New Regional Medical Center

EAST NORRITON, PA

Technical Report
No. 3

November 16

Brian J. Nahas
The Pennsylvania State University
Department of Architectural Engineering
Construction Management Option

AE 481W – Fall 2011
Faculty Advisor: Dr. Robert Leicht

Technical Report No. 3

Brian J. Nahas

Construction Management Option

EXECUTIVE SUMMARY

Technical Report No. 3 focuses on investigation and identification of potential research areas within the New Regional Medical Center's design and construction program. This report was developed through interview and exploration into project management to locate: constructability challenges, schedule risks and compressions, value engineering decisions, and critical industry issues, in order to deliver a summary on the New Regional Medical Center problematic features of technical design and construction methods.

This document includes a critical path schedule and analysis, which further develops constructability challenges which the project encountered. The New Regional's Medical Center's critical path consists of 83 activities over 500 working days. It began on October 29, 2010 and concludes on October 15, 2012. This path revolves primarily around non-accessible drywall finishes in the patient tower, in addition to heavy rough-in in the operating and surgical cores of the medical center, primarily sector 1C. The critical path concludes with many of the finishing elements of the atrium of the facility. This area is the key focus for the final 7 months of the project, as owner furnished equipment begins to be installed. Major constructability challenges include the concrete pour stops, pneumatic tubing, and the patient lifts. The concrete pour stop challenges came about due to a delay on the building enclosure milestone, preventing the ability to condition the building. The other two challenges are directly impacted due to additions to the originally coordinated system, and gaps in coordination and construction sequencing.

Major value engineering (VE) topics involved the redesign of the proposed green roofs and roof gardens to a 20 year TPO single ply, which saved over $2,470,500. Additional topics included scaling back the high end finishes to standard finishes, capturing a savings of $3,855,600. Finally, VE topics that were considered, but not carried through are discussed, notably scaling down the size of the atrium, and redesigning the associated features.

Additional results concerning the PACE Roundtable meeting are reflected with relevant topics for this facility are included. From this conference, and discussion with industry professionals, four problematic features were recognized as potential for the thesis proposal, and spring semester research. These topics include: (1) Level of Detail Just-In-Time BIM Implementation, (2) an Atrium Enclosure Redesign, (3) Concrete Pour Strip versus Expansion Joint, and (4) a Virtual Mockup and Performance Model.

Through the completion of this report, and the distribution of the information contained within, focus will be placed on continued research into the four areas of interest listed above. Investigation into these items, in addition to continued industry commentary, provides a strong lead into proposal elements for the depth and breadth necessary of Senior Thesis. Analysis of the information contained in Technical Report No. 3 permits a comprehensive understanding of the project's challenges, critical path, and the opportunities for the redevelopment of critical industry issues within the New Regional Medical Center. This knowledge will direct the development of the Senior Thesis Proposal.

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.

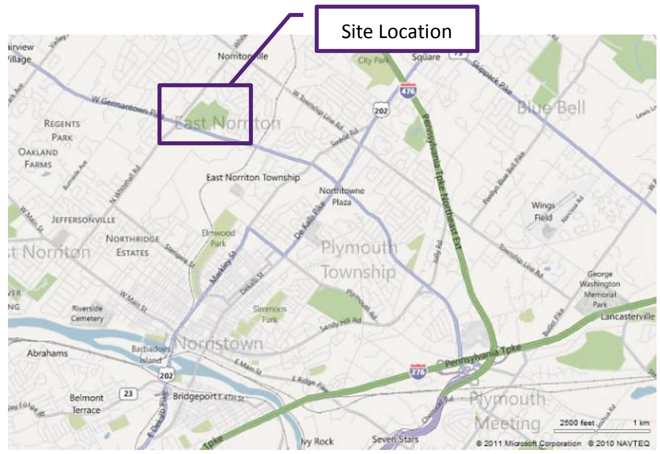


Figure 1: Regional Map | *bing.com*

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.

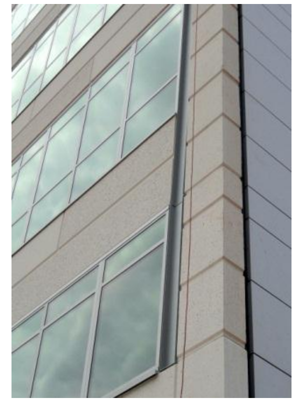


Figure 3: Façade System
Courtesy of Gilbane Building Co.

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

TABLE OF CONTENTS

CONSTRUCTABILITY CHALLENGES

CONSTRUCTABILITY ISSUES

The New Regional Medical Center's design includes multiple construction challenges. The top three unique issues on this project are: (1) concrete pour stops, (2) pneumatic tubing, and (3) patient lifts. Although not necessarily a challenge within themselves, these three components have encountered various constructability issues due to design, coordination, and construction constraints. All three items were a challenge that the site team had to overcome and devise methods for execution in the field. Currently the concrete pour stops and the pneumatic tubing are ongoing challenges on the project.

CONCRETE POUR STOPS

The New Regional Medical Center is roughly 556 feet in length and has two concrete pour stops, per floor, located within each patient tower, which are offset 125 feet from the east and west exterior walls (as noted in Figure 4A). Although the main structure is steel with metal decking, the structural design detailed pour stops in lieu of building expansion joints. This connection detail requires the entire building to be enclosed and climate controlled prior to pouring the final connection. Once the structural steel and concrete decking reach typical interior temperature conditions, and transition through temperature expansion and contraction, this strip will be in-filled, permitting stronger shear strength in the slab and a more rigid frame for the facility (as shown in Figure 4B).

Unfortunately, the building enclosure date was missed on the project, which induced schedule delays for a conditioned facility. Without a neutralized temperature in the space, and adequate time for the materials to expand and contract, the pour strip could not be placed. Ultimately this delay affects interior finishes, such as flooring, as the pour strip areas still contain exposed metal decking and reinforcing for the floor slab.

In order to overcome this issue, and return the project back to the intended schedule, temporary enclosures were made at the connection of the patient tower and the atrium, as the atrium glazing was still being installed. Once temporary enclosure was complete, the towers were conditioned to the heat requirements for the pour strips.

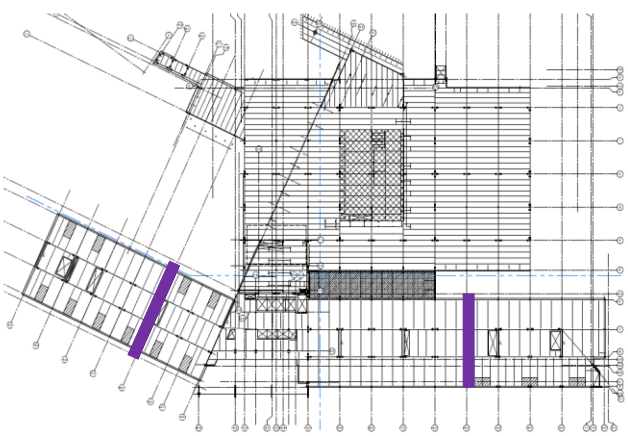


Figure 4A: Second Floor Overall Framing Plan
Detail from Sheet S-120 | Perkins + Will

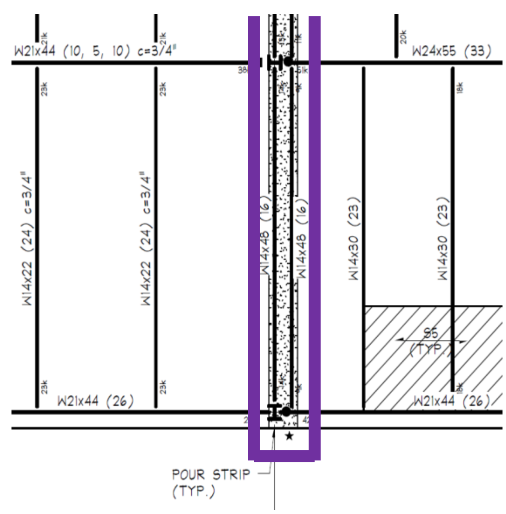


Figure 4B: Enlarged Pour Strip
Detail from Sheet S-220B | Perkins + Will

However, it is still unknown the extent of building expansion and contraction that will occur once the atrium is enclosed and conditioned, and how that will affect the strength of the structure, notably if the pour strips are placed before permanent enclosure. Discussions and reviews have been made with the structural engineer to analyze the development of this alternative plan, in addition to construction phasing required to reach the quality control standards of the pour strip in addition to recovering the schedule and impacts of a delayed floor slab.

