



# THESIS PROPOSAL

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SUBMITTED: 12/14/2012  
REVISED: 01/20/2013

# Executive Summary

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The Thesis Proposal details the four analysis topics that will be performed during the spring semester for the Susquehanna Center Project. As a reminder, The Susquehanna Center Project consists of a renovation of 49,159 square foot and an addition of 58,640 square foot and costs \$26.7M. In the three technical assignments done during the fall semester the project was analyzed from a construction management perspective as a preparation for the core thesis analysis that will take place during the spring semester. The four chosen research topics are: 1) Weather impact on the foundation system schedule 2) Initiation of BIM in renovation projects 3) Alternative façade system 4) Commissioning mechanical systems in renovation projects.

The first analysis tries to analyze how weather impacts the construction of a foundation and how does that come into play in the scheduling process. Also, this research will help find how much does a construction team rely on weather forecasts and what techniques are used in order to prevent weather damages. That should reflect on the scheduling process and the duration of the respective tasks.

The second analysis will to find the best way to make this project eligible and make it feasible to use BIM. A study will be done in the most efficient ways to convert the documentation of the old building into a BIM friendly format. Also, it will aim to find how to go about educating other parties in the project about BIM and the importance of it in an efficient manner.

The third analysis, which includes an architectural breadth, aims to come up with a better alternative façade system and compare it with the old and current system to see what were the owner's different options were with the cost labeled in each option. This requires a value engineering study for the old and current façade systems and a new alternative façade system proposal which includes new architectural design.

The fourth analysis, which includes a mechanical breadth, aims to research on mechanical systems commissioning process in renovation projects and identify its most common issues. The common issues will be studied and taken into account redesigning the mechanical system. It also aims to compile the issues that mechanical commissioners experience just like what happened in the Susquehanna Center project.

The Thesis proposal also includes an analysis weight matrix and a detailed schedule of when each component of the analyses will be performed during the spring semester. Also in appendix is a demonstration of where the breadth areas occur within the analyses performed.

# Table of Contents

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Executive Summary .....	1
Table of Contents .....	2
Project Background.....	3
Analysis 1: Weather impact on the foundation system schedule .....	5
Problem Identification - Research Goal - Background Research - Methodology	
Resources and Tools - Potential Solutions - Expected Outcome	
Analysis 2: Initiation of BIM in renovation projects .....	7
Problem Identification - Research Goal - Background Research - Methodology	
Resources and Tools - Potential Solutions - Expected Outcome	
Analysis 3: Alternative façade system .....	10
Problem Identification - Research Goal - Background Research - Methodology	
Resources and Tools - Potential Solutions - Expected Outcome	
Analysis 4: Commissioning mechanical systems in renovation projects.....	12
Problem Identification - Research Goal - Background Research - Methodology	
Resources and Tools - Potential Solutions - Expected Outcome	
Analysis Weight Matrix .....	14
Appendix A: Breadth topics.....	15
Architectural Breadth –Mechanical Breadth	
Appendix B: Spring Thesis Schedule .....	16

# Project Background

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The Susquehanna Center Renovation and Addition, Harford Community College in Bel Air, MD includes a renovation of the 49,159 square foot and a 58,640 square, which adds up to 106,955 square feet. Having a project that includes both a renovation and an addition required such a great collaboration and coordination between all parties involved in this project.

This project started construction on May 23<sup>rd</sup>, 2011 and was originally planned to finish on September 17<sup>th</sup>, 2012. However, due to weather related impacts, Turner has been granted a 38 working day extension for the Arena Addition. The addition part was then turned over beginning of November and the first basketball game was held November 15<sup>th</sup>. All the construction that is left to do as of the submission date of this proposal is the punch list and finishing up construction of the tennis courts. The Renovation portion of the project has not been affected by the weather impact and already was turned over on September 17<sup>th</sup>. The total cost of the project is \$26.7M after about \$1.65M worth of value engineering savings.

Figure 1 shows a view of both the renovation and addition parts of the project. The canopy of the façade is shown at the left and it extends till it reaches the basketball arena addition at the right, which has a greater height. The photo was taken during construction in early September.



