FINAL REPORT

National Intrepid Center of Excellence
Bethesda, MD

4/7/2010
Ronza Abousaid
AE Faculty Consultant: Mr. James Faust
AE Option: Construction Management

NATIONAL INTREPID CENTER OF EXCELLENCE

http://www.engr.psu.edu/ae/thesis/portfolios/2010/raa5025

Bethesda, MD

DESIGN TEAM

Owner : The Intrepid Fallen Heroes Fund
Contractor : Turner Construction
Architect : SmithGroup
Structural : Cagley and Associates, Inc.
MEP : SmithGroup
Civil : A. Morton Thomas & Assoc, Inc.
Soils : Schnabel Engineering, Inc.

PROJECT OVERVIEW

Location : National Naval Medical Center, Bethesda, MD
Occupants : Military personnel/veterans suffering from traumatic brain injury and psychological issues.
Function : Advanced research, diagnoses and treatment base facility.
Size : 72,000 Square Feet
Stories : 2 levels
Construction Dates: March 9, 2009 – May 10, 2010
Budget : $65 Million
Delivery Method : Design Assist & Design build

ARCHITECTURE

The northeast and south sides are dedicated to clinical and support spaces of the facility. Meanwhile, the northwest side is allocated to the healing and public areas of the building. The exterior wall consists of a curved curtain wall system along with concrete precast panels extending the height of the building 38'-8". The roof consists of a thermoplastic polyolefin (TPO) membrane system. Finally, spacious lobbies and playground areas are provided for relaxation.

STRUCTURAL

The foundation system is composed of reinforced concrete spread footing (3000psi). The first level is a 5" thick slab-on-grade system. The floor to floor height is 15' with 5'-6" difference between the low roof and high roof. Remaining levels consist of elevated 9" thick two–way reinforced concrete slab. Reinforced concrete columns range from a 24"x 24", 12"x 24" ,16"x30" and 16"x24".

ELECTRICAL

NICoE is serviced from an upgraded 15KV primary feeders to a 2500 KVA, 13.8KVA, 480Y/277V, 3PH, 4-Wire primary transformer. Also, a 3000A main-bus continuous switchboard provides power to all building loads. A standby diesel generator rated at 400KW, 480Y/277V, 3p,4W is used for emergency power. In addition, a 225 KVA UPS battery backup is connected to two PDU's that provide the service room with the required emergency power.

MECHANICAL

All mechanical equipment is located on the first and second floor of the mechanical room. The central utility plant on base provides chilled water, high pressure steam, and electrical pump condensate lines. The primary heating and domestic hot water is comprised from high pressure steam. VAV and constant volume control boxes are used throughout the building.

RONZA ABOUSAID
CONSTRUCTION MANAGEMENT | 2009-2010

Turner

TABLE OF CONTENTS

ACKNOWLEDGEMENTS

I would like to thank the following people for their support, guidance, and assistance throughout the development of my senior thesis project.

THE PENNSYLVANIA STATE UNIVERSITY

Dr. Christopher Magent
Mr. James Faust
Dr. Moses Ling
Professor Robert Holland
Professor Kevin Parfitt
Mr. Craig Dubler

TURNER CONSTRUCTION COMPANY

Mr. David Wysong
Mr. Dan Garripoli
Mr. Travis Sigmon
Mr. Dan Braud
Mr. Heth Barkley

GILBANE BUILDING INDUSTRY

Mr. Mark Luria
Ms. Akilah Darden
Mr. Eric Fritz
Mr. Mike Grobaski
Mr. Jerry Sheehan
Mr. Brian Horn
Mr. Mike Dulany
Mr. Greg Dunkle

KINGSPAN CO.

Mr. Rick Gordon
Ms. Lisa Fischer

XETEX INC.

Mr. Ben Fisher

OTHER ACKNOWLEDGMENTS

McGraw Hill Construction
DPR Construction

Executive Summary

The following document is an inclusive analysis on some of the issues which were faced by the National Intrepid Center of Excellence project in Bethesda, MD. There are four main topics of discussion with a construction management emphasis on each topic. Some of these topics are currently faced by the building industry, due to the challenges of the cutting edge technology of Building Information Modeling and the widely used integrated project delivery methods. This report also displays the many benefits which come along with the efficient use of BIM, such as: 3D estimating and the value engineering of alternative building systems. The issues faced by the NICoE project has been due to the lack of a collaborative design and construction team, which can be achieved with an integrated project delivery method such as design-build.

The Project delivery method analysis investigates the possibility, advantages, and disadvantages of using a design-build project delivery method based on the project goals and objectives of NICoE. Research reveals that developers have been leaning towards a leaner project delivery method, such as design-build, since the need to cut cost and shorten the schedule is one of the main focuses for the current building economy. After analyzing the owner's project objectives, his experience and relationship with the team, a design- build delivery method has been suggested for the use on this project. When analyzing the schedule benefits in using a design-build delivery method, it has shown at least a 2 month savings on this project.

When using BIM on project it is very important to have a collaborative team which has a very structured communication plan. NICoE has suffered from collaboration issues due to the miscommunication procedures within the project team. Therefore, a Project Execution Plan has been developed based on the owner's requirements and expectations of the use of BIM. This plan, when used, can eliminate any confusion of many of the coordination and model requirements within the project team. This report also includes many of the industry's views on BIM and their obstacles that come along with this new technology. Although, there is a high initial cost for the training and accommodating the use of BIM within the project team, this technology ultimately increases quality, decreases construction and design costs, and decrease the project schedule.

When using BIM it is also important to take advantage of all its deliverables. Coordination and collaboration is much more efficient when using BIM, but another reason why BIM should be invested in is the 3D estimating aspect is has to offer. Value engineering periods on most projects can take up a lot of time since there is a tremendous amount of cost estimations done in order to value the alternatives suggested (such as the 5 month VE period of the NICoE). Therefore, if 3D estimating is used, alternative systems can be estimated within hours if not minutes. There is also a high initial cost due to training and early planning. After analyzing the initial cost and time spent on both, 3D estimating could be a great benefit to have cut out much of 5 month value engineering period which was spent on this project.

And lastly, with BIM and a collaborative design and construction team, it is possible to have specialty contractors to be involved with the building systems design selection. On this project, heat recovery systems were analyzed for the purpose of cost saving and an energy efficient mechanical system. These heat recovery system has a low life cycle cost and therefore are the new widely used systems within the current building systems design.

PROJECT INTRODUCTION

The Intrepid Fallen Heroes Fund, a national leader in supporting the men and women of the United States Armed Forces and their families, has launched an important new effort to serve our military community. The Fund is building the National Intrepid Center of Excellence (NICoE), an advanced facility dedicated to research, diagnosis and treatment of military personnel and veterans suffering from traumatic brain injury (TBI) and psychological health issues.

NICoE will be a 72,000 square foot, two-story facility located on the Navy campus at Bethesda, Maryland, adjacent to the new Walter Reed National Military Medical Center, with close access to the Uniformed Services University, the National Institutes of Health, and the Veterans Health Administration. NICoE will be designed to provide the most advanced services for advanced diagnostics, initial treatment plan and family education, introduction to therapeutic modalities, referral and reintegration support for military personnel and veterans with TBI, post traumatic stress disorder, and/or complex psychological health issues. Further, NICoE will conduct research, test new protocols and provide comprehensive training and education to patients, providers and families while maintaining ongoing telehealth follow-up care across the country and throughout the world.

The building broke ground on March 6th, 2009 and is scheduled to be completed within a 16 month period. Turner Construction is the construction management group on site along with Smithgroup, which is the design firm for the NICoE project. This project is expected to acquire LEED certification, which will meet the standards of the USBGC. Additionally, Building information modeling (BIM) is used in the design, and construction phases of the NICoE project. This project will be delivery as a CM-at-Risk contract between Turner Construction and Smithgroup. The mechanical and plumbing package will be done by Turner in a design build delivery method. The initial budget is approximately $65 million under a GMP contract.

The design features are highlighted on the northwest side of the building. It is composed of an exterior curved curtain wall system along with concrete precast panels extending the height of the building 38'-8". This houses the healing and public areas of the building such as: auditorium, waiting rooms, lounge, the media "Dive" room, the CAREN (Computer Assisted Rehabilitation Environment) and the spacious lobbies. Situated within the building on the East and south side are clinical spaces which include: MRI rooms, PET/CT rooms, physical, occupational, recreational therapy, Sleep labs, Research Tech, and other support spaces. There are two different roof levels that towers the building. The low roof extends throughout the east and south side of the building. The high flat roof ties into the curved curtain wall system on the north east and west side of the building giving it a special architectural feature. Finally, spacious lobbies and playground areas are provided for the friends and families to relax while their loved ones are being treated.

"This facility will provide treatment that is available nowhere else in the world," said Phil Tobey, a senior vice president at SmithGroup. "With its comprehensive programs and advanced technology, we believe this facility will accelerate the U.S. leadership in the treatment of traumatic brain injuries, and provide the best possible care for the men and women of our armed services."

Project Overview

Client Information

The Intrepid Fallen Heroes Fund was established in the year 2000 to provide financial support for the dependents of United States military personnel lost in performance of their duty. This continued an effort begun in 1982 by Zachary and Elizabeth Fisher, founders of the Fisher House Foundation. Following the bombing of the U.S. Marine barracks in Beirut in 1982, the Fishers sent contributions of $10,000 to every child who lost a parent in the attack. Until Zachary's passing in 1999, the Fishers made hundreds of similar contributions following military losses. These gifts, usually of $25,000, were intended to assist military families through any financial hardships they might face following the loss of their loved ones. This tradition was carried on by Zachary's nephews, Arnold, Richard and Tony Fisher. Following the terrorist attacks on September 11, 2001, and the United States' involvement in the war and terrorism, the need for this support greatly increased and this effort was expanded to the public to help generate the growing need for funds.

The Intrepid Fallen Heroes Fund was established officially as an independent not-for-profit organization in 2003. Through 2005, the Fund provided close to $20 million to families of United States military personnel lost in performance of their duty, mostly in service in Iraq and Afghanistan. The national Intrepid Center of Excellence will be funded for a very important and critical issue faced by the wounded troops: the treatment of TBI (Traumatic Brain Injury). The Intrepid Fallen Heroes Fund is continuing to collect donations from both public and private funds to complete this project. . This facility will serve as a national leader in supporting the men and women of the United States Armed Forces and their families.

Sine this project is fully funded by public and private donations, lots of eyes lay upon it. This raises the expectation levels from both Turner Construction and SmithGroup. As it usually is, cost is crucial factor for a funded project. The owner expects for the project budget to be met. As for quality expectations, it needs to meet the medical facility standards with high-end level 5 finishes. NICoE's project schedule is flexible. Since the majority of the amount of funding for this project is in progress, the owner does not recommend the use of extra dollars on overtime work to be able to recover the schedule. But also expects the project completion date to be met. As for safety, the owner is very stringent for an accident free site. This has been met so far by Turner Construction and continues to endorse an accident free project. Regular owner meetings are held (every 2 weeks) to make sure that the project is going along as expected. Other meetings such as: staff meetings (2-3 weekly), subcontractor meeting (weekly), equipment meetings (weekly), and BIM weekly meetings are held. During the meetings the following is discussed: major issues, 2 week look ahead schedule, start of new activities, coordination meetings, and major changes to the project. These meetings are required by the owner to be able to run the project smoothly without any problems and to meet the expectations discussed above.

One of the most important sequencing phases to the owner is the facility's equipment phase. The owner will be providing all the major high-tech equipment and expects all connections and requirements to be ready on time when the equipment arrives.

Upon completion the National Intrepid Fallen Heroes Fund will transfer the NICoE to the department of defense for staffing and ongoing operations.

Project Delivery Method

National Intrepid Center of excellence is being delivered as a CM-at-Risk project along with design-build contract for the mechanical and plumbing package. Due to the complexity and uniqueness of the project, the owner chose for Turner construction to be involved earlier on and assist SmithGroup (Architecture firm) in the design stages of the project. SmithGroup was chosen based upon their past experience with the owner. They have designed many of the Naval Medical campus's projects and have met the owner's high expectations. SmithGroup has been hired and is under a fixed price contract with the owner.

Turner's early involvement in the project is intended to make both the design and construction phase run smoother by illuminating the problems earlier on. This would help the owner from spending the money on potential change orders and therefore a delay in the schedule of the project. No bids were collected for this job. Mr. Ronald fisher had asked the CEO of Turner Construction to build this project as a contribution to the soldiers of this country. Therefore, Turner construction's fees are very low. In July 2008, Turner was awarded the construction contract for the NICoE.

Turner would not disclose the bonding or insurance requirements for this project in details. However, the subcontractors which are under Turner's contract have been selected through competitive bids, along with the expectation of a contribution to the project. All of the subcontractor's contracts are fixed price contracts. Insurance is required from all the subcontractors. The amount of the contract determines the insurance requirements. For many of major building's system contracts, such as those shown in figure 1, have bonding requirements.

Again, this project is not a typical hospital project. It has given this project an advantage for Turner Construction to be involved early on and use Building Information Modeling with the different subcontractors to understand the complexity and the vision of the project before the bidding process had begun.

Key Contacts

Owner | The Intrepid Fallen Heroes Fund

Construction Manager | Turner Construction

Architect | SmithGroup

Structural Engineer |Cagley and Associates, Inc.

MEP Engineer | SmithGroup

Medical Equipment Consultant | Gene Burton and Associates

Acoustical Consultants | Miller, Beam, and Paganelli

Testing and Inspections | Schnabel Engineering Associates

Communication | Vantage Tech Consulting Group

Blast Consultants | Weildinger Associates, Inc.

CONTRACT TYPES

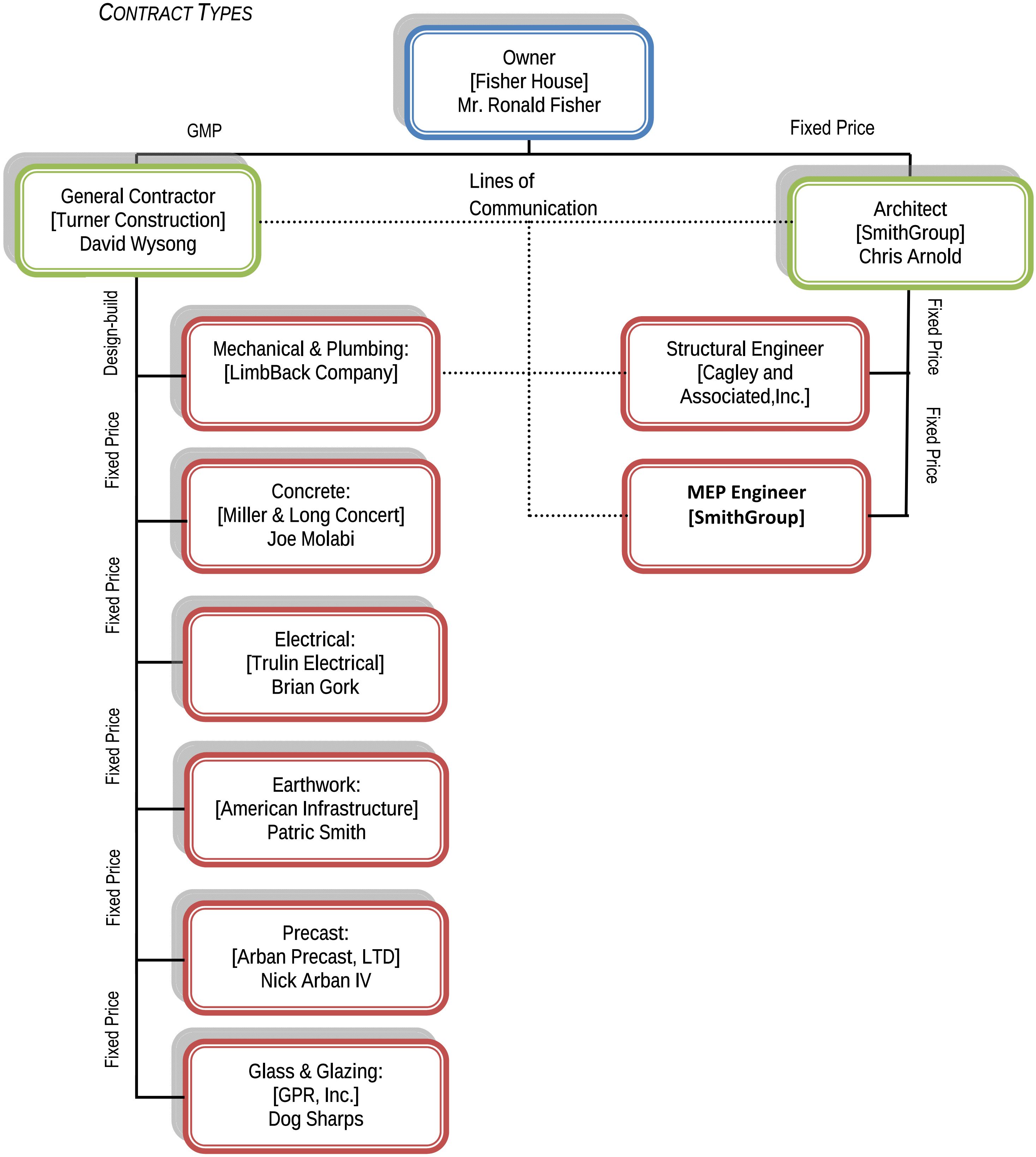


Figure 1 – NICoE Contract Types

Project Management Team

Turner Construction Company consistently delivers qualified professional staff with their extensive in-house resources, tailored to the unique needs of each client and project.

As for the National Intrepid Center of Excellence, the project is led by a Project Manager and a Senior Superintendant. The management side included a Project Executive, Project Manager, BIM Coordinator, a project engineer, and two assistant project engineers. As for the field side, there is a Safety Manager, two superintendents, and an assistant superintendent.

Seen in Figure 2, the project executive oversees the project, visits about once a month and whenever needed. The Project executive provides executive authority necessary to overcome the project team's obstacles and barriers, which are faced on the job. He is also ultimately responsible for this project success. David Wysong, the project manager, is the primary person in charge of the daily activities on site. He is responsible for the agreed-upon projects tasks and activities are completed on time, on budget and within the quality standards which meets the owner's expectations. David works very closely with both his superintendents and the project engineer. Making sure both the field and the office are communicating and work is done correctly and run smoothly without any problems. The Project engineer with his assistants handle all project submittals, most of the RFI's, and review the payment requisitions from the subcontractors.

As for the Superintendents and their assistant, they handle all field installations using approved submittal and shop drawings. Superintendents also supervise the subcontractor's daily activities. The BIM coordinator, Daniel Fernados, coordinates all shop drawings given by SmithGroup and runs the clashes before any drawings are approved. He also runs weekly BIM coordination meetings. As for safety, all of Turner's project team is responsible to bring the attention to any hazardous construction activities that are seen on site. In addition, Dan Garripoli is a full time safety manager on the NICoE. He also takes the role of the second full time superintendent on the job. His main responsibility is to help create a safe environment by preventing dangerous practices on site. He is accountable for being aware of proper procedures and safe construction methods during the hours of construction.

PROJECT TEAM STAFFING PLAN

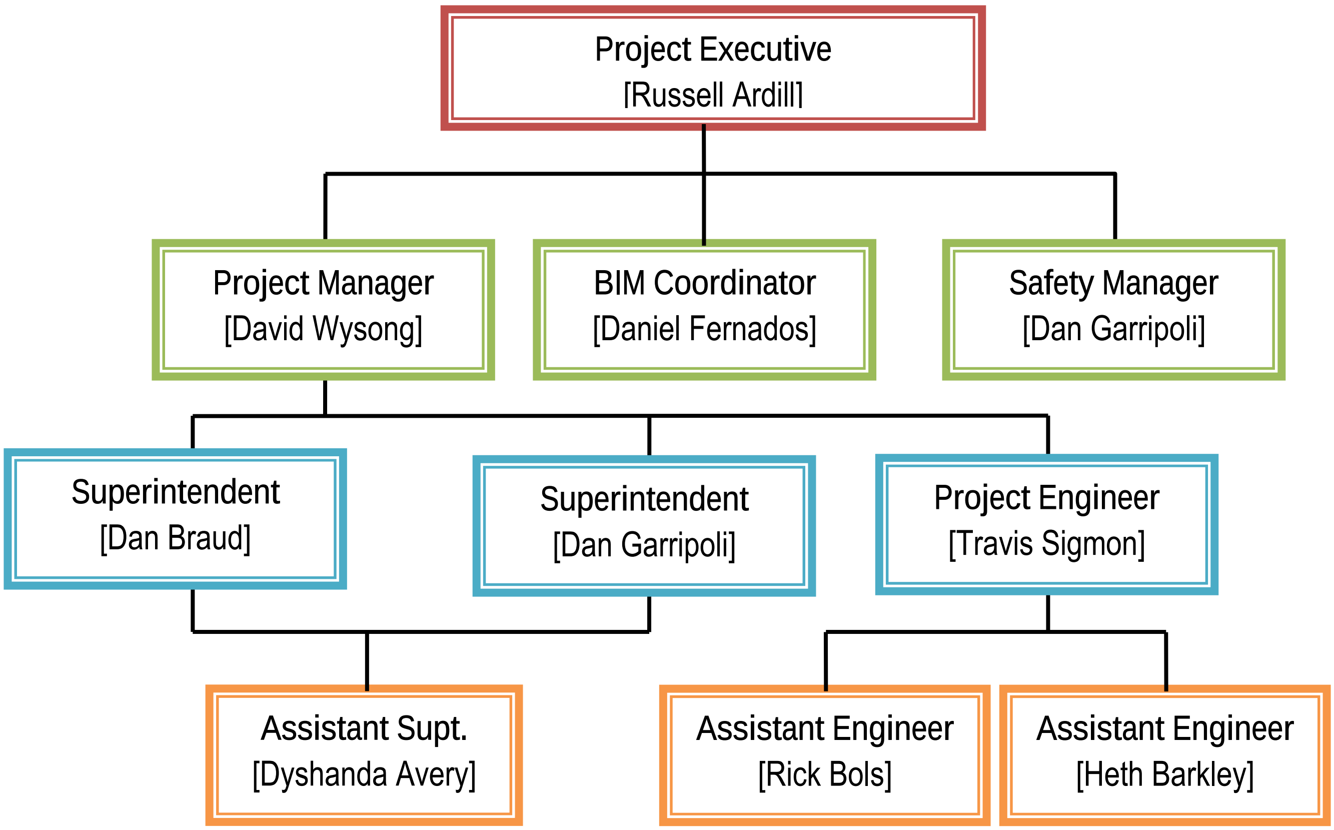


Figure 2 –Project Team Staffing Plan

BUILDING SYSTEMS

DEMOLITION:

The NICoE site was previously a dormitory for noncommissioned officers (NCO). Therefore, a demolition plan needed to be put in place before any construction had begun. The demolition was not done by Turner construction. A large portion of sidewalks, trees and shrubs had to be removed. Some asbestos material was found and was removed from the site. Unsuitable soils became a factor in the design and construction of the project. Taking into consideration the soil borings that were done on site, it was known that the soils were non-compacted and needed to be disturbed and re-compacted to get to the required strength.

