BIM: Expectations and a Reality Check

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Abstract: BIM (Building Information Modelling) is an approach that involves applying and maintaining an integral digital representation of all building information for different phases of the project lifecycle. This paper presents an analysis of the current state of BIM in the industry and a re-assessment of its role and potential contribution in the near future, given the apparent slow rate of adoption by the industry. The paper analyses the readiness of the building industry with respect to the product, processes and people to present an argument on where the expectations from BIM and its adoption may have been misplaced. This paper reports on the findings from: (1) a critical review of latest BIM literature and commercial applications, and (2) workshops with focus groups on changing work-practice, role of technology, current perceptions and expectations of BIM.

Key words: Building Information Modeling (BIM), Computer Aided Design (CAD), Document Management System (DMS), focus groups, coding scheme, perceptions

Introduction

BIM as an IT enabled tool, envisions efficient collaboration, data integrity [7], intelligent documentation [27], distributed access and retrieval of building data [17] and improved project quality through performance analysis, multi-disciplinary planning and coordination [9][11][12].

This paper discusses the preliminary findings of an ongoing research project aimed at developing a technological, operational and strategic analysis of adopting BIM in AEC/FM (Architecture-Engineering-Construction/Facility Management) industry as a collaboration tool.

This paper reports on the following major findings: (1) a critical review of latest BIM literature and commercial applications; (2) an industry needs analysis of changing work practice, role of technology, current perceptions and expectations of BIM through workshops with industry focus groups. The findings reported here form a solid foundation for the next phase of the research, which includes case studies that further validate the findings and seek to provide specifications and guidelines as well as establish industry standards for implementing BIM in practice.

1 Data Collection

Data collected for the research analysis include:

- **Background study: Literature review:** Extensive literature review on BIM has been conducted. Apart from the academic papers on BIM, the reviewed literature also includes white papers and technical reports from vendors (Autodesk, Graphisoft, etc.), guidelines and reports generated by regulatory and government institutions [1][10] and newsletters and articles (www.aecbytes.com) on the practice and trends in AEC industry.
- **Background study: Desktop audit:** A desktop audit of the different types of commercial applications that form a part of BIM approach has been conducted. This involved live demonstrations and trials, information gathered

from product brochures such as [8], and analysis of tools reported by other sources [6] [28], etc. Products evaluated include BIM model servers, design tools, planning tools, analysis tools, design review and viewing tools, FM tools, product libraries and so on. Desktop audit provided an overview of the technological capabilities of the applications, their role in BIM, and development trends of commercial BIM applications.

- **Industry workshop:** Workshops have been conducted with representatives from various sectors of the AEC/FM industry including architects, engineers, project managers, contractors, consultants, academics vendors, and delegates from government agencies. The main goal of the workshops is to uncover and analyse the industry perceptions and expectations about BIM adoption. Workshop discussions were recorded on tapes and then segmented. Segmented data and background study were analyzed firstly using an open-ended approach to identify the main themes. Based on the main themes identified a coding scheme has been developed and applied to the workshop data for detailed analysis.

2 Data observations

2.1 Literature review

Though there have been few examples of adopting BIM in real world projects [5][23][24], the general rate of BIM adoption by the industry has been slow. Lack of initiative and training [4], fragmented nature of AEC industry [19], varied market readiness across geographies, and reluctance to change existing work-practice [19] are some of the reasons for this low adoption rate. In an industry where most projects are handled in multi-organizational teams the lack of clarity on responsibilities, roles and benefits in using a BIM approach is an important inhibiting factor [13].

A recent survey by AECbytes [25] reports the following major findings: (1) Collaboration is still based on exchange of 2D drawings, despite each disciplines working in 3D environment; (2) Significant demand for object libraries, modelling capabilities, and technologies supporting distributed collaborative works; (3) Tool preference varies with firm (organization) size; (4) 3D visualization is not a major concern. Users want to get more out of accurate models than just visualization; (5) Needs for better training materials and technical support; (6) Supports for analysis, performance simulations and interoperability is important, but it is not a burning issue as per the survey.

