Final Thesis Proposal

* Front elevation rendering photo provided by Alexander Building Construction

George Andonie
Construction Option

AE Faculty Consultant:
Rob Leicht

January 17th, 2013

Executive Summary

The following Thesis Proposal intends to define areas of investigation to be completed in the Spring Semester for the Geisinger Grays Woods Ambulatory Care Campus Phase II project. Throughout extensive research performed in the Fall Semester, I identified four analyses that focus on problems or opportunities faced during the construction of this facility. They are based on areas of critical industry issues, value engineering, constructability review, and schedule reduction.

Analysis 1 - Virtual Mockups on Operating/Endoscopy Rooms:

One of the major challenges in the construction of this facility was the great amount of changes that went in designing the Operating and Endoscopy Rooms of this building. Taking over 8 weeks of design reiterations throughout the construction process, this was a costly and time-consuming process which obstructed the trades to begin work in these areas as they were left until the end of the project. This analysis will look into developing and implementing Virtual Mockups, with the goal of improving the efficiency of the design and construction of the facility's Operating and Endoscopy Rooms.

Analysis 2 - Building Façade Prefabrication:

Construction of the building's exterior envelope is the second longest task in the project's schedule. The constructions of the brick veneer exterior walls require an extensive amount of labor-hours and scaffolding to install. This time-intensive process hinders the schedule from being accelerated, and the building from being watertight earlier. This project presents an opportunity to change from stick-built exterior wall construction into a modular design. This analysis will help determine whether the use of prefabricated brick panels will improve schedule, cost, and trade coordination on site. Additionally, a mechanical breadth analysis will be performed in order to determine any significant changes in the building's thermal performance.

Analysis 3 - Equipment Procurement & Installation:

Procuring and installing the medical equipment can become a very challenging process in healthcare projects. Geisinger, the owner for this project, is the one responsible for procuring and coordinating the equipment installation in their facility. Because of the rapid changes in technology and with the purpose of pushing back equipment payments, they try to wait as long as possible in order to procure the latest and greatest equipment for their facilities. This creates a big challenge when it comes to designing the rough-ins, as the contractor does not know exactly what connections each piece of equipment will require until they arrive to the site. Through this analysis, I will research the most effective ways of sharing information on equipment procurement and furnishing to all trades involved with the installation of the equipment connection rough-ins. A strategy will be developed and implemented, focusing on timely decision making while having the least impact in the construction cost and schedule.

Analysis 4 - Re-evaluation of Structural Composite Slabs:

The MEP, interior, and structural systems of the Geisinger Gray's Woods Ambulatory Care Campus account for over 80% of the building's total cost. In an attempt to lower the building costs, value engineering efforts will be done to the building's structural composite slab. Through this analysis, I will evaluate the possibility of altering the second floor slab's lightweight concrete to normal weight. Not only is normal weight concrete cheaper than lightweight, but changing to normal weight concrete may result in cost savings by not having to use any fireproofing. This analysis would require redesigning the complete second floor composite slab. With this in mind, a structural system analysis will be required in order to determine whether any changes have to be done to the building's structure. Additionally, a cost analysis based on material and structural changes will be performed in order to determine whether this value engineering solution provides any cost savings for the project.

Table of Contents

Analysis #1: Virtual Mockups on Operating/Endoscopy Rooms

Problem Identification

As discussed on the previous technical reports, one of the major challenges in the construction of the Geisinger Gray's Woods Ambulatory Care Campus were the great amount of changes that went in designing the Operating and Endoscopy Rooms of this building. It took over 8 weeks of design reiterations in the midst of the construction process in order to determine a final design for these rooms. Using field mockups for both rooms were not only costly and time-consuming, but also obstructed other trades to begin work in these areas as they were left until the end of the project. Any delays or challenges in the construction of these rooms could potentially escalate in delaying the project overall.

Background Research

Mockups are a full-size, detailed model that may be used to address constructability, performance and coordination issues of a given space within a building. Alexander Building Construction makes use of field mock-ups in order to acquire feedback from the end users – facility's doctors and nurses. Although these field mockups have served their purpose for design reviews, they may not be the most efficient way of obtaining design input. Field mockups have proven to be a time consuming and costly process in terms of constructing, re-modifying, and demolishing for this project.

