

Available online at [www.sciencedirect.com](http://www.sciencedirect.com)**ScienceDirect**

Procedia Technology 16 (2014) 1116 – 1125

**Procedia**  
Technology

CENTERIS 2014 - Conference on ENTERprise Information Systems / ProjMAN 2014 - International Conference on Project MANAGEMENT / HCIST 2014 - International Conference on Health and Social Care Information Systems and Technologies

## Appraising effectiveness of Building Information Management (BIM) in project management

Abdulsame Fazli<sup>a</sup>, Sajad Fathi<sup>a</sup>, Mohammad Hadi Enferadi<sup>a,b,\*</sup>, Mayram Fazli<sup>b</sup>, Behrooz Fathi<sup>c</sup>

<sup>a</sup>Civil Engineering Department, Ferdowsi University, Mashhad, Iran

<sup>b</sup>Second affiliation, Address bCivil Engineering Department, college of Eqbal, Mashhad, Iran

<sup>c</sup>Industrial Engineering Department, college of Sajjad, Mashhad, Iran

---

### Abstract

The Iranian construction industry has long been criticized for being inefficient. It has been claimed that 80 percent of all content within the construction process is the same for all projects and there are therefore huge opportunities for improvements. The project manager is essential for the successful delivery of construction projects. The purpose of this paper is to analyze how BIM (Building Information Modelling) can be utilized by project managers as a good tool to simulate project condition to avoid redundant works and waste of time and cost. It was concluded that project managers generally have little knowledge concerning BIM, which makes it hard for them to see its applications. The study revealed that BIM can help project managers in the task of delivering successful projects. BIM a better basis for decisions is provided in comparison with traditional projects.

© 2014 Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license

(<http://creativecommons.org/licenses/by-nc-nd/3.0/>).

Peer-review under responsibility of the Organizing Committee of CENTERIS 2014.

**Keywords:** BIM; construction project; Project success index; 4D modelling ;

---

### 1. Introduction

Nowadays, construction projects are getting more complicated due to multiple separate enterprises working on congested sites. The most important factor of projects failure [1], are time consuming get prepared, redundant

---

\* Corresponding author. Tel.: +0-0915-321-5015; fax: +0-000-000-0000.

E-mail address: [Msc\\_hadi@yahoo.com](mailto:Msc_hadi@yahoo.com)

movements and managing the materials, etc. The most important duty of a manager in a project is to (i) increase; productivity, efficiency, infrastructure value, excellence and its ability to survive (ii) reduce; lifecycle expenses, times consumed through increasing cooperation and relation of stakeholders of a project.[2]

One thing that project managers can do is to design construction projects virtually by parametric Modelling in order to escape probable pitfalls. This kind of Modelling was greatly espoused by manufacturing companies to design, engineer and manufacture products. In the 1990, construction industry has set up the foundation of object-oriented building product Modelling. Now in the world, there is an expanding inclination in Building Information Modelling (BIM) between construction firms. Construction companies now appreciate the behooves of technology. The concept of Building Information Modelling is able to bridge the gap of labor efficiency. To note some prominent examples for which BIM has been utilized, we can refer to Walt Disney Concert Hall and Shanghai Tower and of course some other less prominent and more personal projects. Although BIM has a great rate of usage in developed countries, in a developing country like Iran, there is not a powerful inclination for using it. Thus, this paper is aimed to study BIM to demarcate its advantages and reversal effects posed to construction projects managers.

### *1.1. What is BIM?*

Building Information Modelling (BIM) is a term that is most generally used to define a set of parametric tools and processes for the creation and maintenance of an integrated collaborative database of multi-dimensional information regarding the design, construction and operations of a building, with the purpose of improving collaboration between stakeholders, which reduces the time needed for documentation of the project and producing more predictable project outcomes. [3]

Most of the times people misconceive BIM. The most common fault is that they assume that BIM has a single model or database. While this is not even near the case that BIM is used. We have to bear in mind that BIM cannot replace human. BIM diminishes the redundant and mundane works and it facilitates data processing, but here, human individuals put data into the model. Another mistake that is commonly committed is that people assume that BIM has no errors at all, while this is not the case. Because human beings are capable of inserting some data incorrectly, the errors in BIM are probable.

