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MANAGING DESIGN PROJECTS: METHODS AND POSSIBLE IMPROVEMENTS USING BIM

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The planning and monitoring of the design phase is crucial to ensure the aimed time, cost, and quality performances of the project are met. In this context, monitoring the progress of design is tightly related to the way design is being planned. In other words, the measures taken into account while planning the development of design; whether time, cost or quality measures, are themselves used to monitor the progress of design throughout the project. In this regard, this study sheds light on the methods used to manage design projects, highlights their shortcomings, and suggests new ways to properly manage the progress of design using BIM as a data repository of design information and management decisions. The study reviews current methods used to plan and monitor design projects and suggests improvements in needed areas. Results show that the reviewed methods differ in the way they approach design management and they do not fully represent all design characteristics. Nonetheless, measures used in these methods can mislead managers in detecting the actual progress of design. In this regard, this study suggests a comprehensive framework that builds on existing methods to enhance the management of design and to better control its development.

Keywords: Design management, Planning, Control, LOD, DSM, PPC, Man-hours.

1 INTRODUCTION

Managing the design phase of construction projects can be seen as the most challenging form of management in the Architecture, Engineering and Construction (AEC) industry. While the management of construction can be approached from a linear production perspective, the management of design deals with managing iterative and creative ideas in a social and multidisciplinary environment. Because the difference between the two processes is structural, the use of construction-based measures has failed to properly address design characteristics. Thus, the development of properly tailored design measures is crucial to enhance the management of design generation and product development.

Many aspects complicate the management of the design phase. Some of these aspects are related to the nature of design being an ill-structured and creative process that is basically based upon iterative loops of analysis, synthesis and evaluation (Simon 1984). Other aspects are caused by the involvement of several stakeholders from different backgrounds and mentalities with relative attitudes towards project's value (Buenano 1999). Therefore, proper design management is expected to consider these aspects while planning for the design phase as well as while monitoring and controlling design progress throughout the process.

Researchers have recognized the complexity of managing design tasks due to their interdependent relation. To solve for complex dependencies, the Design Structure Matrix (DSM)

has been developed to help arrange design tasks in a way to reduce rework. Accordingly, better flow of information among design parties is expected (Austin *et al*. 1999). However, scheduling the design program resulting from the DSM requires not only the sequence of activities, but also the start/end dates, durations, and resources requirements of each activity. Accordingly, the lookahead planning technique is suggested to further detail design activities, identify constraints, allocate resources and release work packages (Hammond *et al*. 2000, Hamzeh *et al*. 2009).

Apart from the complexities of managing the design phase, the industry is currently witnessing an increasing use of Building Information Modeling (BIM) as a platform to run design projects. In this context, there are continuous efforts to reap full potentials from BIM and to enhance its implementation in construction projects (Al Hattab and Hamzeh 2016, Eastman *et al*. 2009). Amongst the notable efforts to formalize the development of BIM is the work on the Level of Development (LOD) concept (Hooper 2015, Abou-Ibrahim and Hamzeh 2016). LOD is initially introduced by the American Institute of Architects (AIA) and several parties have worked to define and develop LOD worldwide (AEC UK BIM Protocol 2012, BIMForum 2015, The American Institute of Architects 2013).

The proper implementation of BIM as a platform to run design projects can be beneficial to enhance overall project's value (Barlish and Sullivan 2012, Tribelsky and Sacks 2010). In this context, this study investigates the possibility of enhancing design management by introducing a new framework that uses BIM as data repository of both design and management information. The framework is developed to tackle the major shortcomings witnessed while using conventional management tools to run design projects. It uses real time data related to product and process measures enabling the design manager to constantly check the real progress of design and to better navigate the corresponding project.

2 RESEARCH METHODOLOGY

The research starts by investigating the major methods and corresponding measures used to manage design projects. Then, the pros and cons of each method are analyzed according to certain criteria. Finally, a new framework is developed to tackle the shortcomings witnessed in each of the reviewed methods. Figure 1 illustrates the steps followed in the study.

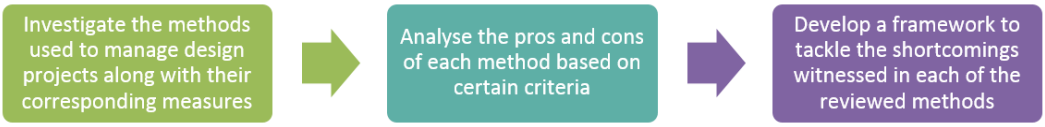

Figure 1. Research methodology.