2.2 Desktop audit

A wide range of products are available for various applications that form a part of the BIM approach ranging from product suites to very specific products for design, analysis and libraries [22]. There is a rapid growth in the number of supporting technologies and products, and only few of these are IFC (Industry Foundation Class) compatible, which means they can only be integrated with specific tools that accept those formats. Tools for early design phase and integration of conceptualization tools is lacking at the moment. Web-based product services can be very useful [5][16] and their numbers are growing, benefiting from the object-based modelling that has gained a widespread acceptance. Object intelligence, which brings associativity and relationships within objects and object properties, and enables modelling constraints [15][18][20] has allowed emergence of more efficient analysis tools [26][3] that can automate processes that are so far primarily manual and time consuming.

2.3 Industry workshop

An open-ended analysis of the workshop data and literature suggests multiple factors for low adoption of BIM in the industry that include: technology, work practice, organizational structure, business interest, user training and so on. Introduction of BIM and BIM model server as collaboration platform will require a different approach to data organization and structuring, and some legal/ contractual measures to deal with security and work-practice related issues. It is also noted that knowledge about BIM varies significantly across the different disciplines within the industry.

2.3.1 Coding scheme

The design of the coding scheme reveals the

importance of various factors affecting BIM adoption. Discipline, content and type categories are used to cluster the data such that we can identify the pattern of BIM awareness, interest and knowledge across different disciplines. Keywords allow identification of major issues across the content categories for which we can set priority based on frequency of occurrence. Annotations and examples of each category are presented in Table1.

Table 1: Annotations and examples for the coding scheme

Criteria	Categories	Annotation with examples
Discipline		Background of the participant; e.g. architect, facilities manager, application vendor, etc
Context		In what circumstances was the statement given
	Initiated	Starting a new subject of discussion; e.g. "*Let us discuss role of BIM in conceptual design*"
	Follow up	In continuation of the ongoing subject; e.g. "*yes, for example…*"
	Reply	In response to a specific statement; e.g. "*for that automated model checkers are there..*"
	Chair	Statement to control the flow of discussion; e.g. "*let us move to other issues"*
Type		The purpose of the statement
	Suggestion/ideas	Discussing solutions; e.g. "*replace document by information as document has a connotation to it*"
	Concern	Doubts and inhibitions; e.g. "*frustrating part is having different regulations across states* "
	Opinion	Indicative statement; e.g. "*as industry picks up they will be forced to adopt..* "
	Observation	Inform based on experience; e.g. "*In civil works, disciplines tend to work in isolation*"
	Query	Asking about; e.g. "*What happens when the project phase changes?*"
	Inform	Information on "as-it-is"; e.g. "*for that automated model checkers are there*"
	Strategy	Discussing measures and approach; e.g. "*one way is to force them*"
	Wish list	Expressing wants, e.g. "*20 yrs down the line you should be able to say what paint the wall had."*
Content		The main subject of statement
	Technical	About tools, formats/standards, features and capabilities e.g. " *current systems not capable of dealing with different levels of detail*"
	Work-practice	About the way or working; e.g. " *…not willing to change the way they work* "
	Data organization	what form? grouping of data, and so on. e.g. "*we can have things like private and public space* "
	Training	Skill acquisition e.g. "*architects learn many techniques that are not used with these tools* "
	Legal/ contractual	Regulatory; e.g. "*organization that owns the information has the rights to change permissions* "
	Organizational-team	Team-responsibilities, roles and collaboration; e.g. " *that would be related to the access rights. Isn't it? What you will see is relevant to what your role is*"
	Process/ method	Protocols, procedures and methodology; e.g. " *you often start with the architect ..in the sense it starts with a 3D model with diff disciplines adding info* "
	Business case	Economic and market feasibility; e.g. "*who builds the model…who benefits from it ….*"

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2.3.2 Data patterns

Three kinds of correlations have been mapped. **Discipline vs. content:** indicates important issues for specific disciplines; **Type vs. content:** indicates knowledge, interest and awareness about the content; and **Discipline vs. type:** indicates knowledge, interest and awareness across disciplines.