It is important to detect different aspects of BIM regarding to better evaluation of projects. Table 1 conveys different aspects of BIM and in which means they have been employed.

Though the Interest among the companies in implementation of BIM has been augmenting persistently, the number of researches about the Project Management point of view is not notable.

In trying to demonstrate that BIM is an advantageous tool for Project Managers, this research was successful. This is because the advantages are not far more than the challenges but also consistent with the function of Project Manager, as defined in the different knowledge areas of the PMBOK. BIM is utilized by construction managers or general contractors to press the amount of work to prepare cost estimates. Additionally, they can make influential 3D renderings. Furthermore, schedule integrated BIM known as 4D BIM is utilized for safety analysis, animations and to prepare site logistic plans. In order to coordinate the work with subcontractors, construction managers can use BIM. Their schedule can be updated with BIM. Finally, they can turn over an as-built building information model to the owner's maintenance team.

## **2. Literature review**

The process of a construction project is usually divided into four successive phases: initiation, design, construction and closure phase [4]. The construction manager job is officially started in a project as soon as it is awarded. The project award timeline to the construction manager and the organizational structure of the project are dependent upon the construction delivery approach. These two factors impact the involvement of the construction managers in the Building Information Modelling process.

Table 1. Specifics of BIM tools

Clash controls	Integration of building information models of different disciplines Check geometrical design Detection and correction of errors and overlap Points of models of different disciplines each other during integration
Analyzes	Energy analyses Environmental analysis
Time estimation (4D)	Linkage of objects to time plan Graphical visualization of projects schedule Early detection of planning errors.
	Optimization of logistical aspects.
Cost estimation (5D)	Connection of objects with price lists for different materials.
	Easy value engineering analysis
	accurate cost estimation at any point in the design phase
	Creates understanding regarding financial implications of design decisions.

In the traditional approach, the design, bid, and build phases follow each other. The architect, typically the lead designer in building projects and construction manager works directly for the owner. The engineering consultants are part of the designer's team. The engineer and the architect first design the building. Upon, the completion of the design phase, the construction manager also is known as general contractors in the traditional approach bid for the job.

Traditional Design-Bid-Build, Construction Management at Risk, Design/Build and Integrated Project Delivery (IPD) methods are the most common project delivery approaches that the industry currently practices. Construction managers or general contractors can use BIM to extract quantities of work to prepare cost estimates. Furthermore, they can provide powerful 3D renderings. Moreover, schedule integrated BIM known as 4D BIM can be used for animations, safety analysis, and to prepare site logistic plans. Construction managers can use BIM to coordinate work with subcontractors. They can also update schedule and costs with BIM. Lastly, they can turn over an as-built building information model to the owner's maintenance team. [5]

Building Information Model can be used freely right from beginning of the project. The intimate collaboration of the designer and the builder can yield to using the Building Information Modelling as a strong and effective process. In the BIM addendum, Design Model and Construction Model are identified. Design Model developed by engineers and architect is expected to be completed at level of detail of two dimensional construction documents. Construction model developed by the contractor and subcontractor is equivalent to Modelling of shop drawings and related information. Developer of each distinct model can work and update his or her own files and are responsible for dimensional accuracy of model. Distinct models can be linked to each other to form a federated model. The federated model can be used for many purposes including clash detection, marketing and facility maintenance purposes [6]

The literature showed a need for better integration of project teams and collaboration between all parties. It also showed the need for a new way of dealing with information, moving from the document paradigm to the Project Integrated Database paradigm. The information analyses pointed in the direction that BIM could be the tool that allowed this better integration of teams and of information. The research study pursued based on that has shown that

it does, with Communication and Coordination as two of the Key Performance Indicators (KPIs) showing more benefits due to the use of BIM in construction projects. must be listed at the end of the paper. Do not begin them on a new page unless this is absolutely necessary.

