Senior Thesis Proposal

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Butler Health System

New Inpatient Tower
Addition and Renovation
Butler, PA

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Construction Option

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Penn State AE Senior Thesis

Executive Summary

The purpose of this proposal is to discuss the three analyses that will be performed for the thesis report for Butler Memorial Hospital's New Inpatient Tower. The topics chosen for analysis all involve technologies and strategies that are relatively new to the construction industry. As these new technologies are beginning to excel in the construction industry, their employment on this project could greatly improve the efficiency and delivery of this project.

Analysis 1: Increasing the Usage of Building Information Modeling
The benefits of using Building Information Modeling are now clearly being displayed to project teams and owners throughout the world. This project team has implemented BIM into a couple of key areas for this project. Both 3D Coordination and 4D Modeling have both been utilized for particular portions of the building. The goal of this analysis is to recognize the benefits of using additional BIM uses for this project. The potential uses and benefits of different uses, which are dictated in Penn State's BIM Execution Guide, will be compared and analyzed for this project.

Analysis 2: Application of a Photovoltaic Energy System
Although this project is known for being a state-of-the-art medical facility, sustainability was one issue that was not addressed to its full extent. Because of the high amount of energy used by hospitals, the idea of adding a photovoltaic energy system will be analyzed. Due to the fact that there is a high cost associated with adding a system of this nature, it will be crucial to look into the lifecycle cost of using this newer technology. The existing energy uses of the building and the potential savings will need to also be incorporated into this calculation. The goal of this analysis is to determine if this system will provide a payback that is acceptable for the owner.

Analysis 3: Implementation of a Prefabricated Mechanical System
With a facility of this magnitude, the schedule was the driving factor due to the costs associated with a hospital's day to day activities. Because the hospital set firm dates for completion and occupation of the facility, any schedule reducing techniques are worth investigating. As the concept of prefabrication is being introduced more frequently into projects, the idea of prefabricating mechanical spaces and systems are becoming more prevalent. While this has potential to significantly reduce schedule time, there may be cost implications that result. The purpose of this investigation will be to determine if using a prefabricated mechanical system will be feasible for this project. Once the cost and schedule reduction capabilities have been compared, this will lead to a decision based on the owner's desires.

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Project Background

Butler Health System is an extensive medical services provider north of Pittsburgh. With about 1,700 employees and 189,000 residents relying on this hospital, it was evident that an expansion project was necessary. The existing facility was aged and had a particularly strained emergency department. To accommodate this need for an expansion, it was determined that Butler Memorial Hospital, the central facility, would be expanded by adding a new inpatient tower. The addition of this new impatient tower is part of a $149 million capital improvement and expansion project. Turner Construction was awarded as the General Contractor on this project. The new tower is a state-of-the-art facility with new operating rooms, medical surgical units, intensive care unit, individual patient spaces, and an extravagant entry level floor. This entry level floor includes a chapel, coffee shop, training classrooms, and auditorium.

The addition of this new tower has a cost of approximately $80 million. This tower is made up of seven floors and has a size of 209,678 square feet. The project broke ground in September of 2008 and was turned over to the hospital in August of 2010. Also included in this project is renovation work near the tie-ins to the new facility.

Rendering of New Inpatient Tower

The driving factor of this project is the schedule. Because the hospital dictated strict deadlines for turnover of the facility, it was critical for the project team to determine the most efficient way to produce a quality project. Because of this, Building Information Modeling (BIM) was utilized for 3D Clash Coordination in order to reduce difficulties in the field.

The complete expansion project is expected to create as many as 230 new jobs over the next four years. The long-term goal is that this will produce almost 300 new jobs on top of that, by 2016. It

is quite apparent that this project is crucial to the local area that it is serving. Because of this, it would benefit the project team and the owner if a project of the highest quality is delivered.

Technical Analysis 1: Increasing the Use of Building Information Modeling

Problem Identification

For the New Inpatient Tower at Butler Memorial Hospital, Building Information Modeling (BIM) was utilized. Due to the complexities of the systems in medical facilities, 3D clash detection was seen as the most beneficial application of BIM. This was a detailed process that took place before and during the construction of the tower. This clash detection included the structural system as well as all MEP work for the building. The other usage of BIM involved 4D modeling. 4D modeling was used to visualize the construction of both the structural steel and the exterior envelope. While these two uses of BIM were highly beneficial to the project, it is plausible that additional BIM uses could have aided the project.