**Figure 1: The facade's canopy of the Susquehanna Center is shown at the left, and the basketball arena addition is shown at the right. The photo was taken during construction in early September.**

## Project Background (cont'd)

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The new addition has 153' steel trusses that span through the new basketball arena addition. It has a beautifully designed curtain wall at the top portion of the walls, which increases the usage of natural light. The owner, Harford Community College, had a goal to make the campus more environmentally friendly and this is one the projects that they had in their master plan. They were originally planning on getting Silver LEED certification for this project. However, the owner decided not to strive for it right before construction started, but still the environment is one of the main components to care about in this project.

The project did go over some construction management issues which some of them were utilized in this proposal for the analyses. Other than the weather impact on schedule, the pool restoration was one of the main ones. The pool is over 30 years old and the owner wanted to completely restore it. The pool was tested beginning of September prior to installation of pool tiles and it turned out it was leaking. The site team was not surprised because for a pool this old, leakage is very possible. That caused a delay to the project as well.

Overall, the Susquehanna Sports Center is a great project for a construction management study as it contains both an addition and a renovation. That has been directly used in Analysis 2 and 4.

# Analysis 1:

## Reduction of weather impact on the foundation schedule

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### **Problem Identification**

The project team has been granted a total of 38 working days as an extension mainly because of the rain impact on the foundation phase. The construction stopped as pouring concrete for footings was in the critical path. The scheduler for this project added 7 working days as a float, but it was not enough. After many discussions between the owner and Turner, they approved the extension. This topic will analyze the incident that happened in the project and see what could have been done differently in both preconstruction and construction phases in order to minimize or eliminate the delay.

### **Research Goal**

The goal of this research is to analyze how weather impacts the construction of a foundation and how does that come into play in the scheduling process. Also, this research will help find how much does a construction team rely on weather forecasts and what techniques are used in order to prevent weather damages. That should reflect on the scheduling process and the duration of the respective tasks. The Susquehanna Center will be taken as an example and as a basis for the research to be done on.

### **Background Research**

In order to initiate the research analysis, there has to be a background research done about weather impacts in foundation systems in the past. In addition, a research will be done on the physical construction techniques to avoid weather impact on foundations. Also, the history of those construction techniques and how they evolved will be helpful.

### **Methodology**

- ❖ Research about the construction techniques and strategies pursued to avoid weather impact and damages on the foundation phase
- ❖ Research and ask about the best ways to account for weather impact on a foundation system schedule
- ❖ Interview the project manager and get more details about the project schedule extension and ask about his opinion on the matter
- ❖ Find other examples of foundation schedule delays due to weather from fellow students
- ❖ Examine other examples and their scheduling process and do a comparison between them
- ❖ Meet with Dr. Anumba and other AE faculty members to talk about this topic throughout the spring semester and learn from their experiences

# Analysis 1 (cont'd)

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- ❖ Compile all the information gathered and try to come up with a better way that could have done to avoid the weather impact happened in the Susquehanna Center
- ❖ Use that to find a generic process that should be incorporated in the scheduling process to better account for weather impacts on foundation systems in future projects

## Resources and Tools

- Turner Construction project team: Project Manager and Project Executive
- Penn State Architectural Engineering faculty – Construction Management and Structure
- Other experienced construction managers
- Project detailed schedule and estimate
- Project's construction documents
- Fellow 5<sup>th</sup> year AE students to find similar examples of project delays due to weather
- Applicable and reputable resources (books, websites, etc) about weather impact on construction activities

## Potential Solutions

In order to minimize the damage of weather in a foundation system, it needs to be analyzed from two different aspects: physical techniques and predicted schedule duration. The physical techniques are all the physical means possible to prevent the foundation system from any weather damages. During the background research, the most affordable and feasible techniques will be considered. All that should reflect on schedule as well, which is the second aspect that needs to be analyzed. Depending on the weather predictions and physical means used, a float will be added to foundation schedule activities. The task duration has to be just right, which is not too small that the project team has to deal with a delay if it went over the allocated duration, nor too large that it will take a much longer duration than desired.

## Expected Outcome

This research topic seems to have a great potential as weather could have a severe damage and it is sometimes underrated because extra weather precautions mean extra money and time spent. This research aims to provide affordable weather precautions that would prevent the majority of weather damages that could happen without having to pay heavily for advanced techniques or having to put very long floats on construction activities with a focus on foundation systems.

