TECHNICAL REPORT 3

National Intrepid Center of Excellence
Bethesda, MD

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TABLE OF CONTENT

EXECUTIVE SUMMARY

This technical assignment begins to identify areas of the National Intrepid Center of Excellence that are potential options for research, alternative methods, value engineering, and schedule compression. A site interview was conducted with the Project Manager of NICoE, David Wysong, to discuss the topics above. Mr. Wysong answered questions pertaining to constructability challenges, schedule acceleration scenarios, and value engineering. The report concludes with some of the project problem identification and construction management activities for technical analysis methods.

The first constructability challenge mentioned by Mr. Wysong was dealing with the U.S Navy. The project is being built on the National Medical Naval campus in Bethesda, MD. This issue has been difficult since Turner Construction has very little control over the exceptionally long review process required and the security necessities on this project. Second is the unexpected weather condition that has faced the DC area. The replacement of the utility lines, limited material staging area, and interior work delays have been the effects of the bad weather. Third challenge is the owner's medical equipment on this project. Most of the building's medical equipment is supplied internationally. Issues have been arising due to the lack of shop drawings and coordination between involved parties. Lastly, is the challenge of tying the two different types of prefabricated facades. Bringing together two different types of systems can result in connection issues, and certain tolerance concerns.

Using a temporary enclosure on the north side of the façade in order to accelerate the water tight status has been the one major schedule acceleration scenario being practiced on this project. This resulted in overlapping the curtain wall system with the interior work activities of the building. This has been a great success by allowing enough time to complete the massive amount of high-end finishes required inside the facility.

Dozens of Value Engineering (VE) ideas have been implemented on the NICoE. This includes: cutting the building's size by 14%, eliminating one of the skylight designs, deleting some of the high-end interior finishes, integrating the precast panels and the curtain wall system on the northwest side, decreasing the amount of landscaping design done, and removing the green roof design. Very few ideas that were contrived were not implemented. All VE measures were taken to reduce the cost of the project and help deliver the project on budget. Careful measures were taken to move money around appropriately and maintain the owner's vision for an impeccable and sleek design.

Next, six problematic features of the project were identifies and considered for further analysis in the final thesis proposal.

The entire document culminated with the development of four construction management analysis activities that address the challenges and problems identified throughout this assignment. Topics chosen for analysis include: the communication issues faced with BIM during the VE period, the usage and process of BIM during the VE period, the alternative prefabricated air handling unit for this project, and the energy usage due to a centralized heating and cooling system. Extensive research and contacts with professionals will be required to successfully understand the process which were used, the existing and alternative building systems, and how to properly analyze each topic. Finally, design and construction implications were considered within the analysis topics included.

CONSTRUCTABILITY CHALLENGES

Owner – The United States Navy

The National Intrepid Center of Excellence is being built on the Naval Medical Center campus in Bethesda, MD. As a result, the U.S navy seal plays a major role of the construction process. A very strict process is required to be followed for review and approval of many of the construction activities before occurring on site. Shop drawings, change orders, and life safety plans are some of the activities that have to be approved by the Navy construction center. This process requires a tremendous amount of extra paper work from Turner construction and their concerned subcontractors. Therefore, the review process on this project has been a challenge to the project team. The project schedule has been affected at times since most of the paper work has to be approved by multiple amounts of people before any work begins.

Security is a major concern when building a project on a military base. Coordination between Turner and NNMC is required throughout the construction phases of this facility. Material deliveries, major construction activities, and manpower are required to be reported back to NNMC on a daily basis. All material delivery items need to be documented and reported 48 hours before arriving on site.

Weekly construction activity reports are also required from the PM. Every laborer on site is required to have a background check, which grants him/ her a name tag. The name tag permits them site access and to work on the project. If overtime work is necessary, it must be reported for approval.

The site logistic plans were limited based on restriction for access roads. Palmer road was the only access road permitted to be used for vehicular access. A security guard is present at all times at the access gates. He is responsible for checking all delivery trucks and laborers' name tags. As a U.S. navy base, the president of the United States and/or general military personal may attend the campus at times. When such events occur, the project is required to be shut down immediately. Therefore, building a project on a military base can arise many construction activity delays, which can affect the productivity on the project and adversely affecting the project schedule.

