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Requirements for a BIM execution plan (BEP): a proposal for application in Colombia

Requisitos para un plan de ejecución de BIM (BEP): propuesta de aplicación en Colombia

JUAN ANTONIO RAMÍREZ-SÁENZ
C.Eng, Universidad de Los Andes, Department of Civil & Environmental Engineering. ja.ramirez917@uniandes.edu.co

JUAN MARTÍN GÓMEZ-SÁNCHEZ
C.Eng, Universidad de Los Andes, Department of Civil & Environmental Engineering. jm.gomez14@uniandes.edu.co

JOSÉ LUIS PONZ-TIENDA
PhD., MSc, MBA, B.Eng, Universidad de Los Andes. Department of Civil & Environmental Engineering. jl.ponz@uniandes.edu.co

JUAN PABLO ROMERO-CORTÉS
MSc, C.Eng, Universidad de Los Andes, Department of Civil & Environmental Engineering. jp.romero985@uniandes.edu.co

LAURA GUTIÉRREZ-BUCHELI
MSc, C.Eng, Universidad de Los Andes, Department of Civil & Environmental Engineering. la.gutierrez725@uniandes.edu.co

- The BEP is a document developed by all the stakeholders that defines the use of BIM in a specific project.
- The development of a BEP is crucial for a better planning and understanding in the management of BIM in a project.
- The BEP could solve crucial problems in the Colombian AEC industry when implementing BIM in a project.
- The BEP is a powerful tool to enable communication and coordination among the stakeholders.
- A granularity review is made in a selection of 20 BEPs around the world to analyze their content.

The Architecture, Engineering and Construction (AEC) Industry in Colombia is starting to implement Building Information Modeling (BIM) in their projects but in a much unorganized way. This issue could be attributed to a lack of unique and public BIM standards and guidelines for the implementation along with the inexistent support to the industry from the Government on the road to implementation. The BIM Execution Plan (BEP) is a procedural process that outlines the project's overall vision with implementation details for the project team to follow throughout the project. In this study, the authors reviewed 20 BEPs searching for the presence of some identified and analyzed subcomponents to determine which documents were more robust. By performing a 27-question survey to understand how different BIM tools affect a BIM implementation, we investigated about the experience of some companies in the industry with five in depth interviews conducted to AEC Colombian professionals. Finally, a presentation of a BEP template that uses the analyzed documents and the identified problems in the interviews, along with an explanation of how was the use of information obtained to develop the new BEP template. Conclusions and recommendations are provided to enhance the BIM implementation in Colombia along with the template and the support files that can also help to develop and integrate future BIM process tools methodologies.

Building Information Modeling (BIM); BIM Execution Plan (BEP); BIM Standards; BIM Guidelines; Colombia

- El BEP es un documento desarrollado por todos los actores interesados, que define el uso de BIM en un proyecto específico.
- El desarrollo de un BEP es crucial para planear y comprender mejor la gestión de BIM en un proyecto.
- El BEP podría resolver problemas cruciales en la industria colombiana de AEC al implementar BIM en un proyecto.
- El BEP es una herramienta poderosa que permite la comunicación y coordinación entre las partes interesadas.
- Se realiza una revisión de especificaciones en una muestra de 20 BEP en el mundo analizando su contenido.

La industria de Arquitectura, Ingeniería y Construcción (AEC) en Colombia está empezando a implementar Building Information Modeling (BIM) en sus proyectos, pero de una manera muy desorganizada. Este problema podría atribuirse a la falta de normas y pautas de carácter unificado y público para la implementación de BIM junto con el apoyo inexistente a la industria por parte del gobierno en el camino hacia dicha implementación. El Plan de ejecución BIM (BEP) es un procedimiento enmarcado en procesos BIM que describe la visión general del proyecto con detalles de implementación para que el equipo siga a lo largo del ciclo de vida del proyecto. En este estudio, los autores revisaron 20 BEPs en busca de la presencia de algunos subcomponentes identificados y analizados para determinar qué documentos eran más robustos. Al realizar una encuesta de 27 preguntas para comprender cómo diferentes herramientas BIM afectan su implementación, investigamos sobre la experiencia de algunas empresas en la industria con cinco entrevistas a profundidad realizadas a profesionales colombianos de AEC. Finalmente, hay una presentación de una plantilla de BEP que se basa en los análisis de los resultados y los problemas identificados en las entrevistas, junto con una explicación de cómo se utilizó la información obtenida para desarrollar la nueva plantilla de BEP. Se presentan conclusiones y recomendaciones para mejorar la implementación de BIM en Colombia, además de una plantilla y los archivos de soporte para que cada empresa que desee desarrollar su propio BEP pueda revisar la información presentada en este documento.

Building Information Modeling (BIM); Plan de Ejecución BIM (BEP); Estándares BIM; Guías BIM; Colombia

Abbreviations: BIM: Building Information Modeling; BEP: BIM Execution Plan/Plan de Ejecución BIM; LoD: Level of Detail/Development

1. INTRODUCTION

Building Information Modeling (BIM) is the process for creating and managing information on a construction project across all its lifecycle, where the building information model, as a digital description of every aspect of the built asset [1], is the key output of this process. In other words, BIM is fundamentally a different way of creating, using, and sharing building lifecycle data [2].