# Analysis 2:

## BIM use in the Susquehanna Center renovation project

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### **Problem Identification**

BIM was minimally used in the Susquehanna Center Project. One of the main reasons is the cost of using it. Although, it will pay itself in the long run and it will be worth it, it was decided not to use BIM. Being a donation dependent project is another factor. Despite the fact that BIM is now very widely spread in the building industry around the nation, some marketplaces lack sufficient knowledge about it. So was the case with some subcontractors in this project. Moreover, since the existing building dates back to 1966, its documentation was not available in a format that would make the BIM process run smoothly.

### **Research Goal**

The goal of this research is to find the best way to make this project eligible and make it feasible to use BIM. A study will be done in the most efficient ways to convert the documentation of the old building into a BIM friendly format. Also, it will aim to find how to go about educating other parties in the project about BIM and the importance of it in an efficient manner.

### **Background Research**

The background research includes finding examples of renovation project that implemented BIM, which could definitely have faced the same obstacles as the Susquehanna Center did. In addition, a research on the best ways to come up with the required BIM documentation is essential. That could be done by either converting the old construction documents or creating new as built construction documents.

### **Methodology**

- ❖ Research about the BIM implementation in renovation project
- ❖ Examine other examples of BIM in renovation projects
- ❖ Research about how BIM is executed when most of the parties lack BIM knowledge
- ❖ Study the best ways to bring BIM friendly CDs for renovation
- ❖ Interview the project manager and get more details about BIM in this project and how would he have implemented BIM if they had to
- ❖ Meet with AE faculty members to talk about this topic throughout the spring semester and learn from their experiences
- ❖ Compile all the information gathered and come up with a better way that could have done to implement BIM in the Susquehanna Center



## Analysis 2 (cont'd)

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- ❖ Use the info gathered to find a generic process for implementation of BIM in renovation project when most of the parties lack BIM knowledge and when CDs are not available in a good format for BIM

### Resources and Tools

- Computer Integrated Construction Research Program. (2009). "BIM Project Execution Planning Guide –Ver. 1.0." October 8, Penn State, University Park, PA, USA.
- Turner Construction project team: Project Manager and Project Executive
- Penn State Architectural Engineering faculty – Construction Management
- Project's construction documents
- Fellow 5<sup>th</sup> year AE students to find similar examples of renovation projects
- Applicable and reputable resources (books, websites, etc) about BIM and the respective topic

### Potential Solutions

A potential solution for this problem is 3D scanning surveying instruments. 3D laser scanning could be incorporated with BIM by scanning the building periodically and sending the information to a database accessible by the respective parties. Those tools could also be used to provide BIM friendly format of construction documents. That is of course to create CDs and models from scratch, but the available documentation for the old building could be used for verification. To ensure the feasibility of this solution, a cost analysis has to be done to it and see whether it could be actually used in the Susquehanna Center project.

As for how to implement BIM in a marketplace that lacks the knowledge of it, a planned coordination has to be done with all parties. This is a problem that comes across in a lot of the projects. It is difficult to bring subcontractors that all know BIM sometimes, and if they do, they might charge a lot extra. A potential solution for this would be to put some requirements for subcontractors in order to get awarded the job. Using a particular software program for drawings is one example. Early involvement with subcontractors especially those who do not use BIM is critical as well. All this could be labeled as different ways to coordinate with other parties in the project, but they need to be researched and experimented in order to know whether they would work or not.

## Analysis 2 (cont'd)

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### **Expected Outcome**

By the end of this research, it is expected that it will provide a good guidance to contractors on how to implement BIM when it seems that there is no place for it in the project. This research also aims to help find the best and most up-to-date techniques for creating the required CDs and models for BIM. BIM will also include many potential improvements to coordination, costs, schedule, safety,..etc

# Analysis 3: Alternative façade system

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## Problem Identification

The façade of the existing Susquehanna Center has been completely redesigned and renovated which greatly impacted the structural system. The owner wanted a better looking facade than the fitness center brick wall and also wanted bigger windows to let more light in. He wanted all that for the lowest price possible. The fitness center was enclosed by a brick wall with small windows. By renovating it, it made the fitness center bigger using a curved shape curtain wall instead of the brick wall. In addition to the structural system, the mechanical and lighting systems were also affected. Although the owner was satisfied with the design, it was expected to be cheaper than this.