The use of virtual reality offers an opportunity to provide less expensive yet similar means to reach consensus decisions among healthcare personnel, designers, and construction contractors. The full-scale, 3-D virtual representation of the operating rooms facilitate design reviews, save time, reduce risk, and solve design and constructability issues in advance of construction. It is evident that using virtual mockups can greatly benefit a project, but every project is different in nature. For this research, I will explore the efficacy of implementing virtual mockups in the operating and endoscopy rooms of the Grays Woods project. A lot of this analysis will be based Sonali Kumar's previous research of using Virtual Mockups for 'Experience-Based Design Reviews' in the Hershey Children's Hospital.

Potential Solutions

One solution for tackling this problem is developing and implementing virtual mockups for the operating and endoscopy rooms of the Ambulatory Care Campus. Through the use of virtual mockups, the end users could be brought in early in the design phase to provide valuable input in order to have a final design prior to beginning construction. Doctors and nurses could walk around the virtual mockup and review the room's layout and practicality of the different locations for medical equipment, connections, tools and cabinets around the room. Through this analysis, I will model the criteria & workflow required for implementing virtual mockups for design-reviews in the construction of the facility's operating and endoscopy rooms. In addition to developing a virtual mockup for the facility's operating room, a schedule analysis will also help determine how moving tasks within the schedule can help inform design decisions without limiting other trades in performing work in these areas.

***See Appendix A-1 for MAE Requirements**

Analysis Procedure

1. Evaluate Existing Schedule & Mockup Process
    - Evaluate Existing Schedule (Project Team)
        - Where in schedule best possible to apply?
    - Evaluate Existing Mockup Process (Project Team)
        - Identify issues with existing mockups
            - Change orders, Additional costs, work & materials
        - Limitations with existing process
    - Read Existing Papers on use of Virtual Mockups
        - Sonali Kumar's Dissertation
        - ICC Papers
        - Virtual Mockups on Healthcare Facilities by Smith Group
2. Develop Virtual Mockup
    - Modify Existing Revit Model
    - Import Model to Unity
    - Capture Efforts of Virtual Mockup Development Process
        - Document Step-by-Step Process
        - Time in Developing Model
        - Potential Costs
        - Complications/Limitations of Virtual Mockup
3. Modify Schedule for Virtual Mockup Implementation
    - Schedule (and incurring cost) savings
    - Trade coordination
4. Evaluate Results
    - Cost/Benefit Analysis (CBA) of Virtual Mockups vs. Traditional Mockups
    - Conclusions and Recommendations

Resources & Data Collection Tools

- Alexander Construction Project Team
    - Matt Hoerner
- Facility's Revit Model (Provided by Ewing Cole)
- Revit & Unity Programs
- AE Faculty/Students
    - John Messner
    - Yifan Zhang
    - Fadi Castronovo
- "Experience-Based Design Review of Healthcare Facilities using Interactive prototypes" Dissertation by Sonali Kumar (2013)
- Immersive Construction (Icon) Lab and Equipment
- AE597F Class – Virtual Facility Prototyping

Expected Outcome

After completing this analysis, we are expected to fully comprehend the criteria and workflow required to develop and implementing virtual mockups for the design and construction of the operating and endoscopy rooms of the Grays Woods facility. By developing the virtual mockup and performing a schedule analysis for implementation, we will be identify whether using virtual mockups will greatly benefit the construction process of the facility's operating and endoscopy rooms. In contrast to the existing field mockups, virtual mockups are expected to be a much more effective tool in obtaining design input from end users by reducing the amount of change orders, rework, and therefore, risks in delaying the project schedule.

Analysis #2: Building Façade Prefabrication

Opportunity Identification

When analyzing the schedule for the Geisinger Gray's Woods Ambulatory Care Campus project, a major activity stood out - the construction of the building envelope. This activity incurred a total of 178 days in the project schedule, second longest after interior work. Stick-building the exterior brick facade requires an extensive amount of labor-hours and scaffolding to install. This time-intensive process hinders the schedule from being accelerated, and the building from being watertight beforehand. Any delays in the construction of this activity could potentially push back the substantial completion date, or even incur additional heating costs for the construction of this project.

Background Research

Multi-trade prefabrication & modularization was a key topic of discussion during the 22nd Annual PACE Roundtable. After discussing this topic with various industry professionals, it was noted that several projects that made use of prefabrication have found significant reduction in their construction schedule. By working offsite under a controlled environment and installing the modules on a just-in-time basis onsite, there is an increase in productivity, safety and quality in the construction of these components.