Background Research Performed

Penn State has put together a BIM Execution Guide, which documents the variety of ways BIM can be used. While it is clearly not feasible to bring every use into the project, it may be beneficial to specifically address a few. These different uses of Building Information Modeling have been discussed in depth in AE 597G: BIM Execution Planning. The various uses of BIM are shown below:

Building Maintenance Scheduling	Design Authoring
Building Systems Analysis	Engineering Analysis
Asset Management	Sustainability Evaluation (LEED)
Space Management and Tracking	Code Validation
Disaster Planning	Design Reviews
Record Modeling	Programming
Site Utilization Planning	Site Analysis
Construction System Design (Virtual Mock-up)	Phase Planning (4D Modeling)
Digital Fabrication	Cost Estimation
3D Control and Planning (Digital Layout)	Existing Conditions Modeling
3D Coordination	

As explained above, the implementation of every use is not practical. The decisions on what uses will be employed are project specific. The owner and/or the project team must be able to receive some type of benefit by employing these uses.

Potential Solutions

In order to decide what BIM uses will be implemented into the project, the owner will make the final decision. The owner, Butler Health System, would need to compare the benefit of the BIM use to the cost of its execution. In the ideal project, the owner would possess unlimited funds and therefore would see the benefit of utilizing BIM to its full potential. Because this type of situation is not real-world, only specific uses will be seen as practical. These can potentially be

determined by seeing how each of these uses have benefited similar construction projects. Also, it is possible that other BIM uses, which are not provided in Penn State's guide, will be applicable.

Methodology

In order to properly perform this technical analysis, the following steps must take place:

- Contact Turner Construction to gain more insight on the specifics of the BIM uses on this project.
- Speak with Turner BIM personnel to go over all benefits that were reaped from these uses.
- Perform additional research into the several uses described in Penn State's BIM Execution Planning Guide.
- Perform research on similar projects that employed BIM. Analyze how BIM was used and the benefits that it produced. Also, analyze the cost impacts of the employment of these uses.
- Interview industry personnel to gain more insight on the benefits and costs of each BIM use.
- Interview University faculty and graduate students to gain more insight on each of the BIM uses.

Expected Outcome

Understanding that the utilization of all uses is impossible, it is believed that this study will explain the most beneficial and plausible uses of BIM for this project. It is also believed that 3D Coordination and 4D Modeling will still be considered two applicable uses. By conducting interviews and looking more in depth into each BIM use, it is also believed that the applicable uses will be similar to other medical projects.

Technical Analysis 2: Application of a Photovoltaic Energy System

Problem Identification

Although the New Inpatient Tower at Butler Memorial Hospital is a state-of-the-art facility, one current construction trend was not touched upon. Despite the several technological advances displayed in this project, the project never possessed any sustainable goals. While the sustainability movement involves several different building practices, one of the main applications is the employment of a photovoltaic energy system. With the immense amount of energy used by a hospital, this system could produce extraordinary long-term cost benefits to Butler Health System. For this analysis, a design of the system will be produced, based on the feasibility of the idea. This topic will also address a couple of breadth topics. With the installation of this system, the generated energy can be tied into electrical energy savings. Also, because of the weight of this system, the structural system of the roof would need to be changed. The additional load added by the system would need to be considered for safe design.

Background Research Performed

Photovoltaic energy systems are considered one of the core ideas in the sustainable building movement. These systems have been used to reduce energy costs for buildings throughout the world. This idea has also carried into the healthcare field of construction. This, as mentioned above, has to do with the fact that medical facilities use a great amount of energy. In order to properly analyze this issue, significant research will need to take place involving these systems and how they have been applied to healthcare projects. This includes medical projects throughout the world.

The installation and application of these systems will be thoroughly researched in order to explain the cost and benefits of installing these systems. This research will be tied into the information presented in AE 598C: Sustainable Building Practices. In this class, the high cost of these systems is compared to the cost benefits throughout the life-cycle of the building. These topics will all be considered when determining the feasibility of a photovoltaic system.

Potential Solutions

As explained above, the design and installation of this system depends solely on the comparison of cost versus benefits. After the complete analysis is performed, there are a few potential solutions:

- The entire roofing area, including the upper and lower roofs, will be utilized for constructing the system.
- Only a portion of the roof will be used for designing a photovoltaic system.
- Due to cost constraints, the installation of this system will be deemed to be unfeasible.

Methodology

In order to properly perform this technical analysis, the following steps must take place:

- Perform additional research on the application of photovoltaic systems to similar medical projects.
- By analyzing the utilities consumption of the tower, the energy costs will need to be computed.
- Significant research will need to take place for photovoltaic system design. Layout, power generated, and cost will be the main focus points.
- By utilizing all of the above mentioned data, a return on investment will need to be calculated for this system.
- This return on investment will need to be compared to the owner's long term plans for the facility, in order to see if the plan is viable.

Expected Outcome

A significant portion of the roof of the new inpatient tower is space that is not utilized. On the upper roof, three air handling units are the only obstructions. Because of this, significant space is accessible for installing a photovoltaic system. Due to this space existing, the main aspect of this analysis will be determining if the system will be beneficial to the hospital. Because hospitals use a large amount of energy, and the owner plans on using the building for a long period of time, it seems like a viable solution to reducing energy costs.