### 3. Method

In this study, to evaluate the outcome of using BIM in construction projects 30 projects in the world that used BIM as a tool have been reviewed. The source of information was case studies or internet. The 30 studies that were reviewed were indicated to have the capacity for more analysis. The information were analyzed to see whether the project has used and benefitted from BIM or not. It is noted that the Coordination Success Criterion was created from the Integration Management PMBOK Knowledge Area. Proceeding works demonstrate that good integration of project members is a crucial factor in its advance. These works also claimed a new viewpoint for dealing with data, moving from the document paradigm to the Project Integrated Database paradigm. The information analysis was to show that the use of BIM has a positive effect on cooperation of group members. To study the integration of multiple organizations 4D design of a house has been developed to measure the problems of using of BIM in projects.

The research study pursued based on that has shown that it does, with Communication and Coordination as two of the Key Performance Indicators (KPIs) showing more benefits due to the use of BIM in construction projects. Besides to the question of the research, some other objectives were explained. The main goal was to indicate that BIM is advantageous in which aspects. In addition to the items noted Communication and Coordination benefits, Cost, Time and Quality Improvement were the other three KPIs proven to have more beneficial influence from BIM in projects.

The second goal of this project was to define integration problems of different models into BIM model. In order to achieve this goal the 4D model of a house has been developed.

#### 3.1. Projects success index

To measure the effectiveness of BIM as a tool in project management successfulness index for projects should be defined. A project is considered successful if the project has been delivered:

- According to its specifications
- Within budget and time
- To the satisfaction of the client, end-users and investors
- With the help of a satisfied project team [7].

1. The data were analyzed to establish in which specific ways the projects benefited (or did not benefit, as the case may be) from the use of BIM. This analysis was done by deriving a list of success criteria related to the output of the project, in terms of meeting time, cost and quality objectives and also related to the management of the process, such as effective scope management and communications. As such they encompassed both project and project management success and reflect the notion of project success being a multi-dimensional concept (Shenhar et al., 2001). It is noted that terminology is fluid in this area, with the terms “success criteria,” “critical success factors” and “key results areas” often used to mean the same thing. Here we use the term “success criteria” to mean how success is defined. Linked to each success criterion will be quantitative measures by which success, against the criterion, is measured – the Key Performance Indicators.

To provide a structure to aid data analysis and presentation of the results, the success criteria were grouped based on the Project Management Institute's (PMI) Project Management Body of Knowledge (PMBOK) Knowledge Areas (PMI, 2008). These Knowledge Areas were chosen as they provide a comprehensive high-level framework encompassing all the dimensions of success. The role and influence of BIM on the completed construction projects was compared with the role and influence expected from a Project Manager, using the success criteria that were derived in Table 2.

3.1.1. Benefits of BIM

By using BIM the communication process which exists between stakeholders in a project can be enhanced strikingly. This is because the 3D models of buildings are far easier to understand in comparison with 2D drawings, where we have to analyze the drawing first and then to make a mental image of what the structure would look like in 3D. Other advantages of using BIM include less time and money consuming production of building visualizations.

Table 2. Success criteria based on PMBOK knowledge areas. [8]

PMBOK knowledge area	Definition	Criterion	Positive consideration
Integration Management	Unification, consolidation, articulation, and integrative actions	Coordination	Improvement
Scope Management	Defining and controlling what is and is not included in the project	Scope	Clarification
Time Management	Accomplish timely completion of the project	Time	Reduction or Control
Cost Management	Planning, estimating, budgeting, and controlling costs	Cost	Reduction or Control
Quality Management	Quality planning, quality assurance, and quality control	Quality	Increase or Control
Human resource Management	Organize and manage the project team	Organization	Improvement
Communications Management	Timely and appropriate generation, collection, distribution, storage, retrieval, and disposition of project information	Communication	Improvement
Risk Management (uncertainty)	Increase the probability and impact of positive events, and decrease the probability and impact of adverse events	Risk	Negative risk reduction
Procurement Management	Purchase or acquire the products, services, or results needed from outside the project team to perform the work	Procurement	Help

In contrast to the traditional projects in which the building visualizations had to be made from scratch, in the projects that use BIM the visualizations can be made from previously created models. In BIM, the foundation for the decisions is better in comparison with the traditional projects. According to [9] Main potential benefits of BIM to project management can be summarized in Table 3