Although prefabrication may greatly reduce a project's schedule, it may not always provide desirable results with regards to project costs. Having the components produced offsite may greatly reduce labor costs, but additional costs could be incurred through the transportation and erection of these components. Other limitations discussed in the PACE Roundtable were long lead times, inspections, and payment limitations. It is important to account for these variables when analyzing whether using prefabrication on a project.

Potential Solutions

The Grays Woods project presents an opportunity to change from typical stick-built exterior wall construction into a modular design. An analysis will need to be performed to determine whether the use of prefabricated brick panels will improve schedule, cost, and trade coordination on site. Nevertheless, this implementation would require a supporting mechanical analysis. For this, insulation & thermal performances of the proposed system will be calculated and evaluated against the existing wall panels. A feasibility analysis based on cost, schedule, and mechanical performance could be performed in order to evaluate whether this is a viable solution for the project.

***See Appendix A-1 for Mechanical Breadth details**

Analysis Procedure

1. Research prefabricated wall panel systems
    - Develop preliminary panel design alternatives
    - Contact manufacturers and warehouses close to the area
    - Develop a cost-benefit analysis to better determine most appropriate system/ manufacturer

2. Implement proposed modular system to project
   - Determine installation procedure, layout and sequencing
   - Address site logistic concerns with equipment and manpower
   - Determine any transportation or installation coordination needs/costs
   - Develop budget & schedule for alternate system
   - Compare budget and schedule impact to existing system
3. Evaluate Mechanical Properties of proposed system
   - Identify insulation properties & thermal characteristics
   - Compare mechanical performance of both systems (Cooling & Heating Load Calculations)
   - Calculate lifecycle costs of mechanical system (AE 598C Tools)
4. Perform feasibility analysis to determine most viable solution
   - Feasibility analysis based on cost, schedule, and mechanical performance evaluation
   - Summarize results and conclusions

Resources & Data Collection Tools

- Alexander Construction Project Team
- Protect Documents and Specifications
- AE Faculty
- Industry Professionals
  - John O'Keefe
- Wall Panel Subcontractor (R.H. Marcon)
- Proposed Panel Manufacturer
- AE310 Class – Fundamentals of Heating, Ventilating, and Air Conditioning
- AE570 Class – Production Management in Construction
- AE542 Class – Building Enclosure Science & Design
  - Professor Ali Memari

Expected Outcome

Prefabricating the exterior brick walls offsite and installing the modules on a just-in-time basis onsite should greatly reduce project schedule. By assembling these modules under a controlled environment, an overall improvement in productivity, safety, quality, and constructability is expected in the construction of the building's exterior wall panels. Additionally, this will greatly alleviate site congestion by removing the scaffolding needed in site to construct these components. Although the project costs are not expected to decline by using prefabrication, a feasibility analysis based on cost, schedule and mechanical performance will be performed in order to evaluate whether this is a viable solution for this project.

Analysis #3: Owner Furnished Medical Equipment Procurement & Installation

Problem Identification

Procuring and installing medical equipment has brought many challenges to the project team throughout the construction of the Gray's Woods Ambulatory Care Campus. The owner, Geisinger Health System, is the one responsible for procuring and coordinating the equipment installation in their facility. Because of the rapid changes in technology, and with the purpose of pushing back equipment payments, they try to wait as long as possible in order to procure the latest and greatest equipment for their facilities. This creates a big challenge when it comes to designing the rough-ins, as the contractor does not know exactly what connections each piece of equipment will require until they arrive to the site.

Background Research

Medical equipment is typically one of the most challenging items to procure in healthcare facilities. Not only do they require long lead times between procuring the equipment and their arrival to the site, but a great deal of work goes into detailing the connections for each piece of equipment. Having equipment procured early in the project should allow for timely decisions in designing the rough-ins for the equipment connections. Unfortunately, the nature of the project does not allow for this to happen.

The owner, Geisinger Health Systems, is the one responsible for procuring and coordinating the equipment installation for this facility. In order to obtain the most up to date technologies, they wait until late in the process to procure their medical equipment. This allows the project team very little time to address the rough-in details for the equipment connections, and a lot of changes have to be done once they arrive to the site. If not well planned and executed, this process may become a risk to the project cost and schedule.