This methodology represents a change of paradigms in the way the AEC industry works, to guarantee the realization of the benefits that BIM offers. This paradigm shift imposes new challenges to the industry due to changes in the contracting strategy, its proper execution in projects and the need of a strong collaboration between project stakeholders, among others [3].

Being this last one, a crucial aspect in the success of implementing BIM in the industry. Nevertheless, the AEC industry is highly fragmented with a lack of full team integration that leads to the fact that the information is difficult to generate, exchange and coordinate, leading to low productivity delays and cost overruns [4].

The AEC industry plays a major role in the economy of Colombia, with an influence growth from 7,2% to 9,4% in the Gross Domestic Product (GDP) between 2010 and 2016 [5]. According to the National Administrative Department of Statistics, known as Departamento Administrativo Nacional de Estadísticas (DANE) in Colombia, construction sector in the AEC industry has grown a 0,9% in the last trimester of 2016 and the infrastructure sector has grown a 5,1% [6].

Although the importance of this sector is very high, like in other countries, construction results in a very inefficient industry, there is a lot of fragmentation, with multidisciplinary and uncoordinated designs and interferences that lead to a significant amount of rework, implying delays, unanticipated field costs, undesired legal implications and a poor-quality final product.

According to a study accomplished by Los Andes University [7], the level of BIM implementation in Colombia remains very low. Although there is a noticeable shift from the traditional 2D drawings to 3D visualization models, the most important components are still lacking, as the integration needed for BIM to accomplish its major benefits, the full collaboration between the stakeholders of the project and the interoperable data for them to work.

Even though Colombian AEC industry is trying to implement BIM on its projects, the industry must overcome some important barriers. The main barrier in the companies' workflow is the resistance to change from standard to integrated and collaborative processes.

Another problem identified in the study is that, once companies in Colombia decide to use BIM in their projects, they find that their suppliers do not use it or are just starting in the learning process, which means that the use of BIM is not homogenous in the industry and that leads to a very slow implementation process.

Another barrier found is the lack of qualified staff and the absence of a clear framework that regulates the liability of BIM professionals. In conclusion, a BIM implementation imposes new and difficult challenges that can lead to conflicts between the stakeholders of the project. BIM requires new skills, new strategies, new ways to interact with the designs and new forms of business configuration in order to facilitate effective collaboration and integration in the different project teams [8].

A way to facilitate a BIM implementation process in a project, in an organized and efficiently manner is through the establishment of a BIM Execution Plan (BEP) before starting the design phase. The BEP is a procedural process that outlines the project's overall vision with implementation details for the project team to follow throughout the project. Also, it helps the employer and the project members to document the agreed BIM deliverables and processes for the project, defining roles and responsibilities for each of those deliverables [9].

To help practitioners and organizations in the BIM implementation process, this paper will outline the necessity of the creation and adoption of BEP in every project that aims to use BIM to create value in any sense. In this line, firstly, an in-depth analysis of the BEP models found in the literature to build a compiled and detailed model with the generally accepted best practices. Secondly, a comparison of this model with experiences in the AEC Colombian industry to stablish a benchmark to help organizations to be more efficient and cost effective. Thirdly, a proposal for a BEP's template is made inspired by the literature review and the problems the AEC Colombian industry is experimenting. Finally, a presentation of some conclusions and recommendations.

2. METHODOLOGY

The main method used to review and analyze the BEPs was conventional qualitative content analysis [10], because the authors were looking to describe what the academy and the AEC industry understand for BEP and what has been developed in the last decade.

The investigation used a sample set of 20 documents from around the world from different types of organizations: academic institutions, government construction authorities, state government, government agencies, private companies and industry non-profit organizations. In order to analyze the BEP's granularity, this study evaluates the content of some components in these documents, reviewing at the same time if they contained some subcomponents, which also emerged from the same review.

The main components considered were taken from the BEP section in a study conducted by [11], with some minor modifications and a few additions. The description of the components and subcomponents is in the next section.

Additionally, the authors designed a survey and conducted five in-depth interviews that was composed of 27 questions. The survey consisted of the following topics: (a) project

management and the use of BIM in the organization; (b) subcontractor's management; (c) BIM models' authors and users; (d) BEP structure; (e) BIM use in the Colombian AEC industry; (f) quality control and control of advances; (g) use of protocols, software and hardware and (h) information management. As for the respondents, 17 Colombian AEC industry's main professionals were invited to reply the interviews; however, only five (29%) accepted the invitation.

From those who responded, four were mainly from large companies and one of them from a subcontractor organization. The research ends with some conclusions and recommendations for future studies on the subject.

At the end, there is a presentation of a BEP template proposal using the analysis of the 20 documents reviewed on this paper. This aims to achieve: 1) to decrease the lack of BIM processes that Colombian AEC industry is experimenting and 2) to show how can be a conception of a BEP template, so the industry can replicate this exercise to either have their own BEPs or come together to define a standard industry BEP template.