PNEUMATIC TUBING

Pneumatic tubing (P-Tube) is located within the entire hospital and consists of 6" tubing connecting 16 stations (as shown in Figure 5). This system also includes blowers and diverters as necessary to provide a fully functional system for the expanse of tubing and stations within each level of the medical center. The P-Tube was associated with the mechanical, electrical, plumbing, and fire protection (MEPF) coordination efforts conducted during subcontractor system design and it was involved in the clash detection process. Due to the small tolerances for this system, in addition to large radius sweeps for tubing, coordination and placement of this system was challenging. However, through multiple iterations of layout design and model sharing between the MEPF subcontractors, the system was designed with layouts being sent directly out of the model to generate the shop drawings.

Due to the strict requirements in the specification which require this system to be installed only after the wet operations are completed, the subcontractor is faced with a difficult installation in order to properly position all of the sweeps and runs of the system. Fortunately, many of the trades in the MEPF coordination process have participated on previous hospital projects, which permitted a greater level of transparency and assistance for the P-Tube subcontractor installation coordination.

Although the original P-Tube design included the expansion of the 4th floor, accommodating up to five additional stations without having to upgrade the main infrastructure of the system, additional stations were added to

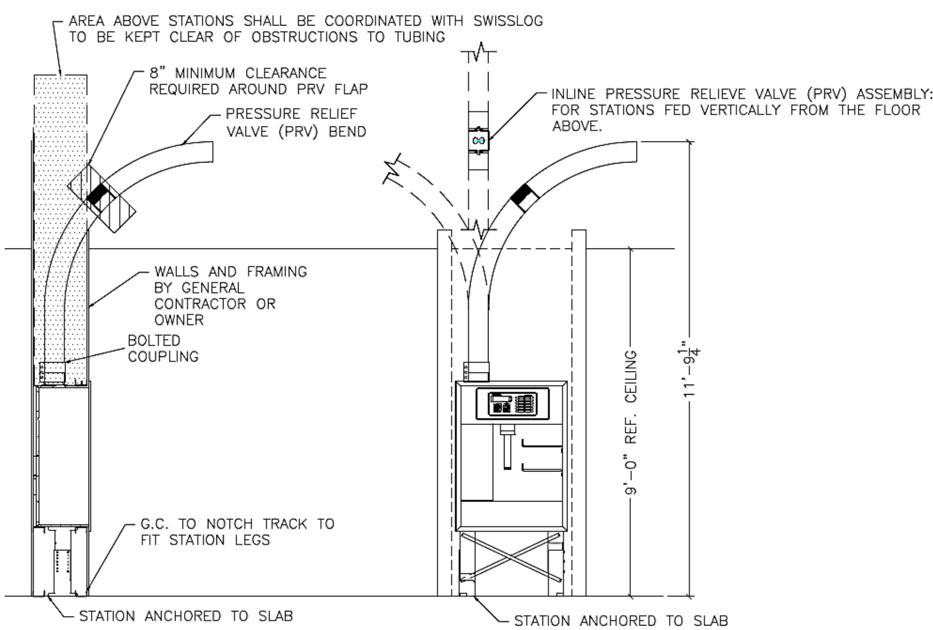


Figure 5: Pneumatic Tubing Station
Detail from Submittal | SwissLog

the ground level. This addition took place after coordination models were signed-off, and after a majority of the overhead rough-ins, of the other systems, were installed. In order to overcome this challenge, the additional P-Tube was modeled with clash reports within the previously coordinated models by the P-Tub subcontractor, in order to find the path of least conflict. Once designed, and approved by the other MEPF trades, conflict components were removed and re-worked around the path of the new P-Tube. This change was associated with an owner's request, resulting in a change order, and required the site team to not only coordinate cost changes of redesign, but also demolition, and reinstallation schedule impacts. This challenge is ongoing for the ground level, and will affect minor system changes and capacity increase on blowers and diverters in other areas of the hospital.

PATIENT LIFTS

The ceiling mounted patient lift system is designed for the transfer of patients between the patient bed, surgical beds, and wheelchairs. The system has fixed recessed rails which are mounted parallel to the patient bed at the location indicated in Figure 6A. The patient lift system will also have a sliding rail that is perpendicular to the patient bed, and pass just below the finished ceiling, spanning between the fixed rails. The lift is designed with a capacity of 770 lbs. or 1,100 lbs. depending on the room type.

The patient lifts were associated with the MEPF coordination process, as this system places a large amount of steel into the ceiling plenum. Although revisions were made to the other systems to accommodate the location of this system directly over the patient bed, challenges occurred during the final structural connection in the installation process. Due to the delivery date of the lifts occurring well after the installation of most overhead rough in, it was extremely difficult to direct the steel into place, let alone secure it to the structural frame at the top of the plenum. This created an issue where some rough-ins had to be removed and reinstalled after the patient lift hangers (as shown in Figure 6B) were in place.

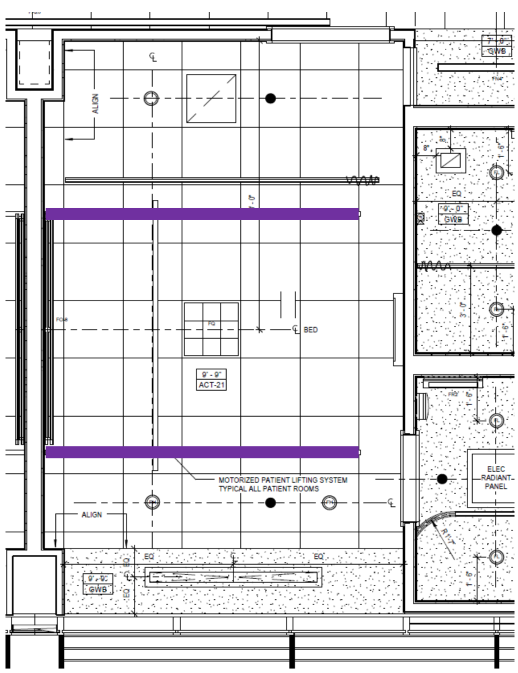


Figure 6A: Reflected Ceiling Plan (Typ. Patient Room)
Detail from Sheet A-537 | Perkins + Will

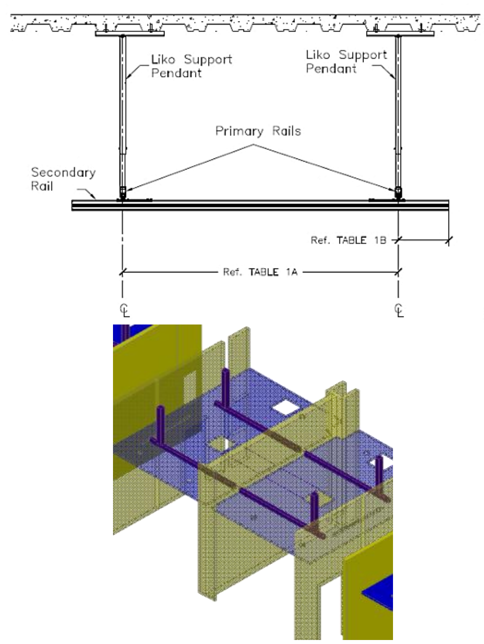


Figure 6B: Component Detail & Model: Patient Lift
Detail from Submittal | Mid-Atlantic Company

SCHEDULE ACCELERATION SCENARIOS

CRITICAL PATH SUMMARY

The New Regional's Medical Center's critical path consists of 83 activities over 500 working days. It began on October 29, 2010 and concludes on October 15, 2012. This path revolves primarily around non-accessible drywall finishes in the patient tower, in addition to heavy rough-in in the operating and surgical cores of the medical center, primarily sector 1C. The critical path concludes with many of the finishing elements of the atrium of the facility. This area is the key focus for the final 7 months of the project, as owner furnished equipment begins to be installed.

Focused items on the critical path include the sequence: (1) Frame Non-Accessible Walls, (2) Drywall Non-Accessible Walls, and (3) Sheet Metal Overhead Rough-In. This sequence occurs in 11 phases and walks from the 4th floor down to 2nd floor, moving from sector A into B (as shown in Figure 7). Once sector 2B is completed, these trades skip over the 1st floor and proceed to the ground level. Ground level critical path activities only include sector A and C. Sector A includes the medical center's cafeteria and kitchen, and sector C includes elements of the emergency room.

Once these three activities are completed on the ground level, they return to the 1st floor and work from A to B to C, and tie into completed areas of D, in addition to future critical path items associated with the operating and surgical rooms. Critical activities in this sector include overhead and in-wall rough-in for plumbing, electrical, medical gas, security, and pneumatic tubing. This area is finalized with partition and ceiling drywalls. Due to drywall's placement on the critical path of sector C, the atrium progress is also added to the critical path.

With the large size of the atrium, scaffolding is required in order to install and finish many of the features located within the ceilings and high walls of this space. All finish elements of the atrium, from scaffolding installation to removal, is a critical activity.