Technical Analysis 3: Implementation of Prefabricated Mechanical Spaces

Problem Identification

As described in prior sections, one of the main goals of BIM for this project was to perform 3D coordination and clash detention. With the complex MEP systems in a hospital, this BIM use saved significant time in the assembly of these systems. With the schedule being so strict for this project, it may be plausible to look for ways to save even more schedule time. Because this clash detection produced models with considerable detail, it may be possible to employ the idea of prefabricated mechanical spaces. Prefabrication with MEP work can be seen on several levels. This includes anything from above ceiling systems to large mechanical rooms.

Background Research Performed

Prefabrication is another construction movement that is currently being seen more frequently in the industry. When projects have tight schedules, such as this project, prefabrication can be seen as a tool to significantly reduce installation time in the field. Because BIM is already being used for 3D coordination, the details for this prefabrication would already be in place. Prefabricated mechanical systems are explained thoroughly by researching other projects. Also, companies such as *MEP Solutions* have implemented prefabricated MEP systems in healthcare, laboratory, schools, etc. While there are several companies that can produce this type of work, this would be a starting point for the research. Also, this concept was discussed during the PACE roundtable. Discussions and contacts from this event would also be highly beneficial in the analysis of this issue. This analysis can also be tied into the sustainability aspect of this thesis. With prefabrication, less waste will be produced during the installation. This makes a considerable statement in terms of sustainability.

Potential Solutions

The choice of using prefabricated systems for building involves several potential advantages and disadvantages. While employing these systems can save significant time on the project schedule, there are also some possible difficulties that could be encountered. Some of these difficulties include transportation restrictions and size limitations in terms of installation of these prefabricated units. Also, if there is not enough detail in the shop drawings, this process would not be possible. There are a few potential solutions to this analysis:

- It will be deemed feasible to use prefabrication for all MEP work, including main mechanical spaces and distributions systems.
- It will be deemed feasible that prefabrication can be utilized in a smaller portion on specific parts of the project.
- Prefabrication will not be seen as an idea that can be applied to the project in a useful manner.

Methodology

In order to properly perform this technical analysis, the following steps must take place:

- Perform detailed research into the application of prefabricated MEP systems in similar healthcare projects.
- Thoroughly research the possible advantages and disadvantages of using prefabricated units.
- Contact builders of prefabricated systems, in order to discuss feasibility issues with this project.
- Determine how prefabrication can be utilized for MEP work on the New Inpatient Tower.

Expected Outcome

Because prefabrication can drastically save time for a project schedule, it is believed that the use of prefabrication for MEP work in the building is an idea that could have been utilized. Due to the detailed models that already exist, because of BIM, it appears as if this can be done with the current details. With a schedule as strict as this project, this will be something that the project team and owner would consider. At the same time, the disadvantages and difficulties that exist with these systems will most likely dictate that complete prefabricated MEP systems will not be possible.

Analysis Weight Matrix

Within the analyses that will be performed for each of the three technical analysis methods, there are four core areas of investigation that must be accounted for. These four areas include research, value engineering, constructability review, and schedule reduction. The following table indicates the weight percentages that each analysis relates to the core areas of investigation.

Description	Research	Value Engineering	Constructability Review	Schedule Reduction	Total
Increased BIM Usage	10%			10%	20%
Photovoltaic System	20%	10%	10%		40%
Prefabricated Mechanical System	10%		10%	20%	40%
Total	40%	10%	20%	30%	100%

Timetable

Due to the complexities and detail necessary to complete the research and analyses for this report, it is critical to stay on task for the semester. The preliminary timetable for this report is included in Appendix B. By staying on this schedule, this will allocate significant time to complete the analyses in a complete and thorough manner.

Conclusions

By completing in-depth investigations into each technical analysis, several current topics of the construction industry will be addressed and related to the New Inpatient Tower at Butler Memorial Hospital. Each analysis will involve adding or changing something about the original project. By increasing the BIM uses for this project, it is possible that the project team will be able to see beneficial impacts without a major change in project cost. The employment of a photovoltaic energy system will reduce energy costs for the owner and will add another state-of-the-art feature to the project. The implementation of prefabricated mechanical systems has the ability to reduce the project schedule. This could benefit the owner because the hospital could be open to serve patients at an earlier date. If new methods of construction and new technologies are introduced into this project plan, the owner has the potential of seeing extraordinary benefits.