3. GRANULARITY REVIEW ON THE BIM EXECUTION PLANS

BIM enables exploration and optimization across multiple dimensions of cost, quality, and schedule, through simulation of a building's environment [12]. BIM implementation process in any given project should be designed according to each projects' requirements and should enable collaboration within the stakeholders and a clear understanding of the information exchange process in favor of being successful.

This is why effective BIM execution requires a comprehensive research due to high levels of information and collaboration necessities [13]. This is the reason why the BEP is a central component of the preparation for any construction project using BIM [11].

It frameworks the overall vision along with implementation details for the project team to follow throughout the project, it should be elaborated in the early stages of the project and be continually developed as new participants are added, being monitored, updated, and revised as needed throughout the implementation phase of the project.

The BEP should define the scope of BIM implementation, identify the process flow for BIM tasks, define the information exchanges between parties and describe the required project and company infrastructure needed to support the implementation, among others.

Through this process, the project team members can perceive some value added, among these, it is worth mentioning that all the parties will clearly understand and communicate the strategic goals for implementing BIM on the project. In addition, organizations will understand their roles and responsibilities in the implementation.

Likewise, the team will be able to design an execution process, which is well suited for each team member's business practices and typical organizational workflows and the purchasing divisions will be able to define contract language to ensure that all project participants fulfill their obligation and even more.

By drawing up a BEP, the entire team will gain value through the increased level of planning by reducing the unknown in the implementation process, thereby reducing the overall risk to all parties and the project [14]. For example, a research conducted by the Taipei University of Technology [15] about a case study of a project in Taiwan, in which a BEP was designed for Facility Management (FM), the results demonstrated that the BEP created for that project was an effective management approach for operation maintenance management.

The authors stated that the advantages of the proposed BIM Execution Plan lie not only in how the maintenance management work becomes more efficient by integration with BIM technologies, but also in how the value and benefits of BIM are maximized to support maintenance management. This clearly shows the importance of developing management tools as the BEP is, for maximizing the value added of BIM in the projects.

In a country that is starting to implement BIM, like Colombia, the development of standards and studies around this topic would help the AEC industry in organizing around the use of BIM to maximize its contribution in the projects as is shown in the Taipei case study.

This paper evaluates the granularity and composition of a selection of BEP documents to outline the importance of this kind of document and its importance in the BIM implementation in Colombia.

As stated above, a thematic division of the documents resulted in different components, from which abstracted subcomponents allowed the authors to evaluate the granularity of each component, with the aim of understanding their structure and foundation. The following is a description of the revised components with their subsequent subcomponents, as described in Table 1:

- **Template:** it is important to consider whether the BEP supplies a template for the user to fill it with project data, following the recommended components that the BEP presents. This makes it easier for the final user to implement a specific BEP in a project. This component indicates whether the BEP provided a template or not.
- **Descriptive or prescriptive BEP**: this component studies the taxonomy of each of the BEPs. Descriptive means whether the BEP depicts or illustrates the recommended steps to take to develop a BEP. On the other hand, prescriptive means whether the document orders or requires the mandatory use of some aspects of its implementation by the owner of the project organization [16].
- **BIM Project scope**: this point specifies the use that BIM models will have in order to carry out the appropriate parameterization in the initial stage of the project.

  For this component, the presence of the following subcomponents was studied: Project information, Project acquisition strategy and BIM objectives.

– **Legally binding document**: this review seeks to indicate whether the BEP document represents a legal bound between all parties involved in the project.

  This component indicates only if the document is legally binding or not.

Component	Subcomponents and/or Symbol	
Template provided	Yes (Y) or No (N)	
Descriptive/ prescriptive	Descriptive (D) or Prescriptive (P)	
BIM Project Scope	♦	Project information
	■	Project acquisition strategy
	▲	BIM objectives
	●	BIM uses
Legally binding document	Yes (Y) or Not (N)	
Roles & responsibilities	♦	Responsibility matrix
	■	BIM manager profile
Collaboration/ communication	♦	Reunion schedule of BIM coordination
	■	Key project contacts in BIM use
	▲	Collaboration & communication strategy
Information exchange	♦	Type of model's format delivery
	■	Process Maps
	▲	Information exchange worksheets
Analysis plan and	Yes (Y) or No (N)	
BEP document update procedures	Yes (Y) or No (N)	
Deliverables/ documentation	♦	BIM deliverables
	■	Drawing production
	▲	BIM deliverable schedule
Modeling requirements	♦	Level of Development and/or Level of Detail (LoD)
	■	Modeling guidelines
	▲	Family naming convention
	●	Modeling standards
Model management	♦	How models will be handled
	■	How models will be saved, stored, named, etc.
	▲	Responsible for As-Built model creation
IT software & hardware	♦	BIM software used
	■	Software versioning management
	▲	Hardware specification
	●	Security and backups

Table 1: Components Subcomponents and/or Symbol

– **Roles and responsibilities**: role that each stakeholder plays during the project's lifecycle and it defines the specific work associated with each role. In addition, there is clear relationships identification among tasks and identified BIM uses.