Finally, in order to deliver a completed project, final walk thru, sign-offs, and inspections conclude the critical path for the New Regional Medical Center.

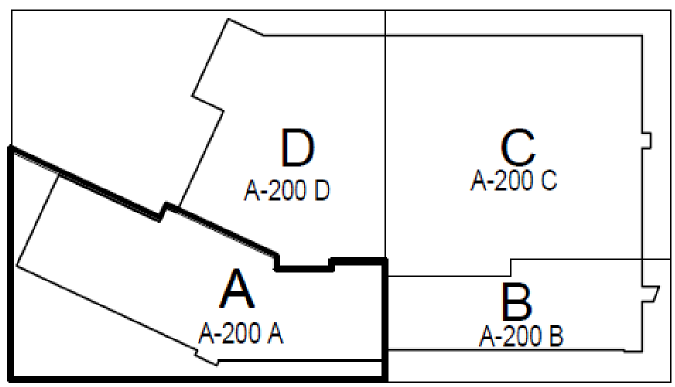


Figure 7: Building Quadrants
Detail from Sheet A-200A | Perkins + Will

See **Appendix A** for the New Regional Medical Center's critical path schedule.

RISKS TO COMPLETION DATE

The largest risk to completion date is missing the enclosure deadline of September 1, 2011. Although not included in the critical path narration above, or in Appendix A, there is minimal float built into this milestone. If missed, and not recovered within the permitted float duration, the critical path described above is impacted beginning with 1st floor sector C activities, resulting in delay of the atrium, and potentially substantial and final completion. Additionally, depending on the delay, other activities such as pouring the concrete pour stops in each wing of the facility may be held due to cold weather conditions within the building. Failure to pour these slab sections on time will create delays on interior flooring of the patient towers, and potentially impact finishes and equipment installation in these areas.

Additional risks to the completion date may involve the 11 phase repetition of (1) Frame Non-Accessible Walls, (2) Drywall Non-Accessible Walls, and (3) Sheet Metal Overhead Rough-In. Although this repetitive process is beneficial for sequencing, productivity, and quality control, there is no additional time built into the initial sequence on the 4th floor. With additional time to properly learn the non-accessible wall details, in addition to the sheet metal overhead details, during the first pass, the trades may be able to pick up on key issues or adapt a learning curve into the future schedule for the installation process.

Finally, without sequencing the sector 1C in-wall rough-ins (plumbing, electrical, medical gas, security, and pneumatic tubing), the construction process may encounter many productivity and work flow challenges. Since all elements are associated to the critical path, it is essential that these trades coordinate and preplan their workflows together in order to minimize overlaps and reworks on the project. Any issues that arise in this installation will affect the completion date. Concern arises in this sector specifically due to the high quantities of material and systems being located in the operating and surgical room. Although the systems have been part of layout during the MEPF coordination process, elements such as receptacles and the wall finishes were not included. Additionally, the coordination process did not review workflow programming for trades and material storage in the confined space.

ACCELERATION OPTIONS

As discussed above, keys areas to accelerate the schedule may include (1) building enclosure activities, (2) non-accessible wall sequencing, and (3) sector 1C in-wall activities. Atrium activities may have potential for acceleration if the project is delayed entering this area, however due to the constraints of the scaffolding involved, it may be extremely challenging to improve upon the existing schedule.

BUILDING ENCLOSURE ACTIVITIES

In order to avoid or mitigate the impacts of a missed enclosure milestone, various processes can be implemented in order to accelerate and recover the schedule. Due to the sequencing of the enclosure and the time of year, the largest impacts will be felt with impending cold weather, and will most likely occur in the atrium area. Due to the complexities of the glazing in atrium, in addition to many custom pieces, this area will be the final cladding to go on the building. With the entire exterior curtain wall panels and glazing installed (less one panel per floor left out for material deliveries), heating the building will be held until the atrium is enclosed due to the large volume of this space.

The glazing for the atrium was installed utilizing the crane on site, in addition to multiple JGL boom lifts, and scissor lifts for workers to access and install each panel within the mullion system. In order to assist in acceleration of enclosure activities, it may be worthwhile to utilize an additional crane to enclose the patient tower quicker, permitting more time within the schedule for the high level of work, in a congested area, for the glazing installation of the atrium.

In addition to this, schedule acceleration could also occur on the interiors trades after a missed enclosure date. If known, temporary doors can be installed within the corridor where it opens into the atrium. In doing so, temporary heat can be started in the wings, utilizing the permanent HVAC and boilers, as scheduled. Once the temperature stabilizes, and the structural system has reached proper deflection, the pour stops can be formed and poured in the controlled environment, as required, and the finishes and flooring installed per the schedule.

With two different programs, (1) involving additional cranes and site logistics, and (2) installing temporary barriers for climate control between the enclosed areas and the delayed (atrium) area, great variations in costs and additional activity interferences may occur. Depth would need to be investigated regarding the additional benefits or

concerns of an accelerated tower enclosure. Also, depth would need to be investigated regarding the ability to pour the concrete pour stop within only a partially climate controlled structure. Regardless of the option, both seem viable solutions to protect the critical path elements which rely heavily on a watertight and climate controlled zone.

NON-ACCESSIBLE WALL SEQUENCE

In order to accelerate the highly repetitive, extremely critical, program for the non-accessible wall sequencing, alternative processes can be implemented. Due to the nature of non-accessible wall partition installation, prefabrication of components is not a viable option, however, an increased work force will help recover or accelerate the process. As long as the three trades involved in the framing, drywall, and sheet metal activities are scaled together, no additional schedule issues should exist since they are the first crews through each sector. By increasing crew sizes, or adding a second shift, productivity will increase, not only keeping these three activities on schedule, but also keep the remainder of the finishes on schedule.

A schedule acceleration of double shifts for the framing, drywall, and sheet metal overhead activities would easily capture buffer in later parts of the critical path. Although essentially an easy resolution, it must be noted that the crews working within this site are union trades. Due to this, specific fee structures, contracts, and double shift measures must be reviewed and approved.

Although this process may seem challenging to overcome, consider the implication of this sequence being delay at any point. If additional schedule items are impacted beyond their float, additional trades, notably any trade associated with building finishes, will need to go onto a double shift. In addition to this, construction management staff must also go onto a second shift.

Again, two analysis options are reached. Acceleration can be conducted to prevent potential delays with (1) the three critical path trades working a double shift, or acceleration can be conducted to recover from a delay with (2) all finishing trades working double shifts. In either option, union labor requirements, contracts, and agreements must be reached and factored into the transition of either option.

SECTOR 1C IN-WALL ACTIVITIES

Acceleration of the sector 1C in-wall activities is critical to recovery or protection of delay on the substantial completion of the medical center. However, the level of detail, in addition to the tolerances and quality control, in this space is critical to the performance of the hospital. Housing all major life support operations for the hospital, sector 1C's schedule needs additional flexibility, or design reviews to ensure accurate installation and trade coordination.

In order to ensure accuracy, taking BIM coordination models for in-wall components into the field can produce a higher level of focus and realization of the staging required to accurately install each component. Considerations for a 4D model including work flow and material storage would not necessarily accelerate the schedule in itself; however, it will produce a more comprehensive simulation on areas of conflict or expose areas for improved productivity. Additional costs to develop this process would mainly involve Information & Technology operations, in addition to a BIM Coordinator or Virtual Design & Construction employee to review and coordinate the spaces with the foremen of each subcontractor within the spaces. Actual costs of schedule acceleration cannot necessarily be quantified until a simulation is developed and analyzed.

VALUE ENGINEERING

KEY IMPLEMENTATION

Change Green Roofs to std. 20yr. TPO Single Ply — DEDUCT **$647,127**

Green Roof Premium	27,236 SF		$599,192
		Subtotal:	$599,192
		Markup @ 8%:	$47,935
		Total:	$647,127

Change Roof Gardens to std. 20yr. TPO Single Ply — DEDUCT **$1,823,450**

Roof Garden Premium	20,590 SF		$1,688,380
		Subtotal:	$1,688,380
		Markup @ 8%:	$135,070
		Total:	$1,823,450

Change Tower Curtin Wall to Panels & Strip Window — DEDUCT **$1,214,803**

Change to Class II Skin	LS		$1,124,818
		Subtotal:	$1,124,818
		Markup @ 8%:	$89,985
		Total:	$1,214,803

Change Interior Finishes to Standard Finishes — DEDUCT **$3,855,600**

Patient Tower	LS		$2,222,000
Services Core	LS		$1,348,000
		Subtotal:	$3,570,000
		Markup @ 8%:	$285,600
		Total:	$3,855,600

Design Structure to 14#/SF — DEDUCT **$1,783,555**

Reduce Steel by 2#/SF	LS		$1,651,440
		Subtotal:	$1,651,440
		Markup @ 8%:	$132,115
		Total:	$1,783,555

Build Helipad in the Future — DEDUCT **$810,000**

Helipad Allowance	LS		$750,000
		Subtotal:	$750,000
		Markup @ 8%:	$60,000
		Total:	$810,000

OWNER GOALS

The value engineering implementations on the New Regional Medical Center were directly related to maintaining high standards of the program features of the facility, while eliminating excessive design features and their related costs. With expectations for the facility to be the leading-edge clinical service center for the Philadelphia region, the facility's operation is first and foremost as a full-service acute care hospital. In order to uphold the standards and the fees associated with reaching this goal, many systems were tailored in the design and preconstruction phase to generate costs savings. Efforts were made to rededicated savings into the most technically advanced healthcare, both in equipment and staffing, for the campus, providing a greater provision of healthcare needs for the community.