CAST-IN-PLACE CONCRETE:

Cast-in-place concrete is used for footings, foundation walls, SOG, both floor levels, high and low roof. The concrete spread footings (3000psi) range from 4'-6"x 4'-6" x 12" to 15'x 15'x33" (WxLxD). Also, the first level is a 5" thick slab on grade (3500psi) with a 6" - 12" transitions in some spaces. SOG is placed on a vapor barrier over a minimum of 4" layer of clean, well-graded gravel or crushed stone over compacted sub-grade, reinforced with 6x6 W2.0 x W2.0 WWF. The cast–in-place concrete columns range from 24"x 24", 12"x 24", 16"x30" and 16"x24". The second floor, low roof and high roof structural plan is composed of a 9" thick two–way reinforced concrete slab (4000psi) with various location drops ranging from 8" – 15". In addition, the central park area requires a post tension reinforced concrete due its heavy loads. The reinforced concrete columns extend to the second floor and require a change in the compressive strength to a 4000psi with a 10'x10'x8"drop panels. At the high roof, low roof and around the curved northwest exterior walls are 24" diameter circular concrete columns with HSS steel connections.

As for the types of formwork used, the concrete formwork is a high load WACO scaffold with 67-1/2" aluminum beams used for both purlins and joists. 5/8" BB plyform is the cast against the surface.

Concrete placement methods were: ground level concrete was placed using both back of truck and Gabrow 3 yard bucket. Columns used a side chute bucket. A couple of the elevated decks were placed with a 47meter Putzmaster truck mounted pump. The placing rate for elevated decks is about 60 yards per hour, limited by the screeding activities not by the placement methods.

PRECAST CONCRETE:

Precast concrete panels along with punched in windows and mechanical louvers will be used throughout the east and south facade of the building. The precast panel connection details are pins in grout pockets at the bottom. Embedded weld plates and 4x4x1/2" angle are bolted to the panels and welded to the concrete.

One crane is used for the placement of the concrete precast panels. The crane is located on the south side of the building, one column line into the building. It is able to pick the 3 yard bucket at the tip of the jib which is 212'. Hook height is 99' above the first floor. The location of the crane was chosen based upon the allowable reaching distance without swinging over the adjacent buildings. The crane was unable to be placed outside of the building due to existing utilities. The foundation for the crane is 30' square and is placed on the 45 to the column grid so it does not interfere with the building foundation.

MECHANICAL SYSTEMS:

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. Two mechanical rooms are located on both floors at the southwest side of the building. The high pressure steam system is used for the domestic hot water and also as a main source for heating the building. A field erected air handling unit located on the second floor in the mechanical room is used as a main source to cool the building. The AHU's supply airflow max is 86,000CFM and min of 68,000 CFM. In addition, variable air volume (VAV) and constant volume control boxes are used through the building to maintain the required temperature. Chilled water pumps located on the first floor in the mechanical room will have a capacity of 950 GPM with a motor data of 25HP, 1.750RPMs, 460 volts, and 3PH. Heating hot water pumps located on the second floor mechanical room will have a capacity of 300 GPM with a motor data of 15HP, 1,750RPMs, 460 volts and 3PH. Lastly, an air conditioning unit located in the computer rooms is used in the: server room, MRI equipment, PET/CT room, CAREN equipment, and media "Dive" room.

FIRE SUPPRESSION SYSTEMS:

The NICoE is designed with a wet-Pipe Sprinkler system. The interior of the building is broken into light hazard occupancy (admin areas, assembly areas, computer rooms etc and normal hazardous occupancy (storage areas, mechanical and electrical rooms and similar stockpiles of combustion materials do not exceed 8'-0"). This provides for the light hazard areas a 0.10GPM per Sq.Ft and a 0.15GPM for the ordinary hazard areas over the hydraulically most remote 3000sq.ft.The fire command center is located on the ground floor in the engineering equipment room on the southwest edge of the building. This room houses the fire alarm control panel, voice amplifier panel, voice evacuation panel, transient voltage surge suppression, and 2 notification appliance power extended panel etc. A pre-action sprinkler system is installed in the server room on the second floor. Each floor, including core and shell is equipped with fire alarm strobe-speaker appliance; manual pull stations, ceiling and wall mounted smoke detectors, and heat detectors.

ELECTRICAL SYSTEMS:

NICoE's electrical system begins at the central utility plant on base and is transferred to the electrical room which is located on southwest side of the building. The power is serviced from an upgraded 15KV primary feeder located in the concrete ductbank. The power is received using a 2500 KVA transformer which steps down the voltage from a 13.8KV to a nominal system voltage of a 480Y/277V, 3PH, 4-Wire which services most of the loads in the building. Receptacles and some lighting fixtures receive power through a 208Y/120V, 3P, 4W system. In addition, a 3000A Main-Bus continuous 480Y/277V, 3PH, 4-Wire switchboard provides power to all loads in the building.

As for emergency power in the building, an exterior factory –assembled and tested standby diesel generator rated at 400KW, 480Y/277V, 3p, 4W system with sub-base fuel tank is provided. Along with the generator are two different circuit breakers rated at 600A, 3p and 225A, 30P. Also, a 225 KVA UPS battery backup system is connected to two PDUs that serve the emergency power in the service room located on the second floor.

MASONRY:

There is a very minimum amount of masonry used in this building. A large portion of the CMU is used as a load bearing curved 22' wall, surrounding the CAREN system, in the northwest side of the building. The CMU dimensions used around the CAREN system is 8"x16", whereas in the mechanical room area it is 6"x8"x16" Normal –weight CMU. The CMU connections are 3"x3"x1/4"MTL angle which is 12" long at 4" O.C. bracing both sides and each is fastened to the slab with a two 5/8" epoxy anchors. No veneer is used. The scaffolding used is a typical masonry walk through with outriggers.

CURTAIN WALL SYSTEM:

There are two different types of glass used within the curtain wall system. Both the IGU-1 and the IGU-3 is a 1.153inch thick glass which is a tinted heat strength float glass. It has a low emissivity coating laminated with clear float glass (LGU-1) with a visible light transmission value of 54%. The IGU-1 has a UV transmittance value of <1% and IGU-3 has a winter U-value of 0.28 and a summer U-value of 0.26. The curtain wall connection details are mostly Halfin embeds in the concrete with "T" bolts connection to the steel sub frame. Additionally, the curtain wall system is pre-assembled in the glazing factory and will be delivered in sections.

TELECOMMUNICATION SYSTEM:

The main telecommunication room is located on southeast side, on the first floor, in room 1067. Telephone and data system are connected to the Communication room and also back to the server room on the second floor with (6) 4" conduits. Each floor is provided with a local telecommunication closet. Voice/data, media, wireless, and computer outlets are provided in almost all rooms throughout the building. Cable Runways are used to transfer the telecommunication cables throughout the building.

SECURITY SYSTEM:

Wall mounted security card access readers are provided outside of selected rooms throughout the building. Most of the highly secured area is located within the southeast and south region of the building. This region of the building is where most of the exam rooms, lab rooms, MRI/CT rooms and all control rooms are located. Also the northeast entrance is an employee only entrance, which also contains a card access reader.

AUDIOVISUAL SYSTEM:

This building contains various audiovisual systems throughout most of the rooms. Flat panel monitors along with surround loudspeakers are provided. The Auditorium, Media "DIVE" room, Research/Tech Room and the AV classroom contain projection screens, video projectors, and loudspeakers for presentations given in those rooms. PTZ cameras are also spread throughout various spaces in the facility for constant patient monitoring. Input and output AV panels are used for multimedia connections in the rooms specified. Most of the AV equipment is wall mounted or ceiling mounted within the various rooms.

LEED DESIGN ASPECTS

The NICoE is a LEED Silver building which incorporates many sustainability design features. One of the most visible features is the curtain wall system which is located on the north and west side of the building. There are two different types of glass used within the curtain wall system. Both the IGU-1 and the IGU-3 is a 1.153inch thick glass which is a tinted heat strength float glass. It has a low emissivity coating laminated with clear float glass (LGU-1) with a visible light transmission value of 54%. The IGU-1 has a UV transmittance value of <1% and IGU-3 has a winter U-value of 0.28 and a summer U-value of 0.26. This will help maintain the space at a comfortable temperature environment and at the same time minimize the energy used to cool and heat the building.

Site developments, water use reduction, construction waste management, enhance commissioning and using both regional and low-emitting material has given the NICoE a drive to comprise a LEED Silver project.

LOCAL CONDITIONS

The National Intrepid Center of excellence will be constructed within the Naval Medical Center site, located on the corner of Rockville Pike and Jones Bridge Road, in Bethesda, Maryland. The majority of the site is currently under construction as mentioned above.

Construction in the Washington D.C metro area is predominately cast-in-place concrete with post-beam structure. Structural steel projects are not common since there is a height restriction that the district has put forth for all new construction in the region. Concrete tends to be used for buildings with levels up to 12-15 stories. Concrete is cost effective, durable, and unlike steel, has no lead time. However, NICoE is owned and run by a government navy base and does not have any zoning restrictions appeal to the design or construction of the building.

As for staff parking, there is a minimum amount of parking spaces on site. Additional parking is available throughout the naval medical center via shuttles. Parking decks are shared with other construction projects occurring concurrently and also the occupants of the navy medical center facilities. Additionally, most of the facilities are fully functional throughout the construction periods. Therefore, all parking decks are typically full during the weekdays. Construction workers are encouraged to either use the metro, which is across from the medical center, or carpool whenever possible. Also, the security for the Naval Medical Center is very tight and can potentially cause some schedule delays.

Security is one a major issue faced by Turner Construction site access. 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. The security process can affect adversely affect the project schedule since it requires almost an hour per person to obtain security clearance. Also, all visitors are required to be escorted by a team member of Turner Construction if entering the site.

Site Plan of Local Conditions

The site is composed of 12 facilities including the National Intrepid Center of Excellence, Children Development Center, the Fisher House, and the USUHS (refer to Google map shown below). In addition to the NICoE project, there are a total of six projects which are under construction concurrently on the same site. This causes some planning between the other projects. The site logistics plan, which is shown in figure 9, has been put in place by Turner Construction. This plan has been in favor of the construction methods that take place on a daily basis. The tower crane location along with the positioning of the material staging has made the lifts and placements of the materials a very manageable task. Palmer road acts as the main access to the site for all of material deliveries. Along with that comes a temporary gravel road which was constructed around the building's footprint for ease of access. Since this site is already occupied, all utilities such as: electrical, water, gas, storm drain, chilled water supply, chilled water return, steam water supply, steam water return, fire hydrant rails, communication, and sewer lines are existing utilities and ready to be tied into NICoE. A brief site plan can be viewed in Figure 3 below. For more detailed existing conditions site plan, please see Appendix B.

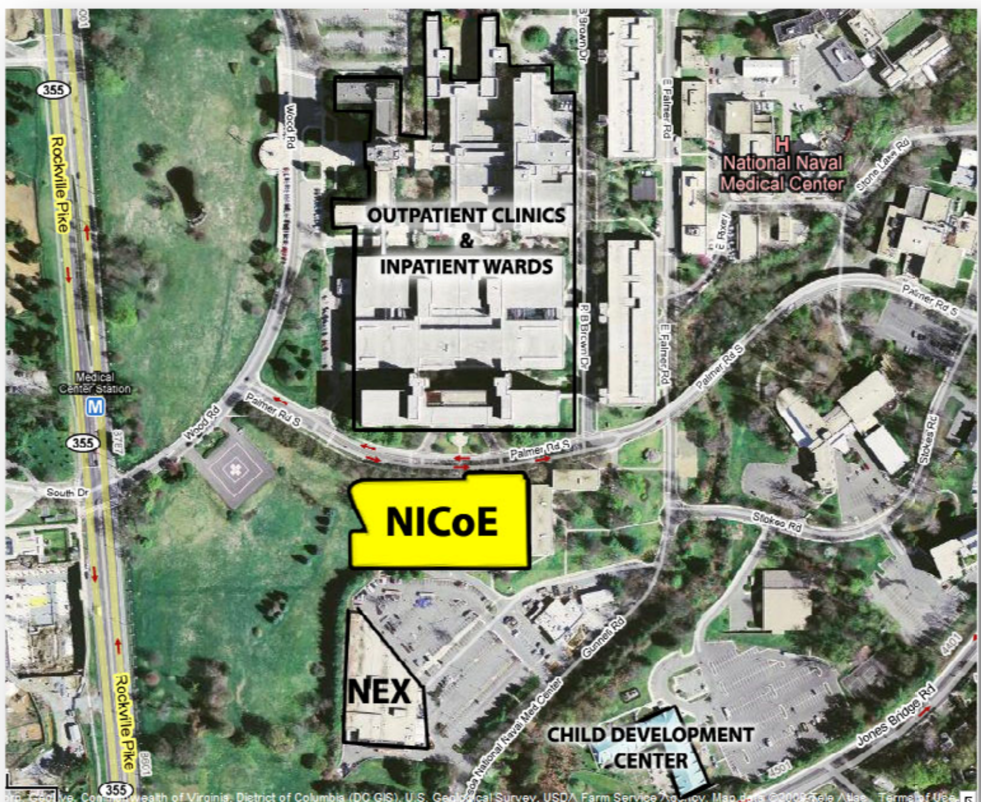


Figure 3 - NICoE Site Overview

Recycling and Tipping Fees:

Turner Construction, with the expectation of recycling for LEED points, has been achieving a 75% diversion goal on the construction site of the NICoE. Turner has contracted Noble East to collect the dumpsters set on site and sort out each of the recycled materials into: concrete, steel, wood and plastic. Therefore, since this is a small project, the materials recycled are not sorted out on site. A 30 yard box, containing 5-6 tons of debris is collected weekly from the site at a cost of $500/pull.

Soil Stratification:

Six geotechnical engineering soil test borings were drilled from April 22 through April 24, 2008, and an additional boring was drilled on May 15, 2008 to evaluate the subsurface conditions at the proposed NICoE building site. A boring Location Plan is included in appendix B.

An identification of soils sheet along with a sample of the Boring log taken from boring test 1, has been attached in appendix III. The soils encountered in the seven geotechnical borings are generalized into the following strata.

Stratum A (FILL): From the ground surface below the topsoil to depths of about 1.0 ft to 13.5 ft. Brown silty sand, and sandy lean clay FILL, with mica, gravel, rock fragments and organic were found.

Stratum B1 (Residual): Below Stratum A to depths of about 8.5 ft to 13.5 ft. Reddish-brown Lean Clay with Sand (CL), and elastic silt (MH), with mica were found

Stratum B (Residual): Below Stratum A to depths of about 5.0Ft to 23.5 ft. Brown to gray, mottled silty san(SM) and sandy silt (ML), trace mica were found.

Stratum C (Residual): Below Stratum B to depths of about 15.0 Ft to 38.6 Ft (max depths investigated in the borings). Brown to gray, mottled, Disintegrated rock was found.

The soil boring tests indicated what type of soil Turner Construction will have to account for in their schedule in the excavation phase. During the excavation phase, Turner encountered some asbestos that was not shown during the boring tests. However, this did not affect the schedule since Turner expected for such issues in the planning phase of the project.

Ground Water Conditions:

Groundwater was encountered at a depth of about 33ft below existing surface grades within boring #4 only. Upon completion of drilling of boring-04, after removal of the augers, groundwater was observed in the open borehole at a depth of about 34 ft below exiting grades. Twenty four hour groundwater level reading were also obtained from boring-04 at a depth of about 18.6 ft below exiting grades and also boring B-07 at a depth of about 24.4 ft below exiting grades. However, groundwater was not observed within the other borings drilled at the site to the depths that the borings terminated.

This will not be a problem since the expected cut of surface is to about 7 ft and up to 1.5 ft fill will be required to reach the proposed lowest slab sub-grade elevation. Therefore an under floor sub -drainage system was not necessary.

SITE LAYOUT PLANNING

As mentioned in the previous section, the National Intrepid Center of Excellence will be constructed within the Naval Medical Center site, located on the corner of Rockville Pike and Jones Bridge Road, in Bethesda, Maryland. The campus site is composed of 12 facilities. Even though there are a total of six projects under construction concurrently at the Naval Medical site, NICoE has plenty of room to maneuver within the site, as shown in Figure 4. As a result, the site logistics were pretty consistent throughout the main construction phases: excavation, substructure and interior work. Material storage, trailers, contractors parking, dumpsters, project fencing/gates, traffic and pedestrian flows remain in consistent locations throughout the duration of the project. The site logistics plans have been put in place by Turner Construction.

As seen in Figure 4, all construction traffic enters and exits the site via South Palmer road. This entrance will also be used as the permanent entrance for the NICoE once the construction is complete. All delivery trucks are brought into the site and travel around the required loop, where they unload their shipments in the proper location. Turner Construction job trailers are located on the far southwest side of the site. This location was selected since the large empty grassed lot is not used by any other buildings or projects on campus. The lunch area, designated for all field laborers, is located adjacent to the job trailers.

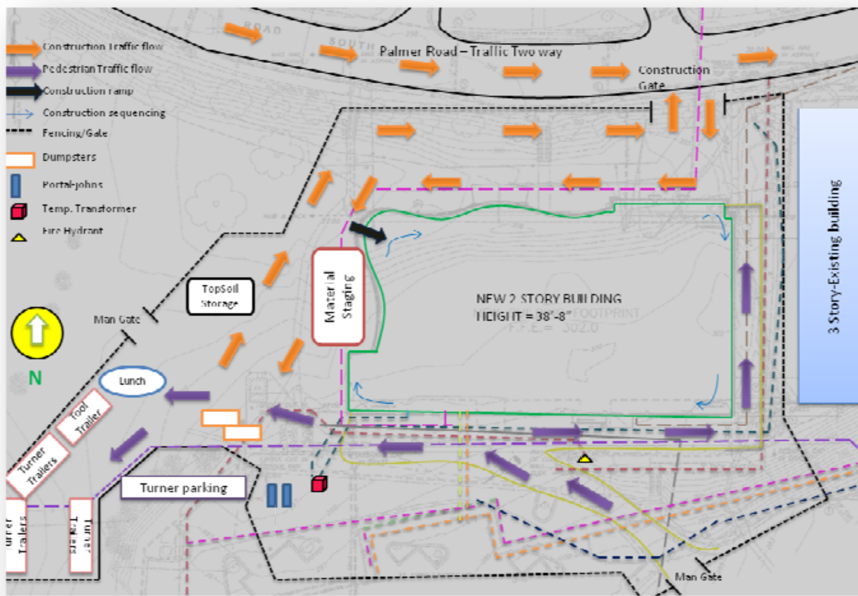


Figure 4 – Site Layout

Two 30 Yard dumpsters, which hold up to 6 tons of debris total, are located on the southwest side of the site, for easy access to both project laborers and truck routes for weekly dumpster pickups. Material storage is placed on the west side, adjacent to the building footprint and in the range of the crane radius. The limited staff parking is located close to the trailers for convenience. A temporary road has been constructed around the west and south sides of the building perimeter to allow for easy workflow around the building. Finally, a fire hydrant has been installed on the south side of the site for safety. Convenient dumpster locations and pathways ensure that a clean and organized construction site will be maintained at all times.

EXCAVATION SITE LAYOUT

The excavation phase for this project is very minimal since most of the spread footings only have a depth of 2.5'. The duration period for this phase is approximately 42 days. The soils that will be removed from this site will be hauled offsite or if found suitable, will be stock piled on the west side of the site for backfill. In order to run temporary power on site, a temporary transformer has been placed on the southwest edge of the building, which ties into existing electrical supply.

STRUCTURAL SITE LAYOUT

The structural phase of this project consists of a slab-on-grade; the concrete elevated slabs and the building envelope. The crane location and the introduction of a concrete pump are the crucial factors between the excavation and structural site plans of the project. The concrete pump will be utilized to deliver concrete for the 2nd floor and both roof levels. However, the crane was unable to be placed outside of the building due to existing utilities. The crane is located on the south side of the building, one column line into the building. This location of the crane was chosen based upon allowable reaching distance without swinging over the adjacent 3-story building. The foundation for the crane is 30' square and is placed on the 45 to the column grid so it does not interfere with the building foundation.

FINISHING SITE LAYOUT

The crane and the concrete pump will be taken off the site at final phase of the project. A key feature for the site layout is the location of loading docks and material hoists within the building perimeter. The material hoists will be located on the northeast side based upon the finishing sequencing of the construction phase. Loading docks, along with the two main elevators, are used throughout the finishing phase of the project for material transportation and owner equipment installation.

PROJECT LOGISTICS

MILESTONE SCHEDULE

The Schedule for National Intrepid Center of Excellence is relatively straight forward in its nature. Turner Construction was awarded the construction contract for the National Intrepid Center of Excellence in July 2008. NICoE broke ground on March 6th, 2009 and is scheduled to be completed within a 16 month period. The project budget was developed around design documents dated Oct 15, 2008. Since then, six (CCD's) design development documents have been issues. Due to user group meeting and numerous RFI's the design was complete by issuing the last CCD-006 dated July 27, 2009. Notice to Proceed was delivered on March 4, 2009. Mobilization promptly followed, by having three main Turner Construction trailers on site.

American Infrastructure began with cutting the site to grade and setting up the gravel road around the perimeter of the building. Miller & Long contractor began the foundation and footing activities on May 2009. Starting from the northeast edge of the building and continuing around the perimeter in a clockwise direction, spread footings were formed, poured and striped within 42 days. This was a very easy and smooth process.

The slab on glad is poured in 7 sections starting June 10, 2009. Following the substructure, pour-1 (which is composed of 8100 Sq.Ft) will begin at the northeast edge of the building. The process will continue by pouring each section around the perimeter in a clockwise direction and ending with the last section at the northwest side. A small section on the south side will be left un-poured for the tower crane location. Twelve days after SOG has been poured, level two is formed and poured in the same process excluding the open area at the northwest side. Level two is poured in 5 sections. Following this process, the low roof is then formed and poured in 3 sections. Last but not least, the high roof is poured from east to west in a 3 pour section process. The tower crane sections will be poured after the removal of the crane on September 11, 2009.

The interiors in this building are comprised of high-end finishes and sophisticated clinical equipment. The sequencing of the finishes will continue in the same fashion as the rest of the building. The finishing sequence starts from the northeast and moves in a clockwise direction in 4 quadrants. Most of the equipment in this facility will be provided by the owner.

DETAILED PROJECT SCHEDULE

Please see Appendix A for the detailed Gantt chart for NICoE.

