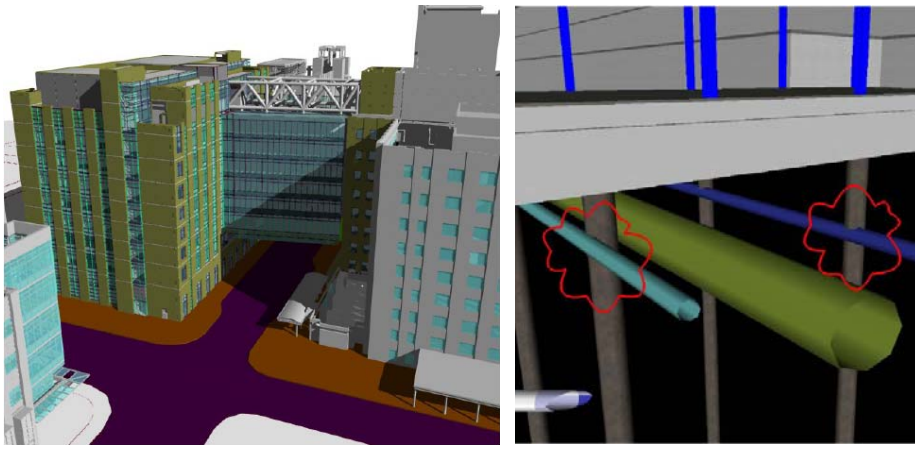
II. Depth: BIM- 3D Modeling

Background Information

BIM is a documentation process that consists of information about a building project in design and construction with the use of technology and collaboration. BIM is beneficial for design, construction, operational visualization, data modeling efficiency and effectiveness. Construction applications such as estimating, scheduling, and design coordination can be implemented with BIM. In order to get the most benefit out of BIM on a project, it has to be implemented at the early stages of the project by the designers, which include the project team, owners, construction manager, and contractors. One of the many advantages of BIM-3D aspect is the visual coordination of the various systems of a building such as the MEP systems. The model in Figure 5.5 shows the possible conflicts and problems between construction and management of trades. With the detection of these conflicts at an early stage in the design, the design team is able to resolve the problem before more time and money is invested, thereby saving the owner money in change orders during construction. BIM's capability is making a positive impact on the construction industry today. A hurdle that is slowing the progress of BIM in the industry today is the fact that owners do not require the design team to use BIM. In a paper, published in 2004 by The National Institute of Standards and Technology (NIST), "The cost of inadequate interoperability in the U.S. capital facilities industry to be $15.8 billion per year. The intended audiences are owners and operators of capital facilities, design, construction, operation & maintenance, and other providers of professional services in the capital facilities industry". The assumption made with BIM is that it is not currently a knowledgeable subject and more explanation is needed on how it is used. Like every new technology older employees often have some difficulty while trying to understand how the new technology is used and determining the benefits of its use. Some may believe that it is too risky to invest in it and may never realize how it will benefit the construction process. Just as AutoCAD is the current design tool today, BIM will be a standard practice and will become the new requirement for design and construction in the future. Clients such as the General Services Administration and the Department of Defense are already defining their requirements for BIM.

After research and further discussion at the PACE Roundtable, I decided that the topic I was most interested in and felt would be most applicable, for my thesis project is the use of Building Information Modeling (BIM)-3D modeling on the City Hospital project. Although this technology was not implemented on Phase I, there are some advantages that would have been gained in designing the hospital with the use of 3D modeling. Building Information Modeling is very exciting because it potentially solves a lot of conflicting issues by helping the design team to determine possible conflicts in the design phase of a project before construction begins. This potential is the reason why I decided to investigate how the use of BIM-3D modeling during the

design phase would have potentially eliminated most of the conflicts between trades during the construction phase of Phase I on the City Hospital project, especially because, upon first look, it seems this project requires a great amount of communication and coordination and therefore stood to gain a lot by utilizing BIM. Weighing and comparing the advantages and disadvantages between using BIM and not using BIM will form the foundation of this research.