Although many of the changes removed aesthetically pleasing features of the project, it was recognized that the savings and redesigns permitted greater flexibility with funding future developments on the project. In addition to this, realization was met with the understanding that captured savings in redesign of the medical center, without impact on the capabilities of the facility and staff in treating patients, permits deeper investment into the medical center's campus future work.

VE CONSIDERATIONS

In addition to the value engineering programs discussed earlier, and consideration of the owner's goals on the project, five additional premiums on the project were investigated for potential cost savings, constructability concerns, and schedule impacts. Although these were not implemented as part of the VE process in design, these concepts were discussed between the New Regional Medical Center, Inc., Perkins + Will, and Gilbane Building Company, in early 2009.

(1) ***Eliminating the Atrium***

The savings associated with eliminating the Atrium and turning it into a single story public space on the first floor would include: (1) eliminating the smoke evacuation system, (2) eliminating the atrium finishes, (3) eliminating the monumental stair, and (4) eliminating the steel premiums on the structure.

Depending on how the building would be reconfigured as a result of this elimination, savings associated with this would amount to $2–3.5 million. This consideration was not implemented due to extensive architectural and structural revisions on the project.

(2) ***Removing the angled architectural corner***

Elimination of this feature will not impact the layouts of neighboring patient rooms. The savings associated with this elimination would include: (1) eliminating custom corner precast panels, (2) eliminating the steel premiums on the structure, (3) eliminating non-usable floor space at the corner.

This architectural design feature carries a premium of $100,000 - $150,000. This consideration was not implemented due to significantly impacting the architectural aesthetics of the building, for minimal savings.

(3) ***Replacing the precast & metal panel with brick and steel studs***

To change to face brick with metal stud back-up would be a cost increase and a schedule impact. A brick system would impact the structural steel weights and the façade installation would increase drastically.

A cost premium was not associated to this VE suggestion due to the increase in overall cost. This consideration was not implemented due to significantly impacting the architectural aesthetics of the building. In addition, it would require a structural redesign with an increase in project cost and longer construction duration.

(4) ***Replacing the precast & metal panel with EIFS panelized system***

Elimination of the precast and metal panel system and replacing with an EIFS panelized system could net a savings of $5 - $8 per square foot. There is approximately 55,000 square feet of panel systems in the New Regional Medical Center's material takeoff.

Savings associated with this system replacement amounts to $300,000 to $480,000. This consideration was not implemented due to impacting the architectural aesthetics and requiring structural connection redesign.

(5) ***Demo the administration wing (4th floor – sector A) & add 24 medical-surgical beds***

The cost associated with demolition of this wing and the fit-out of 24 medical-surgical beds is not conducive to the current facility program. Once occupied and in operation, the facility will review capacity concerns before reviewing the implementation of this plan. Current discussion plans for this expansion to take place in mid-2015, and will include 19,423 SF of conversions. At this time, the administration wing will be relocated to the adjacent Medical Office Building. In lieu of this anticipated change, sector A of the 4th floor will be fit-out with patient services, as feasible, to minimize rework in occupied space of the facility, such as the atrium and sector B of the 4th floor.

Costs associated with this system, amount to $7,783,456. This value includes costs of demolition and fit-out, including equipment, with a 7% escalation per year (priced in mid-2015). This consideration was not implemented due to unconfirmed capacity and patient turn-over data to date.

CRITICAL INDUSTRY ISSUES

PACE ROUNDTABLE

The 20th Annual PACE Roundtable, themed *"Building Innovation into Practice: Keeping What Works"* took place on November 8 – 9, 2011 at the Penn Stater Conference Center Hotel. This event is formatted to provide discussion of critical industry issues, a panel review, and individual development of potential research topics for the upcoming semester. Attendees include industry professional, department professors, Ph.D. and graduate students, and 5th year construction management students. The focus of the Roundtable is to gather research concepts, and key industry contacts in order to conduct research in the upcoming months, in order to present on the topic during the senior thesis presentations in April 9 – 13, 2012, in addition to the PACE Research Seminar and Award Banquet on April 16 – 17, 2012.

Each year, the PACE Advisory Board identifies key concepts which influence current industry issues. This year, three breakout categories were selected, and each category included two discussion topics. Table 1 details the topics presented and discussed this year.

Table 1: PACE Roundtable Discussion Topics

Industry Focus	*Sustainability*	*Process Innovation*	*Technology*
Break-Out Session I	Energy Management Services	Assembling/Procuring an Integrated Team	BIM Services for the Owner – the Role of the Design and Construction Professionals
Break-Out Session II	Learning Systems for Training a Sustainable Workforce	Integrated Decisions for High Performance Retrofit Projects	Strategies and Opportunities for Taking BIM into the Field

See **Appendix C** for notes taken during the Pace Roundtable events.

BREAKOUT SESSIONS

SESSION I: BIM SERVICES FOR THE OWNER

The first breakout session focused on many of the difficulties and challenges of conveying BIM services through the life cycle of a project, and into a usable form for the owner's facility management staff. It was understood that many owners are confused on BIM requirements and interfacing elements necessary to capture usable information. It was also recognized that different types of owners dictate different level of BIM services within project development. The two main distinctions were between an owner and a developer. As an owner, BIM services are more influential because they retain the facility for operation. However, focusing on developers and consistent building turnover, BIM services were less likely to be requested from the owner, as resale values of BIM models and facility databases are not readily defined to date.

Consensus was reach that the BIM for Owners drivers revolve around cost reduction, notably through change order reduction and a more transparent construction information exchange process. However, risk was acknowledged that BIM should be developed through particular metrics that are focused on the delivery process outlined by the owner. Due to legal constraints, information exchange and collaboration should be highly detailed and compliant with various BIM contracts, such as AIA E202, AGC Census Documents, and BIM Addendum.

It was recognized that additional drivers of information exchange has to come from the fabrication facilities, and not necessarily the owner. Software developments must be made in order to take usable data from a designer's model into fabrication facilities, and back out to an owner. Although the owner's facility management staff may require a system restructuring or redevelopment of their asset databases, it is understood that this direction is easier to perform over retooling fabrication facilities.

The construction industry was identified as a difficult industry to develop design and component standards, in order to minimize new, unique details within each project. Although project uniqueness creates great strides in technology and progresses typical means-and-methods, unique and specialty construction on every new project, creates high risks for both the designer and the contractor. BIM level of detail is being challenged consistently with document quality falling due to insurance risks, high profile projects, and complex details. With current developments of owner resources and reflections on BIM strategies, hopes are high for a stronger, more developed, owner understanding on BIM services in the future.

At the conclusion of the session, multiple recommendations were made by industry professional concerning potential research ideas. Below are two concepts which were proposed during the break-out session, and developed through discussion after the conclusion of the PACE Roundtable.

(1) Review and develop BIM project elements

Research the level of detail (LOD) of existing BIM models and the information exchange program on your thesis project. If BIM deliverables were not requested, investigate the added value of a focused BIM development on a particular component in the design. Develop the interoperability necessary to design, attribute, and turnover this element to the owner and the facility management staff. Consider the additional value added with model usage within the construction of the selected element.

(2) Survey owner & facility management staff

Learn the current facility management program that is being utilized on existing owner assets. Survey the facility management staff to understand any additional features that will be added or modified with the inclusion of the new facility. Research if it is possible to merge the BIM system existing on the project into the existing system. Learn why a facility management (FM) model was not requested, and if additional training would need to occur. Review and update the BIM execution documents used on the project to capture the owner's and facility management staff's capabilities. Restructure the project's implementation plan, and propose value added elements for all project stakeholders.

