New Regional Medical Center
EAST NORRITON, PA

Senior Thesis
Final Proposal

December 9

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Department of Architectural Engineering
Construction Management Option

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EXECUTIVE SUMMARY

Senior Thesis Final Proposal identifies four analyses which will be investigated and performed for the final thesis report on the New Regional Medical Center's design and construction program. This report was developed through the identification of a central theme on providing construction efficiency through information exchange, by developing BIM use efficiency in construction planning, schedule efficiency in both an architectural and structural applications, and facility information development and exchange.

Analysis No. 1 | BIM Information Optimization for the Structural Model

It is expected that BIM information optimization will streamline the construction estimating and planning processes on this project. It is believed that this analysis will expose new opportunities for model information usage for the structural system of the New Regional Medical Center. The goal of this analysis is to reduce time needed for estimating and site logistics planning, in addition to leveraging BIM with readily available model information.

Analysis No. 2 | Prevention of Risks in Delay of Atrium Enclosure Construction

An effective schedule analysis and architectural redesign of the atrium curtain wall will provide a strong comparison of the benefits in early designer and builder communication. With extensive research into the conditions that lead to the missed milestone date, this analysis will help develop a procedure in order to recognize potential schedule concerns on future projects with a similar glazing enclosure system. These preventative planning measures will assist in revising activity sequencing and resource loading. With the additional investigation through an Architectural Breadth, as detailed in Appendix A, this analysis will also demonstrate the benefits of modularization.

Analysis No. 3 | Schedule Acceleration Recovery of Delay in Pour Stop Construction

This analysis will develop a feasible schedule acceleration scenario in order to recover from existing construction delays regarding the structural pour stops for the New Regional Medical Center. With the additional investigation through a Structural Breadth, as detailed in Appendix A, this analysis will also demonstrate the influences of the design decision for the pour stop over a typical building expansion joint. This analysis will identify the importance of design alternative discussions between the designer and builders through schedule and cost comparisons.

Analysis No. 4 | Development of a Virtual Mockup for Design Approval, Training, and Facility Management

Incorporation into a working virtual mockup is an innovative solution to provide substantial benefits of project development based on designer – builder – user collaboration. In this analysis, an operating room will be modeled, as designed by the construction documents. This investigation will also develop workflow processes to produce usable models during the construction and operation lifecycle of the hospital. As a package, this visual can be turned over as a focused BIM model, ensuring proper construction logistics, as-built information, user information, and performance standards of the space. The goal of this analysis is to efficiently produce BIM models for design, training, and facility management for the owner, user group, and facility management staff.

THE NEW REGIONAL MEDICAL CENTER

OWNER: THE NEW REGIONAL MEDICAL CENTER, INC.

BUILDING INTRODUCTION

Site Overview

The New Regional Medical Center is located at 559 West Germantown Pike in East Norriton, Pennsylvania (See Figure 1). The selected site is an 84-acre greenfield property, which was previously occupied by an 18-hole golf course, miniature golf course, and auxiliary buildings; this site provides a very accessible and open plan for development. It is located directly off of a main arterial road (Germantown Pike) which bisected half of Montgomery County, and provides access to major roadway systems of neighboring counties. The site design shall preserve over one-third of the property as open green space for patients, visitors, and public walking trails. Along Germantown Pike, on the Southwest and Southeast corners of the property, there are existing establishments that range from restaurants, drugstores, and retail services, as shown in Figure 2.