Discipline vs. content: Design disciplines and managers take a strong interest in issues about processes, methods and the work-practices. Discussions on legal/contractual aspects related to BIM approach were primarily discussed by the design disciplines and BIM service providers, but not the BIM product suppliers. Application vendors mostly provided information on technical aspects. **Type vs. content:** Concerns raised were mainly related to technical, cultural, work-practice and process and method related issues. Technical discussion were primarily information sharing. Strategies discussed were related to technical aspects, processes and business models. **Discipline vs. type:** Most of the concerns raised came from the architects and design disciplines. Design managers discussed about the work-practice issues, and along with contractors posed most queries suggesting least awareness about BIM across these disciplines.

2.3.3 Key issues

The key issues discussed in the workshop are listed below. These issues are grouped based their relevance to contents. Some overlaps are possible across the groups:

- Work-practice and process related issues:

Data organization: With the digital storage of data that allows greater flexibility and economy of physical space, data management and organization is becoming a serious concern for the industry, particularly from the work-practice perspective. Standard practices and procedures need to be

developed to deal with possible data explosion, data classification and grouping, representation and usability. Version management, as discussed below is another important issue that is closely related to data organization.

Version management of project data: If BIM is to be adopted using an integral database where each discipline maintains, modifies and updates the data, then technical measures, work procedures and agreed protocols are needed to ensure data integrity, allowing different versions of the project to be managed throughout the project life-cycle.

Validation and data integrity: Even though 2D drawings can be generated out of intelligent 3D CAD packages [20], the lack of trust on completeness and accuracy of 3D models has remained a major concern for the practitioners involved. As a result, data exchange across the disciplines is limited to 2D drawings. Development of intelligent model checkers, which is an important aspect of BIM approach have eased the concern. However, agreed protocols, and standard evaluation and validation procedures are needed for acceptable design reviews and approvals using 3D models.

As-built data: Facilities management (FM) is an important value-add for BIM, making a strong business case. Design models need to be updated for the changes made during the construction face to ensure accuracy and completeness of the as-built data required for FM. This update stage is missing in most business practices.

- Technical issues:

Standards: Interoperability issues across different commercial software remained a dominant topic during the workshop. Shortcomings in IFC certification of commercial software were highlighted. Issues discussed echo the findings reported by [2].

Register communication and information exchange: Information exchanged between the BIM users through different media are not captured in a BIM model. Participants suggest that BIM servers should allow message flagging and notifications between team members. Though not explicitly discussed, some of the ideas discussed are similar to the concepts of Enterprise Wiki [21].

Security: Apprehensions exist about data security of model servers. These include concerns about Intellectual Property (IP) and protection of copyrights. Concerns relating to network security may have technical limitations, but concerns on design protection (IP and copyrights) can be alleviated by greater awareness and legal measures. IP issues in BIM are legal issues, which are no different to IP issues existing in current practice.

Compatibility of GIS and BIM models: Data exchange between a GIS model and BIM model should be supported, which is missing at present. This is important to many large scale projects.

- Other issues:

Roles and responsibilities: BIM approach requires changes in distribution of roles and responsibilities. Some traditional roles such as drafting may become obsolete, replaced by modellers. New roles, such as BIM managers have emerged to support greater coordination in developing an integrated model.

Training support: Participants raised concerns on the lack of training and awareness on BIM applications. Improved and contemporary training modules are required for practitioners as well as students.

3 Data analysis

Based on the above data patterns, this section discusses the expectations of BIM against the industry's current practice in terms of the three main aspects: product, process and people.