SESSION II: STRATEGIES & OPPORTUNITIES FOR TAKING BIM INTO THE FIELD

This second technology break-out session focused on the benefits of BIM in the field, in addition to strategies, opportunities, and risks of implementation. Overall, comments reflected on technology training and generation gaps typically found within the industry, and the challenges to overcome 2D versus 3D communication. Although many industry comments were in full support of implementation strategies, risks associated with legal concerns on BIM models and document standards were voiced. Notable issues arose with discussion around model ownership and model sharing. Sharing models and information tools have developed to permit levels of access from owning, editing, viewing, to excluding. With hopes to mitigate and manage document controls, a higher level of confidence is instilled.

In addition to an overall sense of BIM controls with field implementation, realization that education of the work force to properly utilize the equipment, technology, and information is necessary. In addition to this, special focus needs to be placed to educate the workforce of where the information is derived from. Explicitly sharing that the same architectural and structural design principles utilized to make 2D documentation is used in 3D documentation, was one of many ways recommended to overcome apprehension with field BIM.

Specific technology platforms were discussed, such as iPads, job-box kiosks, and laser scanning. It was recognized through PACE discussions, in addition to recent articles in Engineering News Record, that technology is the driving force behind differentiation in the current economic state. Although expensive buy-in exists for all parties involved on a project, measurable benefits have resulted. Not only is document accessibility a key asset to field utilization of BIM, but information output and integrated work plans are a recent development in the field. Utilizing BIM models, specific metrics or parameters of the components can be reviewed, and exported into a single work plan. This permits trades to visualize their assemblies on a single printout, or on a tablet, and have pertinent information readily available; in addition, 3D views to complement traditional plan and elevation views can be included.

Progressive concepts such as virtual detailing and look-ahead scheduling for complicated assemblies were discussed. Benefits include a more comprehensive understanding of the construction sequence and the assembly instructions for the project team, quality control officers, and the subcontractor. Taking BIM into the field goes beyond accessibility of project documents and a new work platform for understanding the work-in-place; it permits instant constructability analysis and a higher level of understanding for design coordination and planning.

At the conclusion of the session, multiple recommendations were made by industry professional concerning potential research ideas. Below are two concepts which were proposed during the break-out session, and developed through discussion after the conclusion of the PACE Roundtable.

(1) Research impacts of the use of a particular BIM tool (or technology) not utilized on your project

Shadow different role-players of the project and analyze successes and gaps of information exchange within their work. Consider reviewing the owner, construction manager, subcontractor, fabricator, designer, and program planner. Implement a new technology system or a BIM tool and reflect on the outcomes on productivity, information exchange, and general project development.

(2) Study the impacts of BIM implementation vs. traditional implementation for a particular system

Compare the use of BIM tools (or technology) to traditional methods of project development. Focus on concepts such as: estimating, scheduling, contract language, additional costs or fees, personnel training, productivity, and accuracy. Study the positive and negative effects of implementation and the added (or lost) value of its use. Finally, consider what LOD (or information) is necessary per user at each project phase to optimize design schedule, costs, and model development.

INDUSTRY PANEL

The industry panel focused on identifying innovation and differentiation within a challenging economy. A majority of the focus was on company's internal development, with key areas in sustainability, BIM, and lean construction processes. With a market return expected for the construction industry by 2014 or 2015, there is a great deal of focus on construction company efficiency, in light of limited work and tighter budgets. With concerns over unemployment rates in the construction industry, in addition to design firms, focus was placed on understanding the implications of project contacts changing, in addition to subcontractor failures.

At the conclusion of the PACE Roundtable, a meeting was held on November 11, 2011 with thesis advisor, Dr. Robert Leicht, concerning potential research ideas in addition to a reflection on economic challenges in the building industry. Below are two concepts which were developed through reflection of this meeting and the panel's discussion.

(1) Investigate the impact of a project's contact changing roles within a company, or changing companies. *Review the implication of a project team's office closing or being relocated. Review and develop strategies on how to prevent, recover, or cope with this occurrence as a project team.*

(2) ***Investigate the impacts of the current unemployment on the project's market sector and region****. Is your project experiencing subcontractor failure or supplier issues? Research the cash-flow strategies of the project and develop a more efficient process. Revise payment schedule and contract language to mitigate economic impacts on role-players of your project.*

RESEARCH DISCUSSION

KEY FEEDBACK

At the conclusion of the Industry Panel discussions, dialogue was held between each 5th year construction management student and an industry professional. This meeting reviewed the senior's thesis project, the current status of construction, key takeaways from the two break-out sessions, and concluded with potential research ideas. Below is the major concept which was developed with Jerry Shaheen, Gilbane Building Company.

(1) Study the impacts of LOD BIM documents versus traditional documents in the accuracy of construction management contract development, scope writing, construction processes, and final turnover. Also consider investigating the impacts on other project team members and subcontractors.

Focus on major or typical architectural or structural models; however, consider using other building systems as available. Research who is responsible for the model's different levels of details, or attributes in model elements. Consider interviewing and shadowing each major contributor to the BIM model to learn more about the design and information exchange process.

In addition to this, also shadow the major users of model information, capturing who uses each attribute, and in what fashion they need it. Consider going as deep as investigating all major contributors to the project development: Program Management Staff, Designers, Construction Management Staff, Fabricators, Subcontractors, Vendors, Facility Management Staff, and End Users.

Identify which LOD or attributes are essential to accuracy and project development at the time of use. Consider where LOD design overages occur, where shortcomings exist, and develop an optimization schedule to produce the level of detail necessary at the moment of most critical implementation. Investigate if it is possible to restructure the construction management and design team contracts concerning transfer of modeling risks to permit a more efficient process.

INDUSTRY CONTACTS

Industry contacts were acquired through discussion at the S:PACE (Washington, DC) Field Trip, the PACE Roundtable, and with Thesis Advisor, Dr. Robert Leicht. Table 2 includes an overview of contact information and potential research areas for additional advice.

Table 2: Research Contacts

Contact	*Company*	*Research Area*
Jon Woodsum	Barton Malow	IT & BIM Implementation
Kurt Maldovan	Balfour Beatty Construction	VDC Development
Matt Hedrick	DPR Construction	VDC Coordination
Dave Maser	Gilbane Building Company	VDC Development
Jerry Shaheen	Gilbane Building Company	BIM Strategies
Rich Fiore	Leonard S. Fiore	Contractor Relations
Gene Hodge	Mortenson Construction	Technology in the Field
Derek Cunz	Mortenson Construction	BIM Strategies
Michal Wojtak	Mortenson Construction	Integrated Construction
Ralph Kreider	Penn State University	BIM Strategies
Sonali Kumar	Penn State University	Healthcare Virtual Environments
Steve Ayers	Penn State University	Augmented Reality & Technology
Dr. Rob Leicht	Penn State University	Lean Construction & Productivity
Dr. John Messner	Penn State University	BIM Strategies, Contract Relations
Chris Taylor	Southland Industries	Contractor Relations
Charles Tomasco	Truland Systems Corporation	Contractor Relations

PROBLEM IDENTIFICATION & TECHNICAL ANALYSIS

LOD JUST-IN-TIME BIM IMPLEMENTATION

DEPTH

BIM Model – LOD and Information Optimization

As reviewed in *Technical Report No. 2* the Building Information Modeling implementation on the construction of this project was minimal, however the BIM implementation in design was of high detail. The depth of analysis will reflect the discussion held during the PACE Roundtable event. It will study the impacts in level of detail (LOD) and information embedment of BIM documentation versus traditional models and analysis methods. Analysis will consider the accuracy and level of detail needed within BIM strategies, the impacts on contract development, scope writing, construction process, and final BIM deliverables. If possible, investigation will also take place to understand the usability of information and the LOD necessary for efficient BIM implementation. Cost and schedule analysis of personal training and model development will be compared to added productivity and efficiently in both design and field installation. Additionally, estimate analysis from a BIM model will be compared to traditional estimate processes to develop a contingency scale which reflects LOD variations to accurate costs.

Architectural BIM Model – Optimize for Field & Owner Use

The architectural breadth will involve the investigation into model optimization based off of required and usable information requested by the teams in the field, in addition to the ability for the owner to capture the design into a facility management model. The architectural model will be enhanced and developed for model usage in the field. Particular design elements will be detailed in integrated work sets. This concept permits trades to visualize their assemblies on a single printout, or on a tablet, and have pertinent information readily available; in addition, 3D views to complement traditional plan and elevation views can be included. Additionally, the facility management staff will be shadowed to understand the attributes necessary for their maintenance program. The architectural model will be updated to reflect the LOD of information requests per user group.

Structural: BIM Model – Optimize for Fabrication & Field Use

The structural breadth will involve a similar investigation into model optimization based off of fabrication and erection crew requirements or requests. The structural model will be enhanced and developed for model usage in the fabrication factory, imbedded with finite details for members and custom components. Additionally, this model will be utilized to simulate a steeled steel construction sequence and crane position. Potential analysis will be investigated to understand critical picks, and ensure equipment location is planned appropriately. Additional BIM strategies may be considered, such as steel material tracking and construction status updates, to ensure proper scheduling and production levels.