  For this component, it was studied the presence of the following subcomponents: Responsibility matrix and BIM manager profile.

– **Collaboration/communication**: is the methodology that the project team will use to guarantee a smooth flow of information between the stakeholders and how they will collaborate with each other in general.

  For this component, it was studied the presence of the following subcomponents: Reunion schedule of BIM coordination: it is the scheme of reunions regarding the use of BIM in the project, Key project contacts in BIM use and Collaboration & communication strategy.

– **Information exchange**: this component checks if the BEP uses existing protocols or standards or specifies the project requirements for information exchange.

  The use of protocols ensures the correct exchange of BIM models so that information is not lost and is always readable and useful to all parties involved. This also checks the presence of BIM processes which are curtail for goal fulfilment, collaboration and data flow [17].

  For this component, it was studied the presence of the following subcomponents: Type of model's format delivery, Process Maps and Information exchange worksheets: it is a template that relates the responsible parties to the information that will be exchanged and its requirements

– **Analysis plan and tools**: are the types of agreed analysis and tools that the designers will perform from the BIM models with its corresponding tool (software). This component indicates if it was stated or not.

– **BEP document update procedures**: the BEP is a dynamic and living document that must fit the needs of the project throughout its entire lifecycle and shall be continually developed and refined throughout the project development. Therefore, there should be a clear, concise and agreed way about the BEP's modification or update procedure. This component indicates whether the procedure specification existed or not.

– **Deliverables/documentation**: is the delivery and delivery form that each discipline performs at each defined milestone of the project, with the specific presentation format, the parties involved and the way in which the information is registered.

  For this component, it was studied the presence of the following subcomponents: BIM deliverables, drawing production and BIM deliverable schedule: is the agreed estimate time for the handover of the deliverables.

– **Modeling requirements**: this component refers to the different requirements that modelers must comply with

when modeling parametric objects. The modeling requirements depend on the scope defined in an earlier component.

The importance of this component lies in the direct correlation of the Level of Development of a model and the certainty of the daily work orders of a project. "When LOD 300 is used, only 29% of the daily work orders have corresponding elements in BIM, whereas when LOD 400 is used, 98% of the daily work orders have corresponding elements in BIM" [18].

For this component, it was studied the presence of the following subcomponents: Level of Development and/or Level of Detail (LoD), Modeling guidelines, Family naming convention and Modeling standards.

- **Model management**: as project teams should define and document their global strategy for quality and management control of the model, it was studied in the BEP the presence of the following subcomponents for this component: how models will be handled, how models will be saved, stored, named, etc. and, responsible for As-Built model creation.
- **IT hardware & software**: it is the definition of the technological aspects that each interested party will be using in the development of the project. It defines the software and the version in which each discipline will generate its respective BIM model, how the version update management will be and the capacity of the hardware that everyone uses to facilitate the exchange of information and communication between all the parties.

Document Name	Document short name	Publishing organization	Organization Type	Country	Publication date
AEC (CAN) BIM Protocol	CanBIM	CanBIM	Industry non-profit organization	Canada	2014
AEC (UK) BIM Protocol Project Execution Plan	AEC	BIM UK Commitee	National Standards Agency	UK	2012
Autodesk BIM Deployment Plan	AutoD	Autodesk Inc	Private Company	US	2010
BIM Execution Plan BIM for Architects, Engineers and Contractors	UF	University of Florida	Academic institution	US	NF
BIM Guidelines & Standards for AEC	Indiana	Indiana University	Academic institution	US	2012
BIM project execution planning guide	Penn	The Pennsylvania State University	Academic institution	US	2011
BS 1192-4 and PAS 1102-2:2013	UK	BSI Standards Limited	National Standards Agency	UK	2013
Building Information Modeling (BIM) Guidelines	USC	University of South. California	Academic institution	US	2012
CIC Building Information Modelling Standards	Hong Kong	Construction Industry Council	Government construction authority	China	2014
COBIM (Common BIM Requirements)	Senate	Senate Properties	Government construction authority	Norway	2013
Georgia Tech BIM Requirements & Guidelines for AEC	GT	Georgia Institute of Technology	Academic institution	US	2011
LACCD BIM standards	LACCD	LA Community College District	Academic institution	US	2016
Massachusetts Institute of Technology BEP	MIT	MIT	Academic institution	US	2014
NATSPEC National BIM Guide	NATSPEC	NATSPEC	National Standards Agency	Australia	2011
Official Manual for BIM projects	COE	New York District, U.S Army Corp of Engineers	Government construction authority	US	2009
Singapore BIM Guide	Singapore	Building and Construction Authority	Government agency	Singapore	2013
State of Ohio BIM Protocol	Ohio	State of Ohio General Services Division	State Government	US	2009
Statsbygg BIM Manual	SBM	Statsbygg	Government construction authority	Finland	2012
US National BIM Standard	NBIMS	National Institute of Building Siences -Buildsmart alliance	National Standards Agency	US	2012
VA BIM Guide	VA	Department of Veterans Affairs	Government construction authority	US	2010

Table 2: BEP´s selected for review

For this component, it was studied the presence of the following subcomponents: BIM software used, Software versioning management, Hardware specification and Security and backups.