In order to create a schedule for the National Intrepid Center of Excellence, it is critical to understand the sequencing of the construction activities and how each activity affects the schedule on a daily basis. The purpose of the detailed schedule is to refine the activity requirements of the summary schedule. The information generated in the detailed schedule is necessary for cost estimation analysis.

NICoE began construction in early March 2009 and is scheduled to be completed in Mid July 2010, just over 16 month of construction. Considering the limited time frame, and the 30 subcontractors needed, the construction activities in the schedule must be subdivided by trade. Some of the major activities on this project include:

Mobilization/Demolition/Excavation, Cast-In-Place Concrete, Precast Concrete façade, Curtain Wall system, MEP rough-ins and distribution, interior finishes, and the medical equipment installation.

SCHEDULE NARRATIVE:

The detailed schedule was first broken down into major activities by trades, then further broken down into sub-activities. Corresponding durations to each activity were also included in the schedule. This section will go through the major activities in order with the detailed schedule.

The schedule kicks off with the Notice to Proceed, which was delivered on March 2, 2009, followed by the contractor Mobilization activities.

Site Utilities

Site utility activities began by running existing utility lines from the naval medical center campus central utility plant to the project site. 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. The site is scheduled to be run on temporary power for a 3 month period, then switched to a permanent power using a 3000Amp. transformer.

Excavation

The NICoE project has a shallow foundation design; therefore, minimum excavation is required. Excavation is accomplished using a combination of laid back and shield/trench boxes as necessary depending on the space available around the perimeter of the building. Site restoration and asphalt paving activities are completed later in the project.

Substructure and Superstructure

Following the excavation phase, the structural phase of the project is begun by substructure and superstructure activities. On May 14, 2009, spread footings and foundation walls were formed, poured and stripped in 42 days. Tower crane erection took place on May 19, 2009. The crane was used to lift chute concrete buckets to make way for the placement of the cast-in-place concrete slabs. Next, the slab-on-grade pouring began on June 17, 2009, and was poured in 7 sections.. Finally, the Level 2, low and high roofs were formed, poured, and stripped over a 2 month period.

Building Envelope

The building envelope is comprised of precast concrete panels and a curved curtain wall system. Therefore, it is essential that the subcontractors for the precast concrete, curtain wall, and elevated concrete slabs coordinate to ensure that critical connections are available to fuse all three systems successfully. On September 11, 2009 the precast concrete panels were placed using the on site crane, beginning at the northeast edge and continuing around the building in a clockwise-direction. During this time, the curtain wall subcontractor has been placing the curtain wall system with punched-in windows from the northeast edge, however, working in a counter clockwise direction. The curtain wall is being installed from the interior of the building. After the precast concrete is installed, the crane will be removed from the site and the 30'x30' section of the floor structure will be formed, poured and finished. Roofing, fire protection and waterproofing activities will also be taking place at the same time in order to meet the watertight milestone date (December 25, 2009) and launch the interior activities of the project.

Interior Work

Miscellaneous metals and the elevator installations begin with the building's interior phase. Metal strips for the concrete stairs are installed with metal railings required for the loading dock and the interior staircase. Meanwhile, elevator layout installation took place on August 4, 2009. It is important for the elevators to be up and running for the interior finishing phase, because they will be used to transfer the clinical equipment and materials. Therefore, testing and commissioning of the elevators is a major responsibility of the elevator subcontractor.

Next, drywall activities begin with metal stud framing of the 1st floor after all of the floors have been stripped and finished. Hanging, taping and finishing the drywall occurs concurrently with the interior finishing activities of the project (November 20, 2009- January 11, 2009).

The MEP is a critical path activity in this project. The MEP rough-ins have a total of 12 major activities; starting with installation of the least-flexible to most-flexible items. The MEP rough-in duration is about a 4 months. A 30 day duration time is used to field-erect the air handling unit, which is placed on the second floor mechanical room. Then HVAC testing and balancing is required to ensure the system's performance. The electrical subcontractor, along with the mechanical and plumbing subcontractor, is in constant communication and coordination to ensure the required fit-outs are completed.

Meanwhile, interior finishing and medical equipment installation is taking place. The sequencing of finishes will begin on November 20, 2009, with a majority of the work done by trade-stacking each of the major clinical rooms. The interior finishes will continue in the same sequence as the building façade: beginning at the northeast and continuing in a clockwise direction in 4 quadrants. Along with interior finishes are the clinical equipment installations, provided by the owner. It is important to make sure that all required electrical hookups are installed and ready to be joined with the medical equipment for a secure installation. The interiors of the building are scheduled to be completed on April 7, 2010 which puts the National Intrepid Center of Excellence substantial completion date on May 10, 2010.

Project Cost Summary

The National Intrepid Center of Excellence is a 100% funded project through public and private donations. The land is fully donated along with approximately 20% of the materials used for the construction of the NICoE. Therefore, the subcontractors of this project were involved heavily in the donations of this project. Also, the major high technical equipment is provided by the owner and is therefore directly paid by them (Fisher house). For this reason, it has been requested by the owner that the cost information pertaining to the project not be revealed. The total project cost is approximately $45million. This number is the only number being released to the public. The hard cost for this project cannot be obtained for the reasons mentioned above. Therefore, the actual building construction cost and the major building system costs will be revealed in this report as an estimate using D4cost and RS Means and also a rough order estimate directly from the project manager on site (David Wysong).

For comparison, two methods of cost estimate were used to examine the project cost. A parametric estimate for the NICoE was first run using D4Cost estimating software. As the parameters were expanded, such as the square footage, number of levels, building use, the number of related projects decreased. The Emergency & Med-Surgical Pavilion project in NJ was the closest project that compared to the NICoE. The summary data used from the D4 project seen below, affected the difference in the project cost. The Emergency & Med-Surgical Pavilion project is a new construction project built in April 2003, with a total square footage of 111,871. This project was chosen since it was very similar to NICoE: 2 story hospital, concrete structure with precast concrete walls and floor to floor height of

15.4'. After having to readjust the data used from the Emergency Med-Surgical Pavilion hospital to the NICoE's data; the estimate became further away from the original building cost. A full print out of the estimate has been included in Appendix 1. In conclusion the D4 cost estimate per Sq.Ft, the cost is over 200% low when compared to the actual TC/SF.

The second method used to examine the project cost is a Square Foot estimate using R.S. Means data. A reference from the source on the cost information is shown below. Using the S.F area of a hospital 2-3 story high, along with the type of exterior walls, perimeter and story height adjustments, time and location adjustments and any common additives to the project, originated a typical cost estimate for the specific type of project. In addition to using the RS Means 2009 Sq. Ft estimate, a CostWorks RS Means was also run on a computer program to make sure the hand estimation was done correctly. After having run the calculations, the cost figure comes in 300% lower compared to the actual project cost.

Comparing both estimates to David Wysong's rough order of magnitude seen below, it is obvious that there is a big difference in cost. In addition, after having run both cost estimation methods, both figures have come extremely lower than the actual project cost. Both the D4 Cost and the R.S. means estimates were more than $20 million under the actual project cost of $65million(Including equipment). However, comparing R.S Means estimate to D4 estimate there are very close to each other. This is due to many special construction activities and equipment used on the National Intrepid Center of Excellence. Some of those specialties are:

1. The type of glass used for curved curtain wall system, which extends from north to the west façade.
2. The central park area, which extends the height of the building and has a unique structure with a skylight.
3. The high end interior finishes used.
4. The blast rating of the glazing required on all government projects.
5. The high tech equipment which is used throughout the building such as:
    a. CAREN system (Computer Assisted Rehabilitation Environment)
    b. Hearing and Vision equipment
    c. PT/OT/CT equipment
    d. Virtual reality equipment
    e. Recreational Therapy-Golf Stimulator
    f. Fluoroscope systems

<u>PM Rough Order Estimate</u>

Building Systems	Cost	Donated Amount
Concrete	$3,500,000	$1,000,000
Precast	$1,300,000	$200,000
Glazing	$3,600,000	$500,000
Fire Protection	$250,000	$30,000
Mechanical & Plumbing	$6,000,000	$1,000,000
Electrical	$5,500,000	$300,000
Masonry	$200,000	$50,000
Major Medical Equipment	$20,000,000	N/A

Actual Building Cost

Total Project Cost (TC)	$45,000,000.00
Building Equipment Cost	$20,000,000.00
TC/ Sq.Ft	$ 625.00

D4Cost Estimate 2002 [Parametric Estimate]

Total Project Cost	$22,117,920.00
Total Project Cost/Sq.Ft	$307.193
Building Cost	$19,665,443.00
General Requirements	$1,661,678.00
Site Work	$2,452,487.00

General Conditions Estimate Summary

Turner Construction's typical list of items included within their General Conditions estimate is represented by this GC estimate for the NICoE. This list is broken into 5 categories: Project management / coordination, temporary services, construction facilities, general conditions, and insurance/bonds/testing and inspections. On the list of the GC items, RS Means Building Cost data 2009 was used to calculate the unit cost per item. Each calculated cost was based on a 9 month design phase (40weeks) and a 16 month construction period (73weeks). The total general condition estimate is about $1.7Million (4% of the building cost). Like most general conditions estimate, the salaries for the project management and site supervision team makes up a large portion of the cost. In addition, an examination of the project and construction site location aided in determining the necessary items to include in the estimate.

The following assumptions were made throughout the estimate:

- RS Means 2009 was used to derive individual staffing salaries for the job.
- When staff salaries were not avaliable in RS Means, a 10% increase was used for each of the respective levels.
- Staffing durations are based off of the start dates on the job (Information received from Turner Construction)

Project Staff	%on PreCon	%on Construction phase	Results weeks
Project Manager	75	100	103.00
BIM Coordinator	100	20	54.60
Safety Manager	0	100	73.00
Superintendent	25	100	83.00
Superintendent2	0	100	73.00
Project Engineer	50	100	93.00
Asst. Superintendent	0	100	73.00
Asst. Engineer	35	100	87.00
Asst. Engineer2	0	100	73.00

A summary of the General Conditions cost estimate includes:

- Project management and coordination: $1,509,995.00
- Temporary services: $61,911.00
- Construction Facilities: $28,170.00
- General conditions: $72,964.00
- Insurance/Bonds/Testing & Inspections: $135,250.00

A detailed breakdown of the General Conditons is seen in Figure 5.

General Condition Estimate						
	Description	Qty.	Units	Unit price		Total Cost
Project Management and Coordination						
Project Staff						
	Project Manager	103.00	Wks	$2,975	$ 306,425.00	$306,425.00
	BIM Coordinator	54.60	Wks	$1,950	$ 106,470.00	$106,470.00
	Safety Manager	73.00	Wks	$2,100	$ 153,300.00	$153,300.00
	Superintendent	83.00	Wks	$2,750	$ 228,250.00	$228,250.00
	Superintendent2	73.00	Wks	$2,750	$ 200,750.00	$200,750.00
	Project Engineer	93.00	Wks	$1,800	$ 167,400.00	$167,400.00
	Ass. Superintendent	73.00	Wks	$1,800	$ 131,400.00	$131,400.00
	Ass. Engineer	87.00	Wks	$1,350	$ 117,450.00	$117,450.00
	Ass. Engineer2	73.00	Wks	$1,350	$ 98,550.00	$98,550.00
						$1,509,995.00
Temporary Services						
Project Utilities						
	Temp. Lighting	720	Csf flr	$19.35	$13,932.00	$41,796.00
	Temp. Electricity	12	Wks	$51.70	$620.40	$620.40
Protection						
	Chain Link fence	1560 LF	Month	$11.15	$17,394.00	$17,394.00
	safety Signs	120	SF	$17.50	$2,100.00	$2,100.00
						$61,910.40
Construction Facilities						
Facilities						
	3Job office Trailers	16	month	$455.00	$21,840.00	$21,840.00
	Office Equipment	16	month	$171.00	$2,736.00	$2,736.00
	Office Supplies	16	month	$93.50	$1,496.00	$1,496.00
	Telephones/Fax	16	month	$88.00	$1,408.00	$1,408.00
	Site Signage	30	SF	$23.00	$690.00	$690.00
						$28,170.00
General Conditions						
	Dumpsters	1	Wks	$500.00	$36,500.00	$36,500.00
	Continuous Cleanup	72	MSF	$40.50	$2,916.00	$2,916.00
	Final Cleanup	72	MSF	$84.00	$6,048.00	$6,048.00
	Punchlist,Etc.	1	Each	$5,500.00	$5,500.00	$5,500.00
	Temp. Roads		Lump Sum			$22,000.00
						$72,964.00
Insurance/Bonds/Testing & Inspections						
	Performance Bond		Job	1%	65000	$65,000.00
	Liability Insurance		Job	1%	65000	$65,000.00
	Inspectors	15	days	$350.00	$5,250.00	$5,250.00
						$135,250.00
	General Conditions Subtotalt					$1,673,039.40

Figure 5- General Conditions Estimate

STRUCTURAL SYSTEMS ESTIMATE SUMMARY

All take-off calculations for the structural estimate were performed by hand based off of the construction documents and specifications provided by Turner Construction. RS Means 2009, along with MC^2 Estimating Software, were utilized to calculate the cost associated with the structural take-off for the NICoE. The structural system for the NICoE includes:

- Reinforced Concrete Spread Footings
- Concrete Slab-on-Grade
- Reinforced Concrete Round and Square Columns
- Reinforced Concrete Beams
- Reinforced Elevated Concrete Slabs.

Footings and Columns:

The structure of the NICoE is not a uniform structure. It includes 17 different types of footings ranging from 4'-6"x4'-6" x12" to 15'x15'x33". The columns are also composed of 17 different sizes, which vary from exterior 28" diameter round columns with a height of 36'-6", to interior square columns which are 24"x24"x15' (floor height). Given the size variability, a detailed take off for each of the footing and column types was included within the structural estimate.

Concrete Beams:

The structural system used is a flat slab with 8" drop panels. The drop panels are designed to transfer the loads uniformly to the reinforced column strips. Utilizing the drop panels between the columns and the floor slabs minimized the amount of concrete beams needed within the structure of the building. Five types of beams are included to support the structure around the high traffic areas, such as: the central open staircase and two elevators. A detailed take off for each of the beam types were included within the structural estimate.

SOG and Elevated Slabs:

The slab-on-grade is mostly composed of a 5" thick concrete slab. Transitions to a 6" and a 12" thick slab in some spaces were also calculated. As for the 9" thick elevated slabs, the concrete and formwork estimate was done for each floor and roof level.

Concrete Strengths:

The concrete strength for the footing is given as 3000psi. Slab on grade strength is 3500psi. The strength for the concrete columns, reinforced slabs and beams is 4000psi.

In order to make the detailed estimate process more efficient the following assumptions were made:

- The reinforcement required for the elevated slabs, beams and columns were estimated by an average area per floor and roof.
- Finishing floor methods is with a manual screed, manual float and broom finish.
- Silver Spring, MD location factor was used since Bethesda's location factor does not exist in RS Means
- Overhead and profit are omitted from the cost estimate
- Formwork, reinforcement and concrete waste factors are omitted from the cost estimate.

See figure 6 for a summary of the concrete, formwork and reinforcement quantities of the structural system, along with the labor, material and equipment cost associated with the work performed.

Cast In Place Concrete Estimate								
CSI Code	Descrption	Qty	Units	Material Cost	labor Cost	Equipment Cost	Price/Unit	Totalt Cost
03 11 13.20	Form in place, Beams, 12"x 18" beams, 4use	240.00	SFCA	$ 1.40	$ 4.95		$ 6.35	$ 1,524.00
	Form in place, Beams, 24"x 17" beams, 4use	741.00	SFCA	$ 2.80	$ 5.85		$ 8.65	$ 6,409.65
03 11 13.25	Form in place, Columns, 24" diamter, 4use	4115.00	SFCA	$ 18.65	$ 14.25		$ 32.90	$ 135,383.50
	Form in place, Columns, 24" x 24", 4use	11160.00	SFCA	$ 0.81	$ 5.10		$ 5.91	$ 65,955.60
	Form in place, Columns, 16" x 24", 4use	1364.00	SFCA	$ 0.73	$ 5.15		$ 5.88	$ 8,020.32
	Form in place, Columns, 12" x 24", 4use	678.00	SFCA	$ 0.74	$ 6.14		$ 6.88	$ 4,664.64
03 11 13.35	Form In Place Flat Slab,drop panels,job-built plywood, to 15' high,4use	86915.00	S.F	$ 1.55	$ 3.43		$ 4.98	$ 432,836.70
03 11 13.40	Form in place Equipment Foundation	1860.00	SFCA	$ 1.17	$ 9.10		$ 10.27	$ 19,102.20
03 11 13.45	Forms for spread Footing, Job Built Lumber, 4use	4273.00	SFCA	$ 0.70	$ 2.93		$ 3.63	$ 15,510.99
03 11 13.65	Form in place slab on grade, Edge Forms,wood,4use,ongrade, to 6" high	646.00	L.F	$ 0.38	$ 2.02		$ 2.40	$ 1,550.40
	Form in place slab on grade, Edge Forms,wood,4use,ongrade, 7"to12" high	824.00	SFCA	$ 0.74	$ 2.79		$ 3.53	$ 2,908.72
	Form in place slab on grade,For depressed slabs, 4use, to 12" high	204.00	L.F	$ 0.56	$ 4.04		$ 4.60	$ 938.40
03 31 05.35	Normal Wight Concrete, Ready Mix, 3000PSI	486.00	C.Y	$ 101.00			$ 101.00	$ 49,086.00
	Normal Wight Concrete, Ready Mix, 3500PSI	750.00	C.Y	$ 104.00			$ 104.00	$ 78,000.00
	Normal Wight Concrete, Ready Mix, 4000PSI	2772.00	C.Y	$ 106.00			$ 106.00	$ 293,832.00
03 31 05.70	Beams, elevated, small beams, pumped	15.00	C.Y		$ 36.00	$ 13.15	$ 49.15	$ 737.25
	Columns,Square or round, 12" thick,with crane and bucket	10.00	C.Y		$ 61.50	$ 30.00	$ 91.50	$ 915.00
	Columns,Square or round, 18" thick,with crane and bucket	36.00	C.Y		$ 45.00	$ 22.00	$ 67.00	$ 2,412.00
	Columns,Square or round, 24" thick,with crane and bucket	294.00	C.Y		$ 35.00	$ 17.10	$ 52.10	$ 15,317.40
	Elevated slabs, 6" to 10"thick,pumped	2342.00	C.Y		$ 13.55	$ 4.94	$ 18.49	$ 43,303.58
	Elevated slabs over 10"thick,pumped	63.00	C.Y		$ 12.05	$ 4.39	$ 16.44	$ 1,035.72
	Footings,spread,under 1C.Y, with crane and bucket	5.00	C.Y		$ 55.00	$ 26.50	$ 81.50	$ 407.50
	Footings,spread,over 5C.Y, with crane and bucket	481.00	C.Y		$ 24.50	$ 11.95	$ 36.45	$ 17,532.45
	Slab on grade, up to 6" thick, with crane and bucket	750.00	C.Y		$ 22.50	$ 10.90	$ 33.40	$ 25,050.00
03 35 29.30	Finishing Floors, Manual screed,bull float, manual float & broom finish	114595.00	S.F		$ 0.47		$ 0.47	$ 53,859.65
				Total Cost of Cast in Place Concrete				$ 1,276,293.67

Concrete Reinforcement Estimate								
CSI Code	Descrption	Qty	Units	Material Cost	labor Cost	Equipment Cost	Price/Unit	Totalt Cost
03 21 10.60	Rinforcing in place, Beams and Girders, #8 to #18	1.25	Ton	$ 1,550.00	$ 530.00		$ 2,080.00	$ 2,600.00
	Rinforcing in place, Columns, #8 to #18	119.5	Ton	$ 1,550.00	$ 620.00		$ 2,170.00	$ 259,315.00
	Elevated Slabs, #4 to#7	72.59	Ton	$ 1,650.00	$ 490.00		$ 2,140.00	$ 155,342.60
	6X6 W2.1 x W2.1 WWF 42 ilbs per CSF	540	CSF	$ 28.25	$ 21.50		$ 49.75	$ 26,865.00
	Footings, #4 to #7	5.68	Ton	$ 1,475.00	$ 680.00		$ 2,155.00	$ 12,240.40
	Footings, #8 to #18	4.62	Ton	$ 1,400.00	$ 395.00		$ 1,795.00	$ 8,292.90
				Total Cost of Reinforcement in Concrete:				$ 464,655.90

Figure 6 – Cast-In-Place Concrete and Reinforcement Estimates

The total estimate of the structural system for the NICoE is $1,559,960 ($1,733,289 *0.9(location factor)).

This project is a 100% donated project from both private and public sectors. Subcontractors are heavily involved in donating both materials and labor for this project. Therefore, the actual cost for the structural system is not provided. As a result, the detailed structural estimate is compared to the RS Means CostWorks breakdown estimate of $1,672,950, calculated in Technical Assignment 1. This number is very close, only with a difference of 7.2%.

ANALYSIS I | PROJECT DELIVERY METHOD

BACKGROUND:

The National Intrepid Center of Excellence is being delivered under a CM-at-Risk contract between Turner Construction and the owner. The project budget was developed around design documents dated Oct 15, 2008. Since then, six (CCD's) design development documents have been issued. Due to user group meeting and numerous RFI's the design was complete by issuing the last CCD-006 dated July 27, 2009.

When Turner was brought on board the design of this project was more than 60% complete. A rough order estimate was done by Turner in order to identify if the current design cost will meet the owner's budget. The estimate came well above the owner's expectations. Turner's contract required them to assist the design firm in completing the design within the required budget. Since Turner did not have a contract with SmithGroup, issues arose when it came time to eliminate some of the design features of the building. Turner began with an estimated cost of $63Million dollars. A second estimation was calculated during the 80% completion stage of the design phase. Turner was successful in lowering the estimate by 8%. This estimate was again well above what it is intended to be. By the time the design was complete it was still almost 20%above the set budget.

The design was complete and it was time for the owner to review it and approve the cost. The cost of the design was still above what the owner required. Therefore, value engineering had to be done on the original design. Massive amounts of design changes took place in the 5 months of the value engineering period.

Going through the VE process with the contractor, owner, and designer had its own challenges as well. The distorted usage of the BIM model during the VE process caused the project a 2 month delay (Analysis II). The estimation process used had caused the VE period to last much longer than expected (Analysis III). Lastly, some of the building's systems could have been designed more efficiently when a specialty contractor is involved earlier on with the project (Analysis IV).

GOAL

The goal of this research is to investigate the potential of moving towards more of an integrated design-build delivery method using the CII selection delivery method process. The research will focus on comparing a CM-at-Risk and design-build delivery methods from many of the experienced industry member's point of view. Also in this research, the benefits and challenges in using either a design-build or a CM-at-Risk contract method for projects similar to NICoE will be discussed. A step-by-step procedure for implementing a design-build delivery method for NICoE will also be conducted. Additionally, the research will touch upon the benefits of the utilization of BIM in a design-build project compared to its usages in a CM-at-Risk project.