## Research Goal

The goal of this research is to come up with a better alternative façade system and compare it with the old and current system to see what were the owner's different options were with the cost labeled in each option. This requires a value engineering study for the old and current façade systems and a new alternative façade system proposal which includes a new architectural design.

## Background Research

To start this research, both the old and current façade systems have to be completely understood along with the process of the architectural design in addition to its mechanical and lighting design. **Appendix A** includes a detailed demonstration of where the breadth studies occur within the discussed analyses.

## Methodology

- ❖ Study both the old and current façade systems
- ❖ Produce a cost and schedule analysis
- ❖ Study the building systems in the façade and its relationship to the building systems of the rest of the building
- ❖ Compare old and current facade systems
- ❖ Interview the Lead Designer and ask him about the process of the façade design, what other options they had,..etc
- ❖ Interview the Project Manager and ask about façade demo and construction issues
- ❖ Produce an alternative architectural designs for the façade where it meets the owner requirements but would cost less
- ❖ Do a cost and schedule analysis
- ❖ Produce a complete comparison between all three systems (old, current and alternative)

## Analysis 3: (cont'd)

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### Resources and Tools

- Turner Construction project team: Project Manager and Project Executive
- Hord Coplan Macht team: Lead Designer
- Penn State Architectural Engineering faculty – Construction Management
- Professor Holland and professors from the Architecture department
- Project's construction documents
- Façade's detailed estimate
- Applicable and reputable resources (books, websites, etc) about BIM and the respective topic
- Autodesk AutoCAD and Revit

### Potential Solutions

Using the tools and resources above, it is possible to design an alternative façade system but it might not be better in all aspects considered. In all cases if the owner wanted to save money in the project, he/she is better off changing the design early than late, otherwise it would cost even more. This research analysis is here just to see what different options the owner had prior to construction and what the value engineering potential areas in this project are.

### Expected Outcome

Upon completion of this research, it is expected to have an alternative façade system design that is better in terms of cost, and meets all the owner requirements at the same time. Potential improvements in schedule and constructability are also possible. The alternative design will be thoroughly compared with the old and current systems to see what the different options the owner had in the beginning of the project.

# Analysis 4:

## Commissioning mechanical systems in renovation projects

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### **Problem Identification**

Testing and commissioning are both very critical in construction projects, and if not done correctly could lead to bad consequences. Susquehanna Center project is a good example of this. The main reason why the pool restoration took longer than anticipated in the Susquehanna Center project is the failure of the first test they had on the pool. The test was done while the pool tiles were not installed yet, so that they do not have to take off the tiles in case it fails. It turned out that the concrete and mortar on the pool had cracks and needs to be fixed before installing the tiles. This raises the question of the quality of the checks done prior to construction to help schedulers know the status of the pool. Testing the pool prior to construction is very essential here because the nature of the testing takes 2-4 weeks.

### **Research Goal**

The goal is to research mechanical systems commissioning process in renovation projects and identify its most common issues. The common issues will be studied and taken into account while redesigning the mechanical system. It also aims to compile the issues that mechanical commissioners experience just like what happened in the Susquehanna Center project.

### **Background Research**

The commissioning process for mechanical systems in renovation projects has to be understood. Also, the history of commissioning and the different experiences that commissioning agents went through will definitely be a good start for this research.

### **Methodology**

- ❖ Research the process commissioning for mechanical systems in general
- ❖ Research commissioning for mechanical systems in renovation projects
- ❖ Study the mechanical system of the building and its commissioning process
- ❖ Interview the project manager and the mechanical contractor and get more details about the process of commissioning in the project
- ❖ Meet with AE faculty members to talk about this topic throughout the spring semester and learn from their experiences
- ❖ Mechanical redesign as per findings
- ❖ Compile all the information and findings

# Analysis 4 (cont'd)

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## Resources and Tools

- Turner Construction project team: Project Manager and Project Executive
- Burdette, Koehler, Murphy & Associates, Inc, (MEP contractor for the project)
- Penn State Architectural Engineering faculty – Construction Management and Mechanical
- Project's construction documents
- Fellow 5th year AE students
- AE 476: Building Construction Management II course
- Applicable and reputable resources (books, websites, etc) about mechanical systems commissioning in renovation projects

## Potential Solutions

Early involvement and coordination in the projects prevents many potential problems, so does commissioning. That is why they have to come so early in the project as early as pre-design starts, and they are one of the last people to leave the site after it is finished.