Potential Solutions

The purpose of this analysis is to research the most effective ways of sharing information on equipment procurement and furnishing to all the trades involved with the installation of the equipment connection rough-ins. By focusing on one piece of equipment that has had the most impact on the project, I will be able to research and better understand the constraints that the project team currently encounters during this process. Moreover, a strategy could be developed and implemented, focusing on timely decision making and information sharing between trades. If successful, this strategy could further be implemented throughout the whole project's equipment procurement and installation process.

Analysis Procedure

1. Evaluate Existing Procurement & Installation Process
    - Speak/Distribute Surveys to project team to identify issues with existing process
    - Identify one piece of equipment for focus

2. Perform Research
    - Research on chosen equipment
        - Variations between manufacturers & models
        - MEP Rough-ins, Inputs, Connection Requirements
    - Research different methods & strategies that may be potentially used to reduce cost upfront
    - Research tools/technologies available for implementation in cataloging/developing cut sheets
3. Method/Technology/Strategy Development & Implementation
    - Evaluate to determine most effective method/strategy
    - Develop Implementation Plan
4. Participant Feedback and Result Evaluation
    - Distribute Survey to contractors and equipment provider (Steris) for feedback on Implementation
    - Evaluate benefits of strategy implementation over existing process
    - Conclusions and Recommendations

Resources & Data Collection Tools

- Alexander Construction Project Team
- Medical Equipment Provider (Steris)
- Geisinger Health Systems Representative (Contact)
- Interior & MEP Subcontractors
- AE Faculty
- PACE Seminar Contacts

Expected Outcome

After completing an extensive analysis on this topic, we are expected to determine the best method of handling and sharing equipment information effectively, while having the least impact in the construction cost and schedule. By understanding the constraints that the project team has encountered during the equipment and installation procurement process, I will successfully develop and implement a strategy that addresses these issues successfully.

Analysis #4: Re-evaluation of Structural Composite Slab

Opportunity Identification

The MEP, interior, and structural systems of the Geisinger Gray's Woods Ambulatory Care Campus account for over 80% of the building's total cost. In an attempt to lower the building costs, value engineering efforts should be done to any of the following building systems. While the MEP and interior finishes are vital to the quality and performance of the healthcare facility, the building's structural system could be an area to focus in order to identify possible cost reduction practices.

Background Research

When performing value engineering on a project, the main focus is to identify potential areas to save costs and/or schedule time that will not infringe upon the intent of the design. These should add value to the building, rather than reducing the cost through lower quality. The Gray's Woods structural system provides many opportunities for value-engineering efforts. The building is a two-story steel braced framed structure supported over cast-in-place spread footings and slab on grade. The design uses normal weight concrete for the building's foundation, whereas lightweight concrete for the second floor deck slabs. Although both lightweight and normal-weight concrete can fulfill the same structural function, there is a significant cost premium for lightweight concrete. **Table 1** supports the cost comparison between normal and lightweight concrete based on RS Means 2013. When looking into the concrete properties, normal weight concrete is significantly heavier than lightweight concrete. Not only does it incur more loads in the building's structure, but may also impact the fireproofing and moisture content performances of each.

Table 1 – Cost Comparison between lightweight and normal weight concrete

LW vs. NW Concrete				
Concrete Type	**Unit Weight (PCF)**	**Strength (psi)**	**Cost/CY**	***Cost/SF**
Normal Weight	150 +/- 3	5,000	$108.0	$1.97
Lightweight	110 +/- 3	3,000	$133.0	$2.30

All Costs taken from RSMeans 2013
*2½" thick floor slab including finish, no reinforcing

Potential Solutions

An analysis will be done to re-evaluate the building's structural system, with the objective of lowering the building costs while still maintaining the structural integrity of the medical office building. There is an opportunity of looking into the building's composite metal decking, which uses lightweight concrete for the second floor slab. With over 38,000SF of lightweight concrete used for the slabs, project costs could be substantially lowered by using normal concrete instead. Considering that a great deal of spray-on-fireproofing is being used for the building, fireproofing requirements of normal weight concrete may also be another source of cost savings for the project. By altering the lightweight structural concrete slabs to normal weight concrete, a breadth analysis of the building's structural system would be required to address any structural design modifications. Lastly, material and structural changes should be analyzed in order to determine whether this value engineering solution provides any cost savings for the project.