The Table 2 is a description of the BEP documents reviewed on this research ([9];[19]–[31]). The selection of these documents is from a wide diversity of institution types and countries. It is considered the latest draft/version available on October 2017.

As stated before, each of the 20 BEP documents appointed in Table 2 had a revision of the components and subcomponents described above with the Symbols described in Table 1. Table 3 presents the results.

The authors performed a statistical analysis from Table 3 to find out the most complete BEPs according to the defined indicators. Thus, it is evident from Table 3 that out of the 30 defined subcomponents for this study, the most complete BEPs are the VA's with the presence of 83.3% of the subcomponents, followed by the Pennsylvania's and the Singapore's, both with 76.7% each one.

It is worth highlighting that empty cells on Table 3 do not mean that the document does not mention the component, but it means that the subcomponents proposed in the research are missing. Additionally, the last column (percentage of subcomponents found) might indicate that some BEP documents are better than others are; however, the design of each BEP considered a specific context for its creation and implementation.

Table 3 works as a reference model for the creation of new BEPs by taking information from the documents studied here. As stated before, a BEP helps to organize a project around

BIM Documents	Template provided (Y/N)	Descriptive/ prescriptive	BIM Project Scope	Legally binding document (Y/N)	Roles & responsibilities	Collaboration/ communication	Information exchange	Analysis plan and tools (Y/N)	BEP document update procedures (Y/N)	Deliverables/ documentation	Modeling requirements	Model management	IT software & hardware	Percentage of subcomponents found
AEC	Y	D	♦■▲	N	♦	♦■	♦	N	N	■	♦■▲●		♦■▲	53,3%
AutoD	N	D	♦■▲	N		■▲	♦■	Y	N		♦■	▲	♦▲●	46,7%
CanBIM	N	D	▲●	N		♦	♦▲	N	N	■		♦■	♦■▲	36,7%
COE	N	P	●	Y	♦■		♦■▲	Y	Y	■	♦■	♦▲		36,7%
GT	Y	D	♦■	N	♦	■	■	Y	N	♦	■	♦■▲	♦	43,3%
Hong Kong	N	D	♦	Y	♦■	▲		N	Y	♦■▲	♦■●	♦■▲	♦■▲●	63,3%
Indiana	N	P		Y		♦	▲	Y	N	♦■		▲	♦	23,3%
LACCD	N	P		N	■	♦	■	N	N	■	■	♦■▲	♦	30,0%
MIT	Y	P	♦■▲●	N	♦	♦■	♦■▲	Y	N	♦■▲	●	♦■▲	♦▲	70,0%
NATSPEC	N	D	■	N	♦	▲	▲	N	N	■	♦■▲	♦■▲	♦●	43,3%
NBIMS	Y	D		N	■	▲	♦■	N	N		♦	▲	♦▲●	33,3%
Ohio	Y	P	♦▲	Y		▲	♦	Y	N	♦	♦	♦▲	♦	40,0%
Penn	Y	D	♦■▲●	N	■	♦■▲	♦■▲	N	Y	♦▲	♦●	♦■▲	♦■▲	76,7%
SBM	N	D		N	♦	▲	♦	Y	Y		■	♦■▲	♦■	36,7%
Senate	N	D	▲	N	♦■		♦■	Y	Y		■▲	♦▲	♦■	43,3%
Singapore	Y	P	♦■▲●	Y	♦■	■▲	♦■	N	Y	♦■▲	♦■	♦■▲	♦●	76,7%
UF	Y	P	♦▲●	N	♦■	♦■	♦	N	N	▲	♦▲	♦■▲	♦■	53,3%
UK	Y	D	♦■	N	♦	▲	♦■	N	Y	♦	♦▲	♦■▲	♦■●	56,7%
USC	Y	P	♦■●	Y		■▲	♦■▲	Y	N	♦▲	♦■▲	♦■	♦■	66,7%
VA	Y	D	♦■▲●	N	♦■	♦■▲	♦■▲	N	Y	♦■	♦■▲●	♦▲	♦■●	83,3%

Table 3: Granularity for each BIM execution plan

the use of BIM. It can address many types of problems that companies may be experimenting in the implementation of BIM. The next section presents some of the main problems Colombian AEC organizations are having that a BEP can address.

4. IN-DEPTH INTERVIEWS FROM PRINCIPAL BIM ACTORS IN THE COLOMBIAN AEC INDUSTRY

Colombia is starting to use BIM on their projects but with a slow pace. This is shown in [7], and it demonstrates how the major portion (44%) of the surveyed industry, stated that they became involved with BIM within the past two years, while other major part with 34% in the last year, 15% in the past 3 to 5 years and only 6% for more than 5 years. This outlines in evidence the immaturity of the BIM use in the AEC Colombian industry.

The main BIM uses that the industry is implementing are 3D coordination, design authoring, quantity takeoff and cost estimations, production of 2D drawings, existing conditions modeling and design reviews, among others. One of the interesting results is that the industry is not massively using BIM models for maintenance and operation, prefabrication and energy analysis, which demonstrates the state of immaturity that Colombia is in BIM use.