Turner Construction has addressed these challenges to help ensure that the construction process can run as fast and as smooth as possible despite any extra steps which need to be followed. Perseverance has been the key solution to the long review process. In addition, having a team which fully understands the construction activities and are willing to answer any question arise during the review process, has been a great help. Shop drawings and plans have been delivered from the subcontractors to Turner for review and approval as early as possible to account for the long review process.

Owner meetings have been taking place on a weekly basis in order to solve any outstanding issues. During these meetings, Turner runs through a summary of the project progress and any upcoming events that require security approval by the Navy. The owner's high involvement in the project has been a great help in order to make sure the construction sequencing, schedule and productivity does not get affected by any security issues.

Weather

Figure 1 – Muddy Site Conditions

The DC area has been hit with severe weather in the past three months, which has posed as a major challenge to the project on this job. The placement of some surrounding building utility lines have been delayed since the soil has become disturbed due to the rain. Considering the limited budget amount on this project, temporary roads were not built to accommodate the construction process. Therefore, with all the mud on site (figure 1), material staging area has become very limited. Moreover, the building was not fully enclosed and watertight when the bad weather hit the area. The north side of the building enclosure, composed of the curtain wall system, was not in place at this time. Water and mud was constantly sweeping into the building from various locations. Any interior work, which had already begun, had to be ripped and redone. This issue has affected the productivity on this job along with the project schedule.

To accommodate the unforeseen weather challenges on this project, Turner Construction has put together a plan to begin work overtime and on weekends earlier than they expected.

Figure 2-Temporary Building Enclosure

To achieve weather tight conditions in order to begin the interior work, a temporary enclosure has been placed in placement of the curtain wall system. The curtain wall system has taken a longer lead time than originally planned for. Therefore, the temporary enclosure has been a remediation for any schedule delays for interior work caused by the curtain wall system lag. Getting the building enclosed has also helped with the material storage area problem. Subcontractors have been able to store most materials inside the building.

Even though Turner Construction is currently still dealing with the effects of the weather on this project (figures 3-5), working overtime to make up for any lost time and getting the building enclosed, has been a great start in dealing with the unexpected weather issue.

Figure 3 – Project Access road

Figure 4 – Replacement of Site Utilities

Figure 5 – Material Storage area

Owner Medical Equipment

The NICoE is a 10 day recovery facility, which is dedicated to research, diagnosis and treatments of traumatic brain injury and psychological health issues. The majority of this facility, seen in figures 6-9, is dedicated to many of the sophisticated medical equipment, bought by the owner, such as: CAREN System, Virtual Reality Equipment, Fluoroscope systems, MRI Systems, and CAT labs. Most of the suppliers of the medical equipments are located in the Netherlands. This brings about many construction challenges for both Turner and the involved subcontractors. The major focus for Turner is to communicate and coordinate all medical equipments with the required connections based on the required U.S codes.

The international supplier also makes it difficult to organize a time where all involved parties are available for a coordination meeting. Most of the equipments' shop drawings have not been received from the suppliers. Therefore, coordination is a challenge without having any reference material. The involved subcontractors have been incurring installation risks by not being sure what connections are required for most of this equipment. David Wysong, Turner site project manager, stated, "It is easier to manage a known risk than an unknown risk, which is what this issue has been."

The construction team has been managing this challenge in multiple steps. A set weekly conference call meeting time has been organized between all involved parties. Prior to this meeting, the updated equipment's shop drawings are delivered via e-mail to the PM. This enables the involved subcontractors and Turner Construction to review the design and plan for the steps required upon their arrival. Some of the key questions that arise and must be solved before the equipments arrive on site include:

- Taking into consideration the size of equipment, how will Turner get them into the building?
- Are the required connections available?
- Once placed in the building, how will they be secured?
- What are the maintenance/cleaning requirements for the equipment?

Figure 6- CAREN System

Figure 7-Virtual Reality

Figure 8- Fluoroscope system

Figure 9- MRI System

Curtain Wall Glazing & Precast Panels

The building envelope is comprised of precast concrete panels and a curved curtain wall system. This constitutes the fourth and final constructability challenge, which is tying together the two different façade systems along with the concrete slabs. Since there are multiple subcontractors that are involved with the construction of the curtain wall and precast panels, coordination is essential. The curtain wall system is being performed by GPR, Inc., the precast concrete panels are by Arban Precast, LTD and the concrete slabs are by Miller & Long Concrete.

