TECHNICAL ASSIGNMENT 3

NORTHEAST HOSPITAL EXPANSION
123 Medical Lane, USA

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NORTHEAST HOSPITAL EXPANSION

EXECUTIVE SUMMARY

The Northeast Hospital Expansion project is located at 123 Medical Lane, USA. The project will consist of the construction of a new 10 story patient tower, new parking garage, renovation of select patient rooms in the existing hospital wings, and the relocation and upgrading of the central utility plant servicing the entire medical campus. Technical assignment 3 provides an inside look at the project with an interview with John Ovelman, a project manager on the Northeast Hospital Expansion, that discusses the schedule acceleration scenarios, value engineering topics, and the constructability issues faced throughout the course of the project. Additionally this assignment conducted a BIM use evaluation and includes critical industry issues and feedback discussed at the most recent PACE Roundtable.

SCHEDULE ACCELERATION SCENARIOS

Through the interview with John Ovelman the topic of the construction schedule's critical path and the greatest risks associated throughout the course of the project. It was determined that the construction of the new central utility plant would be the main schedule controller. This also meant that the new central utility plant was also the greatest risk to the entire project being completed by September 2015. The project has already lost 64 days due to a rough winter and spring last year. Moving forward in order to make up time on the schedule the mechanical contractor will work two 12-hour shifts on Tuesday and Thursday as well as an 8-hour shift on Saturdays.

VALUE ENGINEERING TOPICS

In order to cut the overall cost of the Northeast Hospital Expansion, the project team looked to value engineer portions of the project. Through the use of the design assist subcontractors Southland Industries and Dynalectric, whiting-Turner was able to provide the owner a total savings of $3,699,678 on the project. These saves came from the ability to use different equipment in the elevators than specified, relocating the generator switch gear to the ground floor instead of the penthouse, and the elimination of several mechanical requirements that Southland Industries felt were unnecessary. Please note the value engineered items mentioned were not all of the value engineered items, but account for a majority of the major changes to the overall cost of the project.

CONSTRUCTABILITY CHALLENGES

As construction on the Northeast Hospital Expansion progress a couple of major constructability issues appeared. A few of the major issues faced in the field were the inability to fit all of the mechanical and electrical ductwork, piping, and conduit on the ceiling of the basement, lack of hanger coordination with the catwalk in the penthouse, and safety concerns expressed with the amount of overhead brazing. Through the creativity and cooperation of the project team, specialty subcontractor, and designers each of these constructability issues were solved in their own unique ways.

LEADING INDUSTRY PRACTICES EVALUATION – BIM USE EVALUATION

The project team originally implemented BIM on this project for primarily 3D coordination in the design and construction phases. It was also utilized for the authorization and design review. After conducting a new BIM use evaluation it was determined that BIM could be implemented in each of the four phases of the projects life cycle. The most noticeable change here is that the BIM model would be handed over to the owner at the project's completion as a record model and could receive continual updates as changes occur in the building. A critical evaluation of both use evaluations was the performed concluding that the original use for BIM were adequate and fit the needs of the project, but could have been used in other areas of the projects if project funding permitted.

CRITICAL INDUSTRY ISSUES

During the most recent PACE Roundtable several hot industry topics were discussed in breakout sessions. The two breakout sessions attended for this technical assignment were the New Global Drivers: Opportunities and risks and Sustainability in the Global Community. The discussion of new global drivers primarily focused on the risks associated with obtaining materials from a foreign vender and how American building owners can regain their trust in foreign manufacturers. The discussion about sustainability in the global community revolved around sustainability techniques utilized in European and Middle-Eastern countries and how the opinion on LEED is slowly shifting to "LEED if it makes sense" and building owners starting to look into new rating systems like the Living building challenge.

FEEDBACK FROM INDUSTRY ROUNDTABLE

After all of the breakout session topics had been cover, students at the PACE Roundtable had a chance to meet with industry members and discuss possible ideas for areas to research come the spring semester. In this session, I sat down with Ken Lindsey and Andy Rhodes. Ken is the contract Executive for Southland Industries at their office servicing the greater San Diego Area and, Andy is a design engineer at Southland Industries Mid-Atlantic office. After giving them a brief description of the Northeast Hospital Expansion project they came up with a few good research topics. These topics included the use of wet walls to save on material and labor cost, the implementation of SIPS for the construction of the patient rooms, the benefits of bringing specialty subcontractor onto a project during the schematic design phase, and the possible use of modular construction for the highly repetitive patient rooms.