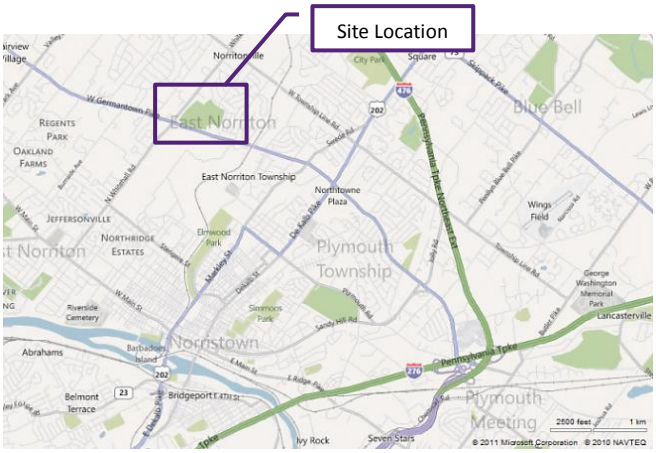

Figure 1: Regional Map | *bing.com*

Architectural Design

The facility's architectural design includes 146 beds: 96-bed medical/surgical, 22-bed intensive care unit, 20-bed obstetrical unit, and an 8-bed neonatal intensive care unit. It also includes a state-of-the-art 24 hour emergency department, advanced cancer care, advanced cardiac services, in addition to cutting-edge catheterization and electro-physiology laboratories (Wooley, 2010). Future campus development plans include direct on-site access to primary care at the adjacent medical office building. The main architectural feature of the project is the five story central patient tower atrium. This atrium serves as the location of the main entrance, and the vertical conveyance systems for the hospital. It also provides a sun-filled space, in which each floor's balcony steps back from the curtain wall to provide an open, large, panoramic view of the surrounding green space and across Germantown Pike onto the preserved lands of the Norristown Farm Park.

Figure 2: Birds-Eye View (Looking North) | *bing.com*

Architectural Materials

The primary building enclosure is a curtain wall system which incorporates precast panels and glazing units, as shown on the following page, in Figure 3. The architectural precast concrete panels are located on the North, South, and East façade of the patient tower, and feature linear windows of consistent size. In order to create aesthetic

variation and texture across the surfaces, sandblasting of varying degree was requested. In addition to this, split-faced concrete masonry units are located on the building at the West, North, and East sections of exterior wall at the Emergency Department and the Central Utility Plant. Metal panel components are located on the building at the West facade of the patient tower in addition to the screen wall surrounding the rooftop mechanical systems for the low roof.

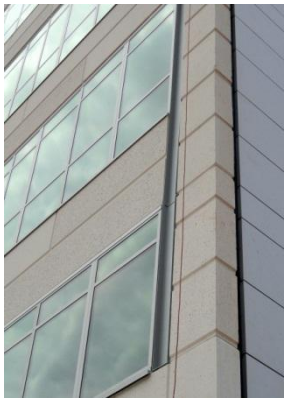

Figure 3: Façade System
Courtesy of Gilbane Building Co.

Sustainability

The New Regional Medical Center is dedicated to implementation of sustainability features within design, construction, and lifecycle of the facility. With consideration for the patients, the community, and the environment, countless steps have been taken by the Einstein-Montgomery Partnership and project team to achieve their goal of a LEED Certified rating for the medical campus. Sustainability features include a land preservation and waste management program, management of solar gain through architectural design and building placement, and design development for implementation of future sustainable technologies.

Construction Programming

The New Regional Medical Center includes 4 stories above grade, with a partial sub-grade ground floor. It will stand at 90'-8" tall, and have a gross building area of approximately 360,000 square feet. The project is being delivered through a construction management at risk contract, under an approximate construction cost of $147 million using a guaranteed maximum price contract.

Construction began on July 6, 2010 and is scheduled to be completed on August 31, 2012.

PROJECT TEAM DIRECTORY

OWNER:	NEW REGIONAL MEDICAL CENTER, INC. [PARTNERSHIP OF ALBERT EINSTEIN HEALTHCARE NETWORK & MONTGOMERY HEALTHCARE SYSTEM]
CONSTRUCTION MANAGER:	GILBANE BUILDING COMPANY
ARCHITECT:	PERKINS + WILL
STRUCTURAL ENIGNEERS:	O'DONNELL & NACCARATO
CIVIL ENGINEER:	BOHLER ENGINEERING
MEP & FIRE PROTECTION ENGINEERS:	PWI ENGINEERING
TRAFFIC ENGINEERS:	TRAFFIC PLANNING & DESIGN, INC
LANDSCAPE ARCHITECT:	WELLS APPEL

