationship conflict is detrimental to decision quality and to affective commitment to the group.” (p.03) | Project Management |
| | (Walker et al., 2007) | The stakeholder engagement strategy is related to the relationship amongst project team and stakeholders. This relationship is governed by trust, power and commitment. | Construction Industry |
| | (Arditi & Gunaydin, 1998) | “The quality of any construction phase is dependent of the relationships strength among participants based on mutual trust and less dependence on legal assistance.” (p.202) | Construction Industry |
| | (Pryke & Smyth, 2006) | “The quality of relationships is a key element in the success of a project. Relationships can be managed and will in turn affect project performance.” (p.25) | Project Management |
| | (Smyth & Pryke, 2009) | “Relationships therefore become a key focus, not only for effective application of the bodies of knowledge, the management of projects and project management tools and techniques, but also for managing the contextual conditions because knowledge and technique provide insufficient clarity and guidance for controlling these factors.” (p.10) | Construction Industry |

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