***See Appendix A-1 for Structural Breadth details**

Analysis Procedure

1. Perform Research
    - Research use of Lightweight vs. Normal Weight Concrete
        - Fireproofing
        - Moisture Properties
        - Cost
        - Benefits of each
    - Speak to experienced AE Faculty (Ray Sowers & Ed Gannon)
2. Perform Structural Analysis (Breadth)
    - Change Lightweight to Normal Weight Concrete
        - Address concrete Thickness
        - Address Metal Decking Type & Span
        - Address Beam & Column Sizing
        - Address Foundation Adjustments
3. Evaluate Proposed Changes
    - Cost Analysis
    - Schedule Effects (if any)
    - Compare budget and schedule impacts
4. Perform feasibility analysis to determine most viable solution
    - Benefit analysis based on cost
    - Conclusions and Recommendations

Resources & Data Collection Tools

- Alexander Construction Project Team
- Protect Documents and Specifications
- AE Faculty
    - Linda Hanagan
    - Ed Gannon
    - Ray Sowers
- Structural Steel & Metal Subcontractor (Altoona Pipe & Steel Supply Co.)
- Steel Construction Manual
- Vulcraft Metal Decking Catalog
- AE404 Class – Building Structural Systems in Steel and Concrete

Expected Outcome

By altering the lightweight structural concrete slabs to normal weight concrete, project costs should be significantly reduced. Not only is normal weight concrete cheaper than lightweight, but changing to normal weight concrete may result in cost savings by not having to use fireproofing in some areas. However, the increased loads of normal weight concrete may require a redesign of the entire building structure; therefore, resulting in a higher structural systems cost. A cost analysis based on material and structural changes will be performed in order to determine whether this value engineering solution provides any cost savings for the project. The project schedule, on the other hand, should remain intact throughout this change, as we would be using the same placement methods for both materials.

Conclusion

The in-depth studies of each analysis addressed above are focused on problems and opportunities identified in the Grays Woods Care Campus project, and implements proposed solutions for each. Expected outcomes on all four analysis aim to produce beneficial and desirable results for the owner, project team, and building occupants overall. Virtual mockups will provide an effective tool in obtaining design input from end users for the operating and endoscopy rooms of this facility. Prefabricating the exterior brick walls offsite and installing the modules on a just-in-time basis onsite will greatly reduce construction schedule and alleviate site congestion. Looking into effective ways of handling and sharing equipment information amongst different trades will allow the procurement and installation process to have minimal impact in the construction cost and schedule by reducing amount of rework. Finally, implementing value-engineering on the building's structural composite slabs should result in significant project cost saving. In concluding these analyses, the design and construction process of the Geisinger Grays Woods Ambulatory Care Campus should be significantly improved and these methods could be utilized on future projects to eliminate similar complications.

This project is the culmination of the 5 years of study I have completed in the Architectural Engineering program at The Pennsylvania State University. As such, I hope to showcase all that I have learned when performing these analyses, while also expanding my professional knowledge as I enter the construction Industry.

APPENDIX A

Breadth Topics & MAE Requirements

Structural Breadth Analysis

The second floor slab of the Geisinger Ambulatory Care Campus facility is designed using lightweight concrete on composite metal decking. Although both lightweight and normal-weight concrete can fulfill the same structural function, there is a significant cost premium for lightweight concrete. Altering the second floor slab to normal weight concrete should be a large source of cost-savings for the project. This though, will require an analysis of the building's structural system. For this structural breadth, I will begin by determining a normal weight composite metal decking for this system. Changes with regards to the concrete thickness, fireproofing, and metal decking forms will be addressed in order to design a composite slab that meets structural requirements. With over 40 pounds per cubic foot heavier than lightweight concrete, normal weight would significantly increase loads to the building's structure. Decking span, beam layout and column and beam sizing will be revised in order to determine whether they can support the additional building loads. Additionally, decking deflections will have to be addressed in order to determine whether any re-shoring will be required to support the structure. By comparing the costs savings between changing to normal weight concrete to those costs incurred with modifying the building's structural system, we will be able to make a final recommendation on whether this change is beneficial to this project.