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TECHINCAL ANALYSIS DESCRIPTIONS

ANALYSIS 1 | BIM INFORMATION OPTIMIZATION FOR THE STRUCTURAL MODEL

PROBLEM IDENTIFICATION

As reviewed in *Technical Report No. 2*, the Building Information Modeling (BIM) implementation on the construction of this project was minimal; however, the BIM implementation was sufficient for various other uses during structural design. This analysis will study the usability in level of detail (LOD) and information embedment of BIM documentation versus traditional document methods. The structural model will be the focus point of BIM information optimization due to the quality of the model developed for the New Regional Medical Center.

BACKGROUND RESEARCH

Technical Report No. 2 consists of the initial research into the structural model BIM analysis. In this report, a full structural system quantity takeoff was produced from the Revit model, and a cost estimate was performed using RSMeans data. The BIM information optimization concept was developed during discussion following the PACE Roundtable event after recognizing the cost savings potential for the estimating team's efforts, in addition to the identification of other usable information for the Construction Management team located within a typical structural model. Through additional discussion with leading construction management firms, this starting point was designed in order to enhance model-based information leveraging. This analysis will research and develop the process to retrieve embedded information to develop a structural steel estimate, identify the location of critical-pick steel members, and develop a 4D site logistics modeling for the erection phase.

POTENTIAL SOLUTIONS

(1) An increase in efficiency for structural steel estimating, crane-pick analysis, and overall site logistics.
(2) Recognition of gaps within embedded model information.
(3) The development of innovative BIM opportunities for construction management project planning.
(4) A more transparent understanding of the structural system on the project.

METHODOLOGY

(1) Retrieve the structural estimate, schedule, pick plan, and models from Gilbane Building Company.
(2) Analyze the documents, notably the structural model for optimization potential.
(3) Perform research on similar implementation strategies, and compile industry data.
(4) Develop the process and guidelines for implementation on the project. Guidelines will include cost and schedule analysis of personal training and changes in productivity and efficiently of workforce.
(5) Outcomes will be reviewed with the project team for reflection and development feedback.

RESOURCES & TOOLS

(1) Industry Professionals
    a. Specializing in BIM Implementation

b. Modelers for structural engineers

(2) AE Faculty – Construction Management & Structural
(3) Gilbane Project Team
(4) Applicable Project Documents
(5) Applicable Software

EXPECTED OUTCOME

It is believed that this analysis will expose new opportunities for model information usage for the structural system of the New Regional Medical Center. These three uses are developed with the goal to identify the information required within the structural model for analysis, reducing time needed for estimating and site logistics planning and producing additional BIM leverage with readily available model information.

ANALYSIS 2 | PREVENTION OF RISKS IN DELAY OF ATRIUM ENCLOSURE CONSTRUCTION

PROBLEM IDENTIFICATION

As reviewed in *Technical Report No. 3*, the atrium glazing enclosure is an extremely challenging element of the New Regional Medical Center. Not only are its finishes located on the critical path of the project, but enclosure delay of the space, and impacts on additional critical activities, is a risk to the project's schedule. The atrium construction process will be analyzed for extremely tight or aggressive activities.

BACKGROUND RESEARCH

Technical Report No. 3 consists of the initial research into the critical path relying on the achievement of the enclosure milestone. Multiple activities were recognized as extremely aggressive, and at risk of delay to the curtain wall enclosure date. Procedures to identify potential concerns and risks for curtain wall installation were identified as a benefit to future projects including similar curtain wall systems.

POTENTIAL SOLUTIONS

(1) Risks for potential delays due to activity sequencing, weather, and other implication will be identified. Insight on these concerns will be attributed to the curtain wall design in comparison with other curtain wall systems.
(2) Equipment, resources, and installation methods will be identified and revised to ensure enclosure milestone is met, satisfying the requirements on the balance of the critical path on the project.
(3) Costs of this analysis will be reviewed in comparison to the project costs of the work, in addition to the actual performance of the work to verify potential of risk identification.