PRELIMINARY RESOURCES AND TOOLS

- Jerry Shaheen – Penn State Law School project - Project Manager
- Akilah Darden – HD Cook Elementary School project - Project Manager
- Mark Luria – Project Executive
- Eric Fritz – Superintendent
- David Wysong- National Intrepid Center of Excellence – Project manger

The Choice Of A Project Delivery Systems

The careful choice of Project Delivery System (PDS) can help overcome many project challenges. A project delivery system is, simply, the contractual structure (exclusive of the financial arrangements) for how the final project is produced and provided, i.e. delivered, to the owner. The appropriateness of any given project delivery system varies, depending upon the project goals, time constraints, cost constraints, party at risk, and existing site conditions. Project owners generally want the same things: construction at the lowest cost, of the highest quality, and done within the shortest period of time. Some goals, however, may take precedent over others. The speed of implementation, for example, may be more important than cost on certain projects. For others, maintainability and low life-cycle costs may be more important than initial cost. Owner control of the design and/or construction may be important for some, while, for others, limiting the risk of costly changes is paramount.

CM-At-Risk – The Process *(Figure 7)*

A very similar delivery method to the traditional design-bid-build is the CM-at-Risk project delivery method which has been undertaken by the National Intrepid Center of Excellence. In a CM-at-Risk contract, the CM holds the risk of subletting the construction work to trade subcontractors and guarantees the completion of the project for a fixed negotiated price following completion of the design. However, in this scenario, the CM also provides advisory professional management assistance to the owner prior to construction, offering schedule, budget, and constructability advice during the project planning phase. This method of delivery provides for flexibility in the implementation of design changes late in the design process (60-95% complete). Thus, instead of a traditional general contractor, the owner deals with a hybrid construction manager/general contractor and therefore, reduces the owner's risk.

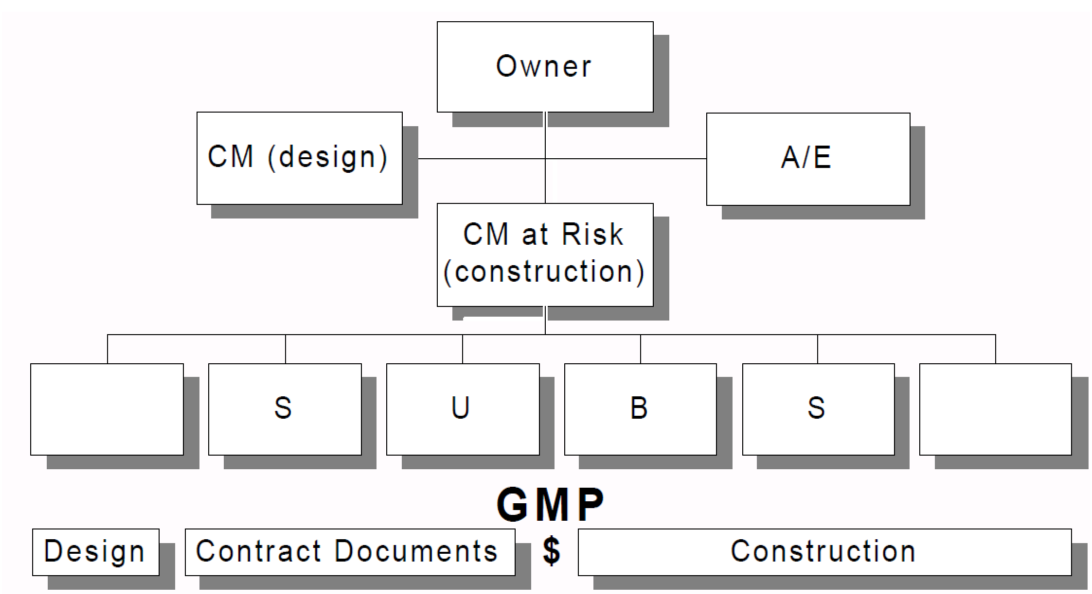


Figure 7 – CM-at-risk Process

CM-At-Risk Advantages

In addition to providing the owner with the benefit of pre-construction services which may result in advantageous changes to the project, the CM-At-Risk scenario offers the opportunity to begin construction prior to completion of the design. The CM can bid and subcontract portions of the work at any time, often while design of unrelated portions is still not complete. In this circumstance, the CM and owner negotiate a guaranteed maximum price (GMP) based on a partially completed design, which includes the CM's estimate of the cost for the remaining design features. Furthermore, CM may allow performance specifications or reduced specifications to be used, since the CM's input can lead to early agreement on preferred materials, equipment types and other project features.

Proponents have cited many advantages to construction management at-risk over traditional methods of procurement. These advantages are:

• Increases the speed of the project and can also strengthen coordination between the architect/engineer and the construction manager.

• The client hires the construction manager based on qualifications, thus better ensuring a construction manager with a strong allegiance to the client, because their business relies on references and repeat work.

• Construction managers, architects/engineers, and the client all collaborate. This creates enhanced synergies throughout the process.

• Transparency is enhanced, because all costs and fees are in the open, which diminishes adversarial relationships between components working on the project, while at the same time eliminating bid shopping.

CM-At-Risk Disadvantages

The primary disadvantages cited in the CM-At-Risk system involve the contractual relationship among designer, CM and owner once construction begins. Once construction is underway, the CM converts from a professional advisory role of the construction manager to the contractual role of the general contractor. At that time, tensions over construction quality, the completeness of the design, and impacts to schedule and budget can arise. Interests and stake holding can become similar to the traditional design-bid-build system, and adversarial relationships may result. While the fixed GMP is supposed to address the remaining unfinished aspects of the design, this can in fact increase disputes over assumptions of what remaining design features could have been anticipated at the time of the negotiated bid (the GMP is a defined price for an undefined product).

> ***"The lack of a firm construction price until late in the project, the lack of risk to the CM- at- risk firm, and the difficulty of explaining project cost increases to the public are regarded by public owners as the main disadvantages of CM-at-risk."***

Additional disadvantages include:

1. Increased CM fees for assumption of risk due to “details” not in the GMP.
2. Difficult for owner to evaluate the GMP or determine whether the best price has been achieved for the work. (negotiated CM-at-Risk fee is not competitively bid)
3. Insurance and bonding responsibilities less certain.
4. No common standards for CM-at-Risk methodology.
5. Construction Manager relationship to the owner changes during the design and construction process
6. Potential conflict if CM also performs work with contractors on other projects
7. Potential decrease in competition for trade contractors because of added bidding and reporting requirements.
8. More contracts for owner to award.
9. Possibility of overlaps or gaps in the scopes of work.
10. Price is not known until all bids are in.
11. Not all Construction Managers bond total project.

Industry Point Of View

Jerry Shehaan (Senior PM on Dickenson School of law – CM-at-Risk contract)

During my interview with Jerry Shehaan, he stated:

“Typically on projects with a traditional or CM-at-Risk contract, the owner selects the architect with a budget in mind. The architect then tries to come up with the most esthetically soothing design which exceeds the owner’s expectations. With that, the budget is either completely spent or well above what can is available. Therefore, the CM spends massive amounts of time trying to eliminate any unnecessary design aspects that may help bring the budget down to what is required. This process is a very challenging process, especially since the CM and the A/E firm do not have any contractual obligations with one another. The architect is also holding a risk by having to guarantee a design that meets code, structural requirements, and at the same time satisfy the owner’s needs. Therefore, the designers are usually very defensive when it comes to the value engineering period.”

He also appointed out the conflicts which arise between the CM estimator and the architect’s estimator which cause many delays in the value engineering process. Both entities will perform their own estimates and then will have to reconcile to a range cost that is then submitted to the owner, which can be declined or approved.

Therefore, it is evident that CM-at-Risk delivery method can be effective in some ways on projects but is not always the best direction to take. A substitute for this method is the new design-build delivery method that is increasing to become the choice of projects contract method to the developers. .

DESIGN-BUILD – THE PROCESS *(FIGURE 8)*

Design-Build is defined as a team-based system organized to provide efficient design and construction processes. Under a design-build method, one entity would handle all aspects of design and construction aspects of the project. This method recognizes that long-term cost-effectiveness, rather than lowest cost construction alone, creates the best value for an owner and leads to lower total costs.

The design build team may be structured in many different ways. The design builder may be a single firm with both design and construction capacity in-house, or it may be a combination of two or more firms with complementary abilities. If there are multiple firms, they may be structured as a joint venture or with one of the firms prime and the other(s) as subcontractor. The critical aspect is that the owner contracts with one entity which has the responsibility for both designing and constructing the facility.

The owner, the A/E, and the general contractor are teamed shortly after the need for the project is identified. The A/E and the contractor are contracted with each other to form one entity, which then contracts with the owner. The participants then work together to balance the competing priorities of initial cost to construct, on-going maintenance costs, operating costs, life cycle costs, aesthetic design, and user functionality and friendliness, and to design and construct a project to meet those priorities.

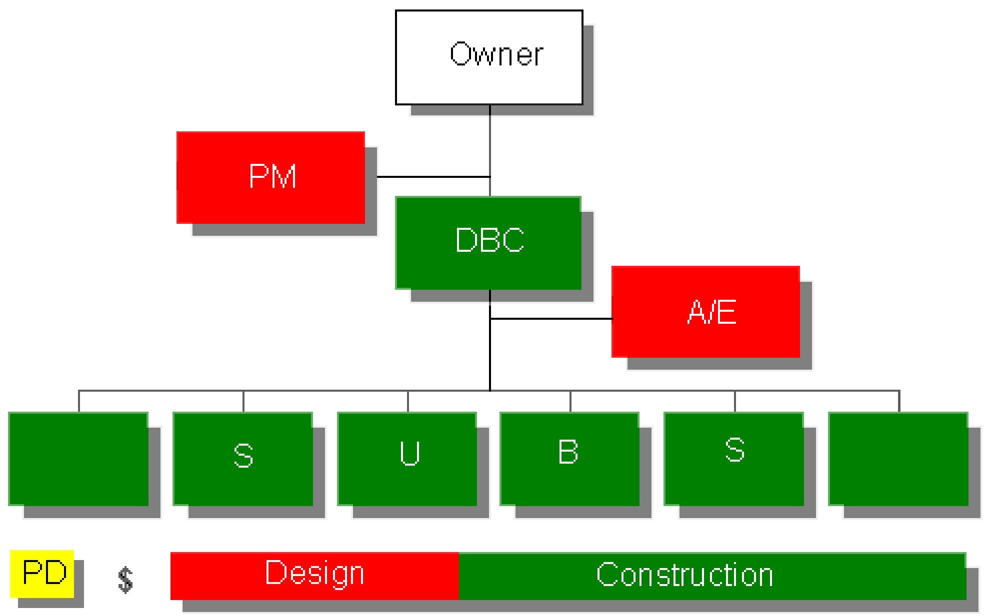


Figure 8 – Design-Build Process

Design build is the fastest growing method of project delivery in the United States and is even more popular abroad. The growth of design build has been fueled by owners who perceive significant advantages resulting from design build compared to more traditional project delivery methods.

Design-Build Advantages

It is important to note that the design-build method, while not focused on saving the owner construction costs, nonetheless often saves the owner money on the overall project. “The combined effects of carrying a construction loan (which typically carries a higher interest rate than permanent financing) and an earlier useful on-line date usually yields considerable overall value to the project and may make seemingly unattainable projects into real opportunities.”

> *“More than 40% of non-residential design and construction in the U.S. is provided through the design-build process. By 2015, this number will grow to more than 50%.”*
>
> *Design-Build Institute of America*

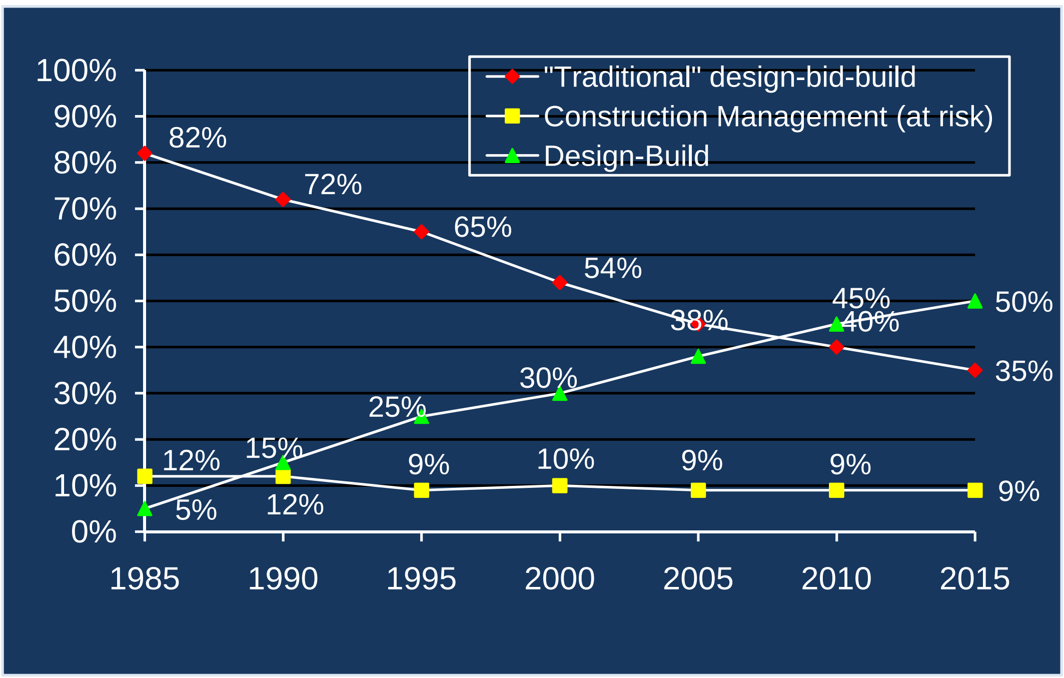


Figure 9 – Percent Usages of Project Delivery Methods

One of the most important advantages which design build has to offer is the shorter duration time. The last months of the design phases overlaps the first months of the procurement/construction phase, resulting in time savings compared to the traditional end-to-end sequence. This both reduced construction cost and hastens the flow of revenue.

In the CM-at-Risk contract structure, in which the designer and the contractor are different entities, procurement and construction usually also begins prior to completion of the design. This is called fast tracking. However, fast tracking has largely fallen into disrepute because of the potential for claims and change order abuses. Contractors often claimed that aspects of the design were completed in an unanticipated manner, resulting in sizeable extras.

Another very important matter to the owner is the broad scope of the design builder's responsibilities for the project. In CM-at-Risk method, once construction has begun, problems with the project often result in finger-pointing, with the designer blaming the contractor and vice versa. Often warranties would not be honored and protracted litigation is necessary to obtain remedies because the designer and the contractor blame each other for the problems. The designer is holding a risk to the project and does not want to put his firm on the line and vice versa.

In design build project, the design builder has full responsibility for the outcome of the project, except for matters for which the owner is responsible. If a plant fails to develop the guaranteed number of kilowatt hours (for example), the design builder is generally responsible. The designer and constructor are the same entity, so blaming each other does not excuse the design builder. Whereas in a CM-at-Risk project, an engineer ordinarily does not guarantee the outcome of his work, in a design build project the engineer's work is subject to and included within the design builder's warranty.

Another consequence of single point responsibility is that it is possible to construct detailed overall performance warranties and to turn them into a meaningful with coordinated liquidated damages clauses. For example, it is common in the design build contract to require the design builder to warrant that the facility will yield an output of a certain number of kilowatt hours and to link that requirement with a liquidated damages clause in the event that the output falls short of the warranty. The liquidated damages could be quantified as the market value of each lost kilowatt hour, enabling the owner essentially to guarantee a minimum revenue stream. The ability to structure the design build contract with such meaningful remedies may be critical to project financing. Overall performance warranties are generally not available in CM-at-Risk construction projects because the constructor may blame the designer and vice versa for the failure. Only with design build is a single entity sufficiently responsible for the project to give such a warranty. However, even in design build projects, the performance warranty will generally have exclusions for defective feedstock or other issues for which the owner is contractually responsible.

For some facilities, particularly those involving new technologies such as NICoE, it is critical for both the designer and constructor to understand the technology and related processes. Plans and specifications can communicate the design concepts, but they do not transfer expertise from the designer to the contractor. In design- build projects, the same entity that had the expertise to design the project also constructs it. Even for facilities that do not rely on new technology, there are often communication problems between the designers and the contractor. Communication difficulties may result in an overly formal or adversarial approach to the project, usually to the owner's expense and detriment. In a design build project, the designer and contractor are the same entity, working toward the same goals, unlikely to suffer the same kinds of communication problems.

Additional advantages include:

- Owner's needs are developed with the Builder, Architect and Subcontractors maximizing current tendencies and performance.
- Greater trade involvement in the pre-construction phase results in a coordinated and interactive (proactive) design with practical means and methods.
- Streamlined contract administration provides most efficient approvals/close out.
- Allows a budget to be fixed at the start of the project (prior to construction) and the design development controlled.

- Trade involvement at beginning ensures Best Value for material selection.
- The bid process and its costs are eliminated.

The design-build process eliminates building owner frustrations due to inferior quality, cost overruns, and scheduling delays by:

- Providing long-term accountability
- Accelerating completion schedules
- Guaranteeing on-time delivery
- Optimizing project efficiencies
- Guaranteeing a maximum cost
- Eliminating redesigns
- Eliminating inferior material substitutions
- Guaranteeing to-spec performance.

Design-Build Disadvantages and Challenge Overcomes

Design-build delivery method is fairly new in the construction industry and experience with the design-build construction has shown that it suffers from some drawbacks compared to the traditional methods.

In a traditional contract method, the owner preserves the designer during the construction phase to help ensure that the facility is built as designed. The designer contracts directly with the owner and owes his loyalties to the owner. In design build projects, the designer and contractor are on the same team and are often, at least technically, unfavorable to the owner. The degree of this issue may vary with the nature of the contract (lump sum contracts are more adversarial than reimbursed cost contracts) and may be reduced if the design builder is hoping to do other projects for the owner. Nevertheless, the changed incentives may create problems for an unsophisticated owner.

Challenge overcomes - Owners in design build projects would be well advised either to have experienced engineers in-house or else to retain an outside consultant for this purpose.

Another disadvantage to the owner is the low owner control he has over the project. Because the owner is on the contractor's team in a design-build project, the owner may find himself without access to the kind of information that it would have on a traditional project (Cm-at-Risk for example.)

Challenge Overcomes – advance planning. The design- build contract should specify the kinds of information and details that the design builder must supply to the owner. The owner must have available sufficient knowledge and experienced personnel or consultants to understand and analyze the information provided by the design builder.

An additional drawback to the design-build contract is the difficulty in obtaining competitive bidding. Design-build projects do not have any competitive bidding occur. The design builder is chosen at the beginning of the project, and there is ordinarily little competitive pressure on the contract.

Challenge Overcomes – To some extent, competitive pressures can be generated by requiring that each trade contract be competitively bid. There is a firm price and schedule which can be guaranteed far earlier than in the CM-at-Risk or any other traditional contract method.

And last but not least, the greatest obstacle is the institutional laws and regulations. Particularly in some areas in the United States, state and municipal laws and regulations severely limit or restrict the use of design build. Many states have competitive bidding requirements for public projects or projects funded with public money. Licensing restrictions for design professionals and contractors may restrict the types of design build business structures. Insurance and bonding may be more complicated to arrange in a design build project.

Challenge Overcomes - Public laws and regulations have been changing as the popularity of design build continues to grow, and the insurance and bonding industries are in the process of developing new products tailored to design build.

> ***"With design-build delivery, the Design-Builder warrants to the owner single-source accountability for meeting all design specifications, as well as project construction, including delivery dates and budgets. Costly and time-consuming redesigns, with their associated change orders, are eliminated."***
>
> *Design-Build Solution, Inc.*

THE PROJECT DELIVERY SELECTION SYSTEM

When owners are tied up with the correct choice of delivery method to use on their projects, it is important for them to consider some of the following features:

1. The project goals and objectives
2. Time constraints
3. Cost constraints
4. Quality of the design
5. Party at risk
6. Existing site condition
7. The familiarity of the delivery method to the construction and design teams
8. Past relationship of the owner and the project team
9. The amount of building design and construction experience the owner has.

In this analysis, two different delivery system selection charts were used. The first is shown in figure 10, this was used in order to make sure a design build delivery method is possible for the NICoE project. Time and cost are very critical on this project. Having an experienced owner such as the Fisher House with an experienced team, with an above standard quality design, and a well defined scope a design Build Contract is therefore possible on this project.