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SCHEDULE ACCELERATION SCENARIOS

Critical Path

The critical path for the Northeast Hospital Expansion starts with the excavation of the foundation and the installation of the lagging, tiebacks, and sheeting and shoring. Once the foundation is dug and the proper safety precautions are in place. Next the Caissons need to be placed. Forming, placing the rebar, and pouring the grade beams and foundation walls follows caisson placement. The slab on grade can then also be placed. With the foundation in place the next major schedule driver is the forming, reinforcing, and placing the concrete structure all the way up through the building. This is where the critical path shifts from the physical structure to the central utility plant accompanying this project. In the basement the installation of the duct riser and the medical gas, CHW, HHW, Steam, NG, and Domestic water mains take control of the schedule. From here the installation of sprinkler heads and branch then control. The critical path then moves from the basement to the penthouse where the rough in of the electrical and telecom risers comes the most crucial activity. Sprinklers in the penthouse then become the driver similar to in the basement. Finally the in-wall close-in inspections and overhead ceiling close-in inspections for testing and quality control of the MEP systems are one of the finally schedule drivers.

Big Risks to Completion Date

The greatest risk to the project meeting its completion in September 2015 is the construction of the new Central Utility Plant. The plant is split between the penthouse and the base of the new patient tower. Excluding the foundations and superstructure of the building, the new Central Utility Plant has a majority of its activities on the critical path. This means for the plant is controlling a majority of the schedule. Some of the major activities involved in the plants completion are the installation of the duct risers and mechanical, plumbing, and sprinkler piping mains and branches in both the basement and the penthouse. The installation of these systems is not the only activity that can greatly impact the schedule, but also the commissioning process from the entire plant. The longer these systems are not commissioned the longer the existing hospital must rely on the temporary central utility plant. Each day the temporary utility plant remains in use adds an enough amount of additional costs to the overall project. The quicker the commissioning process can take the much less risk it becomes to keep the existing hospital functioning. During the testing and commissioning of the new central utility plant,

some of the systems may not pass on the first attempt, which can lead to identifying and solving the problem in the system before being able to retest and commission the system for use in the existing hospital.

Potential Areas of Acceleration and Associated Costs

So far on the Northeast hospital Expansion, the project went through an abnormally rough winter last year and has experienced a total of 64 lost workdays. This being said the project team still intends to meet their completion date of September 2015. In order to meet this agreed upon date with so many days of work lost, the team has identified areas on the project that can be escalated to accelerate the schedule as a whole. The greatest activities in which the project team feels they can make up time on the project are the ones through the mechanical contractor. The mechanical contractor has the ability to work their plumbers, fitters, and sheet metal workers on 12-hour shifts on Tuesday and Thursday. They have also agreed to work an additional 8-hour shift on Saturdays. The increased number of hours worked in a week allows the mechanical systems for the central utility plant and throughout the rest of the building to be completed faster and therefore reach the commissioning sooner. This will allow walls and ceilings to be closed in more quickly, thus allowing the finishing trades to complete each space by the agreed upon completion date.

Increasing the length of workers shifts and adding an additional Saturday shift comes with its own associated costs. On the surfaces, Whiting-Turner will be compensating the mechanical contractor's employees at time and a half. This additional cost for labor can quickly add up when paying an original $50 per hour for the union workers. Beyond just the monetary cost to the job, the workers are also experiencing long work hours. These can result in fatigue, which can hinder the quality of work and safety on a job site. For these reasons, Whiting-Turner only wants the mechanical contractor working the two 12-hour shifts on non-consecutive days with the addition of only an 8-hour shift on Saturday versus a 12-hour shift like Tuesday and Thursday.

VALUE ENGINEERING TOPICS

In order to cut the overall cost of the Northeast Hospital Expansion, the project team looked to value engineer portions of the project. Through the use of the design assist subcontractors Southland Industries and Dynalectric, whiting-Turner was able to provide the owner a total savings of $3,699,678 on the project. These saves came from the ability to use different equipment in the elevators than specified, relocating the generator switch gear to the ground floor instead of the penthouse, and the elimination of several mechanical requirements that Southland Industries felt were unnecessary. Please note the value engineered items mentioned were not all of the value engineered items, but account for a majority of the major changes to the overall cost of the project.

The elevators throughout the entire new construction were originally specified to have their controllers, fixtures, door protection, entrances, cabs, and machines to be provided by a variety of different venders. Whiting-turner discovered that Otis could provide the controllers, cabs, and hall fixtures in lieu of the specified equipment at a fraction of the cost. All of the Otis equipment would still be in accordance with the plans and specifications. However, due to the desired capacity of the patient elevators, Otis could not be used for the cabs and fixtures, but their controller could still be implemented. The saves from this change was estimated at $310,000 with minimal effect to the owner's goals. This is because the design was really not affected since the only real change to the project was the vendor for a majority of the elevator parts.