METHODOLOGY

(1) Interview the project team to obtain information regarding the curtain wall design, system details, and subcontractor information.
(2) Analyze the documents, notably the project schedule and installation requirements of the curtain wall.
(3) Identify the areas of concern and highest risk to the milestone date.
(4) Implement preventative measures to achieve the curtain wall enclosure date.

RESOURCES & TOOLS

(1) Industry Professionals
    a. Curtain wall architect
    b. Curtain wall subcontractor
(2) AE Faculty – Construction Management
(3) Gilbane Project Team
(4) Related Literature
(5) Applicable Project Documents
(6) Applicable Software

EXPECTED OUTCOME

With extensive research into the conditions that lead to the missed milestone date, this analysis will help develop a procedure in order to recognize potential schedule concerns on future projects with a similar glazing enclosure system. These preventative planning measures will reevaluate the planned construction process, in addition to assist in revising to compare and identify the most financially appropriate process. With the additional investigation through an Architectural Breadth, as detailed in Appendix A, this analysis will also demonstrate the benefits of modularization, and a higher level of focus on this critical project element.

ANALYSIS 3 | SCHEDULE ACCELERATION RECOVERY OF DELAY IN POUR STOP CONSTRUCTION

PROBLEM IDENTIFICATION

The schedule acceleration method for the pour stop activity, as mentioned in the *Constructability Issues: Concrete Pour Stops* section of *Technical Report No. 3* will be analyzed. The float on related activities to the concrete pour stops, in addition interior floor finishes will be identified to recognize limits of delay, and affects onto the project's critical path. Acceleration would include the installation of temporary enclosures, the startup of heating equipment, in addition to restructuring the trade coordination and crew sizes to recover the schedule in an appropriate fashion.

BACKGROUND RESEARCH

Technical Report No. 3 consists of the initial research into the pour stop analysis. Discussions and reviews have been made with the structural engineer to analyze the development of this design decision. Additionally, the project team has discussed concerns with changes need to be made regarding interior phasing required to reach the quality control standards of the pour strip in addition to recovering the schedule delays and the impacts on future activities.

POTENTIAL SOLUTIONS

(1) This analysis would revise interior logistics, trade coordination, temporary enclosure systems, and labor agreements to recover from the schedule delay.
(2) Constructability and quality control concerns of this system, under a partially heated structured, will be researched and identified.
(3) The schedule acceleration would be compared against the existing project delay to find the preferred constructability and cost-benefit scenario.

METHODOLOGY

(1) Interview the project team to obtain information regarding the pour stop design, installation process, and subcontractor information.
(2) Analyze the documents, notably the project schedule and installation requirements of the pour stop.
(3) Identify the areas of concern and highest risk to schedule delays
(4) Implement schedule acceleration tactics to recover from the delay in a feasible manner.

RESOURCES & TOOLS

(1) Industry Professionals
    a. Project's Structural Engineer & 3rd Party Structural Engineer
    b. Related subcontractors
(2) AE Faculty – Construction Management & Structural
(3) Gilbane Project Team
(4) Related Literature
(5) Applicable Project Documents
(6) Applicable Software

EXPECTED OUTCOME

This analysis will develop a feasible schedule acceleration scenario in order to recover from existing construction delays regarding the structural pour stops for the New Regional Medical Center. With the additional investigation through a Structural Breadth, as detailed in Appendix A, this analysis will also demonstrate the implication of the design decision for a pour stop over a typical building expansion joint.

ANALYSIS 4 | DEVELOPMENT OF A VIRTUAL MOCKUP FOR DESIGN APPROVAL, TRAINING, AND FACILITY MANAGEMENT

PROBLEM IDENTIFICATION

As discussed earlier in 'Analysis 1 | BIM Information Optimization,' this project underutilized recent growth and implementation of Building Information Modeling. Although not requested by the owner, recent developments in virtual mockup and model interface with the user group, has created interest in a design approval, training, and facility management model. Additionally, the 'Acceleration Options: Sector 1C In-Wall Activities' section of *Technical Report No. 3*, identifies the operating rooms as one of the most critical areas of the hospital, regarding coordination and quality control, in addition to being one of the final elements within the critical path of the New Regional Medical Center. As the first building for the new medical campus, this facility is the perfect opportunity to capture the capabilities of new technologies and information management available, capturing both construction and maintenance benefits.