http://www.virtualbuilders.org/VBR_Presentations/ViConTurner.pdf

Figure 5.5: MEP Clash detection

Methodology

1. Review literature on BIM-3D modeling.
2. Conduct phone interview with Jan Reinhardt, the Program Manager of ViCon - Virtual Design and Construction, at Turner Construction to ask questions listed in Figure 5.6.
3. Attend a 3D modeling coordination meeting with Paul White, MEP coordinator on Phase 2 of the City Hospital project and subcontractors to get an understanding of some of the issues faced and how these issues could have potentially been eliminated during Phase 1 between trades during the construction phase if BIM was used.

Questions:
Questions for Paul White: 1. Why was BIM (3D) not used in Phase I? 2. How and who would be trained for the use of 3D modeling if it were to be used on Phase I? What skills are required? 3. What would have been the benefits to using this technology on Phase I? Explain. 4. Were there any conflicts that could have been avoided if this technology was used on Phase I? 5. What are the necessary steps required in implementing 3Dmodeling? 6. What are some of the challenges being faced in Phase II with the use of this new technology? 7. How much time would have been considered necessary to start up the 3D/4D modeling process? How long did it take in Phase II? **Questions for Jan Reinhardt:** 1. How much time would be considered necessary to start up the 3D modeling process on a project? 2. What are the necessary steps required in implementing 3D/4D modeling on a project? 3. What are some of the advantages in using BIM-3D/4D modeling on a project? 4. What parties would be involved in the BIM process? 5. Are owners becoming more responsive to the idea of BIM? 6. How does Turner initiate BIM to their clients?

Figure 5.6: Research Questions

Research

Current practice utilized on the project:

The conventional way of documenting the design and construction process of a project, used by City Hospital Phase 1, is through the use of 2D drawings. Lines were used to represent the building and drafted into plans, sections, and elevations to show how the building is to be constructed. A booklet of the drawings is communicated with large enough scales so that one can visualize the project. One of the disadvantages of 2D modeling is if a change is to be made in 2D drawings, the change must be modified in all the drawings; elevation, plan, and section. Today, structures can be designed using electronic software such as AutoCAD in 2D and transported as an electronic format. This allows for more detailed and more affluent information.

Proposed Implementation of BIM in Phase 1

In recent years, there has been a growing movement to adopt 3D modeling in developing construction projects. Phase 2 of the City Hospital Project is currently using 3D modeling to coordinate the design and construction process. Unlike Phase 1 of the project, they were able to include the 3D modeling package into the subcontractors' contract. The use of 3D modeling manages any changes made for you, which is very unlike 2D modeling. Once an object is modified in any view, the change is reflected in all views. This reduces the inefficiency caused by poorly coordinated 2D drawings. Buildings are becoming more complicated, especially with the push for more environmentally friendly buildings. The requirements for extensive documentation to achieve LEED points increase the benefits of implementing BIM on a project. For example, the idea of building for sustainability requires the regulation and recording of day-lighting, energy analysis, quantity takeoffs, and to quantify other green effects on a project. The 4D feature is time, the project schedule and the budget can be linked to the integrated model.

During a phone interview on January 26, 2008 with Jan Reinhardt, I was able to get the answers to the questions about 3D modeling as shown in Figure 5.7 below. The answers are based on past or existing projects that use BIM-3D modeling.

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Answered Research Questions:

Questionnaire for Jan Reinhardt:

Q1. How much time would be considered necessary to start up the 3D modeling process on a project?

A1.The time required to start up the BIM 4D modeling process on project would take about two to three weeks among the group. It would take about two weeks to develop the 3D modeling and one day to link the schedule to the model (4D aspect).

Q2. What are the necessary steps required in implementing 3D/4D modeling on a project?