After allowing Dynalectric to provide input on the design towards the end of the design development phase, they found huge savings for the project if the switchgear used to power the two 2 megawatt generators was moved from the generator housing in the penthouse an was relocated to the ground floor. This change to the design created an estimate $765,721 savings to the project. This savings is generated from removing the need to enlarge the unified rooftop enclosure used to house the generators. Additional this change removed the need to hoist the switchgear's parts to the roof of the patient tower and the need to provide additional structural design to support the switchgear at the top of the structure. Furthermore design cost were saved here as well since the generator's switchgear was designed to be placed on the ground floor originally until a last minute change called for the switchgear to be moved closer to the generators themselves. If the switchgear would have been placed in the penthouse with the generators it would have made the owner's operation easier with all of the equipment in the same room. Unfortunately the cost to put all of this equipment in the same room was too great

and the saves to separate the switchgear from the generators was too high not to pass up.

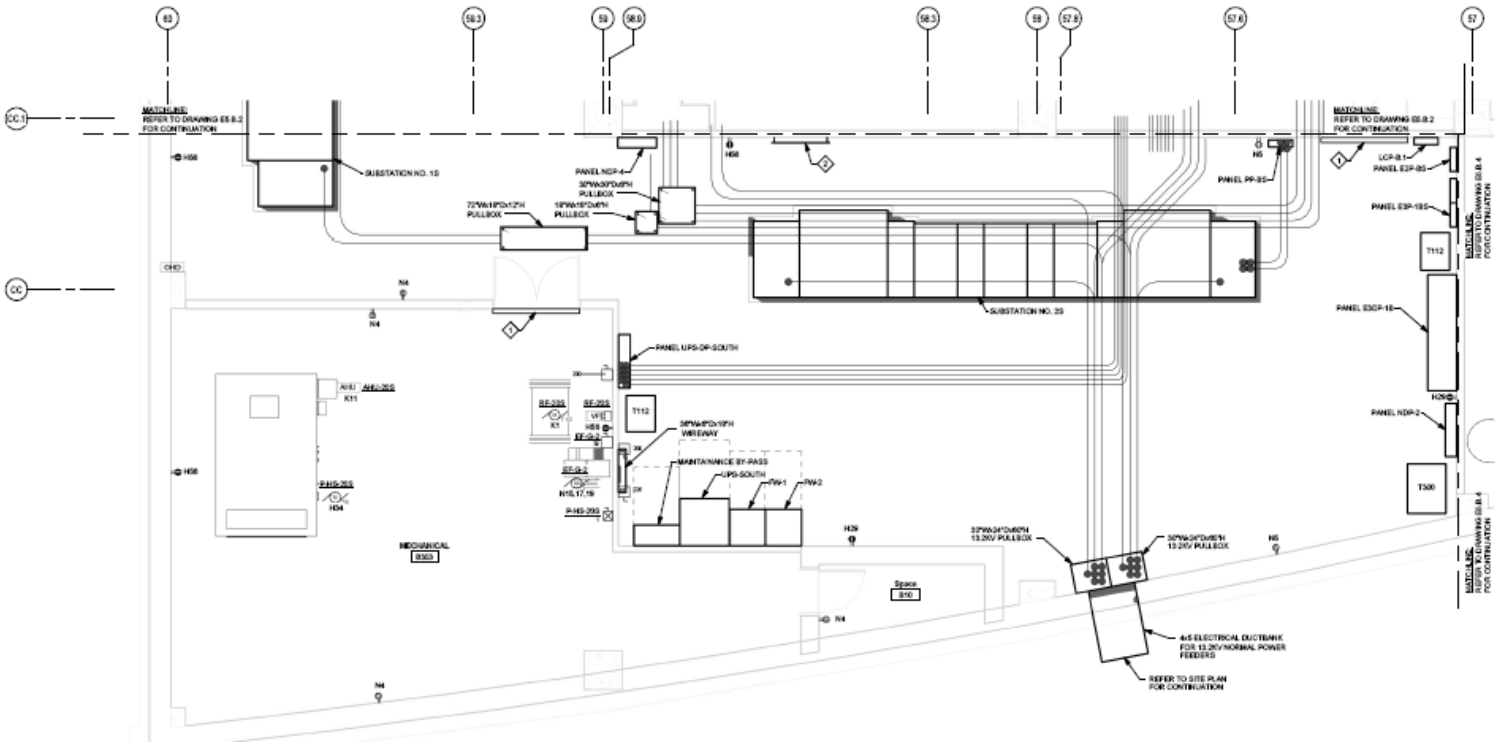
Finally, Southland Industries was the mechanical contractor brought on during design development as a design assist subcontractor. From being brought on early enough Southland was able to convince the owner that certain requirements for the mechanical systems were unnecessary and only added unneeded costs to the overall project. Some of these eliminated requirements ranged from duct cleaning, duct air leakage testing requirements exceeding ASHRAE Standards, adherence to ASME B31.1 (industrial) welding standards in MERs, FM approval on cooling towers, and mitered fittings on piping insulation and canvas jacket on exposed duct. These requirements were found to be excessive and overkill for the type of project this is. Duct cleaning and air leakage were too expensive to conduct at a total cost of $210,000. Though these would assist the owner in reaching a LEED silver certification, the cost was found to be too great. Southland also already welds to the ASME B31.1 standard and did not see a point in charging the owner for a typical industry standard to be inspected. Avoiding the need for this inspection saved a total of $100,000 though it does put the owner at risk of receiving an inferior quality if the Southland does not follow through with the welding standard. Eliminating the need for mitered fittings on insulated pipe provided a savings of $268,000 and the FM approval on cooling towers saved $174,000. Again these saves come at the cost of the owner relinquishing their protection of receiving a verified quality product from Southland. One of the last items Southland value engineered was to decrease the size of the steam headers on the boilers to 36” drums instead of 42”. The 36” drum would meet the designs criteria and be acceptable, but the owner losses the ability to scale up to larger boilers capable of producing more steam. At the cost savings of $100,000 the owner found this acceptable.