ATRIUM ENCLOSURE REDESIGN

DEPTH

Delay Prevention Planning

As mentioned previously, the atrium area is of great concern; 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. The atrium construction process will be analyzed for extremely tight or aggressive activities. These activities will be analyzed and compared to similar systems and installation productivity, in order to identify potential delays. Once located, preventative planning measures will be developed regarding productivity, crew size, working hours, and installation methods to mitigate potential delays. Depth may investigate the benefits of a stronger site logistics plan, a 4D construction model, or trade coordination efforts for the atrium. Additionally, equipment and resource necessary to meet this goal will be reviewed. A cost analysis for any increase or reduction in resources will be conducted, as well as a schedule analysis, to verify if preventative planning is possible and financially appropriate for the atrium and related enclosure concerns.

BREADTH

Architectural: Redesign the Atrium Enclosure

The architectural breadth would involve redesigning the New Regional Medical Center's to align more clearly with the value engineering efforts mentioned previously in the *VE Considerations* section. The extent of redesign will not be as substantial as the VE to reduce it from 4 stories to 1 story, for cost savings. It will be redesigned to meet the enclosure deadline and parallel construction sequencing of the building in order to realistically meet enclosure and deliver the hospital on time. Methods would include research into Medical Center architectural design, materials, and system performance. Constructability, costs, and schedule durations would be reviewed and compared to the existing system. The new program would be developed in Autodesk Revit Architecture, and merged into the existing architectural model to produce renderings.

POUR STRIP VERSUS EXPANSION JOINT

DEPTH

Schedule Acceleration

The schedule acceleration method for the pour stop activity, as mentioned in the *Constructability Issues: Concrete Pour Stops* section will be analyzed. The float on related activities to the concrete pour stops, in addition interior floor finishes will be analyzed 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. Depth for this option would investigate interior logistics, trade coordination, and temporary enclosure systems, in addition to work force increases. Additionally, depth regarding constructability and quality control of this system under a partially heated structured will be investigated.

Discussions and reviews have been made with the structural engineer to analyze the development of this alternative plan, in addition to construction phasing required to reach the quality control standards of the pour strip in addition to recovering the schedule and impacts of a delayed floor slab. This option would finally be compared against the preventative measures to find the optimum constructability and cost-benefit scenario.

BREADTH

Structural: Redesign the Pour Strip as an Expansion Joint

The structural breadth would include structural redesign of the structural concrete pour strip as an expansion joint. 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, and analysis would be performed to compare this system to a building expansion joint. Both occurrences would be analyzed to ensure structural loading are consist, or variations are accounted in design. Additional costs, schedule impacts, and constructability reviews will be considered as a substantial part of the redesign. Methods will consist of hand calculation with virtual mock ups in Google Sketch Up, of each system to covey the differences in design, assembly, and constructability.

VIRTUAL MOCKUP & PERFORMANCE MODEL

DEPTH

Virtual Mockup for Design Approval, Staff Training, & Facility Management

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 or surgical room is possible, with layout, product, and usability review. As stated in the *Acceleration Options: Sector 1C In-Wall Activities* section, this area is critical to an on-time delivery of the New Regional Medical Center. As one of the most congested and technologically advanced areas of the hospital, proper coordination of the in-wall activities should be performed to ensure accuracy in schedule and quality control of the installations. Focusing on both trade coordination and in-wall design and clash detection, BIM will be utilized to plan and layout a typical operating or surgical room. This investigation will also develop a virtual mockup of the facility. As a package, this element 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. Investigation will include modeling and training costs required for facility management use.