A2. The steps are:
Develop a plan
Decide how to break up the building in terms of level of detail /elements
Develop a 3D model (contract out each package, ex: electrical, plumbing, etc.)
Develop a schedule
Link a schedule to plan
Coordination meeting are held weekly and sometimes daily thereafter.

Q3. What are some of the advantages in using BIM-3D/4D modeling on a project?

Q3. It makes you think harder about the schedule and allows for questions to be asked upfront. This process allows parties that are affected by the schedule to ask questions and communicate among themselves. The process minimizes the risk of schedule overlap or delays by months.

Q4. What parties would be involved in the BIM process?

Q4. Anyone that is developing the drawings (design drawings) for example the architect, structural engineer, etc.

Q5. Are owners becoming more responsive to the idea of BIM?

A5.Absolutely, they are asking for it and request it on their projects.

Q6. How does Turner initiate BIM to their clients?

A6.It is brought up during the preconstruction phases. But this tool is so useful; Turner implements the process even if the owner does not request it.

Additional Questions and Answers:

Why was BIM (3D and 4D modeling) not used in Phase I?

It was not included in the contracts of Phase 1 due to time constraints. The request must be included in each contractor's contract and states they are to provide a 3D model of their shop drawings.

Which and how would personnel be trained to use BIM-3D ?

The project engineers (MEP) of the general contractors must have basic AutoCAD knowledge to be able to use BIM. The contractors must also have basic AutoCAD knowledge to be able to convert 2D shop drawings into 3D. It takes about a week to learn 3D and another week to convert drawings into 3D.

How is BIM introduced to owners and the construction industry?

Through conferences, newspapers, advertising, workshops, invitations to projects, and word of mouth. About 15% of architects were using BIM software in 2006 and 30% in 2007 according to AIA. Today 50% of architects are using it and by 2009 about 75%. The big general contractors are already using BIM and the smaller ones are getting there but over all everyone is using it. Turner has currently used BIM on 40 of their projects.

Figure 5.7 Answered Research Questions

To get a better understanding of some of the issues faced on Phase 1 and how these issues could have potentially been eliminated during the construction phase, if 3D Modeling was used, I decided to attend a Modeling coordination meeting at City Hospital for Phase 2 on March 13, 2008.

Most of the trades from Phase 1 were also on Phase 2 and this allowed me to gather information on what issues were faced from both phases for my research topic.

The 3D modeling aspect of BIM is a complex process that requires extensive coordination. Before 3D modeling was implemented on Phase 2, Jan Reinhardt**,** the Program Manager of ViCon - Virtual Design and Construction at Turner Construction kicked off a 3D modeling meeting with all the trades that were to be involved in the summer of 2007. During this meeting the following steps were decided:

1. Developing a plan

   Turner manages the sequencing of the coordination.

2. Decide how to divide building in terms of level and elements (ex: levels and zones)
3. Develop a discipline specific 3D model (ex: electrical, plumbing, etc.)

   The 3D feature of BIM requires the MEP and other trades to each construct a three dimensional digital model of the systems using 3D software such as AutoCAD Revit to be imported into one format that is compatible with other engineering software. The modeling responsibilities of each trade on Phase 2 are shown in Figure 5.8. City Hospital Phase 2 consists of 9 levels and 5 to 6 zones per level. It took about two to three weeks among the group to start up the 3D modeling process on City Hospital.

4. Integrate discipline specific 3D model into NavisWorks

   It took about two to three weeks for each subcontractor to develop the 3D modeling and for Turner to integrate the drawings into NavisWorks as one drawing.

5. Identify conflicts between systems/connections

   Coordination meeting with the presence of the disciplines is held biweekly. During the meetings NavisWorks is used to perform clash detection.

6. Decide how to resolve conflicts

Conflicts are addressed and discussed during the coordination meetings and resolved during or after the meeting.
The subcontractors are at a point where they are comfortable with the modeling software that they are able to perform their own clash detection using NavisWorks before the coordination meetings. This allows for subcontractors to resolve issues among themselves before attending the coordination meeting where major issues are discussed.