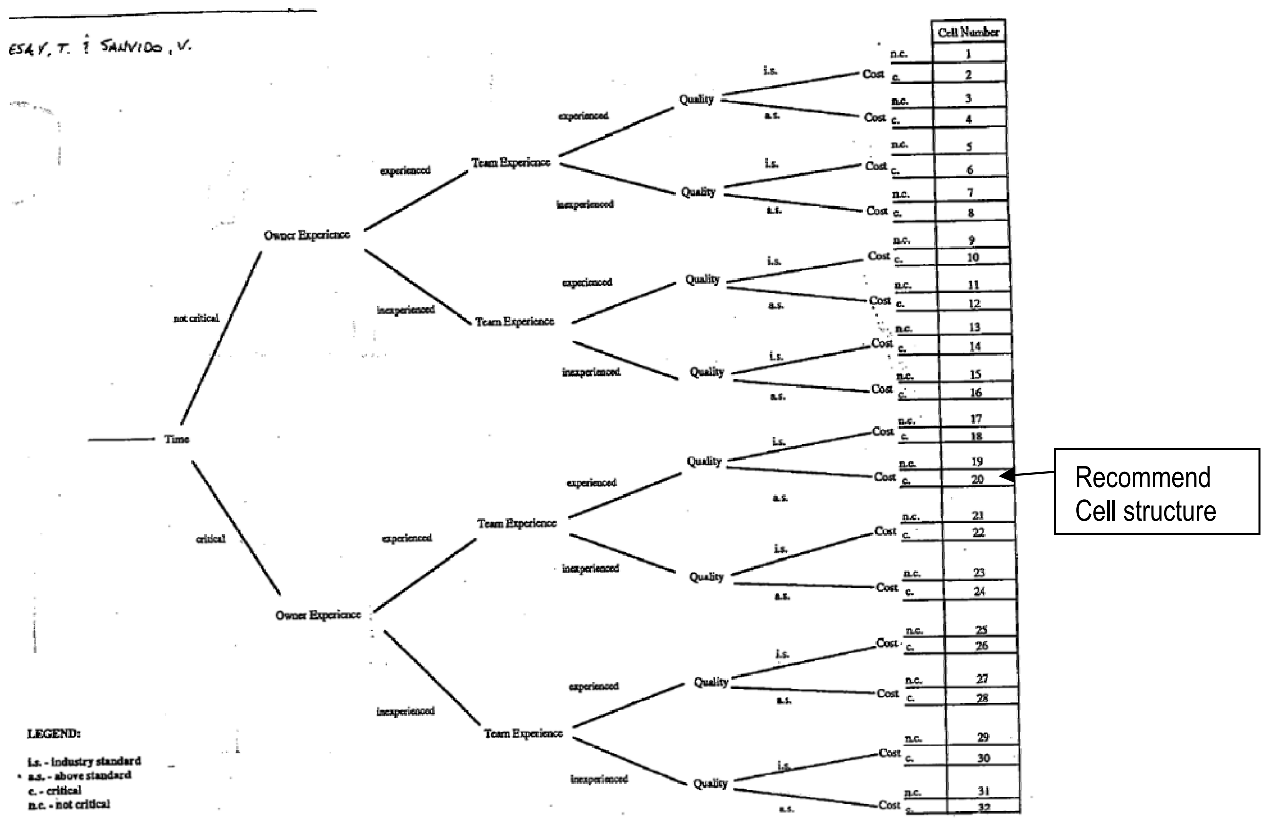


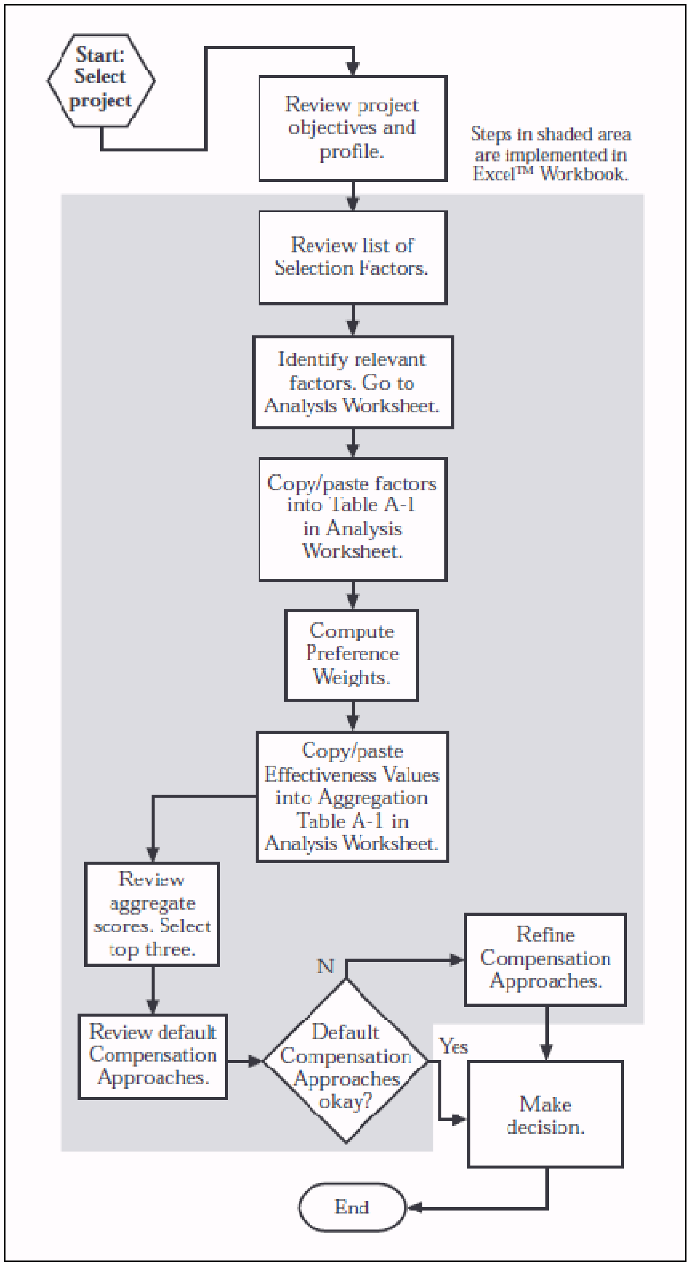
Figure 10 – the project delivery selection system

SCOPE DEFINITION ⟹	WELL DEFINED SCOPE	UNDEFINED SCOPE	WELL DEFINED SCOPE	UNDEFINED SCOPE
	1	2	3	4
CELL NUMBER	ORGANIZATIONAL STRUCTURE	ORGANIZATIONAL STRUCTURE	CONTRACT STRATEGY	CONTRACT STRATEGY
1	TD	CMA, CMGC	LS	GMP, CPF
2	TD, D/B	CMGC, CMA	LS	GMP
3	TD	CMA, CMGC	LS	GMP, CPF
4	TD, D/B	CMGC	LS	GMP
5	TD	CMA	LS	GMP
6	TD	CMA	LS	GMP
7	TD, CMA	CMA	LS	GMP
8	TD, CMA	CMA	LS	GMP
9	TD	CMA, CMGC	LS	GMP
10	TD, D/B	CMGC, CMA	LS	GMP
11	TD	CMA, CMGC	LS	GMP
12	TD, D/B, CMGC	CMA, CMGC	LS	GMP
13	DON'T BUILD	DON'T BUILD	DON'T BUILD	DON'T BUILD
14	DON'T BUILD	DON'T BUILD	DON'T BUILD	DON'T BUILD
15	DON'T BUILD	DON'T BUILD	DON'T BUILD	DON'T BUILD
16	DON'T BUILD	DON'T BUILD	DON'T BUILD	DON'T BUILD
17	CMA, D/B	CMGC, CMA, D/B	GMP, CPF	CPF, GMP
18	CMGC, D/B	CMGC, CMA, D/B	GMP	CPF, GMP
19	D/B, CMA	CMGC, CMA	CPF	CPF, GMP
20	CMGC, D/B	CMGC, CMA	GMP	CPF, GMP
21	CMA	CMA	GMP, LS	GMP
22	CMA	CMA	GMP, LS	GMP
23	CMA	CMA	GMP	GMP
24	CMA	CMA	GMP	GMP
25	D/B, CMA	CMGC, D/B	GMP	CPF, GMP
26	D/B, CMGC	CMGC, D/B	GMP	CPF, GMP
27	D/B, CMA	CMA, D/B	GMP	CPF, GMP
28	D/B, CMGC	CMA, D/B	GMP	CPF, GMP
29	DON'T BUILD	DON'T BUILD	DON'T BUILD	DON'T BUILD
30	DON'T BUILD	DON'T BUILD	DON'T BUILD	DON'T BUILD
31	DON'T BUILD	DON'T BUILD	DON'T BUILD	DON'T BUILD
32	DON'T BUILD	DON'T BUILD	DON'T BUILD	DON'T BUILD

Project Delivery Method Type

The second tool for the project delivery method selection system used is produced by the construction industry institute (CII) project delivery research team. This method has been used by multiple owners and developers to help select the most sufficient project delivery method for their project. For this analysis, this system was used to predict the best and most feasible project delivery system, which can be used of the National Intrepid Center of excellence. The system includes 6 steps which are shown in the following chart:

Please refer to Project Delivery System excel sheets in Appendix C



Process Flow Chart

Step one: NICoE's project objectives and profile

1. Complete project within budget cost ~ Control cost growth
2. Appearance of building must project appropriate image ~ Quality
3. Accommodate special security requirements ~ Quality
4. Complete construction and design within 18 months period ~ Schedule
5. Minimize design and construction rework to less than 3 percent ~ CCD

Step two: (refer to selection factor excel sheet)

1. Factor 1 – Control cost Growth
2. Factor 4 - Facilitate early cost estimate
3. Factor 6 – Control Time Growth
4. Factor 8 – Promote early procurement
5. Factor 10 – Capitalize on expected low levels of changes
6. Factor 20 – Efficiently coordinate project complexity or innovation

Step 3-5: (refer to preference weights table)

Table A-1: Compute Preference Weights

Factor Action Statement	Preference Rank	Preference Scores	Normalized Preference Weight
Control cost growth	1	70	0.18
Facilitate early cost estimates	2	55	0.14
Promote early procurement	3	60	0.16
Capitalize on expected low levels of changes	4	65	0.17
Control Time Growth	5	65	0.17
Efficiently coordinate project complexity or innovation	6	70	0.18
		385	

Table A-2: Compute Aggregate Scores								
PDCS Alternatives ↓	Factor →	Control cost growth	Facilitate early cost estimates	Promote early procurement	Capitalize on expected low levels of changes	Control Time Growth	Efficiently coordinate project complexity or innovation	Aggregate Score ↓
	Preference Weight →	0.18	0.14	0.16	0.17	0.17	0.18	
PDCS 01	Predetermined Effectiveness Values (Table EV-1)	80	0	0	0	20	70	30.65
PDCS 02		50	20	90	20	50	60	48.70
PDCS 03		80	10	0	0	20	50	28.44
PDCS 04		80	10	0	0	20	40	26.62
PDCS 05		50	20	90	30	50	40	46.75
PDCS 06		60	70	100	40	70	70	67.79
PDCS 07		90	90	100	90	90	100	93.38
PDCS 08		70	80	100	100	80	80	84.68
PDCS 09		0	20	80	80	0	0	28.83
PDCS 10		0	0	50	60	0	0	17.92
PDCS 11		100	100	100	100	100	90	98.18
PDCS 12		40	60	100	30	80	80	64.55

Selection factors in preference weight table

Step 6: Review aggregate scores

From this analysis, the top two highest scoring alternatives are as follows:

PDCS 11 – (Turnkey) ⟶ 98.18

PDCS 7 – (Design – Build) ⟶ 93.38

*Notice PDSC 6 – (CM @ Risk) ⟶ 67.79

After conducting this analysis, it is evidential that Design – Build delivery method would be one of the best options for the delivery method choice for this project. There is an approximate 25% difference in effectiveness of a CM-at-risk delivery method compared to a design build system. These numbers can fluctuate based on the weight of each of the project and owner's objectives.

Industry Point Of View

Next for my analysis, I contacted 5 phone interviews with a Project Executive, Project Managers, and a superintends from both GCs and subcontractors, who have many years of experience with different delivery methods in the industry.

McGraw Hill Construction

A construction management and dispute-avoidance consulting firm in phoenix, Arizona completed a construction survey based on alternative project delivery methods. One of the main results found in this survey is the indication that owners are increasingly looking at alternative delivery methods, such as design-build, as a tool to reduce their costs. A majority (57%) said they need to reduce costs. More than a third (38%) also cited the need to shorten project schedules (see Chart 1).

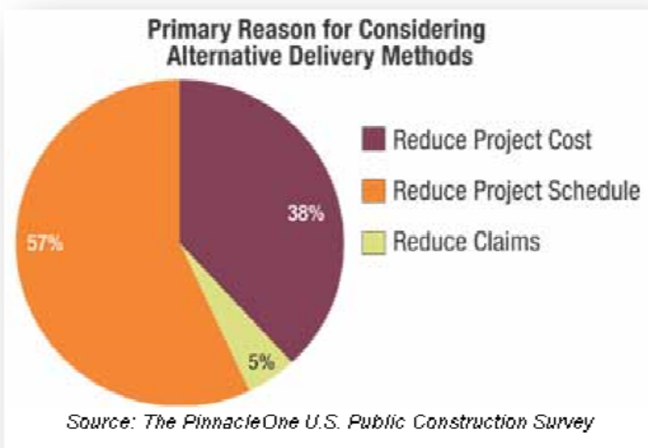


Chart 1 – Primary Reasons for considering alternative delivery Methods

The following chart was collected by the consulting firm mentioned above, which shows the percentages of each of the alternative delivery methods used currently by public owners.

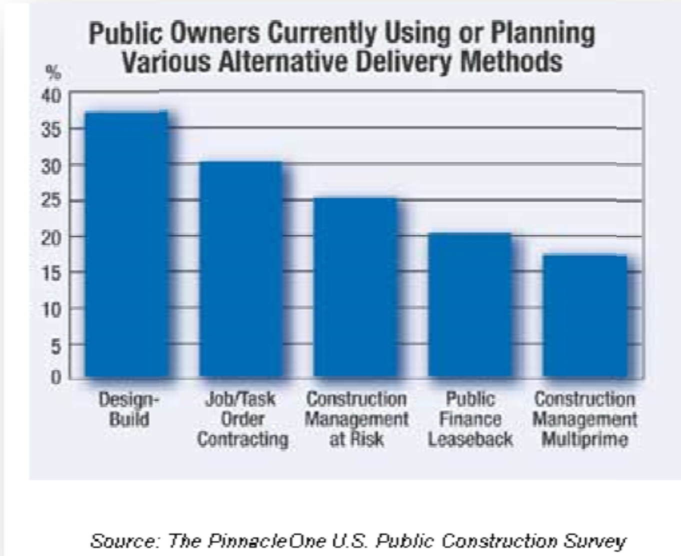


Chart 2 – Alternative delivery methods

Design-build project delivery was the most popular of the alternative project delivery methods. More than a third (37%) of public owners either currently use or are planning to use design-build on some of their projects in the coming year. Design-build appears to be especially popular in the municipal/government sector where 45% of the owners are using or plan to use it.

> *"Compared to the traditional delivery methods used, design build has a 4.5% Lower Construction Cost, 23% Fast Delivery Speed, 7% fast Construction, 21% better quality."*

"Choosing design-build can have several advantages for the public owner. First, the design-builder is a single source of responsibility and it generally results in the project being designed and constructed in a shorter period of time. Because they are together by choice and form one team, the designer, builder and subcontractors should work well together, at least in theory. Errors and omissions in the construction documents are the design-build team's responsibility and that risk is not passed on to the owner.

But two major trade-offs need to be considered with design-build–the owner's loss of control during design and the lack of architect representation of the owner's interest. Design-build also puts tremendous pressure on an owner to know and clearly define criteria and quality for the project at the very start. Failure to do so can result in a disappointing outcome or result in a facility inconsistent with the owner's needs or expectations. When that happens, the owner may have to pay more to get what he wants by issuing change orders to the design-builder. This potentially increases the project cost before construction even begins.

In order to correct problems indigenous to the design-build process, the owner can use a consultant or CM advisor to "bridge" the gap between the owner and the design process, without losing all the advantages of the design-build delivery system. According to the survey, a majority (53%) of the public owners believe agency CM/CM advisor is an effective way to reduce the risk the owners face on projects. A bridging consultant or CM advisor allows the owner to maintain control over important design issues–usually to the 30% construction document phase, or schematic design phase. Through the consultant/advisor, the owner maintains direct communication with the design-builder during the design process.

The existence of a conceptual design that is more compatible with the owner's objectives usually will result in project proposals from design-builders that are easier to compare, which also makes it easier to select the best one. The selection process should take into consideration price, schedule, quality and scope."

Chart 3 shows the increase in total revenue using a design-build delivery method in the past 5 years.

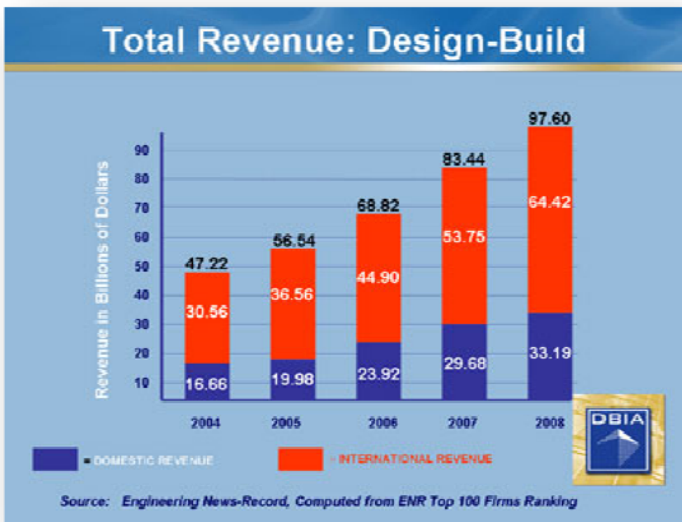


Chart 3 – Total Revenues for Design-Build

.

HD Cooke Elementary School Project – Gilbane Building

HD Cooke Elementary School, located in Washington DC, shifted from a CM-at-Risk contract to a design-build contract method. It includes a renovation of a 1920's and 1960's buildings along with new construction of a 53,000 Sq.Ft wing. The design was completed at the time the contract was awarded. The design was completely out of budget, endured many city code issues, and did not meet the expectations of the owner. As a contingency to the contract, Gilbane Building Company and their Architect firm, Quinn Evans, were tasked with utilizing the existing GMP to redesign the building to make it more cost effective and efficient with a LEED silver project goal.

After speaking with Akilah Darden (Project Manager), she had listed some of the main items/benefits which are considered when choosing a design-build delivery method on specific projects:

- During the value engineering process, the CM was responsible for managing all meetings with the involvement of potential subcontractors for pricing along with the architectural design firm for the efficiency of all value engineering ideas. This process ran very smoothly since it was very interactive with all parties involved. In addition, having the owner involved with the design and value engineering process to meet the required expectations is essential on a design-build project.

- The subcontractors were brought on board as early as the bid process began. The MEP subcontractors, which are one of the most important contractors on this job, were involved in aiding in the design and coordination process prior to mobilization, fabrication and delivery

- "A major savings item to the owner having the CM and the architect work under one contract is for the CM to have control over designing the project to fit the established GMP and be able to provide valuable substitutions based on current market."

Additionally, after interviewing the area superintendent on the HD Cooke Elementary School, he stated many items which were consider when working on a design-build project, these items include:

- Considering the value engineering process done on a design build project compared to a CM-at-Risk project he stated:

  "Gilbane manages the value engineering process. On the HD Cooke Project, We had a budget that had to be met, so we led the meetings and made the ultimate decisions between the Gilbane and designer team. When dealing with certain issues, the owner was consulted for the final decision, but in most cases it was a value engineering decision between Gilbane and the designer. In a design-build, the GC looks for ways to value engineer to save costs in the long run.

  On a CM at Risk – The designer usually leads the value engineering meetings. The designer would usually be more unwilling to value engineer certain aesthetic issues that the GC would recommend. In a CM at Risk project the contractor has less value in value engineering. They do not have any contractual or monetary control with the designer."

- Regarding the comparison of the communication patterns between the designers and the CM, and the Owner and the CM for both delivery methods he stated:

  "Design-Build allows you to be one team. The architect and CM consult daily and the CM can make more decisions in the field. If it is a decision that needs to be engineered, the A/E still needs to be consulted, but on certain aesthetic and other issues in the field, the GC has the ability to make decisions that benefit the project.

  CM at Risk creates two teams, the designer and the CM. In this case, it is easier for one of the team members to take a more hardball stand with certain issues. You have no contractual relationship with each other, so it does not create a cohesive team in many instances. An A/E or CM may be more unwilling to give and take on certain issues that the two teams do not agree on than with a Design-Build where the teams are more closely together from start to finish."

- Comparing the kind of owner involvement used in the design and the VE process with a design-build project compared to a CM-at-Risk project he stated:

  "I think the owner involvement is about the same. The owner involvement still depends on how well the owner knows construction. In my three projects, I haven't seen much of a difference between the two processes."

- Some of the project schedule savings that have been achieved using a design-build project are:

  "Design and construction can coincide. As long as you have all permits and approvals, construction can start prior to design completion. CM will know project better and therefore be able to make better decisions on how to save time. Also, can look at upcoming activities and develop a better plan for construction methods. More decisions can be made in the field which saves time and money."

- Lastly, knowing that this project was a complex project and did not utilize BIM, I opposed the question of recommendation of using BIM and the benefits it would have made on this project. Eric suggested that :

  "Yes I would have recommended BIM on this project. Although this is not a large project, it was a restoration and addition. In the restoration the existing ductwork was all installed in vertical shafts in each room and with no above ceiling MEP systems. All MEP systems were either exposed or in vertical shafts.

  The design added a drop ceiling and all of the systems were above ceiling. The design and CM team tried to keep a lot of the architectural features which caused the ceilings to stay fairly high. In the long run, we had a great deal of trouble fitting the MEP systems above the ceiling and we had to drop some of the ceilings and add bulkheads all around the building, which was not the happy decision made by the designers. Therefore, many of the MEP coordination issues on this project could have been resolved earlier on the project with the simple BIM coordination and collaboration uses.

MARK LURIA - PROJECT EXECUTIVE

Through a phone interview conducted with Mr. Luria, he discusses his construction experience using both CM-at-Risk and design-build delivery method.

He stated that with a design-build project the owner usually bids the project using "bridging documents" , which simply involve the program of the facility, it is very important to make sure these bridging documents include as much of the owner's design view of the building as possible. Therefore, when the construction management is addressing and setting the building budget they are setting a budget for the basis of the design (narrative, schematic, bridging documents, etc.). Additionally, the budget must also include the list of assumptions, exclusions, and clarifications. Lastly, addressing the schedule of the design and construction of the building is very important since it is one of the best benefits to a design-build project.

He included that one of the benefits in his experience to a design-build project is the ability to fast track and begin the construction phase as early as the CM sees can be done. Since the GMP is guaranteed on early with a design –build contract, it transfers the risk to the CM, which has a better knowledge and control of the design, therefore can put packages out to bid as soon as the design documents are complete. Although fast tracking is also used in a CM-at-Risk delivery method, the owner is the person holding the risk instead. Since the GMP is not agreed upon with the CM till all documents are complete, when the packages are out for bidding, the owner is the person guaranteeing the accuracy of the design. Therefore, if the design changes after the bid have been approved by the owner, the owner would have to compensate for the difference. Or perhaps, if the owner divided the bid packages to two stages (rare occasions), the subcontractor can over budget the construction cost in stage 2, which the owner has no choice but to accept the bid. Another benefit to the owner using a design-build project is any errors and emissions during the building process are being taking care of by the CM instead.

Most owners prefer to jump on the schedule, have the lowest cost possible for the design they required, and shift the risk as soon as possible. Mark states that the disadvantage of this method is the owner's loss of control of the design. This constraint can easily be overcome in having a CM agent that works closely with all parties involved. He monitors the program requirements, including the aesthetics, form, and function of the facility based on the owner's expectations before and during the beginning stages of the project.

At the end of the interview I posed the question of what makes the contractor bid on a design-build project. Mark stated that the most important part when looking into bidding a design –build project is how much risk the project holds. This concludes the following factors:

1. The timeline/schedule of the project
2. The complexity of the design
3. The size of the job
4. The design firm choices
5. The relationship of the CM with the owner
6. The quality of the current design/bridging documents

Mechanical Contractor Point of View

Contracting Business-Design/Build- Study Shows Why Design/Build is Just Plain Better

When involved early in a design-build role, MEP contractors frequently offer valuable ideas about where savings can be created without sacrificing quality. They discuss the efficiency of all equipment designed, keeping the owner and the cost goals in mind. They see where time can be saved to advance the project more efficiently toward final completion. Subcontractors also anticipate potential issues and know how to work toward successful resolutions upfront.