Table 3. Potential benefit of using BIM for project managers

Potential benefit for PMs	Why?
Organize the project schedule and budget	An integrated 5D BIM model immediately updates both the schedule and budget when any design change occurs
Work well with the Design Team	By using the integrated 5D BIM model to visualize and explore the impact of changes, s/he can keep project scope in check and become a trustworthy liaison between the designers and Owner
Hiring and controlling the Subcontractors	Having a handle on clash detection and coordination plays a key role in keeping Sub-contractors' work predictable
Requests For Information (RFIs) and Change Orders	Utilizing Coordination Resolution in preconstruction, these numbers can be brought to near zero.
Optimize the Owner's experience and satisfaction	Owner received a big injection of confidence in the GC when the PM showed him/her how design decisions impacted cost and schedule
Project closeout	PM to present a 6D BIM – a facilities resource with information on warranties, specifications, maintenance schedules, and other valuable information
Profit margin	By thoroughly understanding the project in 5D, the PM has more tools at his disposal to keep tight reins, and more reports to monitor progress
Progressive Owners are mandating BIM on their projects:	Becoming the BIM expert, in both preconstruction and out in the field, makes the PM invaluable and a key player.
PM Firm Growth	Project's success with 5D BIM means the opportunity to grow the firm's reputation and helps the corporate team win new business.

### 3.1.2 Challenges with BIM

Some companies focus on production and operate in the construction phase. Architectural and consultancy firms operate in the design phase, and lack of money for smaller companies prevents them from investing in new technologies

Another drawback directed to BIM is that the Iranian construction industry generally is on a beginner level concerning the implementation of BIM. This can make it hard to find stakeholders that have the required competence to participate in BIM projects.

Moreover the researches show that cost and time needed to train staff to work efficiently with BIM is much more than what companies can afford and that make them less interested in BIM. In addition the execution of BIM is more difficult than what software developers suggest. A usual problem is getting different file formats to function properly when creating a combined building information model. This could for example relate to the computation of material volumes. When data is taken from the original building information models a certain value is attained, and when data is taken after the models have been converted into the IFC file format, a dissimilar value can be generated.

A legal problem was also brought up in the interviews claiming that the combined building information model lacks legal validity. Only 2D drawings plotted from the discipline specific models that have any legal validity.

To avoid time and money waste, one has to choose a suitable level of detail for building information model, and this is another challenge. It is for example often necessary to choose if the information required for certain analysis should be added in advance, as there is often not enough time to add this information in retrospect as the project progresses.

## 4. Data Analysis

Parallel to the research question several objectives were defined, the first objective was to identify in which aspects BIM is showing more benefits for construction projects. Added to the already mentioned Communication and Coordination benefits, Cost, Time and Quality Improvement were the other three KPIs proven to have more beneficial influence from BIM in projects. The selected projects are showed in Table A-1

The project studied six BIM utilization activities: visualization, 3D coordination, cost estimation, prefabrication, construction planning and monitoring, and record model. The visualization is generally the simplest use of a Building Information Model such as renderings. As soon as the Building Information Model are produced, the quantity takeoff s can be generated to provide cost estimations on a construction project. Furthermore, the 3D coordination was utilized to detect and eliminate trade clashes and conflicts. In addition to that, detailed prefabrication drawings can be generated to review and coordinate work between trades. Once the drawings are designed to build, the prefabrication of the components of the construction facility can be built to design. BIM based 4D scheduling helps understanding of the construction components and schedule progress that in turn results better construction planning. As the materials including but not limited to prefabricated products arrive at the job site, the planning techniques and 3D model can be combined with other BIM enabled tools to provide construction monitoring services. Based on the construction monitoring, the construction planning can be strategized. This helps to update the schedule and the 3D model. Finally, the record model can be generated as the final progress of the construction as the as-built are completely updated in the Building Information Model.

The benefits for stakeholders and the organizational benefits were not so easy to identify. Organizational improvements were mentioned directly or indirectly in the case studies a few times and the questionnaire survey showed some respondents with opinions related to the improvement of the organization because of BIM use. Table shows the negative and positive impacts of BIM in different knowledge areas of PMBOK indexes regarding to Table 2 indexes.