Not only installation is the challenge, but the fact that these two different façade materials are expected to work together brings about tolerance issues. Precast and glass performs vary differently with thermal, moisture, fire safety, acoustics, material/finish durability, and maintainability properties.

The construction placement method of the curtain wall system has also been a construction challenge. Considering the curtain wall's long lead time, a temporary enclosure has been placed in order to remove the curtain wall from the critical path and continue with interior installation. As a result, the crane, which was placed inside the building, had to be removed to ensure full enclosure. Considering both the necessary enclosure and crane removal, questions on the placement method of the curtain wall system arose.

These major issues involving the façade of the building had to be studied by all parties involved to be able to come up with the best solution possible. Coordination meetings have been taking place concerning both systems. Shop drawings are utilized during these meetings to make sure all required connections between all systems are available before installation begins. As for the performance concerns, a great deal of engineering has been done from both the designers and the subcontractors to ensure this system.

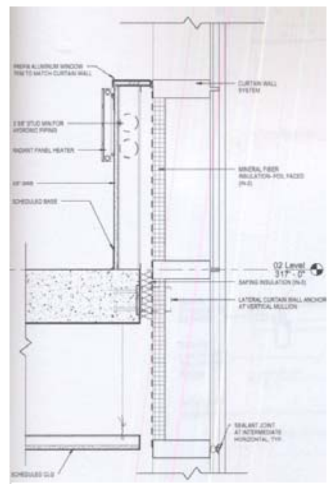

Figure 10 – Curtain Wall & Precast Panels Connection Details

Figure 11- Scaffolding along with a trolley system for the placement of the curtain wall system

Finally, for the placement of the curtain wall, the PM on the job suggested a scaffolding system along with two trolleys to hang along a track around the perimeter of the north side (figure 11). The installation system so far has been a success to the subcontractors and Turner Construction.

SCHEDULE ACCELERATION SCENARIOS

Critical Path

Activity	*Description*
Site Utilities	An extensive amount of underground site utilities are performed on this site. The chilled water supply and return lines along with the high pressure steam and the electrical pump condensate lines are run underground from the central utility plant on base to the building mechanical room. The owner (NAFAC) is responsible for making sure campus utility lines are available for contractor use. It is very important to have temporary utilities available, as they are required for the all construction activities occurring on site.
Precast Concrete Panels	A major part of the building façade is composed of precast concrete panels. A timely delivery of the precast members puts this activity on the critical path. The members are manufactured nearby the job site, and materials need to be delivered and stored just in time for erection. Any delay in the deliveries would have a drastic affect on the schedule.
Curtain Wall System	The second major part of the building façade is the curtain wall on the north side of the building. This system was originally on the critical path since it is also a long lead item and can affect the building's watertight date which effects the interior activities start dates as well. After making the decision to place a temporary enclosure in place of the curtain wall, this item was removed from the critical path schedule.
Concrete Placement	Concrete slabs must be poured in order to set equipments within the building. It is essential for the slabs to be poured in a timely manner in order for all other interior construction activities followed to occur.
Interior Finishes	This facility includes high-end finishes in most areas. It is important for all medical rooms to be finished and cleaned prior to respective equipment start-ups. Since equipment start-ups are to be commissioned, it is critical that rooms are completed on time, if not early.
MEP	MEP rough-ins must be coordinated and installed in a timely manner in order to hook up all required equipments within the building. Testing and balancing the mechanical equipment can take up a great amount of time, and the earlier this procedure begins the better. Also, all medical equipment hook-ups are required to be available when the medical equipment arrives in order to begin commissioning.
Medical Equipment	There are $20 Million dollars worth of owner's medical equipment which is expected to be delivered, installed, and commissioned. The medical equipment is being delivered from the Netherlands. As mentioned, extensive coordination between all involved parties has been in place. Once a piece of equipment arrives and has been started, the controls subcontractor can begin figuring out the controls associated with that equipment and testing the connection and sensors available. This process must be done for all medical equipment within the building before turning the building over to the owner.