APPENDIX A

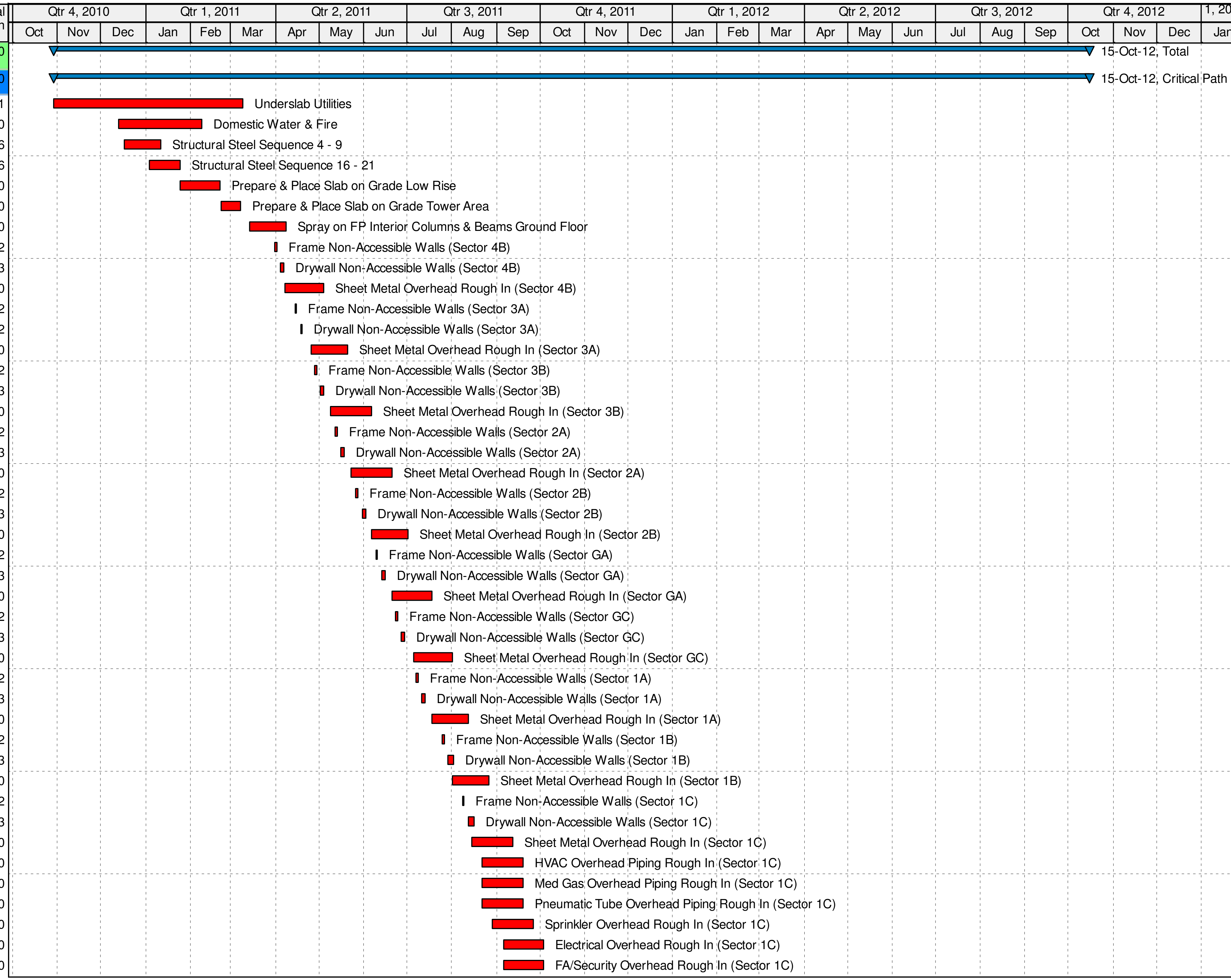
CRITICAL PATH SCHEDULE

AE 481W - Senior Thesis

BRIAN NAHAS

CONTRUCTION MANAGEMENT

Activity Name	Start	Finish	Original Duration
Total	29-Oct-10	15-Oct-12	500
Critical Path	29-Oct-10	15-Oct-12	500
Underslab Utilities	29-Oct-10*	09-Mar-11	91
Domestic Water & Fire	13-Dec-1(	08-Feb-11	40
Structural Steel Sequence 4 - 9	17-Dec-1(	11-Jan-11	16
Structural Steel Sequence 16 - 21	03-Jan-11*	24-Jan-11	16
Prepare & Place Slab on Grade Low Rise	25-Jan-11*	21-Feb-11	20
Prepare & Place Slab on Grade Tower Area	22-Feb-11*	07-Mar-11	10
Spray on FP Interior Columns & Beams Ground F	14-Mar-11*	08-Apr-11	20
Frame Non-Accessible Walls (Sector 4B)	31-Mar-11*	01-Apr-11	2
Drywall Non-Accessible Walls (Sector 4B)	04-Apr-11*	06-Apr-11	3
Sheet Metal Overhead Rough In (Sector 4B)	07-Apr-11*	04-May-11	20
Frame Non-Accessible Walls (Sector 3A)	14-Apr-11*	15-Apr-11	2
Drywall Non-Accessible Walls (Sector 3A)	18-Apr-11*	19-Apr-11	2
Sheet Metal Overhead Rough In (Sector 3A)	25-Apr-11*	20-May-11	20
Frame Non-Accessible Walls (Sector 3B)	28-Apr-11*	29-Apr-11	2
Drywall Non-Accessible Walls (Sector 3B)	02-May-1	04-May-11	3
Sheet Metal Overhead Rough In (Sector 3B)	09-May-1	06-Jun-11	20
Frame Non-Accessible Walls (Sector 2A)	12-May-1	13-May-11	2
Drywall Non-Accessible Walls (Sector 2A)	16-May-1	18-May-11	3
Sheet Metal Overhead Rough In (Sector 2A)	23-May-1	20-Jun-11	20
Frame Non-Accessible Walls (Sector 2B)	26-May-1	27-May-11	2
Drywall Non-Accessible Walls (Sector 2B)	31-May-1	02-Jun-11	3
Sheet Metal Overhead Rough In (Sector 2B)	06-Jun-11*	01-Jul-11	20
Frame Non-Accessible Walls (Sector GA)	09-Jun-11*	10-Jun-11	2
Drywall Non-Accessible Walls (Sector GA)	13-Jun-11*	15-Jun-11	3
Sheet Metal Overhead Rough In (Sector GA)	20-Jun-11*	18-Jul-11	20
Frame Non-Accessible Walls (Sector GC)	23-Jun-11*	24-Jun-11	2
Drywall Non-Accessible Walls (Sector GC)	27-Jun-11*	29-Jun-11	3
Sheet Metal Overhead Rough In (Sector GC)	05-Jul-11*	01-Aug-11	20
Frame Non-Accessible Walls (Sector 1A)	07-Jul-11*	08-Jul-11	2
Drywall Non-Accessible Walls (Sector 1A)	11-Jul-11*	13-Jul-11	3
Sheet Metal Overhead Rough In (Sector 1A)	18-Jul-11*	12-Aug-11	20
Frame Non-Accessible Walls (Sector 1B)	25-Jul-11*	26-Jul-11	2
Drywall Non-Accessible Walls (Sector 1B)	29-Jul-11*	02-Aug-11	3
Sheet Metal Overhead Rough In (Sector 1B)	01-Aug-11	26-Aug-11	20
Frame Non-Accessible Walls (Sector 1C)	08-Aug-11	09-Aug-11	2
Drywall Non-Accessible Walls (Sector 1C)	12-Aug-11	16-Aug-11	3
Sheet Metal Overhead Rough In (Sector 1C)	15-Aug-11	12-Sep-11	20
HVAC Overhead Piping Rough In (Sector 1C)	22-Aug-11	19-Sep-11	20
Med Gas Overhead Piping Rough In (Sector 1C)	22-Aug-11	19-Sep-11	20
Pneumatic Tube Overhead Piping Rough In (Secti	22-Aug-11	19-Sep-11	20
Sprinkler Overhead Rough In (Sector 1C)	29-Aug-11	26-Sep-11	20
Electrical Overhead Rough In (Sector 1C)	06-Sep-11	03-Oct-11	20
FA/Security Overhead Rough In (Sector 1C)	06-Sep-11	03-Oct-11	20