Mechanical Breadth Analysis

The efficiency of the building's mechanical system relies heavily on the thermal performance of the exterior enclosure. In order to justify the replacement of the unitary brick masonry walls by prefabricated panels, a mechanical analysis of the proposed system's thermal efficiency must be performed. Insulation & thermal characteristics of the proposed system will be evaluated in order to determine whether there are any significant changes in the building's thermal performance. Changes in the building's cooling and heating loads will be calculated and used to conduct a lifecycle cost analysis to fully understand whether implementing precast exterior wall panels would be beneficial for this project.

MAE Requirements

The MAE requirements for the senior thesis research will be fulfilled on the first analysis, the implementation of Virtual Mockups for the Operating and Endoscopy rooms of the Grays Woods project. Master Level course 'Virtual Facility Prototyping' (AE597F) evaluates different ways of implementing models in order to improve the efficiency of building design and construction. Throughout this course, I have learned to use various programs and tools, such as Revit and Unity, which are commonly used in the industry for developing these technologies. The knowledge and modeling experience acquired throughout this course will be greatly beneficial in developing and implementing virtual mockups for the operating and endoscopy rooms of this facility.

APPENDIX B

Weight Matrix

Analysis Weight Matrix

As shown in **Table 2**, a weight matrix has been created to visualize the level of effort involved with each analysis. This involves four core thesis investigation areas of the following four areas:

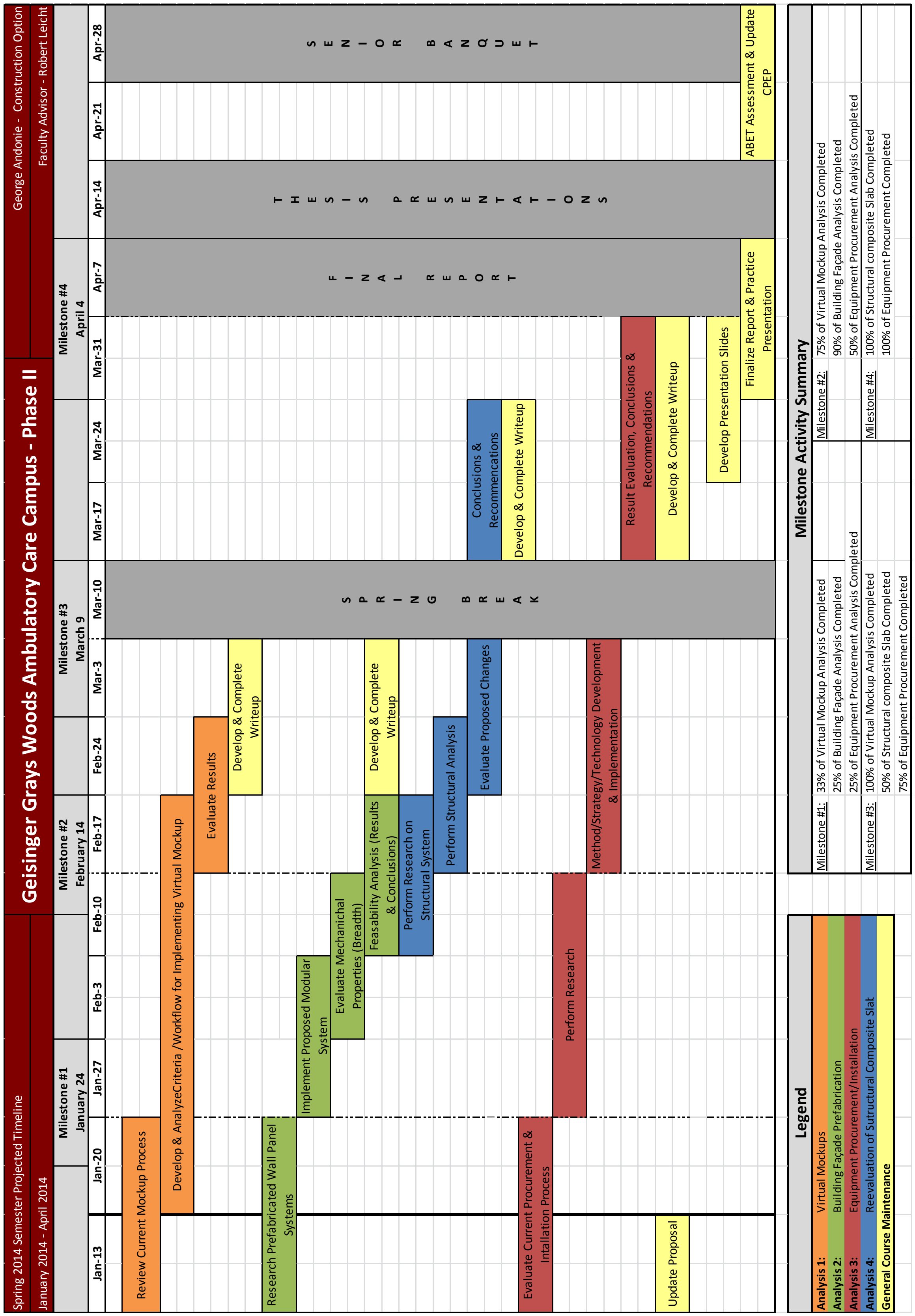
1. **Critical Industry Research:** Address a current issue facing the construction industry, and perform an independent research on this issue.
2. **Value Engineering Analysis:** Identify potential areas to save cost and/or schedule time that will not infringe upon the intent of the design.
3. **Constructability Review:** Evaluate a building system of your choice to identify alternative design schemes that would ease coordination problems.
4. **Schedule Reduction/Acceleration:** Choose an area of the project that has presented challenges and frustrations to the contractor, and implement a plan to assist with this issue.