Risks to Project Completion Date

<u>Long Lead Items</u>

According to Project Manager, David Wysong, the highest risk to project completion date is receiving long lead items on time. The building façade is composed of two prefabricated long lead items, precast concrete panels along with the two different types of curtain wall systems. It is very important to receive those items on time to be able to achieve watertight status and move along with the interiors of the building. Second, long lead item on this job are all hallow metal door frames. All door frames on this job are composed of welded hallow metal frames. Since the design of this project has been constantly changing, there has been an addition of a large amount of door frames that can take up to 12 weeks of fabrication.

NICoE has massive amount of long lead medical equipments. The CAREN System, Virtual Reality Equipment, Fluoroscope systems, MRI Systems, and CAT equipment, will be delivered from the Netherlands. It is very important to receive these items on time, in order to make sure all medical equipment is connected and performing as required. Commissioning on all medical equipment has to be done before the building is turned over. Also, there are a number of high end finishes required in the interior of this facility, including curved wood paneling and interior glazing that also have long lead items. Potential delays can impact other interior finishes. It's important to note that medical equipment cannot be set before all the rooms' interior finishes are done.

There is a large quantity of long lead items on this job and most are dependent on each other. Consequently, it is very important to manage and keep an eye on all delivery items in order not to negatively impact the schedule.

<u>End user Changes</u>

The National Naval Medical Center (Owner) has been involved throughout the entire design process. The end users of this facility have only recently become more involved with the project. After looking over the design and equipment of the facility, the end users have been requesting changes to the design and construction of the project. This process has resulted in a lot of redesign to the interiors of some of the lab rooms.

Potential Schedule Acceleration Scenarios

One key area that has been used to accelerate the schedule is the temporary building enclosure, which was put up on Nov 5, 2009. It resulted in taking the curtain wall system off of the critical path and achieving watertight status almost 2 months before originally accounted for. Originally the curtain wall system and the interior finishes had a start-finish relationship on the project schedule. Now these two activities are overlapping. As previously stated, the interior finishes are expected to take a long time to install and any time that can be gained is crucial. In addition, once the work moves into the interior, there are going to be very few opportunities to accelerate the schedule by a considerable amount.

Since the curtain wall manufacturer has more time to fabricate and deliver the curtain wall system, there were some costs recovered from the original curtain wall bid price (which paid for most of the temporary enclosure.) The owner is very happy with this decision since the project will still be delivered on time despite the design changes that have been implemented.

VALUE ENGINEERING TOPICS

Due to NICoE being a 100% funded project, budget is essential to the owner. The original design was completed by October 15, 2008. Turner Construction was then awarded the construction contract in July 2008. Turner immediately began to look for areas where they could implement value engineering without modifying the functionality of the building. The design has undergone major changes due to budget cuts and end user involvement. Currently, Turner Construction is using CCD-9 on the project site.

Turner's main objective is to make sure that the entire project team remains flexible with the project regardless of any design adjustments. David Wysong (PM) worked closely with SmithGroup and the owner to make sure that the project goals were not detracted or affected by any means. Considering the project is being funded by private and public donors, the budget is monitored closely and money must be moved around strategically. SmithGroup's main concern is the design. They have worked very hard to make sure that nothing is altered and the integrity of their design is maintained. Despite the different interests, all three parties were able to work very closely together to find a design that can meet all interests.

Turner and the owner sat down to discuss all VE ideas that can be implemented on this project. David Wysong explained that the owner has a very keen eye for identifying and estimating potential VE options. Multiple VE ideas were implemented on this project even before breaking ground. Most of the ideas discussed in this document are large VE options that were used to detect expensive, aesthetic components that served no functional purpose and therefore, were not necessary for the facility to operate.

Most of the VE ideas that were discussed during the design phase have been implemented. The exact cost savings for deleting these items are unknown. Although, it is important to notice that there were eliminated in order to meet the inflexible budget. For this reason, the owner was not opposed to deleting these items since they did not drastically affect the overall design.

Implemented Value Engineering Topics

Building Size

The original building design was 3 stories, 84,000 sq. ft. Originally there was an extensive amount of open space in the middle of the building. It was suggested to narrow the building by taking off a 30' bay from the middle. Lab spaces, auditorium, lobbies and office spaces were much larger than what was required. It was then suggested to shrink the building to 2 stories high and the ceiling height by 2'-8"'. This resulted in lowering the high roof by 2'-8" which meant less concrete and less curtain wall material. This has produced a tremendous amount of cost savings to the owner by decreasing Turner's bid number.