Activity
Summary
Milestone

NEW REGIONAL MEDICAL CENTER

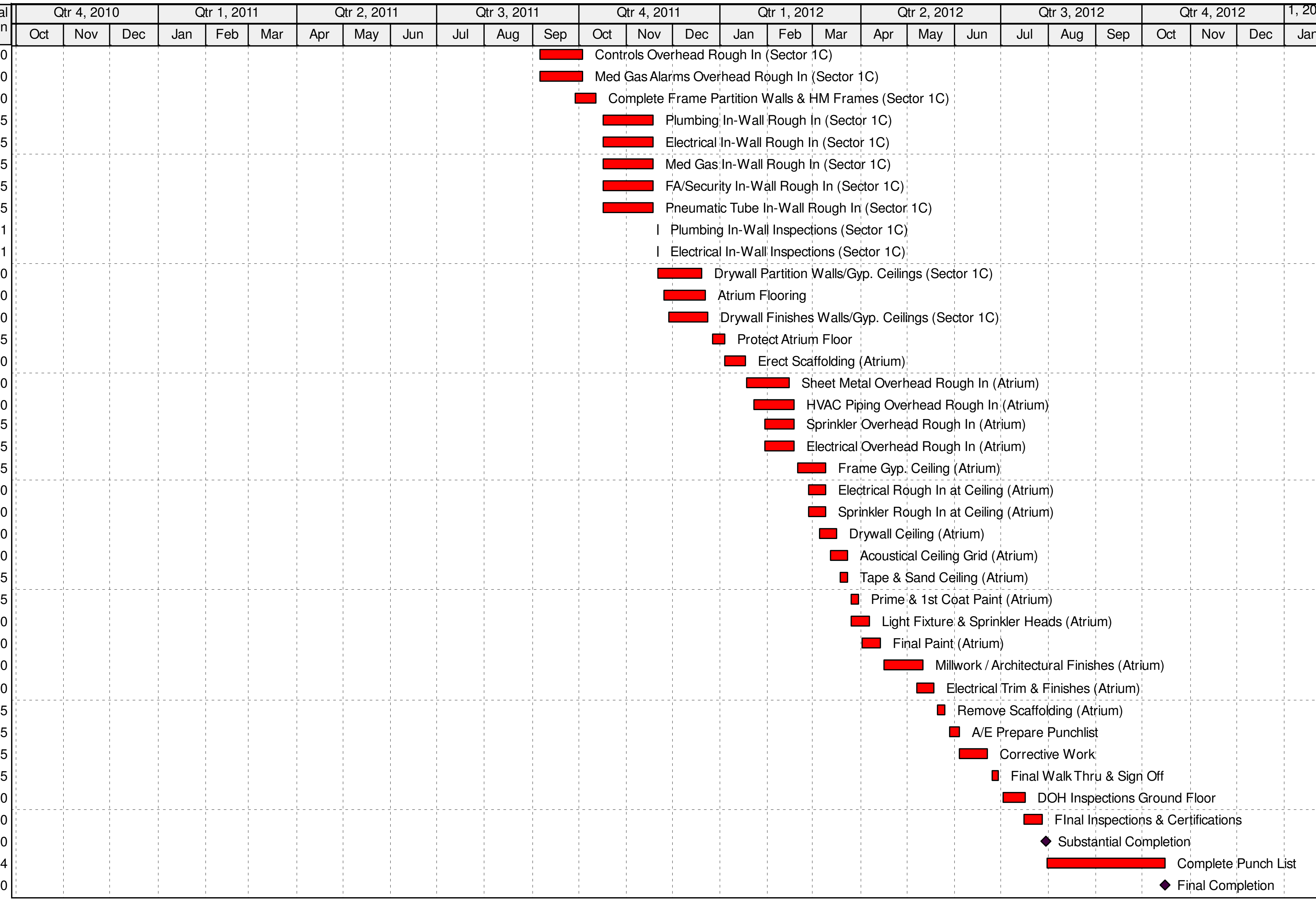
EAST NORRITON, PA

AE 481W - Senior Thesis

BRIAN NAHAS

CONTRUCTION MANAGEMENT

Activity Name	Start	Finish	Original Duration
Controls Overhead Rough In (Sector 1C)	06-Sep-11	03-Oct-11	20
Med Gas Alarms Overhead Rough In (Sector 1C)	06-Sep-11	03-Oct-11	20
Complete Frame Partition Walls & HM Frames (S	29-Sep-11	12-Oct-11	10
Plumbing In-Wall Rough In (Sector 1C)	17-Oct-11*	18-Nov-11	25
Electrical In-Wall Rough In (Sector 1C)	17-Oct-11*	18-Nov-11	25
Med Gas In-Wall Rough In (Sector 1C)	17-Oct-11*	18-Nov-11	25
FA/Security In-Wall Rough In (Sector 1C)	17-Oct-11*	18-Nov-11	25
Pneumatic Tube In-Wall Rough In (Sector 1C)	17-Oct-11*	18-Nov-11	25
Plumbing In-Wall Inspections (Sector 1C)	21-Nov-11	21-Nov-11	1
Electrical In-Wall Inspections (Sector 1C)	21-Nov-11	21-Nov-11	1
Drywall Partition Walls/Gyp. Ceilings (Sector 1C)	21-Nov-11	19-Dec-11	20
Atrium Flooring	25-Nov-11	22-Dec-11	20
Drywall Finishes Walls/Gyp. Ceilings (Sector 1C)	28-Nov-11	23-Dec-11	20
Protect Atrium Floor	27-Dec-11	03-Jan-12	5
Erect Scaffolding (Atrium)	04-Jan-12*	17-Jan-12	10
Sheet Metal Overhead Rough In (Atrium)	18-Jan-12*	14-Feb-12	20
HVAC Piping Overhead Rough In (Atrium)	23-Jan-12*	17-Feb-12	20
Sprinkler Overhead Rough In (Atrium)	30-Jan-12*	17-Feb-12	15
Electrical Overhead Rough In (Atrium)	30-Jan-12*	17-Feb-12	15
Frame Gyp. Ceiling (Atrium)	20-Feb-12*	09-Mar-12	15
Electrical Rough In at Ceiling (Atrium)	27-Feb-12*	09-Mar-12	10
Sprinkler Rough In at Ceiling (Atrium)	27-Feb-12*	09-Mar-12	10
Drywall Ceiling (Atrium)	05-Mar-12*	16-Mar-12	10
Acoustical Ceiling Grid (Atrium)	12-Mar-12*	23-Mar-12	10
Tape & Sand Ceiling (Atrium)	19-Mar-12*	23-Mar-12	5
Prime & 1st Coat Paint (Atrium)	26-Mar-12*	30-Mar-12	5
Light Fixture & Sprinkler Heads (Atrium)	26-Mar-12*	06-Apr-12	10
Final Paint (Atrium)	02-Apr-12*	13-Apr-12	10
Millwork / Architectural Finishes (Atrium)	16-Apr-12*	11-May-12	20
Electrical Trim & Finishes (Atrium)	07-May-1	18-May-12	10
Remove Scaffolding (Atrium)	21-May-1	25-May-12	5
A/E Prepare Punchlist	29-May-1	04-Jun-12	5
Corrective Work	04-Jun-12*	22-Jun-12	15
Final Walk Thru & Sign Off	25-Jun-12*	29-Jun-12	5
DOH Inspections Ground Floor	02-Jul-12*	16-Jul-12	10
FInal Inspections & Certifications	16-Jul-12*	27-Jul-12	10
Substantial Completion	30-Jul-12*		0
Complete Punch List	31-Jul-12*	15-Oct-12	54
Final Completion	15-Oct-12*		0



Activity | Summary | Milestone

NEW REGIONAL MEDICAL CENTER

EAST NORRITON, PA

APPENDIX B

PACE ROUNDTABLE NOTES

Student Name BRIAN NAHAS

Session #1

Topic: BIM SERVICES FOR THE OWNER - THE ROLE OF DESIGN & CONSTRUCTION PROFESSIONALS

Research Ideas:

(1) REVIEW & DEVELOP BIM PROJECT ELEMENTS

- RESEARCH LOD BIM MODELS & INFORMATION EXCHANGE EXISTING ON YOUR PROJECT. ALTHOUGH "BIM" FM DELIVERABLES WERE NOT REQUESTED, INVESTIGATED THE ADDED VALUE OF FOCUSED INTEROPERABILITY & A FOCUSED ELEMENT W/ BIM ATTRIBUTES TO THE OWNER & F.MGMT.

(2) SURVEY OWNER & FACILITY MANAGEMENT STAFF

- LEARN CURRENT FM PROGRAM & PRACTICE. CAN YOUR PROJECT BIM SYSTEM BE MERGED OR TAUGHT TO STAFF? WHY DID THEY NOT REQUEST A FM MODEL? TAILOR BIM EX TO OWNER & FMGMT'S CAPABILITIES. RESTRUCTURE IMPLEMENTATION PLAN. PROPOSE VALUE-ADDED FOR OWNER, FMGMT, END-USERS.

Session #2

Topic: STRATEGIES & OPPORTUNITIES FOR TAKING BIM INTO THE FIELD.

Research Ideas:

(1) PICK A PARTICULAR BIM TOOL OR TECHNOLOGY NOT UTILIZED ON YOUR PROJECT & RESEARCH THE IMPACT OF IT'S USE.

- SHADOW DIFFERENT ROLE-PLAYERS OF THE PROJECT. REVIEW SUCCESSES & GAPS IN BIM TECHNOLOGY. IMPLEMENT A NEW SYSTEM AND REFLECT ON OUTCOMES.

(2) FOCUS-IN ON A PARTICULAR SYSTEM OR COMPONENT.

- COMPARE THE USE OF BIM TOOLS TO TRADITIONAL METHODS. FOCUS ON ESTIMATING, SCHEDULING, CONTRACT LANGUAGE, ADDITIONAL COSTS VS. SAVINGS, PERSONNEL. RESEARCH THE +/- OF IMPLEMENTATION & THE ADDED-OR-LOST VALUE OF ITS USE. WHAT LOD IS NECESSARY PER CONST. PHASE & USER?

Industry Panel: Differentiation in a Down Economy

Research Ideas:

(1) INVESTIGATE THE IMPACT OF A PROJECT'S CONTACT CHANGING ROLES, COMPANIES, REGION. REVIEW & DEVELOP STRATEGIES ON HOW TO PREVENT, RECOVER, COPE AS A PROJECT TEAM.

(2) HOW IS THE CONSTRUCTION UNEMPLOYMENT RATE IMPACTING YOUR PROJECT? HAVE YOU EXPERIENCED SUB-FAILURE OR SUPPLIER ISSUES? RESEARCH THE SCHEDULE & ECONOMIC IMPACTS TO YOUR PROJECT.

Industry Member Discussion

Key Feedback:

Which research topic is most relevant to industry? What is the scope of the topic?

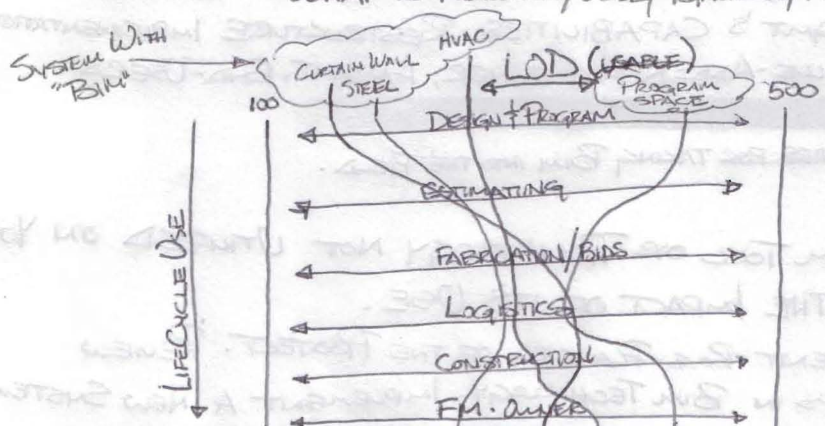
LOD "BIM" MODEL VS. TRADITIONAL ACCURACY IN "CM" SCOPES & TURNOVER

↳ FOCUS ON MAJOR/TYPICAL ARCH. OR STRUCTURAL MODEL, & RELATE TO OTHER SYSTEMS THAT MAY NOT CONTAIN AS MANY USABLE ATTRIBUTES.

↳ WHO MODELS EACH LEVEL, WHEN IS IT NEEDED, WHO USES THE ATTRIBUTES & IN WHAT FASHION?

↳ SHADOW DESIGNERS, CM, FABRICATORS, SUBS, F.MGMT STAFF.

° WHAT IS NEEDED/USED/IGNORED/ADDED



	DESIGN	FAB. INSTALL	ESTIMATE
STEEL	SHAPE BAYS	SHAPE CONNECTION SEQUENCE	SHAPE LAYOUT lb/lf.
DUCT	LAYOUT SYSTEM TYPE	SIZES CONNECTIONS LAYOUT	SYSTEM TYPE THERMO-CFS
FRAMING	WALL LAYOUT / TYPE	THICKNESS LAYOUT COMPONENTS IN-WALL TRADES	THICK. LAYOUT. IN-WALL TYPE

Suggested Resources:

What industry contacts are needed? Is the information available?

DESIGN TEAMS ON PROJECT

PRECON. TEAM

FIELD TEAM

FABRICATORS

SUBS (OF RELATED SYSTEMS)

BIM EX & IT

MATT @ DPR
BRIAN @ BARTON MALOW
JON @ "
DAVE @ GILBANE
JERRY @ "
RICH @ FIORE

STEVE @ PSU
DR. MESSNER @ PSU
DR. LEICHT @ "
RALPH @ "
KURT @ BALFOUR BEATTY
MATT @ TRULAND

APPENDIX C

THESIS REFERENCES

References

Leicht, R. (2011, November 14). 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

AutoCAD Architecture 2011. (2011). USA: Autodesk.

Microsoft Excel. (2010). USA: Microsoft.

Primavera P6 R8.1. (2011). USA: Oracle.