7. Documentation of conflicts and solutions

   The drawings and clash reports are maintained by Turner Construction on Turner ViCon server and are updated weekly. All conflicts and clashes are resolved independently by each discipline and that the design corrections are to be uploaded to the server within the deadline given. Most of the clashes on Phase 2 were due to the pitch of the plumbing pipes and conflicts with the HVAC sheet metal.

Steps 4-6 as shown in Figure 5.9 will be repeated until there are no clashes detected during the clash detection or all parties are comfortable with constructability of the final coordinated design.

Modeling Responsibilities for the City Hospital Project

Company	Role	Modeling Scope	3D software	Phase Model Created/Coordinated
3rd Party Company	Architect	Architectural Modeling in 3D	AutoCAD 2007	Design Development
Turner Construction Company	Construction Manager	Overall Coordination of MEP in 3D	NavisWorks	Construction Documents and During Construction
Burns	Mechanical Subcontractor	Piping in 3D	AutoCAD MEP 2008	Construction Documents
SMM Industries, Inc.	Structural Subcontractor	Ductwork in 3D	AutoCAD MEP 2008	Construction Documents
Carr and Duff	Electrical Subcontractor	Conduit and Cable trays in 3D	AutoCAD MEP 2008	Construction Documents
Chadwick	Plumbing Subcontractor	Plumbing System in 3D	AutoCAD 2007, QuickPen	Construction Documents
Majek Fire Protection	Fire Protection Subcontractor	Fire Protection System in 3D	AutoCAD MEP 2008, HydroCAD	Construction Documents
Johnson Controls, Inc.	Integrated Technology Contractor	Controls in 3D	AutoCAD 2008	Construction Documents