Table 2 – Weight Breakdown for each Analysis

Weight Matrix					
Analysis Description	**Critical Industry Research**	**Value Engineering**	**Constructability Review**	**Schedule Reduction**	**Total Weight**
Analysis 1: Virtual Mockups	10%	-	10%	5%	**25%**
Analysis 2: Building Façade Prefabrication	15%	5%	10%	10%	**40%**
Analysis 3: Equipment Procurement/Installation	5%	-	5%	5%	**15%**
Analysis 4: Structural Composite Slabs	-	15%	5%	-	**20%**
Total Weight	**30%**	**20%**	**30%**	**20%**	**100%**

APPENDIX C

Spring Semester Projected Timetable


Spring 2014 Semester Projected Timeline
January 2014 - April 2014
Geisinger Grays Woods Ambulatory Care Campus - Phase II
George Andonie - Construction Option
Faculty Advisor - Robert Leicht
Milestone #1 January 24
Milestone #2 February 14
Milestone #3 March 9
Milestone #4 April 4
Jan-13
Jan-20
Jan-27
Feb-3
Feb-10
Feb-17
Feb-24
Mar-3
Mar-10
Mar-17
Mar-24
Mar-31
Apr-7
Apr-14
Apr-21
Apr-28
Review Current Mockup Process
Develop & AnalyzeCriteria /Workflow for Implementing Virtual Mockup
Evaluate Results
Develop & Complete Writeup
Research Prefabricated Wall Panel Systems
Implement Proposed Modular System
Evaluate Mechanichal Properties (Breadth)
Feasability Analysis (Results & Conclusions)
Develop & Complete Writeup
Perform Research on Structural System
Perform Structural Analysis
Evaluate Proposed Changes
Conclusions & Recommencations
Develop & Complete Writeup
Evaluate Current Procurement & Intallation Process
Perform Research
Method/Strategy/Technology Development & Implementation
Result Evaluation, Conclusions & Recommendations
Update Proposal
Develop & Complete Writeup
Develop Presentation Slides
Finalize Report & Practice Presentation
ABET Assessment & Update CPEP
SPRING BREAK
FINAL REPORT
THESIS PRESENTATIONS
SENIOR BANQUET
Legend
Analysis 1: Virtual Mockups
Analysis 2: Building Façade Prefabrication
Analysis 3: Equipment Procurement/Installation
Analysis 4: Reevaluation of Sutructural Composite Slat
General Course Maintenance
Milestone Activity Summary
Milestone #1: 33% of Virtual Mockup Analysis Completed
25% of Building Façade Analysis Completed
25% of Equipment Procurement Analysis Completed
Milestone #2: 75% of Virtual Mockup Analysis Completed
90% of Building Façade Analysis Completed
50% of Equipment Procurement Analysis Completed
Milestone #3: 100% of Virtual Mockup Analysis Completed
50% of Structural composite Slab Completed
75% of Equipment Procurement Completed
Milestone #4: 100% of Structural composite Slab Completed
100% of Equipment Procurement Completed