In terms of the **product**, expectations from BIM vary across the disciplines. Design disciplines see BIM as an extension to CAD, while contractors and project managers expect BIM to be a more intelligent DMS that can take-off data from CAD packages directly. While there are evident overlaps, BIM server vendors seem to be aiming to integrate the two requirements. Desktop audit suggests that the existing BIM servers are not yet mature for either purpose. However, even with the present capabilities BIM servers can be used for improved project collaboration. Some contradictions to the AECbytes survey are observed in the workshop data. Unlike the survey results IFC and interoperability are found to be a dominant concern. Lower importance of

interoperability in the survey may be the result of (a) Assumed scope of BIM: Respondents in the survey may be using only one proprietary tool e.g. Revit or Bentley, that provides BIM approach within few disciplines (Architecture, Structure, MEP), and hence data format may not be an issue ; (b) Non-willingness of users to know about the technical aspects of interoperability. Discussions in the workshop suggest that users are hesitant discussing new and technical jargons. They emphasize the signif icance of standards such as IFC. However, from the usability side all they expect is a simple and intuitive interface. These discussions echo the findings reported in literature [2][14]. Similarly , unlike the AECbytes survey, visualization still proves to be an important factor. Users such as designers, with CAD background, are expecting BIM servers to support integrated visualization and navigation that is comparable to the native applications they use. Users such as contractors and project m anagers, with DMS background, expect visualization and navigation to be an important feature of BIM servers that is missing in existing DMS (document m anagement systems) solutions. Interestingly, barring a few exceptions [27] most academic research and studies have emphasize BIM as an enhancement to CAD and downplayed the document management aspects to it. This could possibly be the result of investigations concentrated towards design disciplines.

In terms of the **process**, BIM adoption would require a change in the exist ing work practice. An integrated model development needs greater collaboration and communication . A different approach to model development is needed in a collaborative setting where multiple parties contribute to a single shared model [20]. Standard processes and agreed protocols are required to assign responsibilities and conduct design reviews and validation. Experience from DBMS (Database management systems) will be useful for data organization and m anagement, but organizations will need to develop their own data management practices to suit their team structure and project requirements.

Different business models will be required to suit varied industry needs [29]. BIM model can be maintained in -house or outsourced to service providers. In the later cas e additional legal measures and agreements will be required to ensure data security and user confidence.

In terms of **people**, new roles and relationships within the project team s are emerging. Dedicated roles such as BIM m anager will be inevitable for large scale projects, as already seem in some real world projects. Team members need appropriate training and inform ation to be able to contribute and participate in the changing work environment.

4 Conclusions

Trends observed from the desktop audit suggest that as BIM m atures it is likely to integrate the existing CAD packages and DMS into a single product. Workshop data demonstrate that f or BIM to succeed and be accepted in the industry all stakeholders have to be informed about the potential benefits to their disciplines. Analysis of collected data shows that (a) lack of awareness; (b) focus on BIM as advancement to CAD packages , and (c) relative downplaying of BIM's document management capabilities ha ve inhibited the interest of non -design disciplines in the AEC industry towards BIM a doption. This may be the result of research investigations focusing on BIM and the design community . This study reveals that user-centric BIM research has to be more inclusive since the success of BIM adoption lies in collective participation and contribution from all the stakeholders in a building project . Special training material such as [1] can be very useful in this respect.

Next phase of this research involves case studies to explore and verify the issues identified from the collected data . Case studies are being designed to involve active participation of both design and non -design disciplines in a collaborative project around BIM model servers. T raining sessions for all related disciplines have been conducted to accustom them to the new BIM tools. Analysis of the case studies seeks to provide specifications and guidelines as well as establish indu stry standards for implementing BIM in practice.

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References

[1] AGC, America: The Contractors Guide to BIM, California Construction, 2006.

[2] Aranda-Mena G , W akefield R. Interoperability of building information - myth of reality? In: eWork and eBusiness in Architecture, Engineering and Construction , Martinez & Scherer (eds), London , 2006: 127-133.

[3] Bajzanac V . Model based cost and energy performance estimation during schematic design . Construction Informatics Digital Library, 2005.

[4] Bernstein PG , Pittman J H. Barriers to the adoption of Building Information Modeling in the building industry , Autodesk Building Solutions, 2004.