3 MAJOR METHODS USED FOR MANAGING DESIGN PROJECTS

This section explores the major methods and their corresponding measures used to plan and monitor design projects. The three main methods considered in this study are: (1) the Top-Down planning approach using Work Breakdown Structure (WBS), (2) DSM combined with Lookahead Planning (also known as DePlan from Hammond *et al*. 2000), and (3) the use of LOD to plan design development in BIM-based projects.

3.1 Top-Down Planning using Work Breakdown Structure (WBS)

In the top-down management approach, managers break down the project into smaller activities and subjectively estimate required man-hours and needed resources to finish each of these sub-

activities. In this scenario, managers build on their experience and make analogies to similar projects to subjectively estimate the required time and effort needed to finish each activity. Once the WBS is ready, the planner constructs an activity network and estimate total project's duration by identifying the critical path (Bashir and Thomson 1999).

This approach is very important to simplify the design undertaken and divide the project into manageable portions while assigning responsibilities to involved designers. However, problems in this approach reside in the following: (1) the reliance on subjective assessment of needed man-hours for each design activity, (2) the assumption that all needed activities are included in the WBS which is not always the case where new design tasks might emerge during design execution significantly affecting project's progress, (3) the use of the CPM method that does not capture the iterative nature of design where much more complicated interdependencies are present, and (4) the use of man-hours and Earned Value techniques to reflect on design progress. For instance, to assess progress using earned value techniques, the design manager would compare actually produced submittals or models with the planned submittals schedule. In this regard, finishing 25 plans out of 100 scheduled ones does not directly reflect a 25% completion of the design project where nothing is revealed about the actual information embedded in those submittals. In design, tracking only the produced submittals (whether plans, BIM models, or any other type of submittals) is not enough to assess actual design progress. In fact, the integrity and maturity of design information embedded in those submittals is what governs the actual progress of design. The same analysis applies when using the man-hours technique, where consuming 50% of man-hours does not reflect the completion of 50% of design.

3.2 DSM Combined with Lookahead Planning (DePlan)

DePlan follows two major steps to plan and control the production of design. The first step transforms the design process model into a DSM based on information dependencies among design tasks. The second step generates Weekly Work Plans (WWP) using the Last Planner system and Lookahead planning. Deplan uses Percent Plan Complete (PPC) to measure the progress of design by calculating the percent of completed activities out of scheduled activities (Hammond *et al*. 2000).

DePlan plays a major role in transforming design from an ill-structured and chaotic process to a more systematic and formalized process. Although DePlan enhances the management of iterative activities by using DSM and Lookahead planning to make sure constraints are removed and information flow is achieved, it does have some shortcomings. At the level of value generation, DePlan does not directly reflect the value of generated design in the eyes of involved stakeholders. At the level of design progress, it can only reflect progress in terms of activities completed out of scheduled activities, not in terms of actual design maturity. So although the PPC value might be high, it does not necessarily reflect a matured design. Finally at the level of design deliverables, DePlan is not attached to the quality of design deliverables whether they are drawings or BIM models.

3.3 LOD Plan for Design Development in BIM-Based Projects

With the emergence of BIM technologies in the AEC industry, a new way to plan the development of design, using the LOD concept, appears. Accordingly, the development of design is staged by defining which elements need to be modeled, at which phase, at what LOD level, and by whom. Accordingly, and as part of the BIM execution plan (BIM-XP), designers are required to model their design using the elements that appear in the BIM-XP according to pre-defined LOD levels. In this regard, designers are expected to follow the LOD guidelines to know

how to graphically model these elements and which data to include in them (The American Institute of Architects 2013).

The LOD concept is essential to cope with BIM-based design where actual parametric objects are used in the model not sketches as in traditional 2D-CAD. LOD serves as a communication language between designers to highlight the actual maturity of their models and this is essential in a BIM environment for information sharing and coordination. However, the current concept and use of LOD shows some weaknesses. By definition, the current notion of LOD includes only six levels ranging from LOD 100 to LOD 500 (including LOD 350) without defining partial LOD levels witnessed throughout design. So, although elements are expected to reach their planned LOD levels at each design milestone according to the BIM-XP, these elements witness several maturity statuses throughout design due to iterations and coordination among stakeholders. Therefore, LOD can help design managers detect design maturity only at design milestones, not throughout design iterations and solution development. Nonetheless, being pre-defined, the use of LOD may not be as flexible as needed by designers where project specific LOD levels might be wanted. Moreover, LOD reflects the development of one model elements and therefore the development of the entire BIM model is not reflected.