To be able to contrast the benefits of the implementation of the BEP in a BIM based project with the local industry problems, five in-depth interviews were conducted to BIM Managers from some of the main construction companies in the country.

The surveys showed interesting results. First, there are some basic requirements in terms of individual and interpersonal skills for the people involved in BIM processes. Thus, most respondents agreed that one of the most important and difficult barriers is to change people's mindsets.

The industry is reluctant to change, because traditional ways of working undertaken for several years may be less cumbersome and stressful to implement. Additionally, it was clear that the way each surveyed company has addressed the BIM implementation is different from each other, and all of them stated that there has not been an organized way to approach a large-scale implementation by the industry.

From the surveyed professionals, two stated that there is no support from the government; however, if the government created standards, it would help companies to take valuable information for them to develop their own internal standards, which would homogenize the use of BIM. A good example of one of those standards, as stated by one of the respondents, could be de development of a standard BEP from the government for all the public biding projects that intent to use BIM.

Moreover, BIM often requires rethinking and redesigning business processes. There were identified many troubles in the managerial processes associated to a BIM implementation in Colombia. This was clear in the interviews because most respondents stated that there was a lot of rework since they are getting their subcontractors' designs in 2D-CAD and they must model those designs in the BIM software.

One respondent argued that this is due to the low involvement on BIM implementation of the different discipline's designers in the industry. In addition, the lack of modeling standards or guidelines is another obstacle, according to one respondent.

As for modeling requirements, an agreed way and LoD (Level of Development/Detail) must exist for model creation in each of the project stages, so the different disciplines can achieve their BIM objectives. For one of the respondents, whom is dedicated to carry out sustainability consultancy to projects this is a relevant issue.

For their company is very important that models are created in certain ways so they can run the different analysis on the software the company implements with the goal of performing the sustainability consultancy. A probable solution could be to agree a model creation process and manipulation from the beginning of the project through the development of a BEP.

In relation to the implementation of Integrated Project Delivery (IPD) practices, periodic coordination meetings represent a concern because BIM Managers are not sure how to manage and facilitate multi-discipline coordination meetings. According to one respondent, these meetings extended to the point where they became a waste of time for some designers.

Probably, this might happen because the entire design team was involved at the same time, without having to gather the whole team at the same time. A solution to the 3D coordination procedure, meeting frequencies, durations, and communication and information exchange procedures could be to agreeing from the beginning when and how these reunions and procedures will take place with each one of the stakeholders and record the commitments in the BEP.

Another very important point is the involvement of the construction site team on the BIM implementation. The implementation cycle will never close if project's construction do not implement BIM properly. This issue was a concurrent problem for some of the respondents.

One of the professionals stated that they send the BIM models to the construction team, but they were not using them for any purpose. The respondent said that they were confident that just by sending the BIM models, the construction team would use them for control purposes on the construction site and this was not happening, wasting or missing some of the main benefits that BIM implies.

By involving the construction team from early stages of the project during the development of a BEP, the construction industry could achieve that every stakeholder involved in the project understands the uses that BIM will have at every stage of the project's lifecycle.

Finally, BIM is very much about the ecosystem of integrated technologies [32] Therefore, the IT (Information Technology) was included in the survey and was found to be a great barrier in the implementation according to the results. The main reasons are the high cost of software licenses and the required hardware to run them, which needs to be regularly

updated and it needs to be able to manage a vast amount of information, which makes it very costly too.

Additionally, all parties involved in the BIM use can also clarify the software version (and its management) to ensure interoperability along the project development. Moreover, another concurrent issue identified was the exchange of information in the BEPs documents' study. Respondents indicated in this regard that the storage of information and the exchange procedures are difficult task to handle in their projects.

5. A PROPOSAL FOR A BIM EXECUTION PLAN TEMPLATE

As mentioned before, the Table 3 shown in this document, works as a model for the creation of a new BEP depending on the interests and objectives of the companies in each project during the development of their new BEP document. For this paper, the authors created a proposal for a BEP template using this model according to some criteria explained below.

The main objective was to create the most robust template that the model can conceive by implementing all the subcomponents analyzed on this document and to help the Colombian AEC industry in their troubles with the BIM implementation. It is important to mention that the BEP must suit the unique characteristics of the project so it may not be necessary to include all the subcomponents proposed on this paper.

To accomplish that objective, the authors reviewed each of the components guided by which BEPs had the greatest number of subcomponents examining the Table 3. For example, the BIM Project Scope component review indicated that all the proposed subcomponents were only in barely four documents.

Out of those four documents, the most complete one as a reference, as the Percentage of Subcomponents Found column in Table 3 shows, is the Veterans Affair's BEP. Using this untie criteria, the VA's BEP document supplied the information to create the BIM Project Scope component on the template.

Following the same procedure of the BIM Project Scope component creation, each one of the components and subcomponents described earlier for this document had a revision and adaptation. If there were more than one BEP with the same number of subcomponents, the most complete document between them according to the Percentage of Subcomponents Found column supplied the information. It is important to mention that when reviewing a subcomponent and only one document contained it, the document in question supplied the information.