From talking with the project team, many of the current project team could not answer as to which value engineered options were declined by the owner since they were not involved at this point in the project, but said they could supply a list of declined options in the future. To their knowledge they could not remember a value engineered option not being accepted.

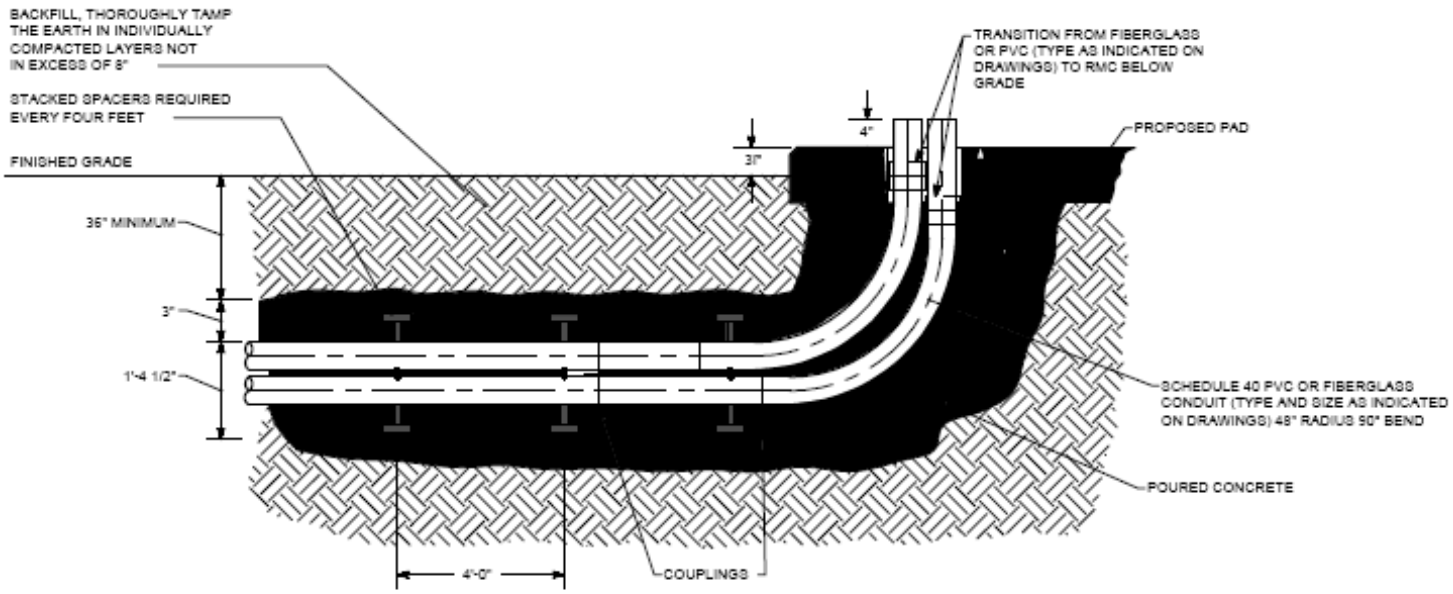
CONSTRUCTABILITY CHALLENGES

As construction on the Northeast Hospital Expansion progress a couple of major constructability issues appeared. A few of the major issues faced in the field were the inability to fit all of the mechanical and electrical ductwork, piping, and conduit on the ceiling of the basement, lack of hanger coordination with the catwalk in the penthouse, and safety concerns expressed with the amount of overhead brazing.