Almost half of the respondents considered that the Project Manager should be BIM Proficient and 24% of them considered that the Project Manager should be in charge of overall BIM Management. The research shows that BIM is an Information Management Tool that goes way beyond its design functions. For this reason the author is pretty confident to state that it is the PM who should lead the BIM Management the same way the PM is the leader in

setting up other IT systems and protocols in complex projects. To show that a 4D model of a house has been developed in The Revit Architecture 2010 as it has been depicted in Fig.1.

Table 4. Negative and positive impacts of BIM as PM tool

Key Performance Indicator	Positive perception			Negative perception		
	Total mentions	Total number of projects	% of total projects	Total mentions	Total number of projects	% of total projects
Cost Reduction or Control	29	21	60.00%	3	2	5,71%
Time Reduction or Control	17	12	34.29%	4	3	8,57%
Communication Improvement	15	13	37.14%	0	0	0,00%
Coordination Improvement	14	12	34.29%	7	3	8,57%
Quality Increase or Control	13	12	34.29%	0	0	0,00%
Negative risk reduction	8	6	17.14%	2	1	2,86%
Scope Clarification	3	3	8.57%	0	0	0,00%
Organization Improvement	2	2	5.71%	2	2	5,71%
Software issues	0	0	0.00%	9	7	20,00%

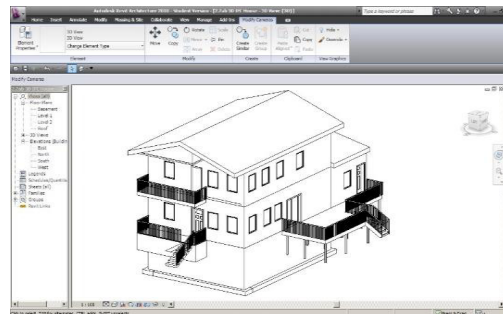


Fig. 1. Prototype Revit House Model.

The creation of a 3D housing model using the Revit Architecture 2010 showed the powerful features of BIM. The creation of an element on a view such as floor plan translated correctly to a different view such as elevation view. This saved a lot of time in comparison to if the design were drawn in traditional 2D view. Furthermore, the parametric modelling detected the conflicts of elements. The use of this feature eliminated duplication or overlapping of elements. The prototype house model illustrated benefits of parametric modelling in comparison to 2-dimensional computer aided drafting (CAD). The parametric model denied overlapping of the elements. Also, there were no errors, omissions or conflicts of information at different views. A few set backs were realized with the prototype house model.

The visualization at any given time of the project can be enhanced at Gantt view with the drag of the timeline. This helps a better understanding to prepare for sequencing. Figure 2: Synchro 4D Prototype House Model depicts the timeline, activities, and model of the project. The particular timeline picked translated into progress of construction and selection of the ongoing resource activities in green within the house model. In this case, that would be the insulation, drywall, and taping activities. There were no temporary components modelled for the project. Hence, the site logistics planning were not studied.

Synchro was used for BIM based scheduling. Synchro is a powerful tool to create 4D and 5D models, the capability of linking 3D design models to the associated tasks of a CPM schedule allowing users to create project

simulations that identify and resolve dynamic time-space clashes and that optimize project performance. This quick linking approach enabled the generation of a 4D model within seconds. The generated IFC entities on the schedule could be also exported as a schedule file to use for scheduling purposes in MS Project or Primavera. BIM based schedule included 32 main activities and 270 subtasks which consisted of 160 main building elements. The subtask generation with link option took the majority of the scheduling efforts.