4 PROS AND CONS OF EACH METHOD

This section presents the pros and cons of each of the three methods and their corresponding measures based on a set of criteria as highlighted in Tables 1 and 2. Table 1 reflects the ability of each planning approach to satisfactory manage the design process. The Top-Down approach is good at dividing the design undertaken into manageable design activities, but it fails in meeting other criteria. The combined DSM and Last Planner system is good at dynamically capturing design iterations while ensuring streamlined information flow among stakeholder; however, it is not directly linked to design deliverables (in other words, dynamics of the design process are not linked to the development of deliverables being models or drawings). The LOD Planning method fails to capture the iterative nature of design and it is relatively rigid to handle design dynamics since it is related to a pre-defined set of LOD levels; however, assigning adequate LOD levels to each discipline, at the right time, can streamline the flow of information among parties. Most importantly, the LOD planning method is the only method that relates design activities to modeling activities and therefore to product's development.

Table 1. Pros and cons of each method.

Criteria	Top-Down using WBS	DSM & Last Planner	LOD Plan
Divides design to manageable entities	Good	Good	Good
Ensures streamlined information flow	Unsatisfactory	Good	Satisfactory
Manages design process dynamically	Unsatisfactory	Good	Unsatisfactory
Captures design iterations	Unsatisfactory	Good	Unsatisfactory
Links design activities to design deliverables	Unsatisfactory	Unsatisfactory	Good

Table 2 highlights the ability of corresponding measures to reflect product and process characteristics. Man-Hours and Earned Value techniques can serve as a good indicator for incurred costs and consumed time. They can also reflect designers' productivity and planning quality if weighed against actual design progress assessed by the design manager. However, man-hours and EV techniques alone do not reflect actual development of the design or the fulfillment of owner's value. As for the PPC measure, it gives an indication about the time and cost performance of the project by reflecting the compliance to the plan; but, it cannot reflect

actual design development or the fulfillment of owner's value. However, PPC is good at reflecting designers' productivity and planning quality. Finally, the LOD level is satisfactory to reflect design development at major milestones, but it cannot continuously track actual design progress occurring in a multidisciplinary environment. LOD can be used to reflect planning quality and designers' productivity if the manager compares planned and actual LOD levels at a given time, but this gives just an indication. Moreover, LOD alone does not reflect the time and cost performance of the project or the realization of owner's value.

Table 2. Pros and cons of corresponding measures.

Criteria	Man-Hours/ Earned Value	PPC	LOD Level
Reflects time and cost performance	Good	Satisfactory	Unsatisfactory
Reflects designers' productivity	Satisfactory	Good	Satisfactory
Reflects planning quality	Satisfactory	Good	Satisfactory
Reflects design development	Unsatisfactory	Unsatisfactory	Satisfactory
Reflects owner's value	Unsatisfactory	Unsatisfactory	Unsatisfactory

5 BIM-BASED DESIGN MANAGEMENT FRAMEWORK

The framework builds upon these three methods and it is suggested to be a comprehensive approach to manage the design using BIM. The framework targets the development of design at the level of BIM models where actual objects are being drafted to represent design intents. The framework is divided into two major parts: Part (1) that targets collaborative planning before the start of design information generation, and Part (2) that targets the scheduling and controlling of design activities during the design information generation process. Figure 2 presents the major steps followed in each part of the framework.