BACKGROUND RESEARCH

Technical Report No. 3 consists of the initial research into the virtual mockup opportunities associated with this analysis. Similar to model development for subcontractor coordination, a virtual mockup can be built for owner review, and staff training. Utilizing specialized facility, immersion into the virtual operating room is possible, with layout, product, and usability review. As one of the most congested and technologically advanced areas of the hospital, proper coordination of the elements within the room should be performed to ensure quality control of the installations, operation, and maintenance.

POTENTIAL SOLUTIONS

(1) Decrease costs through utilization of virtual mockups.
(2) Increase user group and owner's input on layout and space development.
(3) Decrease potential for unforeseen delays during operating room construction.
(4) Focused coordination and programming efforts to increase quality control.
(5) A more transparent understanding of the operating room maintenance on the project.

METHODOLOGY

(1) Research implementation and development of operating room mockups and training models.
(2) Consult owner and facility management staff to identify needs, requests, and attributes for the FM model.
(3) Develop virtual mockup of operating room as base model for design reviews.
(4) Upgrade design review model to staff training and user group model.
(5) Detail virtual mockup to create facility management model per the requests of the owner and FM staff.
(6) Outcomes will be reviewed with the owner and FM staff for reflection and development feedback.

RESOURCES & TOOLS

(1) Industry Professionals

a. Specializing in BIM Implementation
b. User Groups

(2) AE Faculty & Researchers – Construction Management
(3) Gilbane Project Team
(4) Applicable Project Documents
(5) Applicable Software
(6) Applicable Immersion Facilities

EXPECTED OUTCOME

In this analysis, BIM will be utilized to plan and layout a typical operating room, as designed by the construction documents. This investigation will also develop a virtual mockup of the facility and provide a comparison to the built mockups. As a package, this visual can be turned over as a focused BIM model, ensuring proper construction logistics, as-built information, user information, and performance standards of the permanent elements of the space. Model turnover and interoperability will be essential to a successful performance model. Analysis will include modeling and training costs required for facility management use.

SPRING THESIS OBJECTIVES

ANALYSIS WEIGHT MATRIX

A weight matrix, shown in Table 1, was developed in order to appropriate allocate effort between the four core areas of investigation. The percentages within the matrix signify the expected level of time and effort assigned to each of the four analysis areas, including the two breadths associated with the Atrium Enclosure Analysis and Pour Stop Analysis, as identified in Appendix A.

Table 1: Weight Matrix of Distribution in Investigation Areas

Analysis Description	Industry Research	Value Engineering	Constructability Review	Schedule Reduction/Acceleration	Total
BIM Information Optimization	15%	-	5%	-	20%
Atrium Enclosure & Breadth	-	10%	10%	10%	30%
Pour Stop Analysis & Breadth	-	10%	10%	10%	30%
Virtual Mockup & FM Model	15%	-	5%	-	20%
Total	30%	20%	30%	20%	**100%**

PRELIMINARY SCHEDULE

In order to ensure a comprehensive investigation into each analysis and review of the outcomes for the thesis research on the New Regional Medical Center, a preliminary schedule for the spring semester has been developed. This schedule focuses on each of the four analysis areas, in addition to the incorporation of the two breadth topics. Four milestones were provided by the course moderators and are as follows: (1) January 27, (2) February 13, (3) March 2, and (4) March 26. In addition to this, the final written report is due on Wednesday, April 4, 2012, with the Faculty Jury Presentations taking place the following week (April 9 – 13). On Friday, April 27, 2012, the Thesis Project will conclude at the Senior Banquet.

See **Appendix B** for the complete Spring Semester Preliminary Schedule.