Additionally, decreasing the building size resulted in reducing the storm water retention area. Originally the retention system was designed as a 100' x 11' x 70' whole, with a 6' diameter pipe, which extended 80' deep. The resulting retention area is 30' x 30' x 5 'gravel pit. This system has saved almost $300, 000 dollars for the owner.

Skylight

Another architectural feature that was discussed for possible VE ideas was the two original sky lights that were located on the south and north side of the building. The two original round skylight designs were 20' and 40' diameter. Since they only serve an aesthetic purpose, it was suggested to remove one of the skylights and design a 30' diameter skylight which cuts through the central park area. This idea was immediately accepted by all parties since it had a $300,000 cost savings to the owner and the architect's skylight idea was not completed demolished.

Finishes

This facility has an extensive amount of high-end finishes that were applied in the original design. The finishes had driven the cost of the interior subcontractor's bid very high. Therefore, many interior finishes were removed completely. Examples of some finishes that were eliminated include: stainless steel trim pieces around the main stairwell, a 30' wide stone wall in the lobby, terrazzo flooring, and some wood paneling located on the interior round walls. Removing some of these architectural aesthetic features, but still keeping in mind the owner's expectations, saved the owner more money in the end.

Landscaping

The extensive original landscaping design came well over budget. It included the removal of many existing trees and altering the surrounding surfaces. As VE ideas were discussed, many of the existing trees were suggested to be kept as is. Small calipers were preferred to be used, which may take longer to grow than what is originally planned for, but yet was another aesthetic feature that was not very necessary to have.

Precast Wall Panels & Curtain Wall System

The Northwest side of the building is composed of a curved 38'-8" Precast wall panels along with a curtain wall system. The original design extended the precast wall panels 6" beyond the exterior face of the Northwest side of the curtain wall system. Therefore, the precast panels were originally designed to be a stand-alone structure. This served no purpose other than a unique aesthetic feature which would have cost the owner an extra $1.5Million dollars to the overall building cost. It was suggested to integrate both the curtain wall and the concrete precast panels as one system. This resulted in: reducing the amount of curtain wall material used, finishing the precast panels only on the interior side of the building, and reducing the size of the low roof. Since the precast panels are much cheaper than the curtain wall system, this decision resulted in saving an extensive amount of money and time on the project.

Green Roof

NICoE is pursuing a LEED certification. Therefore, a green roof was designed to be built on the high roof of the building. The design of a green roof requires the structure to accommodate a 200/300 Ib load. This meant that the structure design needs to be able to contain a heavy load, which requires a much thicker structural design. Also, maintenance is required for a green roof. The end users did not want to go through the maintenance hassle required by the green roof. After analyzing the amount of LEED points which will be gained by having a green roof, the cost of this system, and the maintenance required, it was concluded that this idea was not an optimal decision for this project. Therefore, the green roof was eliminated from the design. The removal of the green roof had reduced the structural design load to 20/40 lb load, which meant less concrete used. This resulted in saving almost $1 Million dollars for the owner.

All in all, the value engineering ideas that were implemented on this project have reduced the project cost by 40%. Some design changes are currently taking place since the end building users have just gotten on board. As mentioned above, the owner was involved in all VE ideas and the objectives of all parties were kept in mind during the process.

Rejected Value Engineering Topics

There were no substantial VE ideas that were considered but not implemented. There were very few areas of the NICoE project that were untouched by value engineering due to a request from SmithGroup and the owner. All components of the project have been looked at with a very critical eye as an effort of the entire project team to deliver this building within budget.

PROBLEM IDENTIFICATION

Problem 1: BIM and Value Engineering Communication

The National Intrepid Center of Excellence is utilizing BIM techniques for coordination between the design and construction of the project. A 3D Revit model was developed by SmithGroup in the design phase of the project. The model included the structural, mechanical, plumbing, electrical, exterior and interior architectural features. Turner was given access to the NICoE model upon joining the project. Turner Construction then studied value engineering ideas that had potential to be used on the project to meet the required budget.