With the new central utility plant being constructed in the basement and the penthouse of the new patient tower, the Northeast Hospital Expansion contained an even greater amount of mechanical, electrical and plumbing equipment and materials. This would create an issue in the basement when it came time to hang all of the mechanical duct and piping, plumbing, and electrical from the ceiling. It was discovered that with the mechanical duct, piping and plumbing in place there would not be enough space to run the conduit for the electrical on the ceiling while maintaining enough head space for a person to walk safely. The project team then decided the next best option was to run the conduit underneath the slab on grade. The project team knew this would be rather expensive at an additional cost of $300,000-$400,000, but could not determine a cheaper, safer, and more efficient method for running the conduit. Below is a drawing demonstrating how the underground conduit would be run and where the pull boxes would located for pulling wire. The conduit would need to be laid prior to the placement of the slab on



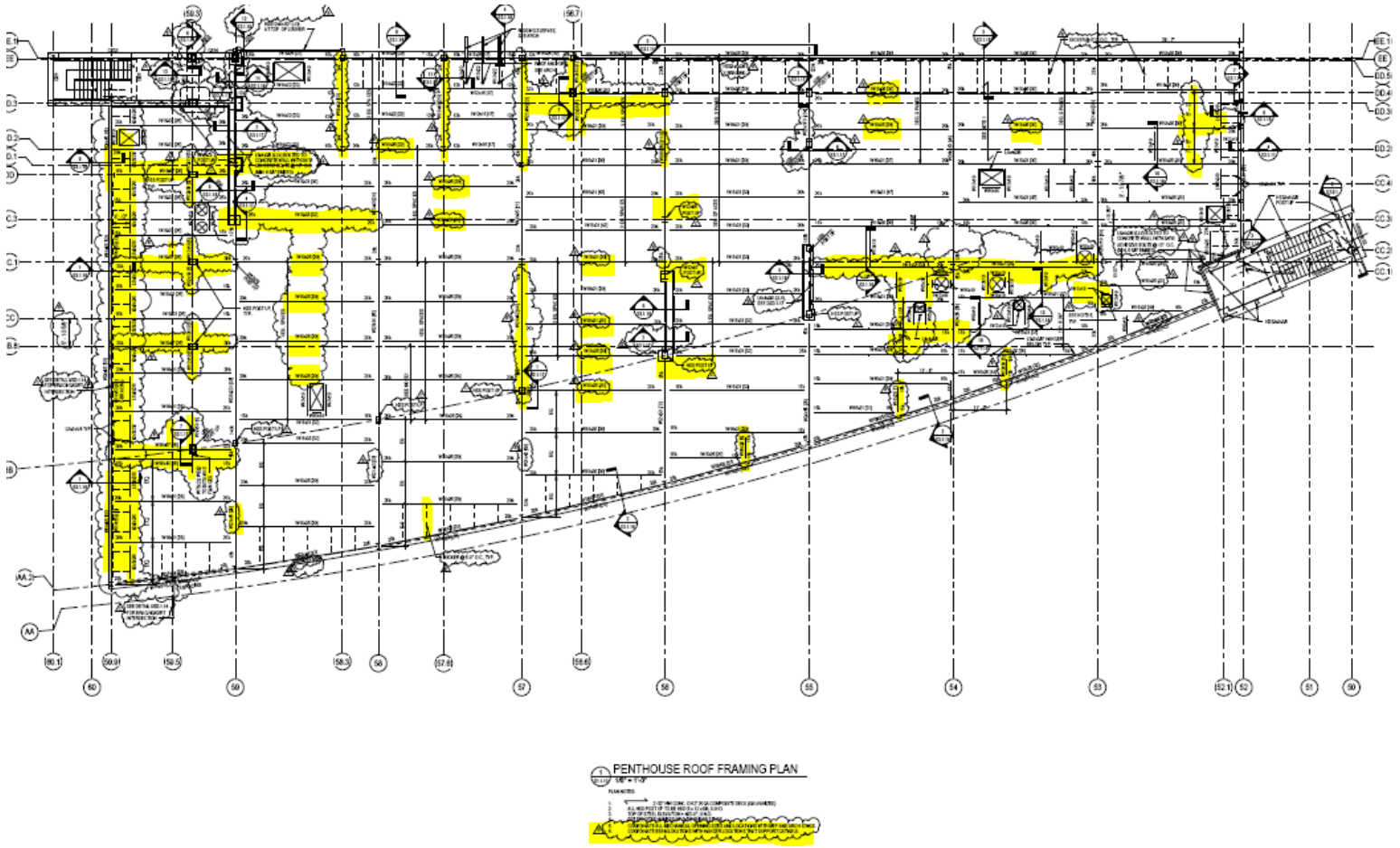
grade to avoid the need to cut and place the conduit separately adding even more cost. Below is a detail of how the underground conduit would be run through an underground duct bank.