Following these criteria, the information for all the components on the proposed template were mainly drawn from the VA's, the Pennsylvania State University's and the Singapore's BEPs, apart from the Analysis Plan component that was drawn out from the Autodesk BIM Deployment Plan. There is a presentation of the tables on the template with some slight changes to have a more organized and clearer BEP.

The document of the proposed template can be found in the link (http://bit.ly/BEP_Template_Ingeco) along with an excel support file with all the tables consigned in the document so they can be modified to suit each project needs.

The authors proposed the subcomponents order of presentation in the template and is open to discussion. There is no correct way to arrange the information in the BEP template and this is a topic worth discussion between the stakeholders in the early stages of the project.

It is worth mentioning that the main problems found during interviews from the Colombian AEC industry actors mentioned before, are mitigable by approaching to them in the proper way, for instance, through the preparation of an early and concise document that covers all possible scenarios.

This was one of the main objectives for creating the template. Finally, the authors expect that the template work as a reference for industry actors to develop their own BEP, either by reviewing the content of the template or by using the model inspecting the documents mentioned in Table 3.

6. CONCLUSIONS AND RECOMMENDATIONS

Once the 20 BEP documents were reviewed, the problems and limitations that the Colombian AEC industry experience concerning the BIM implementation in their projects was understood, and the creation of a template for a BEP was carried out, a final analysis could be performed and some conclusions are presented below:

- The fact of having a low percentage in the calculated results (Percentage of Subcomponents Found column) does not indicate that a BEP is deficient; on the contrary, it means that it takes into account the context and focuses on a solution to a very specific problem that the Institution was facing.
- The most complete BEP documents turn out to be the best reference for shaping a BEP structure for a new project.
- A successful BEP implementation converges all the involved parties' objectives in to one, concerning the way BIM actors' processes and technologies will be interacting with each other during the project, so problems can be reduced in the implementation and communication for all the stakeholders is enhanced.
- BIM adoption in Colombia is growing year after year. For this reason, it is urgent and necessary to organize the Colombian AEC industry regarding the BIM use. Thus, involvement of the government is crucial to support the implementation, through the creation of standards that are transversal to all the parties in the business is imperative.
- In most large and medium Colombian companies, the use of BIM is gradually beginning, yet, there is a very low implementation of contractual documents like the BEP, which helps the implementation to be more organized in an industry that is mostly implementing BIM in an empirical manner.
- Through the development of a BEP, managers, designers, contractors and subcontractors will understand more clearly

their role and responsibilities, regarding the BIM implementation in the project.

- The implementation and use of BIM depends largely on the organizational culture; therefore, the BEP must reflect the working procedures that every organization has. The study conducted on this investigation can help companies to develop their own BEP by reviewing which components and subcomponents they need to include to their BEP.
- Through a large-scale use of a standard BEP from the Colombian AEC industry, the BIM implementation will keep increasing and there will be an improvement in the collaborative work. The BEP template proposed in this document can help to set the cornerstone that helps that large-scale implementation of this tool in the industry.

It is important to outline the necessity of the implementation of this kind of documents in Colombian companies, accompanied by academia, with the interest of collaboratively achieve the most suitable solution.

Additionally, it is crucial to thoroughly research on the BEP's composition and granularity in pursuance of understanding not only the presence of some subcomponents but the complexity, the quality, impact in the project and relationships among subcomponents.

Similarly, the need for further research of BIM Implementation Plan (BIP) to complement the investigation performed on this paper exists.

The BIP is the general plan that a company uses to implement BIM inside an organization. The BIP outlines the answer to the question of "how a company is using BIM?" as a BEP outlines the answer to "how a project is using BIM?"

It is important to highlight the need of the elaboration of National BIM standards in Colombia from the union of government, industry and academia to achieve a better BIM implementation in the country.

The revision of the implementation methodologies and techniques employed on other countries and the development of more researches on this topic can contribute to the achievement of a better implementation.

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8. REFERENCES

[1] National Building Specification (NBS), "What is BIM?," 2017. www.thenbs.com/knowledge/what-is-building-information-modelling-bim. [Accessed: 01-Jun-2017].

[2] C. Eastman, P. Teicholz, R. Sacks, and K. Liston, BIM Handbook A guide to Building Information Modeling, Wiley. 2011.

[3] O. Hamdi and F. Leite, "Conflicting Side of Building Information Modeling Implementation in the Construction Industry," J. Leg. Aff. Disput. Resolut. Eng. Constr., vol. 6, no. 3, pp. 1–8, 2013, doi: 10.1061/(ASCE)LA.1943-4170.0000137.

[4] A. A. Aibinu and S. Venkatesh, "Status of BIM Adoption and the BIM Experience of Cost Consultants in Australia," J. Prof. Issues Eng. Educ. Pract., vol. 140, no. 3, pp. 1–10, 2014, doi: 10.1061/(ASCE)EI.1943-5541.0000193.

[5] K. Ortega Burgos and C. F. Rueda Gallardo, "Evolución del impacto comercial de los proyectos de edificaciones: un indicador líder," Bogotá D.C., 2017.