CONCLUSION

Through the four areas of technical analysis, in addition to the two breadth topic introduced in Appendix A, the proposed thesis project for the New Regional Medical Center's is design to provide construction efficiency through information exchange. It is expected that BIM information optimization will streamline the construction estimating and planning processes on this project. An effective schedule analysis and architectural redesign of the atrium curtain wall, in addition to a structural redesign of the concrete pour stops, will provide a strong comparison of the benefits in early designer and builder communication. Finally, the development of a virtual mockup, and detailing for construction and building operation will identify innovative solutions and provide substantial benefits of project based designer – builder – user collaboration.

This document is a working submission and will be revised through advisor and industry contact feedback.

APPENDIX A

BREADTH TOPIC ANALYSIS

BREADTH TOPICS

The following two breadth topics include analysis into technical disciplines, beyond construction management, that are taught within the Architectural Engineering program at The Pennsylvania State University. These breadths focus on investigations into the alternative discipline in order to enhance concurrent analysis topics within the construction management technical investigation, and supplement research efforts within the thesis project.

ARCHITECTURAL BREADTH | *CONTRIBUTES TO TECHNICAL ANALYSIS 2*

The architectural breadth will involve redesigning the New Regional Medical Center's to align more clearly with the value engineering efforts mentioned previously in the 'VE Considerations' section of *Technical Report No. 3*. The extent of redesign will not be as substantial as the VE recommendation to reduce the atrium from 4 stories to 1 story, for cost and schedule savings purposes. Redesign will be implemented to revise the assembly feature of the atrium's curtain wall glazing. Redesigning efforts will push for modularization of the glazing in order to meet the aggressive enclosure deadline and parallel construction sequencing within the rest of the building. Additionally, the goal of the breadth is verify the benefits of prefabrication of this critical path item. Methods would include research into Medical Center architectural design, materials, and curtain wall performance requirements. Constructability, costs, and schedule durations would be reviewed and compared to the existing system. The new design would be developed in Autodesk Revit Architecture, and merged into the existing architectural model to produce renderings for owner review. Architectural details, including assembly programming will complete the architectural breadth analysis.