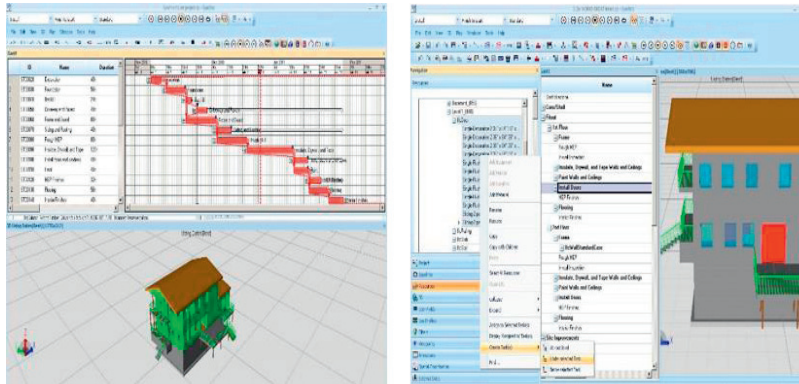


Fig. 2. Synchrono 4D Prototype House Model

Several difficulties were encountered during the 4D modelling of the house. This included splitting walls and column modelling issues. These items were successfully corrected in the Revit Architecture 2010. Schedule generated in MS Project was successfully imported to Synchrono. Once the resources and schedule activities were interlinked, the advantages of the 4D modelling were realized. As the timeline was selected for a particular day, the planned progress of the virtual construction project was immediately shown in the model. Lastly, an interoperability issue was found when the schedule and prototype model were updated outside of the Synchrono model and was imported back to Synchrono.

## 5. Conclusion

The main task of a project manager is to deliver a project successfully. Because project managers more or less know little about BIM, they usually do not appreciate the benefits of BIM in construction project. The project manager must make decisions in the project process. When BIM is used, it is easy to see the consequences of the decisions. Therefore a better basis for decisions is offered through BIM in comparison with traditional projects and the project manager can do a better job. BIM leads to a better communication with stakeholders, which is a crucial element in creating a mutual understanding of aims of the project, and therefore fulfill the requirements of the client. The quality benefits that BIM provides are most valuable for project managers concerning maintaining control of a project. During the design phase, the project manager can easily see how much the work has progressed in the building information model; giving the project manager a better basis for assessing the schedule and budget more accurately. The result is a better control over the project. The interviewed project managers saw potential improvements coming from linking the building information model to time, which would lead to increased control in the construction phase. Although many of the advantages of BIM are not directly related to the project manager, they contribute to the project all in all. Affecting indirectly the project manager positively, BIM helps the project go smoother towards a successful delivery. When the project is successful, there will be more profits for all stakeholders, including the project manager.

Among the challenges ascribed to BIM were; adding unnecessary information that leads to time and money waste, legal issues pertaining to model's legal validity, technical problems with the execution of BIM, as well as the lack of cohesion in the industry. However, the principal challenge was the personal opinions towards the execution



of BIM. To use BIM, people have to be convinced of its benefits. Another challenge showed in the study was related to BIM execution; especially the time and cost required for educating members to work efficiently with it.

Pilot projects are vital for changing the personal opinion and bring BIM use. For stakeholders to accept BIM, a circumstance to experience its benefits should be provided.

This research also determined the role of a Project Manager in BIM projects. Almost half of the respondents considered that the Project Manager should be BIM Proficient and 24% of them considered that the Project Manager should be in charge of overall BIM Management. The research shows that BIM is an Information Management Tool that goes way beyond its design functions. Because of this, the author is almost sure to state that it is the PM who should lead the BIM Management the same way the PM is the leader in setting up other IT systems and protocols in complex projects.

During the course of this project, utilization of BIM and its benefits were realized. Furthermore, review of Building Information Modelling tools, mainly Revit Architecture and Synchro further displayed the powerful use of 3D, 4D and model based scheduling. This indicated that the construction industry is definitely moving forward with BIM concept and BIM tools. The BIM is starting to become a common practice in the construction industry. The current interoperability challenges will eventually be mitigated and BIM tools will become more cost effective and time saving.

Construction industry is keeping up with technology and innovation once led by manufacturing industry. Especially, BIM and its tools are becoming widely adopted. The construction industry use parametric modelling to design, coordinate and prefabricate components of buildings. The design and coordination reduces errors before construction. The prefabrication provides high quality productions of materials in controlled environments while reducing costs and installation time in the field. Error reductions and quality products with shorter installation time increase labour productivity in the construction industry. These benefits are essentially important towards closing the labour productivity gap between construction and manufacturing industries. As the construction industry addresses the setbacks of BIM tools and use Building Information Modelling collaboratively, the benefits of BIM will be optimized. This will reduce and ultimately eliminate the labour productivity gap between the construction and manufacturing industries.

Building Information Modelling is beneficial to construction industry. BIM utilizations such as coordination, construction planning, and prefabrication, make construction projects more efficient. In other words, BIM provides time and cost savings and yields better quality construction products. Various BIM tools can be used to implement BIM in construction projects.