[5] Campbell DA. Building Information Modeling: The Web3D Application for AEC , Web3D 2007, Perugia, Italy, April 15–18, 2007.

[6] CyonResearch. The Building Information Model, A Look at Graphisoft's Virtual Building Concept, 2003.

[7] Ellis BA . Building Information Modeling: An Informational Tool for Stakeholders, 2006.

[8] EPM T echnology, *EXPRESS DAT A MANAGER ™*, *Information* **1**(6), 2004.

[9] Fischer M, Kunz J. The scope and role of information technology in construction . In : Proceedings of JSCE (**763**):1-8, 2004.

[10] GSA . GSA BIM Guide Series, URL: http://www.gsa.gov/bim, 2007.

[11] Haymaker J, Suter B. Communicating, integrating and improving multidisciplinary design and analysis narratives. In: Design Computing and Cognition '06, John S G (eds), 2007.

[12] Haymaker J, M, Kam C, Fischer M . A methodology to plan, communicate and control multidisciplin ary design processes. Construction Informatics Digital Library , 2005.

[13] Holzer D. Are You Talking T o Me? Why BIM Al one Is Not The Answer . In Proceedings of the Fourth International Conference of the Association of Architecture Schools of Australasia, 2007.

[14] Howard R, Bjork B . Building information modelling – Experts' views on standardisation and industry deployment. Advanced Engineering Informatics 22: 271 – 280, 2008.

[15] Ibrahim M, Krawczyk R . The Level of Knowledge of CAD Objects within the Build ing Information Model . ACADIA22, Connecting Crossroads of Digital Discourse, 2003.

[16] Ibrahim M, Krawczyk R, Schipporiet G . A web -based approach to transferring architectural information to the construction site based on the BIM object concept, CAADRIA 2004.

[17] Ibrahim M, Krawczyk R, Schipporiet G . Two approaches to BIM: a comparative study, ECAADe 2004.

[18] Ibrahim M, Krawczyk R, Schipporiet G . CAD smart objects: potentials and limitations, ECAADe 21, digitial design: 547-552.

[19] Johnson R E , Laepple E S . Digital Innovation and Organizational Change in Design Practice . CRS Center Working Paper no. 2, CRS Center , T exas A&M University, December 2003.

[20] Lee G , Sacks R, Eastman CM. Specifying parametric building object behavior (BOB) for a building information modeling system. Automation in Construction 15: 758 – 776, 2006.

[21] Kalny O. Enterprise W iki: An Emerging T echnology to be Considered by the AEC Industry. AECbytes Viewpoint **31**, March 19, 2007.

[22] Khemlani, L. Supporting Tech. for BIM Exh ibited at AIA 2007, Building the Future, *AECbytes*, 2007.

[23] Khemlani, L. Third Annual BIM Awards Part 1, Building the Future , *AECbytes*, 2007.

[24] Khemlani, L. Third Annual BIM Awards Part 2, Building the Future, *AECbytes*, 2007.

[25] Khemlani, L . Top Criteria for BIM Solutions, A survey conducted by AECbytes, 2007.

[26] Mitchelle, J, W ong, J and Plume, J: 2007, Design Collaboration Using IFC, A case study in thermal analysis, *Proceedings of CAADFutures 2007* (Eds.) Dong A, Vander Moere A & Gero JS, Springer; pp: 317-329.

[27] Popov V , Mikalauskas S, Migilinskas D, V ainiunas P . Complex usage of 4D information modelling concept for building design, estimation, scheduling and determination of effective variant, T echnological and Economic Development of Economy (**12**) 2: 91-98, 2006.

[28] STATSBYGG: 2006, Experiences in development and use of a digital Building Information Model BIM according to IFC standards from the building project of Tromsø University College (HITOS) after completed Full Conceptual Design Phase (report), R&D project no. 11251 Pilot project, Tromsø University College (HITOS) for testing IFC.

[29] Wakefield R, Aranda-Mena G, et al. Business Drivers For BIM, RMIT, Australia, 2007.