STRUCTURAL BREADTH | *CONTRIBUTES TO TECHNICAL ANALYSIS 3*

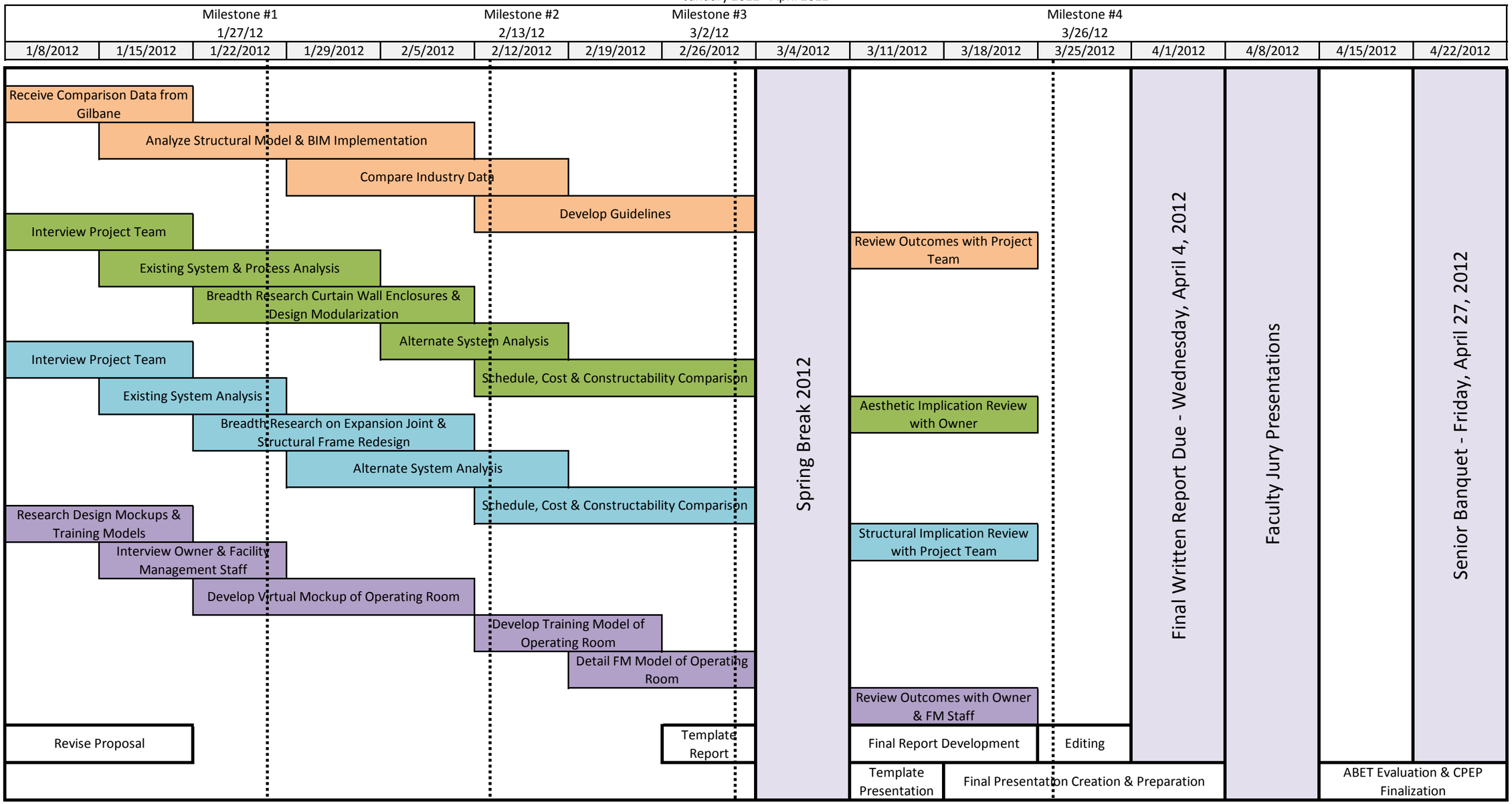
The structural breadth will include structural redesign of the concrete pour stop as a typical building expansion joint (or as recommended otherwise by the project's structural engineer). Case studies would be analyzed to review the conceptual and structural differences within these two systems. The structural engineer would be consulted on the decision to utilize the pour strip in the original design, and structural calculations will be performed to compare this system to a building expansion joint system. Additional costs, schedule impacts, and constructability reviews will be considered as a substantial part of the redesign, notably focusing on foundation changes, and steel frame revisions. Methods will consist of hand calculation in addition to virtual mock ups in Google Sketch Up and/or Autodesk Revit Structural of each system to covey the differences in design, assembly, and constructability. Structural details of the new system, including framing plans will complete the structural breadth analysis.

APPENDIX B

SPRING SEMESTER PRELIMINARY SCHEDULE

PROPOSED THESIS SEMESTER SCHEDULE

January 2012 - April 2012



Milestone 1	Structural Pour Stop Analysis Completed
Milestone 2	Breadth Research & Operating Room Virtual Mockup Completed
Milestone 3	BIM Optimization Guidelines & Operating Room FM Model Completed
Milestone 4	Outcome and Implication Review & Commentary Completed

	BIM Structure Analysis | Information Optimization
	Atrium Enclosure Analysis | Delay Prevention
	Pour Stop Analysis | Schedule Acceleration
	Virtual Mockup | Design Approval, Training, & Facility Management

APPENDIX C

THESIS REFERENCES

References

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Leicht, R. (2011, December 1). The Pennsylvania State University, AE Department. (B. Nahas, Interviewer).

Packer, A. (2011, October 28). Gilbane Building Company. (B. Nahas, Interviewer).

PACE Roundtable. (2011, November 9). (B. Nahas, Attendee).

Shaheen, J. (2011, November 9). (B. Nahas, Interviewer).

Software

Microsoft Excel. (2010). USA: Microsoft.