> *"A recent study of 120 projects at the McClure Co. found that design/build project ended up with 90% fewer field-generated change orders than traditional contract projects. This resulted in projected "cost-growth" savings of 98%, or more than $1.7million dollars."*

This study was lead by Dr. Riley, an associated professor at Penn State University, which shows the hard evidence when using a design/build delivery method for MEP reduces the numbers of change orders occurring on the project. Comparing McClure's design/build delivery method to other delivery methods, it was found that:

- "Cost growth due to unforeseen change order was 98% lower.
- The average size of all change orders was 50% lower.
- The size of unforeseen change order averages 77% smaller.
- The number of unforeseen change orders was reduced by 90%,
- Cost growth due to change orders was 71% lower"

Figure 2. Summary of key research findings.	Design-Bid-Build Projects	Design/Build Projects	Percent Improvement
Avg. Change Order Size	$10,400	$5,200	50%
Avg. Unforeseen Change Order Size	$9,5501	$1,2502	86%
No. of Change Orders	309	289	7%
No. of Unforeseen Change Orders	114	15	87%
% Growth from Change Orders	16.6%	4.7%	71%
% Growth from Unforeseen Change Orders	5.6%	0.1%	98%

Figure 45- Summary of the key research results

Design Build project allows the mechanical contractor to have a say in the design of the system earlier on with the project and therefore affect the quality of the final outcome. As the above study makes it clear that "a mechanical contractor such as McClure Co. has the potential to decrease the numbers of change orders through more fluid adjustment to the project design, operational efficiencies, and team-building across construction trades and professions." At the end this process benefits the owner, themselves, and the quality, time, cost of the project itself.

David Wysong- Senior Project Manager-National Intrepid Center of Excellence

Next for my analysis, it was important to take the opinion of the current Project Manager on site about the possibility of an alternative project delivery method for NICoE and the benefits it would have had on the project team.

He stated that it is important to have a more of a collaborative project team when it comes to a project like NICoE. This is due to the high technicalities in most of its unique construction methods. BIM was not used on this project as sufficiently as they hoped it to be, due to many of the insufficient communication and collaboration procedures between the project team.

David stated that having a design-build delivery method would give the project team an opportunity to have an "active" architect during the BIM coordination meetings assigned each week. During the meetings the architect was not always present which had a tremendous affect on the coordination process. After running the clash detections and proposing changes, without having the architect/engineers present, all issues had to be written as an official RFI with backups and reasons then sent out to the architect. This process could easily take longer that intended for. He stated with a design-build delivery method an interactive modeling session would be possible, resulting in solving many of the issues which were faced during this project.

When choosing the correct Project delivery method on your project he stated:

> *"The cost to build should not be the only determining factor on the choice of Project Delivery System. Rather, the complexity of the project, the amount of initiatives and knowledge required of the A/E and the builder, and the complexity of the competing goals of the owner should determine if the traditional method or more of a collaborated delivery method is suited for the project."*

In conclusion to the conducted interviews, the building industry is moving towards a more collaborative contract methods. “For complex design projects, a design build delivery method is definitely a good choice for the owner to prefer. It is highly recommended for the design firm to be in constant communication and open to design recommendations from the CM to have a building which emphasizes a high quality/performance project.” Additionally, Teams interested in winning future design-build projects understand they must bring more to the table than the lowest bid. They must work together to meet the owner’s goals for quality, budget and schedule, and they must develop strong relationships to ensure the team’s long-term growth and success.

Design-Build: Does it Guarantee Project Success?

Project success is not determined solely by the choice of delivery systems. Professor Victor Sanvido recently conducted a study on project delivery for the Construction Industry Institute. This study showed that the best performing projects have the following attributes:

- Adequate to excellent ability of owner to make decisions;
- Adequate to excellent scope definition,
- Excellent team communications
- Qualified contractor pool
- High ability to restrain the contractor pool through prequalification and short listing

Likewise, the worst performing projects were characterized by:

- Contractors engaged late in the design process,
- Limited or no prior team experience,
- Onerous contract clauses,
- An owner lacking ability to make decisions,
- No prequalification of bidders

It is clear that if a design-build project has all of these "worst-performing" features, it will probably be troubled.

Schedule Benefits Foe NICoE

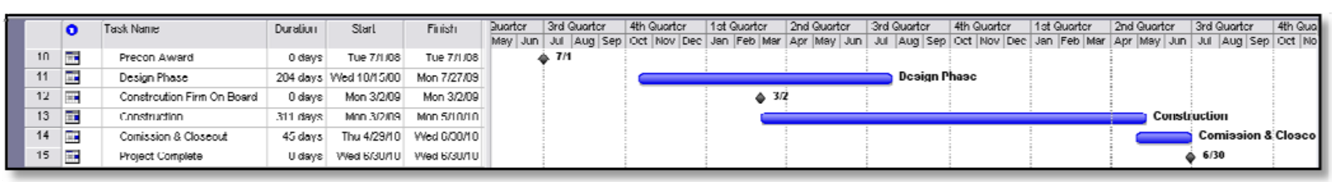


Figure 10- Current Schedule Used for NICoE

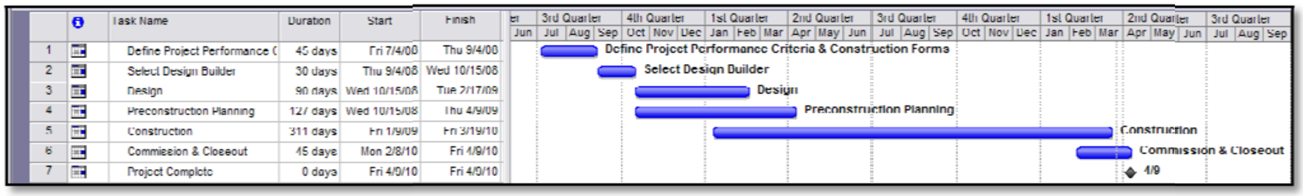


Figure 11- Alternative Design-Build Delivery Method Schedule for NICoE

The original schedule used on the NICoE project shown in figure 10, has had many issues along the lifecycle of the project. The design phase of the project had taken 3 times as intended to be due to: the many design changes before and during the beginning stages of construction, an over budget design, some over designed building systems, inefficient usage of BIM, and a slow process between the CM, owner, and the design firm.

Design-Build Step-By-Step Process

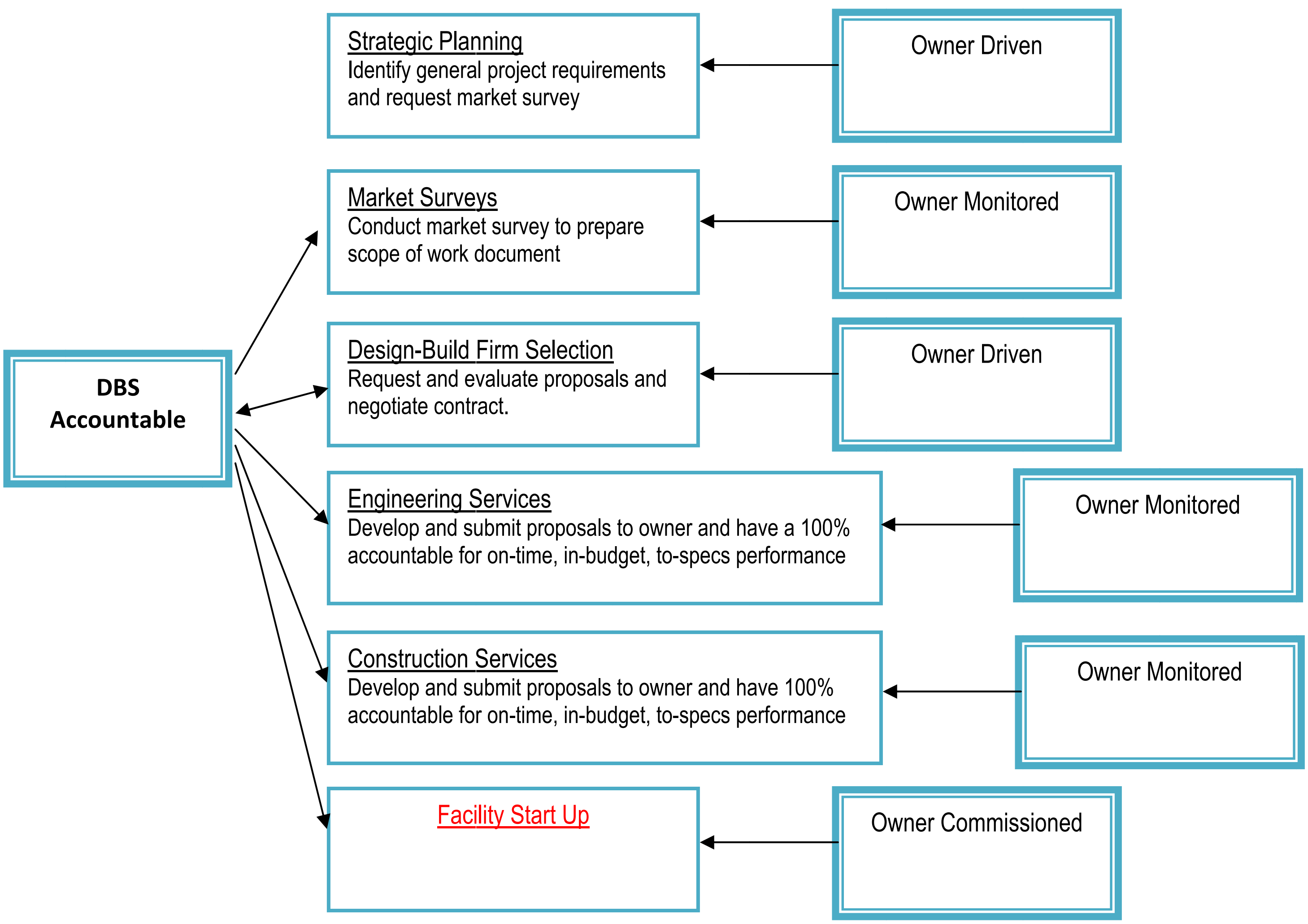


Figure 12- Design-Build Step-by-step process
Source-Design-Build Solutions, Inc.

CONCLUSION

As the building industry is focusing more on the technologies it has to offer for leaner construction process, it is important to acknowledge the need for a collaborative team process during the life cycle of the design and construction phases. There are many benefits mentioned about for moving towards an integrated delivery method. Owner's cost savings have shown to be possible by: the elimination of design and construction changes, more efficient building systems uses, and an overall better quality projects.

Analysis II: Using BIM As A Better Communication Tool

Background:

The National Intrepid Center of Excellence is utilizing BIM 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, sprinkler, 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.

The Value Engineering process went on for approximately 5 months, beginning in August 2009 and ending in December 2009. Once 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. Therefore, the BIM model was not used as a continuous progression working model. Moreover, the 3 other design engineers were never required to update their model and resubmit. The model update requirements and responsibilities were never explicitly assigned.

Poor communication between the designers and the GC during the value engineering process has caused many delays on this project. A drastic change that was not implemented on the 3D model during the VE stage is lowering the second floor ceiling height by 2'-8", which meant less plenum space available. Therefore, after the VE process ended and weekly coordination meetings began, the project team 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 second floor, the problem became apparent.

This issue caused Turner Construction a batch of lost coordination time and wasted cost to the project. Resulting from the two month delay which was required to update all value engineering changes to the 3D model, and or solve the problems as they become apparent on the field.

Goals:

The goal of this research is to identify three spaces which were affected by the inefficient use of BIM on this project and identifying the cost and schedule effects due to this issue. Next is come up with a clear BIM execution plan which can be used by the project team throughout all stages of the project based on a more collaborative project delivery method. Clearly identify the modeling requirements and responsibilities for the project team in all contracts. Develop a 3D model which is a continuous progression working model used throughout the lifetime of the project. Resulting in the use of BIM as better communication tool between all parties involved. In addition, through interviewing industry members whom have current experience with BIM projects, identifying some of the benefits and challenges they are currently facing using this newly innovative technology.

Preliminary Resources and Tools:

- Craig Dubler – Involved in BIM execution planning in the Architectural Engineering department of Penn state.
- David Wysong – Senior Project Manager on the NICoE project.
- Mike Dulany – BIM coordinator on the Fort Belvoir hospital project.
- Todd Povel – BIM coordinator
- Revit Architecture, Navisworks, Projects

3D Modeling Process

The first step of this analysis was to gain access to the 3D Revit Model from SmithGroup. After gaining access to the 3D architectural model, along with some pictures of the clashes found on the field (resulting from the inefficient use of the BIM model) I began modeling the MEP clashes using Revit MEP software. Three different clashes around the building were modeled. After modeling these clashes, both items clashing, along with the architectural model were imported into Navisworks, and a clash detection was run. The resulting clash was then imported as an image.

This process continued with fixing the certain clash found. Going back to Revit MEP and fixing the clash, then rerunning the clash in Navisworks and making sure that it is fixed. Throughout this process, the time was tracked for fixing each of the clashes found.

Clashing Location 1

The first clash modeled was on the second floor/high roof above the main open stair well shown in figure 12. This clash originated due to inefficient coordination between the plumbing and the mechanical contractor. Coordination was run based on the original ceiling height of 17'-8". This meant that the ductwork had sufficient 3" clearness between the ductwork and the roof drain shown. This clash was modeled in Revit MEP shown in figure 14. The clash was then fixed by going back to Revit MEP and moving the ductwork on the other side of the roof drain, shown in figure 15.

Figure 12 - Clash between Roof Drain & Ductwork

Figure 13 – Field solution to the issue.

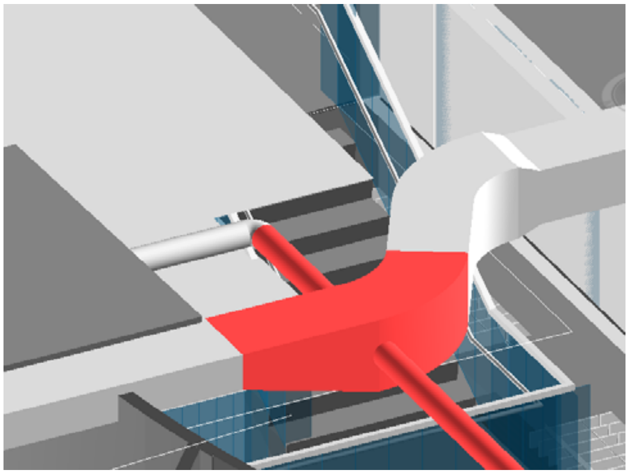


Figure 14 – 3D modeled clash

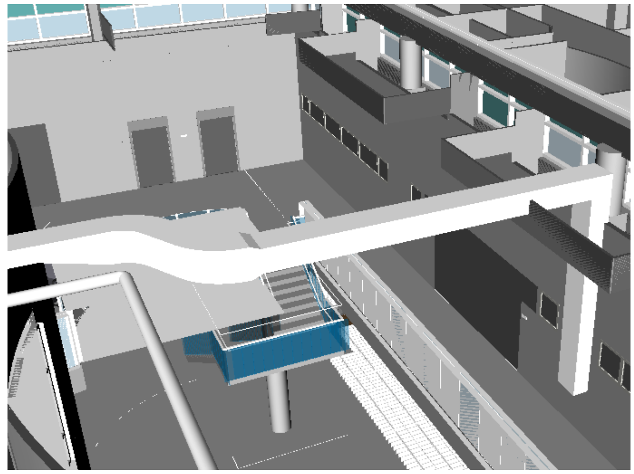


Figure 15 – 3D clash fixed

COMPARING COST AND SCHEDULE EFFECTS DUE TO CLASH LOCATION 1

According to the project manager, David Wysong, the clash shown above had cost approximately $2,200. This included 44 man hours of 2 laborers to take down what was originally installed, solve the issues, and reinstall accordingly.

This clash was one of the main clashes detected on the field after all coordination were run using BIM. Whereas, if written communication procedures were followed and the model was up to date when coordination meeting were run, this issue could have been solved in multiple of ways. A simple fix of moving the ductwork 6" could have solve this issue earlier on as shown in figure 15.

CLASHING LOCATION 2

A second clash was detected after placing the ductwork on the surrounding structure of the CAREN system located on the far northwest side of the building. Shown on figure 16 is the original design of a return registers from the CAREN system room into the ductwork. These returns were coordinated on an elevation height that allowed them to tie into the ductwork from underneath as shown in figure 16. As the ductwork was installed with the drilled holes to fit the return duct, the elevations were inaccurate for the designed ceiling height.

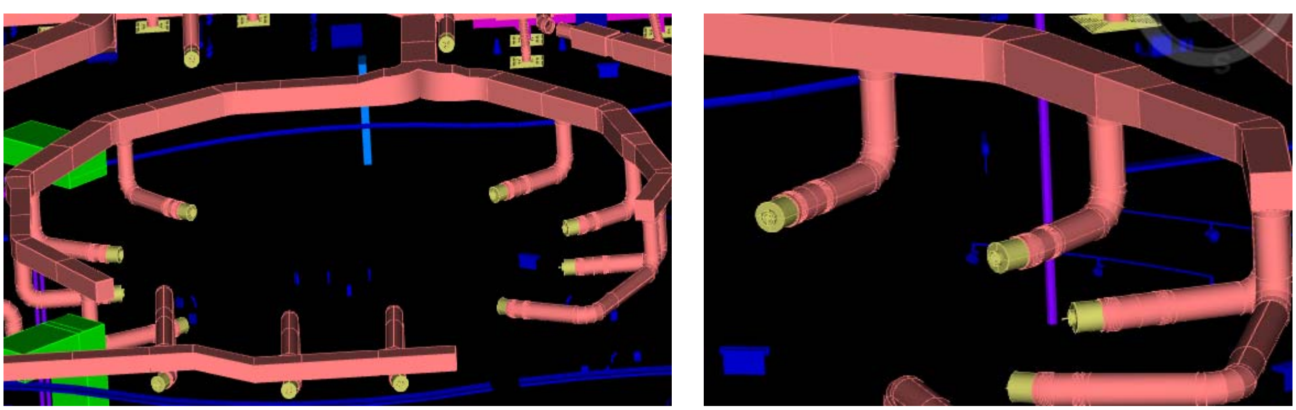


Figure 16 – original Ductwork Design in the CAREN Room

COMPARING COST AND SCHEDULE EFFECTS DUE TO CLASH LOCATION 3

This issue caused the field approximately 26 man hours in order to tear down the cutout ductwork and reinstalled ductwork which has cutouts on the sides as shown in figure 17. This rework was the correction to this issue that had caused the field approximately a total of $1500 to fix. This number excludes the coordination time, which was put into coordinated for both those systems in the beginning. An elevation change caused the return registers to tie into the ductwork in a 90 degree angle instead as shown in figure 17.

Figure 17- Field solution to the issue

CLASHING LOCATION 3

A second clash was detected in the MRI room, located on the second floor, between the drywall on the exterior wall and the roof drain plumbing pipe shown on figure 18. The pipe's diameter was larger than the space available between the drywall and the exterior wall. This clash was modeled in Revit MEP shown in figure 20.

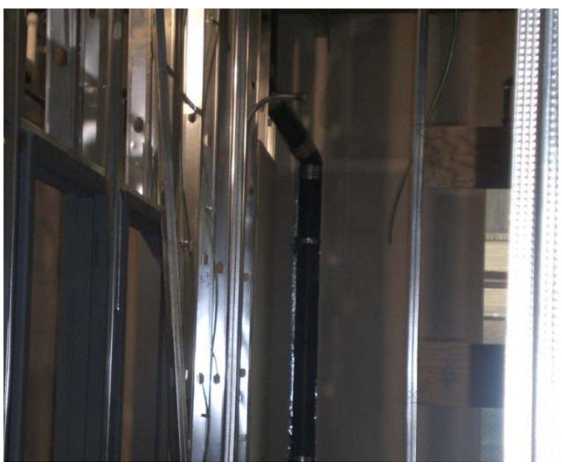


Figure 18 – Drywall and roof drain clash

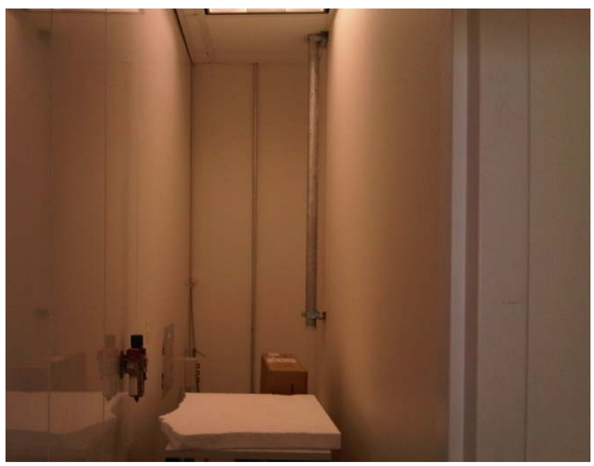


Figure 19 – field solution to the issue

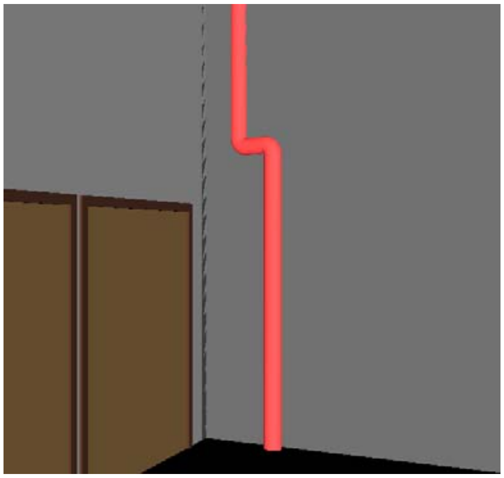


Figure 20 – 3D model of the clash found

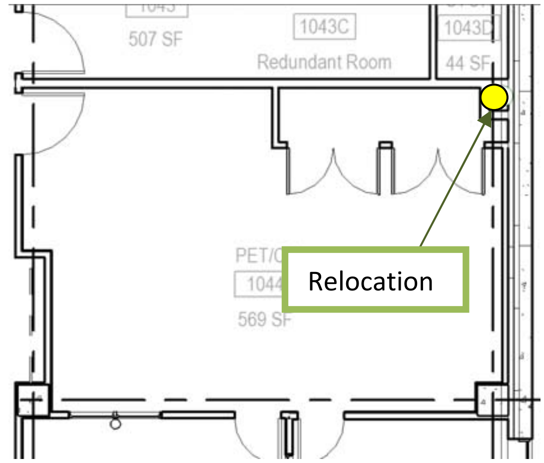


Figure 21- Relocating the roof drain

COMPARING COST AND SCHEDULE EFFECTS DUE TO CLASH LOCATION 3

Since the room is fully enclosed with line lead walls, it would be very expensive to build a bulkhead around the exposed pipe. Therefore, the superintended suggested to move the pipe into the closet within the room seen in figure 21 (2'-3" away). The rework of this issue has cost the project a total of 12 man hours and $350 dollars.