Using the 3D model, the team was able to illustrate the recommended design changes on this project to the owner. The owner then could distinguish the difference between the original and the suggested designs and evaluate the value of the changes. The Value Engineering process went on for approximately 5 months, beginning in August 2008 and ending in December 2008. During this process, some of the approved value engineering ideas from Turner Construction and SmithGroup were not modeled into the original 3D model used in the coordination meetings.

Other communication issues between the designers and the GC during the value engineering process have caused many delays on this project. A drastic change that was not implemented on the 3D model is lowering the ceiling height by 2'-8", which meant less plenum space available. Therefore, coordination meetings, which were run on a weekly basis, were using the original 3D model without the new and approved ceiling height of 15'. This meant that all clash detection between MEP and structural trades were being run according to the original ceiling height of 17'-6".Once the work began on the first floor, the problem became apparent.

This issue caused Turner Construction a batch of lost coordination time and wasted cost to the project. Poor communication has resulted two months of delay time to update all value engineering changes that were approved to the 3D model.

Problem 2: BIM and Value Engineering Process

Another issue is the distorted BIM process used by the project team. SmithGroup spent major amounts of time and money to develop a sufficient and accurate 3D model. The architectural model was also the base for all other designers to place other required building equipment within. Having 5 different designers involved in the development of the 3D model was a challenging issue on this project. Once this model was developed and value engineering course began, different designers were not all involved in this process simultaneously.

As mentioned above, during the value engineering process, the model was used to demonstrate the advantages and disadvantages of the suggested ideas. The owner was also able to see the overall architectural affects and decide on whether to approve or disapprove the suggested ideas. However, cost estimation was not done using the 3D model. The suggested or approved ideas had to be hand calculated by Turner's estimation department. Therefore, the VE process period was taking much longer that it would have if the model was a continuous working 3D model.

Once any VE ideas were approved by the owner, they were documented to apply those changes onto the model. Since the VE period lasted for over 5 months, VE meetings were held once a week with massive amounts of changes suggested by Turner and SmithGroup, some of the changes were not applied immediately. Moreover, the 5 other designers were never required to update their model and resubmit. The model update requirements and responsibilities were never explicitly assigned.

When coordination meetings were run on the first and second floor for the MEP and structural system, none of the involved trades noticed the 2'-8" ceiling height change. Therefore, this distorted process has caused the project a one month delay to the schedule. A fast and more efficient process could have been done if there is a continuous working 3D model.

Problem 3: Field Erected Air Handling Unit

A field erected air handling unit located on the second floor in the mechanical room is used as a main source for cooling the building. The AHU's supply airflow maximum is 86,000CFM and minimum of 68,000 CFM and delivers a 100% fresh air supply throughout the building. This field erected air handling unit was claimed to be an over-designed system. SmithGroup had designed the system based on all hospital requirements. A detail that was overlooked when designing the system is that the NICoE facility does not emit any natural gases in the labs, which would have required a 100% fresh air supply.

The over design of this system along with SmithGroup's field erection decision, has resulted in a much higher cost and more time required on the project schedule for the erection of the unit. A prefabricated unit, which is designed based upon the actual building requirements, would have saved cost and time on this project.

Problem 4: Energy Use

The chilled water supply and return lines, along with the high pressure steam and the electrical pump condensate lines are run underground from the central utility plant on base to the building mechanical room. The high pressure steam system is used for the domestic hot water and as a main source for heating the building. This design brings about possible issues with the building's thermal comfort zones. Since the heat is controlled from the central utility plant, very minimal temperature control can be done in the actual facility. Considering the amount of labs and patient rooms available, the temperature control may affect the efficiency and productivity of this facility.

Problem 5: Day Lighting

Currently, NICoE is pursing LEED silver certification; however, the day lighting credit is not being pursued. To achieve a day light credit, a building must have 75% day lighting in occupied spaces. For NICoE, it seems highly feasible to achieve this credit since 45% of the façade is composed glass. Most of the glazing overlooks the lobbies and not the work spaces. Achieving day lighting will also reduce electrical loads and improve the work environment quality in this facility.