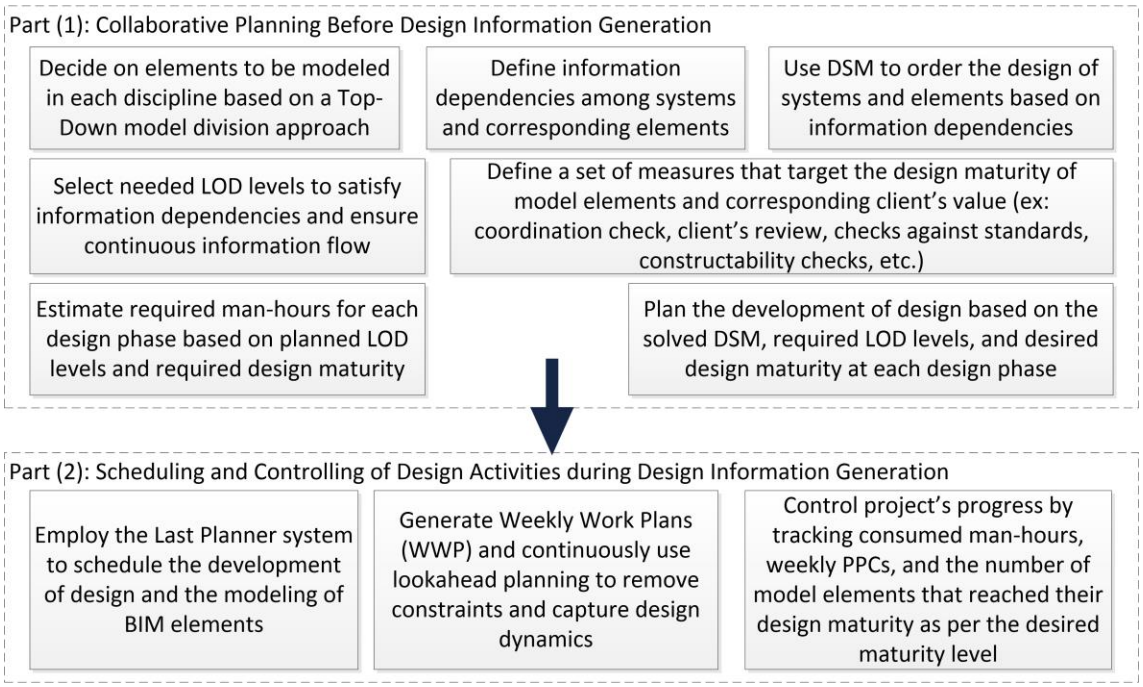

Figure 2. Suggested framework.

6 CONCLUSION

Different techniques are currently used to plan and monitor design projects. While each method has its strengths and weaknesses, design projects need new planning and control methods to overcome current shortcomings. Nonetheless, the increasing use of Building Information Modelling (BIM) in the construction industry, especially at the design phase, calls for the development of new measures that suits the object-oriented nature of BIM. This study investigates current methods used to manage design projects and analyses their adequacy in reflecting several design management aspects. Afterwards, a framework is suggested to enhance the management of design projects. The framework builds on the strengths of each of the investigated methods and provides a comprehensive approach to manage the process of generating design information. The framework is divided into two major parts. Part 1 includes several steps that aim to enhance pre-project planning using collaborative planning techniques, while the second part provides several steps to enable design manager to cope with the dynamic nature of design activities and to enhance the monitoring and controlling of design progress.

References

Abou-Ibrahim, H., and Hamzeh, F., Enabling Lean Design Management: An LOD-Based Framework, *Lean Construction Journal*, 12-24, 2016.

AEC UK BIM Protocol Version 2.0., 2012. Retrieved from https://aecuk.files.wordpress.com/2012/09/aecukbimprotocol-v2-0.pdf in October 2014.

Al Hattab, M., and Hamzeh, F., Using Social Network Theory and Simulation to Compare Traditional Versus BIM-Lean Practice for Design Error Management, *Automation in Construction*, 52, 59-69, 2016.

Austin, S., Baldwin, A., Baizhan, L., and Waskett, P., Analytical Design Planning Technique: a Model of the Detailed Building Design Process, *Design Studies*, 20, 279-296, 1999.

Barlish, K., and Sullivan, K., How to Measure the Benefits of BIM-A Case Study Approach. *Elsevier, Automation in Construction*, 24, 149-159, 2012.

Bashir , H., and Thomson, V., Metrics for Design Projects: A Review, *Design Studies, 20*, 263-277, 1999.

BIMForum, *Level of Development Specification*, 2015.

Buenano, G., *The Becoming of Problems in Design: Knowledge in Action to Frame Wicked Problems*, PhD Thesis, Department of Architecture, University of California, Berkeley, 1999.

Eastman, C., Lee, J., Jeong , Y. and Lee, J., Automatic Rule-Based Checking of Building Designs, *Automation in Construction, Elsevier*, 18, 1011-1033, 2009.

Hammond, J., Choo, H., Austin, S., Tommelein, I., and Ballard, G., Integrating Design Planning, Scheduling, and Control With DePlan, *8th Annual Conference of the International Group for Lean Construction*, Brigthon, UK, 2000.

Hamzeh, F., Ballard, G., and Tommelein, I., Is the Last Planner System Applicable to Design? A Case Study, *17th Annual Conference of the International Group for Lean Construction*, Cuperus, Y., and Hirota, E. H. (ed.), 165-176, Taipei, Taiwan, 2009.

Hooper, M., Automated Model Progression Scheduling Using Level of Development, *Construction Innovation*, *15*(4), 428-448, 2015.

Simon, H., *The Structure of Ill-Structured Problems*, in *Developments in Design Methodology*, Cross, N. (ed.), J. Wiley & Sons, Chichester, UK, 1984.

The American Institute of Architects, *Guide, Instructions and Commentary to the 2013 AIA Digital Practice Documents*, 2013.

Tribelsky, E., and Sacks, R., Measuring Information Flow in the Detailed Design of Construction Projects, *Research in Engineering Design*, 21, 189-206, 2010.