Even though the problem was fixed accordingly in the field it could have been avoided using Revit MEP as shown in figure 21.

These issues were one of many coordination issues that have risen during the MEP construction of the second floor. A simple miscommunication during the BIM coordination process has cause a total of 2 month delay and an approximate $55,000 changes on the field. Therefore it is important for projects that are utilizing BIM to have a clear communication, collaboration, and model structure BIM execution Plan in order to avoid most issues mentioned above.

BIM EXECUTION PLAN

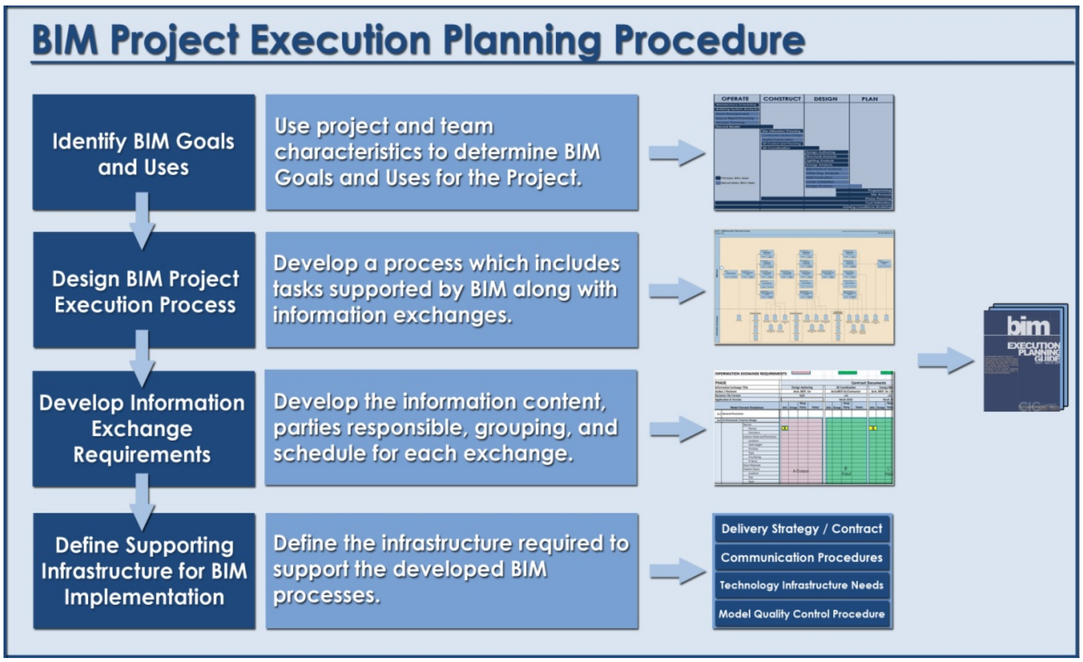
My next step in my analysis, is conducting a BIM Execution Plan by using the BIM Execution Plan Guide template given to me by Greg Dubler (Penn State Graduate Student). Using this template and only emphasizing on the communication, collaboration, and the model structure procedures to be used by the National Intrepid Center of Excellence project team. It is important to have a BIM execution plan which highlights the goals and uses of BIM for all projects utilizing the BIM technology. The template plan was created from the buildingSMART alliance™ (bSa) Project "BIM Project Execution Planning" as developed by The Computer Integrated Construction (CIC) Research Group of The Pennsylvania State University.

"To successfully implement Building Information Modeling (BIM) on a project, it is important to develop a BIM Execution Plan. The BIM Project will define the uses for BIM on the project (e.g. design authoring, cost estimating, and design coordination), along with a detailed design of the process for executing BIM throughout the project lifecycle."

BIM Execution Plan Procedure

"The four steps within the procedure include:

1. Defining high value BIM uses during project planning, design, construction and operational phases;
2. Using process maps to design BIM execution;
3. Defining the BIM deliverables in the form of information exchanges; and
4. Developing a detailed plan to support the execution process.



Source: Penn State Computer Integrated Construction Research Program

The goal for developing this structured planning procedure is to stimulate and direct communication and planning by the project team during the early phases of a project. While there is no single best method for BIM implementation on every project, each team must effectively design a tailored execution strategy by understanding the project goals, project characteristics, and the capabilities of the team members." ~ *www.engr.psu.edu/ae/cic/BIMEx/procedure.aspx*

So how does a company, which is utilizing BIM on their project, begin developing a BIM execution plan?

This process can begin with the simple accomplishment of the 4 required plan development meetings. Meeting 1 involves defining BIM uses and goals on the project. The owner should be involved with this meeting in order to make sure all team members are on the same page and for all to understand the expected requirements for the usage of BIM for this project. Meeting 2 involves designing the BIM process. During this step, all process maps will be developed as the sample shown in figure 23. "These process maps provide a detailed plan for execution of each BIM use. They also define the specific Information Exchanges for each activity, building the foundation for the entire execution plan. The plan includes the Overview Map (Level 1) of the BIM Uses, a Detailed Map of each BIM Use (Level 2), and a description of elements on each map, as appropriate."

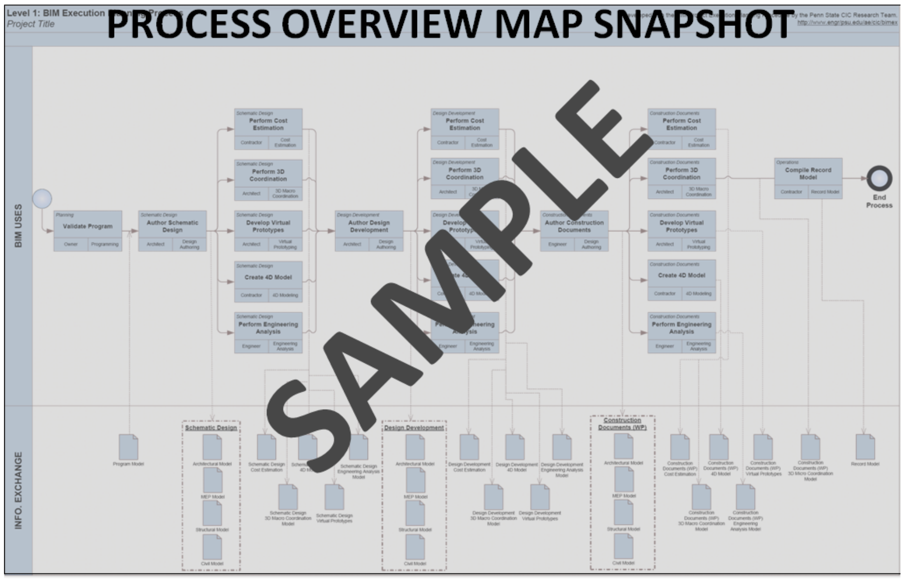


Figure 23-Sample of Process Maps
Source: Penn State Computer Integrated Construction Research Program

The process then continues with Meeting 3. This step includes all information exchange procedures used during the lifecycle of the project. Additionally, all requirements which will be delivered to the client according to divisions of the CSI Uniformat II structure will be discussed and reviewed by the client. Communication and collaboration procedures are a very important step within this meeting. The communications methods, document management, information transfer, and record storage will be considered within this meeting. All model procedures and updates (required per contract, frequency, participants, locations) along with the model delivery schedule of the information exchange will also be broken down in detail. Additionally, the interactive procedures within the project team will be focused on in order to understand the required physical environment throughout the lifecycle of the project and to accommodate all the necessary collaboration, communication, and reviews that will improve the BIM decision making process. Other requirements will be included within this step, such as: project deliverables, Model structure, Technological Infrastructure Needs, etc. Last but not least, meeting 4 includes Finalizing the BIM execution plan.

BIM Execution Plan For NICoE

For this analysis, the BIM Execution Plan focused only on the communication, collaboration, and the model structure requirements as mentioned above. BIM's most important benefit in this industry is to help ease communication patterns between all project teams. Therefore, it is very important to make sure there is an adequate plan that can be implemented by the project team during the lifecycle of the project. The BIM execution plan put in place for this analysis is to maximize the efficiency of using BIM to its fullest potential. The owner's, designer's, contractor's, and subcontractor's responsibilities and requirements for BIM on this project were investigated inorder to come up with the best beneficial plan for this project.

Please see appendix D for the BIM execution plan for NICoE

INDUSTRY POINT OF VIEW

JERRY SHEHAN – SENIOR PROJECT MANAGER ON THE DICKENSON SCHOOL OF LAW – PENNSYLVANIA STATE UNIVERSITY

On this project, Gilbane Building Company initiated the idea of using BIM in assisting with the design and construction of this project. Therefore, Gilbane was responsible in hiring a 3rd party (Dr. Messner, Penn State University Professor) in the schematic design stage of the project to develop a 3D model which can be used on this project. Gilbane was responsible in paying all of the expenses for the usage of BIM since it was not required by the owner. This model was then used as the base element to all subcontractors' models.

A BIM Execution Plan was developed by Dr. John Messner and his fallow graduate students, in order to meet the goals of the BIM uses on this project. In addition, it was very important to clearly identify the BIM requirements in each of the contractors' contracts, shown in Appendix C, in order to make sure all parties understand and recognize their responsibilities in terms of the BIM requirement on this project. All coordination meetings were run on a weekly basis in order to eliminate all clashes found before construction begins. In addition the model was used on a daily basis. Subcontractors became very reliable on the model and asked to view it any time there was a problem on the field. At the end of the project many contractors gave positive feedback and recommendations on their experience with BIM. For example, shown below is a letter written by John Himmelberger, Vice president of Farfield Company (electrical and mechanical company) stating his positive experience with BIM on this project.

F A R F I E L D

RECEIVED
JAN 1 2 2009
GILBANE BUILDING CO.
PENN STATE UNIVERSITY

January 9, 2009

Gilbane Building Company
270 Walker Drive, Suite 102
State College, PA 16801

Attn: Mr. Jerry Shaheen

Mr. Shaheen,

I would like to take this opportunity to pass along some good news regarding the New Dickinson School of Law Building at Penn State University. This project used 3D Building Information Model (BIMS) for coordination of all trades. This was a new process for The Farfield Company and with the cooperation of the Gilbane team and the Farfield team, the entire process provided good information for the coordination of all trades involved. Also, it was very helpful with layout and installation details. This building has very unique features that with the use of the BIMS process, we recognized labor savings that resulted in an increase to our overall profitability on this project.

I want to thank you and your entire team for their effort and cooperation in making the BIMS process a huge success for the project. I have no doubt that it contributed to the overall success of this entire project.

Thank you again, for giving The Farfield Company the opportunity to be a part of your team.

Very Truly Yours,
THE FARFIELD COMPANY

John P. Himmelberger
Vice President

When asking Jerry Shehan on some of the goals which were used on this project he pointed the following:

- To create additional efficiency in the design and construction of the building
- To identify coordination issues in the design as early as possible
- To enhance the architect's vision for the building
- To comprehend and communicate the architect's vision clearly
- To create a tool which supports collaborative and rapid problem solving
- To allow end-user acceptance of spaces prior to construction
- To reduce the need for expensive physical mock-ups
- To coordinate trades effectively
- To increase productivity during construction by giving everyone a clear vision and work path
- To reduce the number of RFIs during construction
- To reduce the number of change orders for the project
- To decrease time consuming and costly field coordination
- To allow the owner advance their research efforts to improve the construction industry as a whole
- To increase everyone's knowledge of immersive modeling and improve the process for future applications.

When asking Jerry Shehan the approximate cost savings he has made using BIM on this project, it was very hard to sufficiently evaluate an adequate hard cost, but approximated at least a savings amount of $150,000 in unforeseen collisions that were fixed before construction has begun.

> *"Using BIM on this Project is what made this project possible to be delivered on time and within the required budget"*

FROM THE ARCHITECT'S POINT OF VIEW -ERIKA EPSTEIN- ARCHITECT

"With architects and consultants (mechanical, electrical, landscaping, etc.) all using BIM models, we can more easily collaborate during the design process to minimize errors and to be more efficient and productive. As the design progresses, and decisions are made about systems and materials, we continue to update our shared BIM models; we also start to embed data, such as material choices, into the models"

HOW DOES BIM AFFECT THE ARCHITECT/ENGINEER DYNAMIC?

"With engineers we exchange 3D virtual models of our work from the beginning. We use IFC and/or DWG files. IFC is a format that retains the embedded data. Both formats allow us to overlap models, similar to how we used to overlay 2D drawings. Additionally, the use of clash analysis software such as Solibri and Navisworks make all our work easier by detecting all clashes.

As we overlay our models in our respective programs, we can all see how well the systems are working together. Each discipline retains responsibility for their work as shown in the 3D virtual model, just as they do with their 2D drawings and specifications. This is far more efficient and accurate than overlaying the many independently drawn 2D drawings. Each drawing is just a different view (section, elevation or plan). Two-dimensional depiction of the same 3D element can easily be mis-drawn in one or more views. This type of error can multiply when shared with rest of the team. With a 3D virtual model, you draw each 3D element once as a 3D object"

From The Construction Manager Point of View –Duane Gleason- Project Manager

"It really depends on how savvy the contractor is, and how committed he is to BIM. It is undeniable that some of the contractors out there still just have the software, and they talk about it, and they see the beauty of it, but they are not really fully using it. For them, the process is different for the first couple weeks, but then it kind of gets back to the same old routine. However, for the contractors who have really embraced BIM, it changes the entire dynamic once the project is handed over to them. They are pushing coordination from day one, and they are holding their efforts to the data that is inside the models from day one, and linking submittals to the models, and tracking as much as they can through the models.

I don't think there are a lot of architects yet handing over the models, so it is going to need a couple more years of refinement before things begin to change quickly. But what we are seeing now is that general contractors who are getting the jobs see the value of the BIM models. By having a 3D model for pre-bid, they are able to flesh out any missing information, see any conflicts and optimize the project. BIM shifts the focus to planning so that, once the building starts, there are few surprises."

How does BIM affect the architect/engineer dynamic?

"I think it just makes everything a lot easier. I think that there is a lot of responsibility on the contractor to explain to owners what they are getting and make owners feel good about the money they are spending. But sometimes that is unproductive time for a contractor. With the 3D virtual model, you don't have to explain anything. You open it up, you put everyone into a virtual plan room, and you show them what they are getting. You ask them if it is what they want, if they are happy with it, and if there are things they want to be different. If they do want to change something, you can show them right away what the impact will be from all points of view -- aesthetics, construction, costs and so on. It takes down some of the friction in some of the relationships because you don't ever have to question anyone when there is a 3D virtual model sitting right in front of the whole group telling the story."

"You have all your project areas, tasks and costs included in the model, and everybody is aware of them. For example, you could use a tool such as Vico Cost Manager to print out every single value in the entire project. From there, you can see money spent compared to the estimate, and you can see graphically where your project started to go south -- you have green dots that go to yellow and, finally, to red..It means there is a whole lot less of he said, she said, and going through coffee-stained, hand written daily reports."

> *"In a BIM environment, as a contractor or as a participant, you need to think before you speak and think before you deliver because you're held to it when you submit a model. The proof is in the pudding. You better work hard on it, and you better believe what you put into it, because there is no going back once you submit it."*

From The Subcontractor Point of View – Paul Harsch- ISEC Inc.

"I think from a subcontractor's point of view, the biggest difference with a BIM project is the way you have to communicate. Just a couple years ago "at-risk" construction was peaking, so the approach was to follow the orders of the GC, to do what the GC said when the GC said it and to avoid conflict. Now, it is all out on the table. The model tells the entire story.

Everyone has his cards face up, so he has to communicate honestly and put more information out there than he might be used to putting out there. Subcontractors will lay out their plan for how they are going to do the work and what the true cost is. Building in fudge factors won't work anymore because they won't be needed. Once subcontractors assemble their portion of information into the total repository of information along with everybody else, the rest of their job just goes a lot smoother. They essentially get brought into the whole BIM project where now they are interested in the drywall guy and how his work relates to theirs, and they are thinking about what makes more sense -- getting the ductwork into a particular space or getting the pipe work into it first."

> *"If subcontractors are involved early on in a BIM project, then they can influence the design. If not, they can use tools like Navisworks and Bentley Navigator to do the analysis of the building to see how their piece fits in. They can see these things before they go out to build."*

I believe there are benefits all along the way from day one of a BIM project. It just depends on how quickly subcontractors can work the collaboration activity to their benefit. After the fact, if they are involved with long-term building maintenance, as an HVAC contractor might be, they can be the custodians of the model for the building owner and monitor certain aspects of maintenance and system operations over time."

On the first BIM job, hard cost is being invested and will have a one job payback period. once you have the training already done. Moving along the next BIM job you already have the training and therefore you have a competitive advantage over many other subcontractors.

Obstacles to BIM Acceptance

"At present, one of the major drawbacks to BIM is the learning process that companies must go through as they use it.

"This is not about buying some software licenses, sending your people to class for a week and then you're in the new world," Jacobi says. "It's a transformational way of doing business, and it does take training and investment."

"The learning curve is enormous because it's such a different environment than what most people are used to," adds Ron Meyer, project architect with HKS Inc. of Dallas. He is using Revit's version of BIM (internally only) to design a hospital/physicians office project in San Antonio for the Christus Santa Rosa health care system.

"Revit wants you to think in a different way," Meyer says. "BIM contains so much more information than AutoCAD or any drafting programs before."

After gaining experience on several BIM projects, HKS is beginning to show improvements in efficiency, productivity and quality, he says. "I think we're about to turn the corner where it's helping us out with our bottom line," Meyer adds.BIM also requires owners and building team members to rethink their traditional working relationships.

"I think eventually it's going to rewrite how we word our contracts with clients and contractors, and it's going to rework our traditional phases from schematic design and design development through bid negotiations and the construction phase," Meyer says. "The product enables all the industry players to work together."

RECOMMENDATIONS/CONCLUSION

NICoE has utilized BIM on their project and have been successful but with minor glitches due to communication and collaboration team issues mentioned above. These problems would have been avoided by investing in more of an upfront planning from both the project team and the client by clearly identify the roles, objectives, expected outcome, within a detailed BIM execution Plan as shown in appendix D. Additionally, it is very important to have a collaborative team on a complex project such as NICoE. Therefore a design build project which is utilizing BIM would be much more efficient by having the designer present at all meeting and "active" in all decisions made and making sure the model is a continuous working 3D model which is being updated and used to its fullest potential.

There are countless of benefits for the usage of BIM on your project. However, the goals and usages differ from one project to another depending on the complexity of the project and the client's goals and requirements. Therefore, it is important to have a clear BIM execution plan that highlights the details of the BIM goals, requirements (communication, structural model, collaboration, etc.) and usages on each project. In addition, it is important to have a client that fully understands the BIM technology and uses it to its fullest potential with a collaborative project team that also understand the benefits of BIM on their project.

Another use of BIM which is a possible cost and time saving aspect on this project, demonstrated in analysis III, is the use of 3D estimation. 3D estimation can be used during the earlier stages of construction and design phases along with the alternative building systems during Value Engineering to expedite the process.

ANALYSIS III: 3D ESTIMATING

Background:

Continuing on with improving the lengthy VE period on this project, the estimating period of the VE process had taken much longer than expected. There had been 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. Turner Construction spent massive amounts of time and a number of resources on estimating the ideas suggested during the VE period. Materials and alternative systems being suggested were taken off by hand using the 2D construction documents. It was very important to the owner to understand the cost and architectural impacts that will be affected by the Value Engineering ideas before he approved any of the suggestions made by Turner and SmithGroup. Therefore, this process became very redundant and time consuming to the project team. Various amounts of money had been spent on this process that took much longer than it was intended for.

Goal:

Using the developed 3D model, there are several software products available which contain more efficient and faster estimation feedbacks. These different software packages should be analyzed for potential benefits to be used during the VE estimation period to expedite the take off process and help with the comparison of design alternatives. The analysis will compare new products such as Revit Quantity schedules to the traditional estimating methods used. This analysis will also compare the alternative exterior façade panel materials and structural designs and demonstrate how 3D estimation can be used when comparing alternative building systems.

Preliminary Resources and Tools:

- RS Means 2009
- Revit Quantity Schedules
- Fort Belvoir hospital- Mike Dulany, BIM coordinator
- Rob leicht – DPR
- Kingspan- Insulated metal panels manufacturer

TRADITIONAL ESTIMATE

This analysis will compare the original and current façade of the northwest side of the building. This process began with the estimation of the materials, labor, and equipments savings towards the curtain wall system design change on the northwest side of the building using the traditional estimation methods. The northwest side of the building is composed of a curved 38'-8" curtain wall system along with precast wall panels. 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, which meant more curtain wall material. In addition, the original building design was 3 stories, which meant the curtain wall system extended an extra 15' high, totaling a height of 53'-8".

Using the traditional methods, the curtain wall material was taken off manually using a ruler and a scale from the 2D construction drawings. Using an excel spread sheet, the pieces which had the same size of glass were counted together and had its own line item. Each piece of glass had the same approximate length of 2'-8.2". However, the lengths of the pieces varied upon the level they were located in. Additionally, frames were counted for each piece of glass.

After taking off the current curtain wall design that had been approved by the owner, the same method was used to count the original design. First, I removed the precast panels that were integrated within the curtain wall system and replaced each with the appropriate amount of glass and frames, considering the size and type used. Additionally, I added a floor level to the current design and counted the additional frames and glass that had been in place before the design had changed.

Next step, was calculating the material, labor cost for both systems. In order to get the total cost it was necessary to calculate the total square footage of glazing used in each system. Square footage = (height x width x # frames x # faces). Using RS Means 2009, the total square footage was assigned to specific glazing material and labor total cost. This step was then repeated for the original design as well. All of the costs of labor and material are then multiplied by location factor of 0.9 (Silver spring, MD). There was no need for time factors since RS Means 2009 was used.

Results

According to the square foot takeoff of the current design, there is a total of 8,478 Sq.Ft of curtain wall material used. The total cost of the curtain wall system is **$ 534,114** for material, and **$ 103,856** for labor. Factoring in the location factor of 0.9, this brings a grand total of **$ 574,173** for the current curtain wall design.

Whereas according to the square foot takeoff of the original design, there is a total of 18,616Sq.Ft of curtain wall material used. The total cost of the curtain wall system is **$ 1,172,808** for material, and $ **228,046** for labor. Factoring in the location factor of 0.9, this brings a grand total of **$ 1,260,769** for the current curtain wall design.