Problem 6: Owner's Medical Equipment

Coordination has been a major issue when it comes to the medical equipment of this project. Most of the medical equipment required in this project is purchased by the owner from the Netherlands. Turner Construction has no contract with the equipment's suppliers. Therefore, this issue becomes challenging when it comes to coordination between the involved parties. SmithGroup and Turner Construction do not prefer any design changes based on the continuous design equipment changes by these suppliers. It has been a constant battle between the project team to get all medical equipment shop drawings to be able to finalize the design of this project.

TECHNICAL ANALYSIS METHODS

BIM and Value Engineering Communication

Although a 3D model has been developed by the designers, poor communication between the project team has decreased the overall benefits of the BIM applications on this project. BIM is a developing concept in the construction industry. Although not many industry professionals are familiar with the BIM, it has proved very useful for the owners, designers, engineers and general contractors. On this project, SmithGroup and other designers were required to develop a 3D Revit model in their contract. Since most of the designers involved were unfamiliar with BIM responsibilities and legalities, the contract language was very vague. As a result, during the Value Engineering period, BIM model changes were not updated accurately.

An analysis of this issue will require the following:

1) Developing a 3D model of the original design using Revit Architecture.

2) Interviewing different parties involved in the VE period regarding the process and evaluating communication patterns used during the VE meetings.

3) Looking into the contract language concerning the BIM application used on this project between the designers, owner, and the GC.

4) Developing the “fixed” 3D model according to all approved VE changes.

5) Analyzing the benefits of having a continuous working 3D model (progression model) in the VE period.

6) Comparing the structural and mechanical difference between both models used.

7) Calculating the cost and schedule effects that had been made.

BIM and Value Engineering Process

The issue mentioned above, was not only due to poor communication between parties involved, but also due to the distorted BIM process used during the VE course of the project. The VE period had taken the project team 5 months to achieve the owner’s required budget. There has been a significant amount of changes that were implemented on this project. Changes took place beginning from cutting the building’s square footage to changing the interior finishes of some of the laboratories. The 5 months used for the VE process could have been cut in half if the BIM techniques had been used to its fullest. One of the main time-consuming processes used during the VE period is the hand estimating of the suggested ideas. The usage of 3D cost estimation software with a continuous working 3D model would have been a great benefit to this project.

An analysis of this issue would require a hand cost estimation of the changes made to the original design. Then, using the updated 3D Revit model along with Autodesk quantity takeoff, and developing a 3D cost estimation sheet. Continuing on by calculating the time and cost spent for both hand and the 3D estimation. Next will be, breaking down a step by step procedure on the implementation of the BIM process during the VE period and the benefits that will be gained by using this process.

Field Erected Air Handling Unit

As mentioned in the previous section, the current air handling unit system designated for this facility, is an over-designed field erected system. The AHU system is designed to use a maximum of 86,000 CFM and a minimum of 68,000 CFM. It was designed to deliver 100% fresh air supply throughout the building, although was not necessary. The field erection of such an AHU this size can take up to 13 days and could possibly be less efficient than a prefabricated system.

An analysis of the AHU system would require to calculate the actually CFMs required for this facility and compare it with the existing design. An efficient alternative system would then have to be researched through contacting available suppliers throughout the region and noting the long lead time that is required for a prefabricated system. The next parameter that will be evaluated is the material cost saving using the new AHU design. Next, the impact on the schedule must be reviewed since the new design will be prefabricated. Lastly, a comparison of energy efficiency consumed by the original and the new design will be calculated with the overall energy building loads.

Energy Use

Most of the major utility lines such as: chilled water supply, chilled water return, high pressure steam, and the electrical pump condensate lines are run underground from the central utility plant on campus. This design brings about possible issues with the building's thermal comfort zones. Since the heat and air conditioning is controlled from the central utility plant, very minimal temperature control can be done in the actual facility. This can drive up the energy consumption costs for the building.

A decentralized system can be analyzed using the thermal loads required for each of the building spaces. Considering the square footage of this building, one possible chiller will be able to handle this load, which could possibly be placed in one of the two spacious mechanical rooms available. Contacting local suppliers for the unit required would be the next step in the analysis process. Comparing the long term cost and energy savings of the overall suggested system will be done to support my recommended design change. The analysis will continue with a detailed schedule impact of this alternative system. Lastly, I will evaluate the advantages and disadvantages of this recommended change.