However, the main solution or outcome that this research is moving towards is a definition of the commissioning process for renovation projects. That definition could work as tips and recommendations for commissioners based on previous commissioning experiences in renovation projects.

## Expected Outcome

The main expected outcome of this research is a commissioning process dedicated to renovation projects like the Susquehanna Center project. The research is also expected to help gather a compilation of commissioning experiences in renovation projects and how the team overcame it. All this should help with the actual operation of the mechanical system.

# Analysis Weight Matrix

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The table below illustrates the amount of time and emphases that will be allocated among the four analysis areas during the spring semester. A detailed schedule for the research that will occur during the spring semester is attached in **Appendix B**.

#	Analysis	Critical Issue Research	Value Eng.	Constructability Review	Schedule Acceleration	Total
1	Reduction of weather impact on the foundation schedule	15%	5%	5%	15%	30%
2	BIM use in the Susquehanna Center renovation project	15%	5%	-	10%	30%
3	Alternative façade system	-	10%	5%	5%	20%
4	Redesigning and commissioning mechanical systems in renovation projects	15%	-	-	5%	10%
	<b>Total</b>	<b>30%</b>	<b>20%</b>	<b>10%</b>	<b>30%</b>	<b>100%</b>

In conclusion, the four analysis topics chosen for research during the spring semester seem to have big potential. They were all chosen based on the information gained after the construction management research conducted during the 3 technical assignments. In addition, the PACE roundtable meeting helped generate new ideas and relate the current construction industry issues to what the 5<sup>th</sup> year AE students have seen in their projects.

# Appendix A: Breadth topics:

## **Architectural Breadth**

Analysis 3, Alternative façade system, includes an architectural breadth as it is needed to redesign the façade system to propose an alternative façade system. The process will be first studying the old and current façade systems, where it will be looked at from an architectural point of view, and what the key architectural features that have been changed. Next, the lead designer will be interviewed and asked about the actual design process of the façade. After that, all the information gained will be gathered and taken into account while designing the façade. The final product would be 3D model of the new proposed façade.

## **Mechanical Breadth**

Analysis 4 will include a mechanical breadth as it deals with commissioning mechanical systems. In order to get the most out of the commissioning process, the commissioning team usually arrives at the design stage of the project to get their input and to maximize the coordination. That concept will be implemented in this analysis by conducting a commissioning study and redesigning the mechanical systems as per the outcomes of the study.



			1/28/2013 Milestone 1		2/11/2013 Milestone 2		3/1/2013 Milestone 3				3/26/2013 Milestone 4	Haitham Alrasbi Advisor: Dr. Chimay Anumba												
Proposed Thesis Spring Semester Schedule January 2013 - April 2013																								
7-Jan	14-Jan	21-Jan	28-Jan	4-Feb	11-Feb	18-Feb	25-Feb	4-Mar	11-Mar	18-Mar	25-Mar	1-Apr	8-Apr	15-Apr	22-Apr									
Resubmission of Proposal	Research construction weather impact							Spring Break				Final Report Due	Faculty Jury Presentation April 8-12	Update CPEP and Report	Senior Banquet April 26th									
				Interviews																				
				Research examples			Develop better scenario																	
	Conduct research								Create a generic plan															
	Examine examples		Research lack of BIM knowledge																					
				Interviews																				
				Compile info		Create a generic process																		
	Study old and current façade systems																							
				Interviews																				
				Produce alternative architectural design																				
						Core Analysis																		
									Complete comparison															
	Conduct research																							
			Study project's mech. system																					
			Interviews																					
				Mech redesign																				
					Compile info																			
								Begin power point																
								Finalize Report																
Legend	Analysis 1: Weather impact on the foundation system schedule							<div>Milestones</div> <div>(1) 1/28/2013 - Research Complete</div> <div>(2) 2/11/2013 - Interviews Complete</div> <div>(3) 3/1/2013 - Core Analysis Complete</div> <div>(4) 3/26/2013 - All Content Complete</div>																
	Analysis 2: Initiation of BIM in renovation projects																							
	Analysis 3: Alternative façade system																							
	Analysis 4: Commissioning mechanical systems in renovation projects																							