[6] Departamento Administrativo Nacional de Estadística (DANE), "Indicadores económicos alrededor de la construcción - IEAC," Bogotá D.C., 2017.

[7] J. M. Gómez-Sánchez, J. S. Rojas-Quintero, and A. A. Aibinu, "The Status of BIM Adoption and Implementation Experiences of Construction Companies in Colombia," VII Elagec, no. November, pp. 601–611, 2016.

[8] O. A. Olatunji, "Constructing Dispute Scenarios in Building Information Modeling," J. Leg. Aff. Disput. Resolut. Eng. Constr., vol. 2, no. August, pp. 128–135, 2016, doi: 10.1061/(ASCE)LA.

[9] Building and Construction Authority, "Singapore BIM Guide - V2.0," Cornet, pp. 1–70, 2013.

[10] H.-F. Hsieh and S. E. Shannon, "Three Approaches to Qualitative Content Analysis," Nord. J. Digit. Lit., vol. 2015, no. 1, pp. 29–42, 2015, doi: 10.1177/1049732305276687.

[11] R. Sacks, U. Gurevich, and P. Shrestha, "A review of building information modeling protocols , guides and standards for large construction clients," J. Inf. Technol. Constr. (ITcon), vol. 21, no. October, pp. 479–503, 2016.

[12] M. Fischer, H. W. Ashcraft, D. Reed, and A. Khanzode, Integrating Project Delivery. John Wiley & Sons, Inc, 2017, doi: 10.1002/9781119179009.

[13] B. Gercek, O. B. Tokdemir, M. E. Ilal, and H. M. Gunaydin, "BIM Execution Process of Construction Companies for Building Projects," Resilient Struct. Sustain. Constr., pp. 1–6, 2017, doi: 10.14455/ISEC.res.2017.5.

[14] J. Messner et al., "BIM Project Execution Planning Guide - Version 2.1," Build. alliance, pp. 1–135, 2011, doi: 10.1017/CBO9781107415324.004.

[15] Y.-C. Lin, Y.-P. Chen, W.-T. Huang, and C.-C. Hong, "Development of BIM Execution Plan for BIM Model Management during the Pre-Operation Phase: A Case Study," Buildings, vol. 6, no. 1, pp. 1–8, 2016, doi: 10.3390/buildings6010008.

[16] M. Kassem, B. Succar, and N. Dawood, "Building information modeling: analyzing noteworthy publications of eight countries using a knowledge content taxonomy," Build. Inf. Model. Am. Soc. Civ. Eng., pp. 329–371, 2015, doi: 10.1061/9780784413982.

[17] E. Alreshidi, M. Mourshed, and Y. Rezgui, "Factors for effective BIM governance," J. Build. Eng., vol. 10, no. July 2016, pp. 89–101, 2017, doi: 10.1016/j.jobe.2017.02.006.

[18] M. H. Song, M. Fischer, and P. Theis, "Field Study on the Connection between BIM and Daily Work Orders," J. Constr. Eng. Manag., vol. 143, no. 5, pp. 1–4, 2015, doi: 10.1061/(ASCE)CO.1943-7862.0001267.

[19] Massachusetts Institute of Technology, "MIT BIM Execution Plan," 2014.

[20] Georgia Institute of Technology, "Georgia Tech BIM Requirements & Guidelines for Architects, Engineers and Contractors," no. September, pp. 0–38, 2011.

[21] Statsbygg, "Statsbygg BIM Manual Version 1.2.1," Sbm, vol. 1, pp. 1–98, 2013.

[22] Indiana University, "BIM guidelines & standards for Architects, Engineers, and

Contractors," 2015.

[23] BuildLACCD, "LACCD Building Information Modeling Standards," p. 33, 2016.

[24] British Standard Institution (BSI), "PAS 1192-2:2013 Specification for information management for the capital/delivery phase of construction projects using building information modelling," 2013.

[25] NATSPEC, "NATSPEC National BIM Guide," no. September, p. 27, 2011.

[26] National Institute of Building Sciences, "National BIM Guide for Owners," 2017.

[27] Ohio State Architect's Office, "State of Ohio, Building Information Modeling (BIM) Protocol," p. 25, 2010.

[28] Hong Kong CIC, "CIC Building Information Modelling Standards," pp. 0–103, 2014.

[29] Finnmap Consulting Oy et al., "COBIM v 1.0," pp. 1–22, 2012, doi: 10.1007/978-3-642-12691-8.

[30] Autodesk, "Autodesk BIM Deployment Plan: A practical framework for implementing BIM," p. 42, 2010.

[31] University of Florida, "BIM Project Execution Plan Template for Architects, Engineers and Contractors," pp. 1–32, 2017.

[32] R. Sacks and E. Pikas, "Building Information Modeling Education for Construction Engineering and Management. I: Industry Requirements, State of the Art, and Gap Analysis," J. Constr. Eng. Manag., vol. 139, no. 11, p. 4013016, 2013, doi: 10.1061/(ASCE)CO.1943-7862.0000759.

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