DETAIL - TYPICAL UNDERGROUND DUCTBANK INSTALLATION

NOT TO SCALE

Another issue that became evident was once the project team began construction on the catwalk in the penthouse. When it came time to hang the mechanical and plumbing hangers there were a massive number of conflicts with the steel members in the catwalk. The activity of hanging the mechanical hangers halted until all clashes could be resolved. The figure on the next page demonstrates the amount of clashes that occur by the clashes being highlighted in yellow. The project opted for the use of 3D coordination and for the hanger layout and catwalk to be redesigned. The 3D coordination forced the collaboration of the steel erector, mechanical subcontractor, and electrical subcontractor. Once all involved contractors approved the redesigned hanger layout and catwalk design work commenced and the issue was resolved.



The final constructability issue the team project brought to light was the mechanical contractor's concern for safety in the number of overhead brazed connections. The projects specifications call for all HVAC piping connections to be completed through brazed connections. The mechanical contractor stated that this would be quite dangerous for their fitters to be using an open flame to make pipe connections for all connections. Safety concerns are increased here when working from a ladder in tight spaces. The mechanical contractor suggested the option of using propressed connections for a majority of the piping since it has been found to hold an equivalent bond between pipes and fittings. A propress connection is also faster and easier to make in the field so productivity was seen as an additional advantage in utilizing this method. The propress connections were then approved for HVAC piping of 4" or less in diameter. A similar approval was also then granted for all plumbing connections throughout the construction project.

BIM USE EVALUATION

Currently at the Northeast Hospital Expansion project BIM has been utilized in a number of different ways. The BIM model was first formed in the design phase for 3D coordination between all of the different system, design reviews, and design authorization. The model was also used to show existing conditions such as the terrain and the existing hospital wings. Once it came time to enter the construction phase the model is now being utilized for 3D coordination and record modeling. At this time it is unclear how the model will be utilized during the operation phase of the building.

X	PLAN	X	DESIGN	X	CONSTRUCT	X	OPERATE
	PROGRAMMING	X	DESIGN AUTHORING	X	SITE UTILIZATION PLANNING		BUILDING MAINTENANCE SCHEDULING
	SITE ANALYSIS	X	DESIGN REVIEWS		CONSTRUCTION SYSTEM DESIGN		BUILDING SYSTEM ANALYSIS
		X	3D COORDINATION	X	3D COORDINATION		ASSET MANAGEMENT
			STRUCTURAL ANALYSIS	X	DIGITAL FABRICATION		SPACE MANAGEMENT / TRACKING
			LIGHTING ANALYSIS		3D CONTROL AND PLANNING		DISASTER PLANNING
			ENERGY ANALYSIS	X	RECORD MODELING	X	RECORD MODELING
			MECHANICAL ANALYSIS				
			OTHER ENG. ANALYSIS				
			SUSTAINABLITY (LEED) EVALUATION				
		X	CODE VALIDATION				
	PHASE PLANNING (4D MODELING)	X	PHASE PLANNING (4D MODELING)	X	PHASE PLANNING (4D MODELING)		PHASE PLANNING (4D MODELING)
	COST ESTIMATION		COST ESTIMATION		COST ESTIMATION		COST ESTIMATION
X	EXISTING CONDITIONS MODELING	X	EXISTING CONDITIONS MODELING	X	EXISTING CONDITIONS MODELING	X	EXISTING CONDITIONS MODELING

Table 1: BIM Use List based on re-evaluation

After reviewing the current BIM uses, the uses of BIM on this project were re-evaluated. A BIM use list and Level 1 Process Map were created from the re-evaluation. The BIM use list can be seen above and the Level 1 Process Map has been

included as Appendix A. The re-evaluation determined a number of additional areas in which BIM could be utilized on the project.

For the planning phase of the project, a BIM model could be implemented for an accurate representation of the existing conditions. By modeling the existing conditions it can be more easily determined the plot of land Northeast Hospital has to work with and the possible constraints placed on the site. These constraints range from the existing hospital wing constricting the site and also the amount of parking currently available on site for staff and patients. The existing conditions if created at this phase can then be carried throughout the remainder of the project.

In the design phase of the project, BIM can be implemented for design authorizations, design reviews, 3D coordination, code validation, phase planning, and again the existing conditions. By including design authorization and design reviews at this phase of the project, the major contractors for the project can begin to provide input as to ways to improve the design for constructability and efficiency. This would allow for contractors to sign off when they feel the design not only makes sense, but also possible build and is safe for their employees to construct. The ability to 3D coordinate virtually in the design phase has the potential to save the field from running into clashes and discrepancies from the construction documents and at the same time provides the contractors better ideas as to the type of spaces they will be working in and sharing with the other trades. With the creation of a BIM model, codes can be more easily check since the architect and designers have a chance to see the building virtually to make sure they are in compliance with all current codes regulating buildings like the IBC. Finally, the ability to demonstrate the different phases of this project to the contractor would be highly beneficial since it would allow them to not only have a better idea of which trades need to be on site when, but also how many trades will be in the same area and will need to be aware of each other.