## Appendix A. Data of selected projects

Table A 1. Details of the selected project to apprise effect of BIM.

Project name	City	Country	Type	Project name	City	Country	Type
Shanghai Tower	Shanghai	China	Office Skyscraper	School of Cinematic Art	Los Angeles, CA	USA	Education
CMG Medical Office Building	Mountain View, CA	USA	Healthcare	Expeditionary Hospital		Middle East	Healthcare
La Bongarde	Paris	France	Retail	Maximilianeum Expansion	Munich	Germany	Residential
Palomar Medical Centre West	Escondido, CA	USA	Healthcare	Terminal 5, Heathrow	London	UK	Airport Terminal
Research 2	Aurora, CO	USA	Laboratories	UCSF Cardiovascular	San Francisco, CA	USA	Laboratory
Springfield Literacy Centre	Springfield, PA	USA	Education	Texas A&M Health Science Centre	Bryan, TX	USA	Education

Project name	City	Country	Type	Project name	City	Country	Type
St Helens and Knowsley PFI	Merseyside	UK	Healthcare	St Joseph Mission Hospital	Orange, CA	USA	Healthcare
Endeavour House	Stansted	UK	Office	Department of Energy	Amarillo, TC	USA	Industrial
Palace Exchange	Enfield	UK	Retail	SF Public Utilities Commission	San Francisco, CA	USA	Government
General Motors plant, Flint	Flint, MI	USA	Industrial	ShoWare Centre	Kent, WA	USA	Sports Arena
Eagle Ridge		Canada	Residential	US Food and Drug Admin HQ	Silver Spring, MD	USA	Lab + Office
Dickinson School of Law	Old Main	USA	Education	Festival Place	Basingstoke	UK	Retail
Blackfoot Crossing	Calgary	Canada	Museum	Sutter Health Medical Centre	Castro Valley, CA	USA	Healthcare
Modi'in		Israel	Retail	University of Suffolk Campus	Ipswich	UK	Education
Walt Disney Concert Hall	Los Angeles, CA	USA	Concert Hall	Cascadia Centre	Bothell, WA	USA	Education

## References

- Granroth, M. BIM – Building Information Modelling, orientation in a modern work method, (BIM – Byggnads Informations Modelling Orientering i en modern arbetsmetod). Kungliga Tekniska Högskolan, Stockholm. 2011. 71pp
- Teicholz, Paul. Labour Productivity Declines in the Construction Industry: Causes and Remedies. AECbytes4 (2004). Web. Mar. 2010. <aecbytes.com>.
- NBIMS (2007). National Building Information Modelling Standards: Overview Principles, and Methodologies. National Institute of Building Sciences, United States (Version 1: Part 1)
- NE (2011). Nationalencyklopedin [Online]. Available at: <www.ne.se/projektledning> [Accessed 18 Jun 2011]
- Eastman, Chuck, Paul Tieholz, Rafael Sacks, and Kathleen Liston. BIM Handbook. New Jersey: John Wiley & Sons, 2008. Print.
- Lowe, Richard H., and Jason M. Muncey. ConsensusDOCS 301 BIM Addendum. Construction Lawyer 28.1 (2009). Associated General Contractors of America. Web. 18 Mar. 2011. <agc.org>
- Antvik, S. & Sjöholm, H. Projekt – ledning och metoder. SIS Förlag, Stockholm. 2005. pp. 14-15
- PMI. A Guide to the Project Management Body of Knowledge (PMBOK® Guide). 2008. 5th edition. Project Management Institute, Newton Square, Pennsylvania, USA
- Allison, H. 10 Reasons Why Project Managers should Champion 5D BIM software. 2010. VICO Software.
- McGraw-Hill, 2010a. The Business Value of BIM in Europe. Getting Building Information Modelling to the Bottom Line in the United Kingdom, France and Germany.
- McGraw-Hill, 2010b. Green BIM. How Building Information Modelling is contributing to green design and construction. [online] Available at: Green BIM. How Building Information Modelling is contributing to green design and construction [accessed on 26th November 2010]
- Morris, P.W.G., Hough, G.H., 1987. The Anatomy of Ma
- Manning, R., Messner, J. Case studies in BIM implementation for programming of healthcare facilities. Information Technology in Construction. 2008.