Figure 5.8: Modeling Responsibilities on Phase 2 of City Hospital

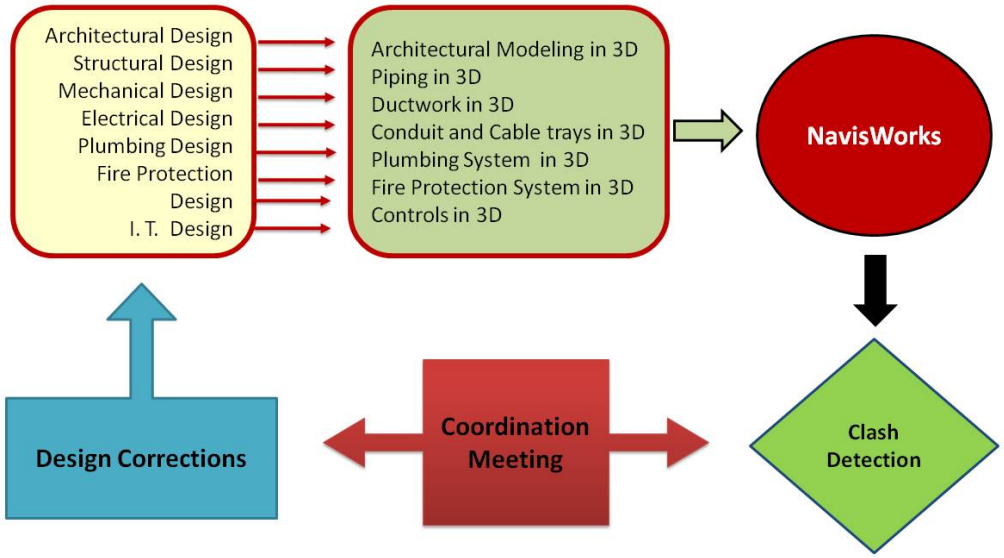

Figure 5.9: Conflict Resolution Process on Phase 2 of City Hospital

There are a few challenges faced with using this new technology on Phase 2. For example, some of the subcontractors who were new to the 3D learning programs had to overcome the learning curve to use the program. Once applications became repetitive or they began to get a feel for the process it began to run smoothly and meeting times were lessened. The project manager for Chadwick (Plumbing) commented, "It was frustrating at first but once you get a hang of it, you quickly see the benefits". For all the contractors, City Hospital was the first project where all the subcontractors were using 3D modeling for coordination. For SSM Industries (HVAC), City Hospital was their first project using 3D modeling. Another challenge was the price for software packages needed for 3D modeling and the constant upgrades or new software being introduced to the subcontractors on a semiannual or annual basis. Chadwick stated that the upgrades would not have any significant difference to prior versions of the software and continues to use the AutoCAD 2006 even though AutoCAD 2008 is the most recent version being used. Also, 3D modeling software outpaces the hardware on computer systems. For example, a 3D model for the first level of Phase 2 would take about 800 MB of space. So subcontractors have the added cost of upgrading computer hardware apart from upgrading the modeling software.

According to the subcontractors that were working on Phase 1 and currently working on Phase 2, using 3D modeling would have been a huge advantage if it were to be used on Phase 1. Since Phase 1 houses the Central Utility Plant which consists of immense MEP equipment and connections, 3D modeling would have been ideal in seeing the spatial relationships and allowing the project team to integrate their designs electronically to identify conflicts in three dimensions. Using 2D drawings is time consuming and inefficient when compared to 3D. There

were several conflicts experienced during Phase 1 that is believed could have been avoided with the use of 3D modeling. For example, 80- 4" electrical conduits were to span from Level A (Phase 1) to Level 7 (Phase 2). There were many issues with this system running into other systems as it was to rise through each level to level 7. The use of 3D modeling may have potentially made it easier to detect the systems that would have clashed with 80 conduits and helped to redesign a more feasible system before construction. In another example, there was a clash between Burns Mechanical and Chadwick's piping. A 24" pipe was interfaced with other piping and it resulted in changes to the pipe on three separate occasions. On Phase 2, the use of 3D modeling allows Chadwick to prefabricate their piping which reduces installation time on the project site.

Although it is too early to determine the overall benefits of using 3D or 4D modeling on Phase 2 since it's still under construction, there are examples from other healthcare facilities that were successful with the use of BIM. The Comer Center for Children and Specialty Care at the University of Chicago Hospitals were able to "shorten the design schedule … reduce interferences between M/E and structural systems… [and only] six RFI's compared to hundreds using traditional 2D drawings" with the use of the technology (Barista, 28). The 250,000 s. f. Camino Medical Group medical office building in California experienced zero RFI's and change orders having to do with mechanical and electrical coordination and they were able to prefabricate building systems which reduced their MEP and fire protection labor cost by 20%.

With City Hospital intending to be LEED silver certified, the use of BIM on City Hospital has the ability to support key aspects of the sustainable design and implementation. Environmental concerns have been a huge topic in the media due to the issue of greenhouse gas emissions and the rising cost of energy. With the building industry contributing "30% of greenhouse gas emissions and generate[ing] 136 million tons of construction and demolition waste (approx. 2.8 lbs/person/day)", a new approach of practicing the design, construction, and operation was needed (Autodesk, 1). BIM helps manage information and documentation for LEED certification very easily and under one database, a centralized design management tool. For example, the management of material quantities, material usage, lighting design, specifications, design alternatives, submittals, energy performance, the scheduling of building equipment, etc. The fourth dimension of BIM helps determine areas, volumes, and cost of materials that are needed to be submitted for LEED credits such as renewable, reused, and recycled materials. Specifically on hospitals, BIM aids in the design and construction of the complex and repetitive nature of the buildings. The real time visualization aspect of BIM allows for designers to present alternative set-ups to their clients. Not only can MEP activities and interrelations be monitored but patient and staff flow can be documented. The fourth dimension can help plan for temporary egress, construction sequencing, and material and equipment staging.