The construction phase was determined to benefit from site utilization planning, 3D coordination, digital fabrication, record modeling, phase planning, and existing conditions again. Due to the highly constrained site and amount of equipment necessary on site at one time, the job site would benefit from the ability to create accurate site utilization plans for each phase of the project to maximize coordination and logistics. 3D coordination would be similar to how it was utilized in the design phase except here it would be for RFI's or any change orders that occur in the field that may affect other areas of construction. This is especially to the MEP contractors attempting to fit all their systems into the shafts, walls, and ceilings. Digital fabrication would be extremely helpful since it would allow for the subcontractors to detail and prefabricate segments of systems to construct a safer and higher

quality building. The record model would be kept just like as-built drawings so the model can then be turned over to the owner at the end for an accurate model to be referenced during operation for any changes or maintenance problems. Finally, phase planning here could be implemented as a 4D SIPS model for the patient room construction since each trade only needs to be in each room for about one day of work. This would help significantly coordinate the trades as to which trade should be working where.

Lastly after the building is turned over to the owner, the owner should receive a record model with existing conditions. This would allow the operations phase to continue to update the model as the building undergoes minor changes and renovations. This will hopefully avoid any clashes or unforeseen conditions existing within the structure when the time comes to make changes and update the structure.

Critical Evaluation

Thought the re-evaluation of the BIM usage seems a good idea to implement, there are a few issues as to why certain uses for the BIM model were not considered. Any 4D model on the project was considered to cost more time and money than it was worth. It may be nice to demonstrate the order and flow of trades through a space, but the time it takes to create a 4D model can be quite massive. The schedule for this project shifts from week to week and if one trade performs slower than other during one week and faster the next week the 4D model becomes a full time job to manage in itself. In this instance it may be easier to proceed without 4D model. Also code validation may be unnecessary since the experienced designers are most likely aware of the majority of codes affecting this structure. Finally a BIM model may not be necessary for a site utilization plan. A less sophisticated model may actually work better at demonstration how the site should function and be laid out. Ultimately the originally implemented BIM plan meets the need of the site without taking too much time to update.

CRITICAL INDUSTRY ISSUES

Breakout Session #1 New Global Drivers: Opportunities and Challenges

The first breakout session at the PACE Roundtable was about present day and emerging challenges and opportunities driving construction at the global level. The discussion of the breakout session mainly dealt with the global sourcing of materials and the risks associated with buying material from overseas. Through the discussion it was determined that the risk from ordering these materials is not so much with the quality of the product, like the problem has been in the past. Now the issue with order material overseas is timely deliveries. The best way to avoid a late delivery is to stay in constant communication with these overseas venders and track packaging, shipment, and arrival dates. A common example of a material that can be bought overseas for cheap and can greatly impact the schedule is curtain wall. Curtain wall if bought from a foreign vendor must be thoroughly tracked and the vendor should be called to provide constant updates. It should also be noted that the Buy American Act, which specifies specific countries in which materials can be purchase for the project, now affects many project in the United States. The specification may also require material to be bought from specific countries as well. These specifications came from the past lack of quality from foreign products.

The past lack of trust led the conversation towards how foreign venders could attempt to regain American owners' and designers' trust back. In order to be reintroduced the products need to be retested and certified to meet the American standards. Beyond the obvious though, these products would need to come at a low up front cost to beat out currently trusted and native competitive products. This would entice contractors to suggest the foreign product to owners. Sales people would be the ones who suggest the foreign products to the contractors. From this conversation one can still see price is still a primary driver in the market.

Based on this breakout session it may be a good idea to look into value engineering expensive native materials for foreign material. A possible material might be the curtain wall since Northeast Hospital has quite a bit. A good contact for the procurement of foreign materials would be Steve Rowlinson, a professor at the University of Hong Kong with experience dealing with construction and contracting in numerous foreign countries. Another good contact would be either Ken Lindsay or Raj Vora since both have dealt with foreign venders working at Southland Industries.

Breakout Session #2 Sustainability in the Global Community

The second breakout session at the PACE roundtable dealt with sustainability and how it is view and utilized throughout the global community and not just the United States. The main focuses of this discussion were different sustainability standards unique to other countries, the incentives used to drive sustainability, and current day sustainability rating systems used in the United States.

To begin the discussion the group talked about how countries in Europe deal with sustainability. One of the more interesting methods taken away from this discussion were hotel keys that needed to be inserted into a key slot in order for lights and equipment to function. This means an individual would need to take out their key when they leave the room forcing them to turn off the power to all the lights and electronics in the room. DC power distribution is also becoming more common. This is due to solar power produce a DC current. Entire lighting systems are starting to be hooked up to DC system that can be powered by solar panel arrays. Another interesting point about European sustainability is that it is not just encouraged, but enforced by law. If an individual is found not recycling they can be fined a severe amount to punish them for harming the environment.