Appendix A

Breadth Topics and MAE Requirements

Breadth Topics and MAE Requirements

In order to display competency in the other options of Architectural Engineering, at least two breadth analyses must be performed. For the already described technical analyses, the following breadth topics will be discussed:

Renewable Energy/Electrical Breadth

Technical Analysis 2 deals with the implementation of sustainable technologies into the project. In particular, the addition of a Photovoltaic System will be discussed. With the addition of a PV system to the New Inpatient Tower at Butler Memorial Hospital, significant changes would be made in terms of renewable energy. In order to determine if this application of a PV system would be feasible, the amount of energy produced would need to be calculated. The hospital currently is strictly provided energy by the local electric grid. The addition of this system could drastically reduce the amount of energy that is pulled from this grid. This will also reduce the overall energy costs of the building. Hospitals are known for consuming large amounts of energy. With the available roof space for implementing this system, it is possible that large amounts of energy could be produced.

Structural Breadth

When considering the addition of the aforementioned PV array, there will clearly be changes in the loading on the roof system of the new tower. Due to the added structural load of installing an array of photovoltaic panels, the structural system will need to be changed accordingly. This change to the structural system is also an issue that must be taken into consideration when deciding whether or not the addition of this array is economically feasible. Due to this addition, the structural system will have to be changed. Some of the potential solutions include:

- The addition of steel beams or columns to the design.
- The sizes of the existing beams or columns will need to be increased accordingly.

These two solutions will need to be compared for economic purposes. After properly calculating the necessary structural changes, costs will need to be determined and added to the financial analysis.

MAE Breadth

The MAE Requirements of this thesis will be mainly based on two courses in the Integrated Program. In AE 598C: Sustainable Construction Project Management, several different sustainable technologies have been discussed. One of these technologies is the implementation of a photovoltaic system. The in-class discussions and research will be used to provide a basis for this analysis.

In addition to this analysis, AE 597G: BIM Execution Planning will be utilized for the BIM Usage Analysis. During this class, Penn State's BIM Execution Guide has been thoroughly

discussed. With this knowledge, the BIM uses in this guide will be implemented into this project and the feasibility of employing additional uses will be analyzed.

Appendix B

Spring Semester Preliminary Timetable

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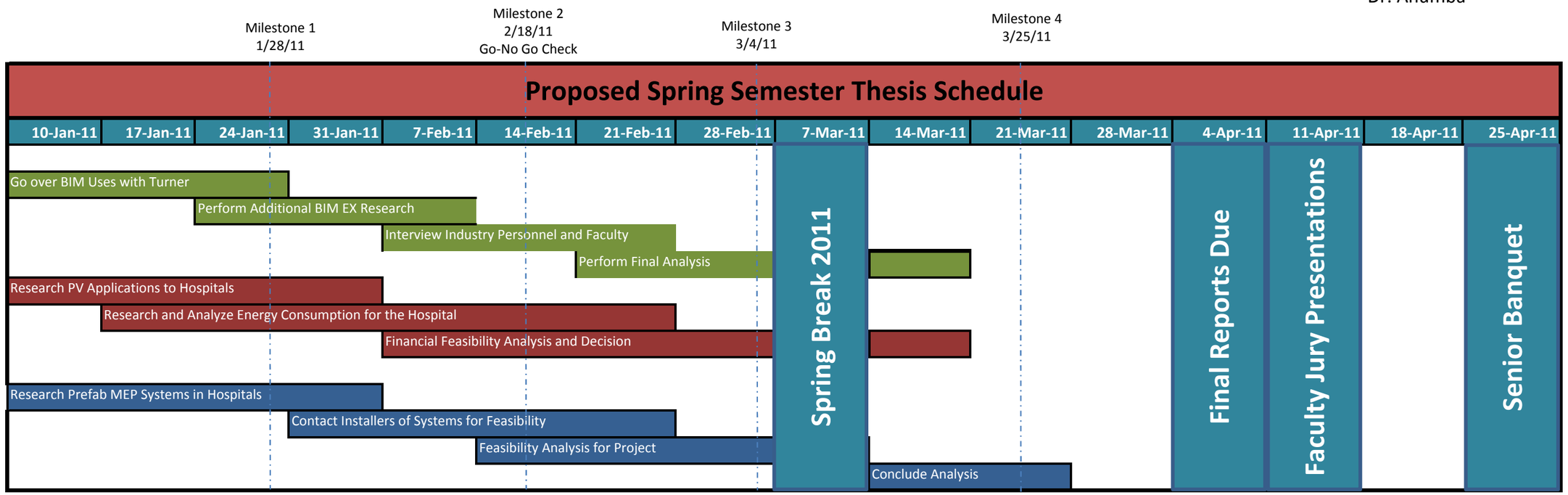

Milestones	
1	Analysis 1 Research Complete, 2&3 Ongoing
2	Analysis 2&3 Financial Work Ongoing
3	All Analyses in Evaluation Stage
4	All Analyses Completed

	Analysis 1	BIM Usage Analysis
	Analysis 2	Photovoltaic System
	Analysis 3	Prefab Mechanical Spaces