This idea of requiring people to be sustainable led the conversation to shift towards the type of incentives available to bringing about sustainability. Other than just outright making sustainability a law and enforcing it with fines, the other options are to provide government incentives to building owners building sustainable buildings or educating building owners on the savings associated with constructing a green building.

The group then got into a discussion about the current thoughts on LEED and where the industry is headed next. The general consensus was that that LEED is beginning to shift from a “shopping for sustainability” and buying LEED credits to the implementation of LEED if LEED makes sense. This means more owners are not striving for the highest LEED certification they can achieve, but instead they are attempting to build green buildings from the start and if their design ends up meeting a LEED certification then great, but if not they will not spend the extra cash to chase it. More owners are beginning to shift towards a new rating system called the Living Building Challenge. This challenge is similar to LEED. It attempts to push buildings for a net zero affect on the environment, material sustainability, net zero water usage, and that the building can be used as a teaching tool. A good point was also brought up stating that there needs to be a balance between energy efficiency and air quality in buildings for them to remain a functional design. There is no point in being sustainable if we cannot use them to begin with.

Though there was a lot of great discussion about sustainability in the global community, there was no real standout great contact in the group. The attendees seemed to contribute their own area of expertise. Dr. Somayeh Asadi may be of the greatest assistance in the implementation of a more European approach to sustainability due to her knowledge of Europe and the Middle East's sustainable systems and how they could be modified to meet American needs and standards.

FEEDBACK FROM INDUSTRY ROUNDTABLE

After all of the breakout session topics had been cover, students at the PACE Roundtable had a chance to meet with industry members and discuss possible ideas for areas to research come the spring semester. In this session, I sat down with Ken Lindsey and Andy Rhodes. Ken is the contract Executive for Southland Industries at their office servicing the greater San Diego Area and, Andy is a design engineer at Southland Industries Mid-Atlantic office. After giving them a brief description of the Northeast Hospital Expansion project they came up with a few good research topics.

The first of these topics was the possible implementation of wet walls between patient rooms to minimize the amount of plumbing pipe necessary for domestic water and wastewater. To do this toilets and sinks can be placed on opposite sides of a wall and utilize the same main pipes to drastically save material and labor costs. They also said a similar idea could be implemented with the medical gas lines in the casework.

Another topic of interest would be the implementation of SIPS on all of the patient floors since every room is basically the same. SIPS could be paired with a 4-D model to allow for better coordination between all of the necessary trades thus completing all of the patient rooms in the most efficient manner.

Ken and Andy also thought this project could have benefitted from the subcontractors having been brought on as design assist during the schematic design phase versus the design development phase. By bring the subcontractors in this early, more efficient design could have been suggested through alternative systems or minor modifications to the designer's specified systems.

Finally they thought the Northeast Hospital Expansion could have benefited from modular patient rooms or bathrooms. Though building the mechanical systems offsite has not been proven to be cheaper, this method is safer for the construction workers and provides a more quality product in the end.

All of their suggestions were beneficial in moving forward and both Ken and Andy said they could be reach for any further questions I might have in researching any of these topics.

APPENDIX A: BIM USE EVALUATION – LEVEL 1 PROCESS MAP

Level 1: BIM Execution Process Map

Northeast Hospital Expansion

BIM USES

Design and Preconstruction

Construction

Operation

Planning
Existing Conditions Modeling
Owner | Existing Condition Model

Schematic Design
Authorize Schematic Design
Architect | Design Authorization

Schematic Design
Perform 3D Coordination
Architect | 3D Coordination

Schematic Design
Create 4D Model
Contractor | 4D Modeling

Schematic Design
Code Validation
Architect | Code Validation

Schematic Design
Existing Conditions Modeling
Owner | Existing Condition Model

Design Development
Author Design Development
Architect | Design Authorization

Design Development
Perform 3D Coordination
Architect | 3D Coordination

Design Development
Create 4D Model
Contractor | 4D Modeling

Design Development
Code Validation
Architect | Code Validation

Design Development
Existing Conditions Modeling
Owner | Existing Condition Model

Construction
Author Construction
Owner | Programming

Construction
Perform 3D Coordination
Architect | 3D Coordination

Construction
Create 4D Model
Contractor | 4D Modeling

Construction
Existing Conditions Modeling
Owner | Existing Condition Model

Construction
Digital Fabrication
Specialty Contractor | Digital Fabrication

Construction
Record Modeling
Contractor | Record Model

Operation
Existing Condition Modeling
Owner | Existing Condition Model

Operation
Record Modeling
Owner | Record Model

End Process

Unaccepted Design

Design Review

Unaccepted Design

Design Review