Therefore, the saving to the owner that has been done according to the redesign of the curtain wall system is **$686,596** (Please see table 2)

NEW Glazing Takeoff					
Face	**Approx. Width(ft)**	**Approx. height (ft)**	**Frame Count**	**Quantity**	**SF**
IGU Glazing	2.68	2.68	3	127	2736
	2.68	2.68	1	127	912
	2.68	5.33	1	74	1000
	2.68	9.33	1	74	1750
	2.68	12	1	66	1994
	2.68	4	1	8	86
				Total:	**8479**

Glazing Takeoff (extra floor & extended Precast panels)					
Face	**Approx. Width(ft)**	**Approx. height (ft)**	**Frame Count**	**Quantity**	**SF**
IGU 3 Glazing	2.68	2.68	5	155	5566
	2.68	2.68	1	102	733
	2.68	5.33	1	102	1457
	2.68	9.33	2	155	7751
	2.68	12	1	94	3023
	2.68	4	1	8	86
				Total:	**18616**

Table 1: Curtain wall 2D hand takeoffs

	Current Design												
	Unit Cost Estimate												
Qty	**Description**	**Crew**	**Daily Output**	**Labor Hours**	**Unit**	**Material**	**Labor**	**Mat. O&P**	**Labor O&P**	**Total O&P**	**Ext. Mat. O&P**	**Ext. Labor O&P**	**Ext. Total O&P**
8478	Curtain Wall, aluminum, stock, double glazed, incl. glazing, average	H1	180	0.178	S.F.	$ 57.50	$ 7.40	$ 63.00	$ 12.25	$75.25	$ 534,114.00	$103,855.50	$ 637,969.50
Total											**$ 534,114.00**	**$103,855.50**	**$ 637,969.50**
	Original Design										Location Factor =		$ 574,172.55
	Unit Cost Estimate												
Qty	**Description**	**Crew**	**Daily Output**	**Labor Hours**	**Unit**	**Material**	**Labor**	**Mat. O&P**	**Labor O&P**	**Total O&P**	**Ext. Mat. O&P**	**Ext. Labor O&P**	**Ext. Total O&P**
18616	Curtain Wall, aluminum, stock, double glazed, incl. glazing, average	H1	180	0.178	S.F.	$ 57.50	$ 7.40	$ 63.00	$ 12.25	$75.25	$1,172,808.00	$228,046.00	$1,400,854.00
Total											**$1,172,808.00**	**$228,046.00**	**$1,400,854.00**
											Location Factor =		$ 1,260,769
													$ 686,596.05

Table 2: Cost summary using RS Means CostWork

Revit Quantity Schedules Estimate

Continuing on in comparing the traditional 2D hand estimation with 3D estimation method, I began using Revit quantity schedules to assist with my analysis. The estimate was calculated in the same way as the traditional method except using material quantities collected from the Revit model schedules rather than hand counting the materials. The quantities were then matched with RS Means CostWorks data. The numbers of hours using Revit schedule method was then recorded for the analysis.

The first step in getting an accurate Revit quantity schedule is creating an accurate Revit model. Therefore, it is important for the model to be a continuous working 3D model to get the accurate quantities required. The model was done by SmithGroup Architectural firm according to the latest design updates (October 2009).

The next step is getting the quantities from the Revit model. This is fairly simple and quick. Inside Revit Architecture there is an option under the view menu bar which is Schedule/Quantities, this enables you to schedule almost any assembly that the model has been inputted with. The entire curtain wall glazing materials were designated under the wall assembly, since it is considered as a wall type. Under the wall types there are 4 different curtain wall types used within the exterior of the building. Curtain wall TBI-Curve-3', Curtain wall TBI-Curve-3' @ precast, Curtain wall TBI-Curve-3' @ door, and Curtain wall-TBI-10'.

When creating a schedule inside Revit, it is important to pick the correct selection of fields within the certain assembly required. The family, type, volume, width, length, and area are the fields which were picked for this quantity schedule. These fields were then sorted by type so that just the curtain wall glazing quantity would be used.

The most important step in creating a Revit Quantity schedule is formatting the fields selected within the schedule. First, it is important to make sure each field has the quantity totals button selected. Next, fields must be formatted to the correct units (decimals). This is very critical in order to be able to transfer this schedule into a useful excel spreadsheet.

Once the schedule was created in Revit, it was exported as a txt file. This ext file was copied into an excel sheet similar to the manual takeoffs. Since there was no access to the original 3D model, a simple Revit quantity schedule was done for the precast panels located on the exterior of the building. The square footage of the precast panels was then added to the current curtain wall design square footage. Along with that, the square footage of the curtain wall of the second floor was doubled since the original design was 3 stories high with no integration of the precast panels.

The areas for both designs were then multiplied by the cost per square foot of each assembly including labor, material, and equipment of for both curtain wall system designs. All of the costs were then multiplied by the location factor of Silver spring, MD (0.90).

STEP-BY STEP PROCESS IN MAKING A REVIT QUANTITY SCHEDULE:

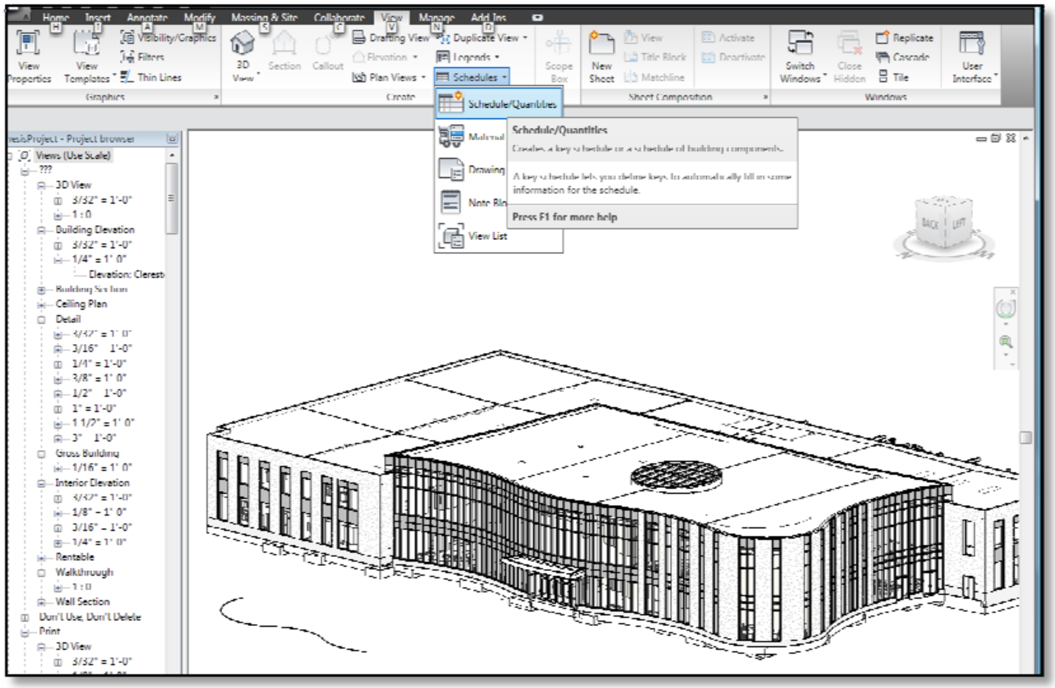


Figure 24- Step 1: Selection of the schedule option

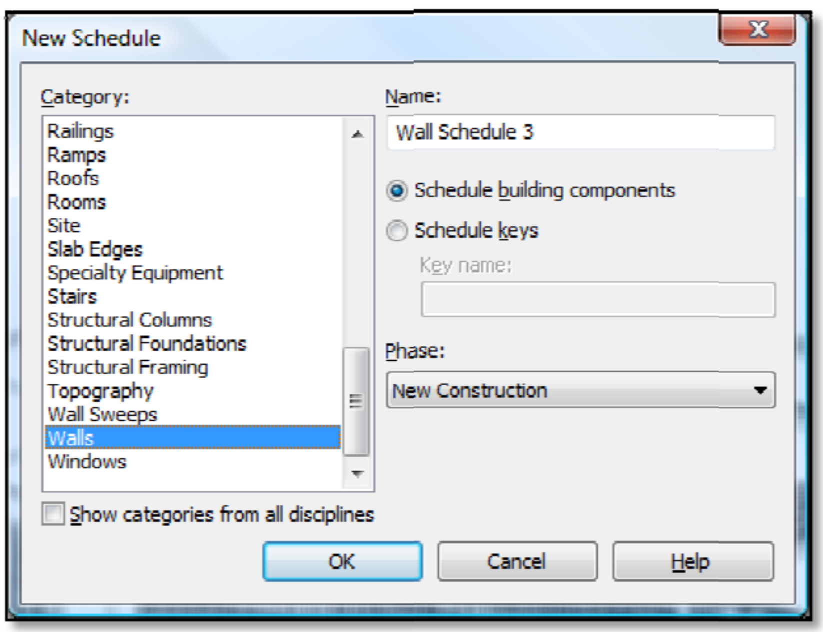


Figure 25- Step 2: Selection type of assembly required.

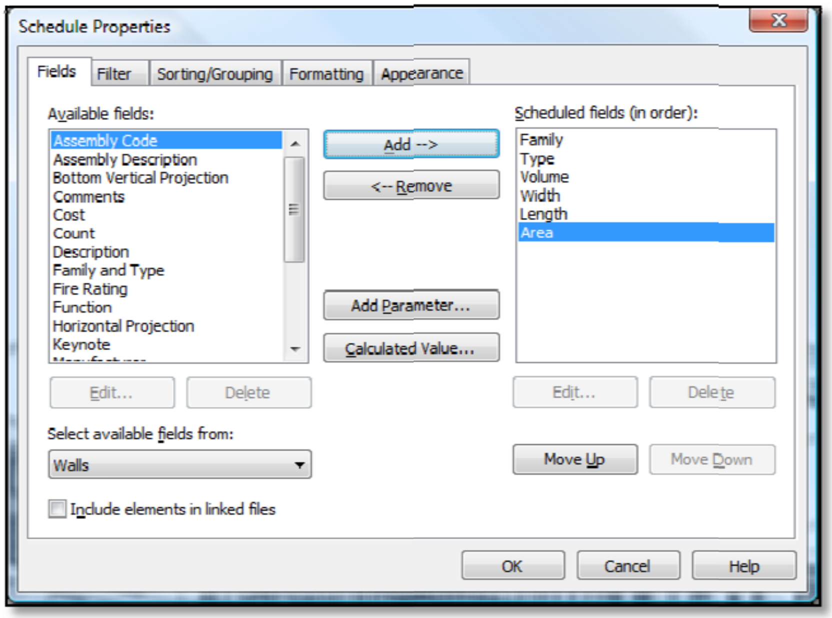


Figure 26- Step 3: Selection of fields required within the quantity schedule

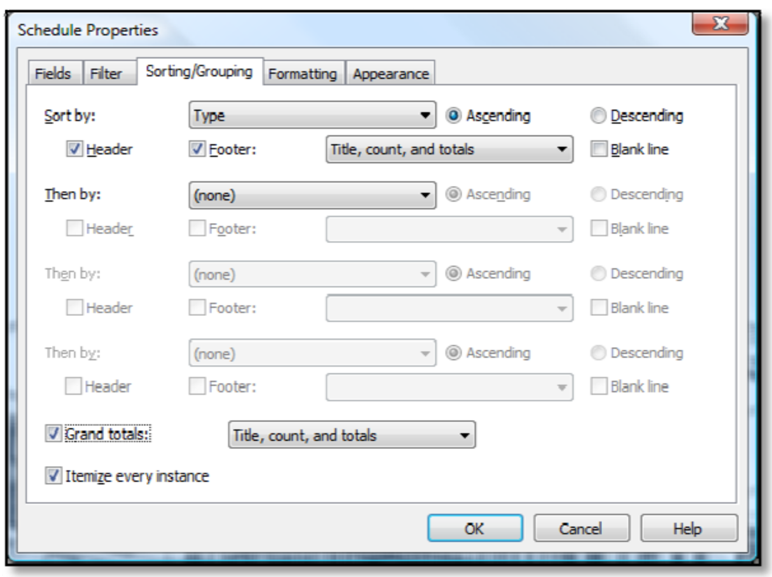


Figure 27- Step 4: Sorting/Grouping the schedule based on type of assembly.

Wall Schedule 3					
Family	Type	Volume	Width	Length	Area
Curtain Wall-TBI-CURVE-3'					
Curtain W	Curtain Wall-TBI-CURVE-3'			24' - 0"	567
Curtain W	Curtain Wall-TBI-CURVE-3'			6' - 0"	223
Curtain W	Curtain Wall-TBI-CURVE-3'			5' - 11 5/16"	221
Curtain W	Curtain Wall-TBI-CURVE-3'			1/16"	0
Curtain W	Curtain Wall-TBI-CURVE-3'			11' - 11 15/1	447
Curtain W	Curtain Wall-TBI-CURVE-3'			1 1/2"	4
Curtain W	Curtain Wall-TBI-CURVE-3'			12' - 1 9/16"	452
Curtain W	Curtain Wall-TBI-CURVE-3'			24' - 0"	894
Curtain W	Curtain Wall-TBI-CURVE-3'			12' - 0"	447
Curtain W	Curtain Wall-TBI-CURVE-3'			11' - 10 3/4"	443
Curtain W	Curtain Wall-TBI-CURVE-3'			32' - 3 7/8"	1204
Curtain W	Curtain Wall-TBI-CURVE-3'			8' - 7 1/2"	332
Curtain W	Curtain Wall-TBI-CURVE-3'			24' - 0"	63
Curtain Wall-TBI-CURVE-3': 13					5300
Curtain Wall-TBI-CURVE-3' @ Precast					
Curtain W	Curtain Wall-TBI-CURVE-3' @ Precast			3' - 0"	112
Curtain W	Curtain Wall-TBI-CURVE-3' @ Precast			6' - 0"	224
Curtain W	Curtain Wall-TBI-CURVE-3' @ Precast			3' - 0"	112
Curtain W	Curtain Wall-TBI-CURVE-3' @ Precast			3' - 0"	112
Curtain W	Curtain Wall-TBI-CURVE-3' @ Precast			6' - 0"	224
Curtain W	Curtain Wall-TBI-CURVE-3' @ Precast			3' - 0"	112
Curtain W	Curtain Wall-TBI-CURVE-3' @ Precast			3' - 0"	112
Curtain W	Curtain Wall-TBI-CURVE-3' @ Precast			3' - 0"	112
Curtain W	Curtain Wall-TBI-CURVE-3' @ Precast			6' - 0"	224
Curtain W	Curtain Wall-TBI-CURVE-3' @ Precast			3' - 0"	112
Curtain W	Curtain Wall-TBI-CURVE-3' @ Precast			6' - 0"	224
Curtain W	Curtain Wall-TBI-CURVE-3' @ Precast			3' - 0"	112
Curtain Wall-TBI-CURVE-3' @ Precast: 12					1789
Curtain Wall-TBI-CURVE-3' at door					
Curtain W	Curtain Wall-TBI-CURVE-3' at door			6' - 0 5/8"	233
Curtain Wall-TBI-CURVE-3' at door: 1					233
Curtain Wall-TBI-CURVE-10'					
Curtain W	Curtain Wall-TBI-CURVE-10'			45' - 0 1/4"	276
Curtain W	Curtain Wall-TBI-CURVE-10'			3' - 5 1/2"	21
Curtain W	Curtain Wall-TBI-CURVE-10'			121' - 10 3/4"	747
Curtain W	Curtain Wall-TBI-CURVE-10'			45' - 4 13/16"	278
Curtain W	Curtain Wall-TBI-CURVE-10'			57' - 3 1/4"	351
Curtain W	Curtain Wall-TBI-CURVE-10'			3' - 10 5/16"	24
Curtain Wall-TBI-CURVE-10': 6					1696

Figure 28- Step 5: Curtain wall assembly quantity schedule.

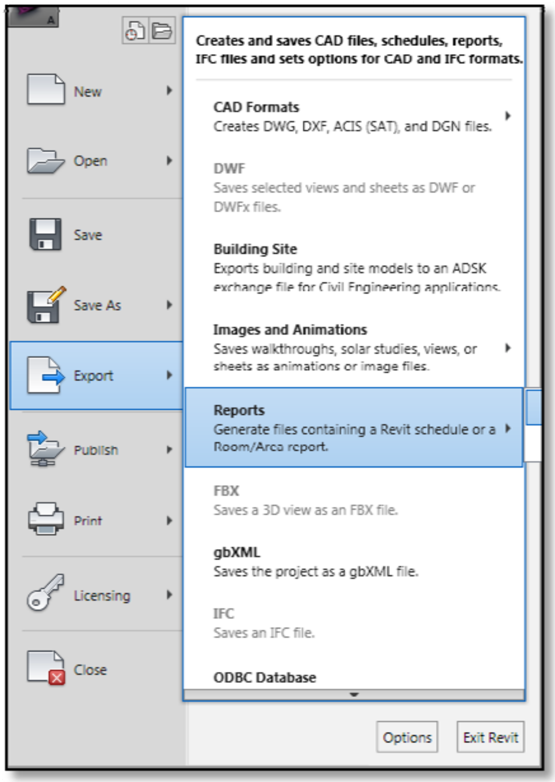


Figure 29- Step 6: Exporting the schedule as a txt file.

Wall Schedule 2					
Family	Type	Volume	Width	Length	Area
NICoE-Base at Curtainwall 2nd fl: 3					
NICoE-ScreenWall Precast					
Basic Wall	NICoE-ScreenWall Precast	140.80 CF	1' - 3 3/4"	2' - 10 9/16"	108 SF
Basic Wall	NICoE-ScreenWall Precast	147.15 CF	1' - 3 3/4"	3' - 0 1/8"	113 SF
Basic Wall	NICoE-ScreenWall Precast	147.15 CF	1' - 3 3/4"	3' - 0 1/8"	113 SF
Basic Wall	NICoE-ScreenWall Precast	294.29 CF	1' - 3 3/4"	6' - 0 1/4"	226 SF
Basic Wall	NICoE-ScreenWall Precast	294.29 CF	1' - 3 3/4"	6' - 0 1/4"	226 SF
Basic Wall	NICoE-ScreenWall Precast	434.56 CF	1' - 3 3/4"	8' - 10 11/16"	342 SF
Basic Wall	NICoE-ScreenWall Precast	289.71 CF	1' - 3 3/4"	5' - 11 1/8"	228 SF
Basic Wall	NICoE-ScreenWall Precast	434.56 CF	1' - 3 3/4"	8' - 10 11/16"	342 SF
Basic Wall	NICoE-ScreenWall Precast	289.71 CF	1' - 3 3/4"	5' - 11 1/8"	228 SF
Basic Wall	NICoE-ScreenWall Precast	144.85 CF	1' - 3 3/4"	2' - 11 9/16"	114 SF
Basic Wall	NICoE-ScreenWall Precast	294.27 CF	1' - 3 3/4"	6' - 0 1/4"	226 SF
Basic Wall	NICoE-ScreenWall Precast	294.27 CF	1' - 3 3/4"	6' - 0 1/4"	226 SF
Basic Wall	NICoE-ScreenWall Precast	147.14 CF	1' - 3 3/4"	3' - 0 1/8"	113 SF
Basic Wall	NICoE-ScreenWall Precast	147.14 CF	1' - 3 3/4"	3' - 0 1/8"	113 SF
Basic Wall	NICoE-ScreenWall Precast	147.14 CF	1' - 3 3/4"	3' - 0 1/8"	113 SF
NICoE-ScreenWall Precast: 15					

Figure 30 – Precast wall panels quantity schedule.

Results

According to the square foot takeoff of the current design, there is a total of 9,019 Sq.Ft of curtain wall material used. The total cost of the curtain wall system is **$ 568,197.00** for material, and **$ 110,483.00** for labor. Factoring in the location factor of 0.9, this brings a grand total of **$ 610,812.00** for the current curtain wall design.

Whereas according to the square foot takeoff of the original design, there is a total of 18,616Sq.Ft of curtain wall material used. The total cost of the curtain wall system is **$ 948,150.00** for material, and $ **184,362.50** for labor. Factoring in the location factor of 0.9, this brings a grand total of **$ 1,019,261.00** for the current curtain wall design.

Therefore, the saving to the owner that have been done according to the redesign of the curtain wall system is **$408,450.00** (Please see table 3)

	Current Design												
	Unit Cost Estimate												
Qty	**Description**	**Crew**	**Daily Output**	**Labor Hours**	**Unit**	**Material**	**Labor**	**Mat. O&P**	**Labor O&P**	**Total O&P**	**Ext. Mat. O&P**	**Ext. Labor O&P**	**Ext. Total O&P**
9019	Curtain Wall, aluminum, stock, double glazed, incl. glazing, average	H1	180	0.178	S.F.	$ 57.50	$ 7.40	$ 63.00	$ 12.25	$ 75.25	$ 568,197.00	$110,482.75	$ 678,679.75
Total											**$ 568,197.00**	**$110,482.75**	**$ 678,679.75**
	Original Design											Location Factor =	$ 610,811.78
	Unit Cost Estimate												
Qty	**Description**	**Crew**	**Daily Output**	**Labor Hours**	**Unit**	**Material**	**Labor**	**Mat. O&P**	**Labor O&P**	**Total O&P**	**Ext. Mat. O&P**	**Ext. Labor O&P**	**Ext. Total O&P**
15050	Curtain Wall, aluminum, stock, double glazed, incl. glazing, average	H1	180	0.178	S.F.	$ 57.50	$ 7.40	$ 63.00	$ 12.25	$ 75.25	$ 948,150.00	$184,362.50	$1,132,512.50
Total											**$ 948,150.00**	**$184,362.50**	**$1,132,512.50**
												Location Factor =	$ 1,019,261
													$ 408,449.48

Table3 : Cost summary using RS Means CostWork

ESTIMATING METHODS COMPARISON

After running both estimation methods there were many variances regarding the time it took to process each estimation method, the total cost, the material quantity, and the level of detail each involved. The actual cost of the current curtain wall design was given by project manager on site in order to compare both methods to determine which is the most accurate. The results of this analysis will determine that using BIM to assist in estimation procedures is the next step in BIM implementation in the building industry.

Throughout the process of estimating the time for each takeoff and estimate was tracked. The traditional 2D estimate took about one and half hours, using both construction documents and an excel spread sheet to assist in the takeoffs quantity. After counting all the materials manually for both the current and the original design, a total of 18,616 Sq. Ft of glazing material was calculated for the original design and a total of 8,479 Sq. Ft was calculated for the current curtain wall design. When multiplied by the cost of the material and labor, the cost of the original design totaled **$ 1,260,769.00** compared to the current design which is **$ 574,172.55.**

Using Revit Architecture the curtain wall glazing material was inputted into a Revit Quantity Schedule. This material takeoff schedule was process within 10 minutes by simply filtering the correct type of assembly required. The majority of the time was spent setting up the Revit schedule to include all of the information that is required including formatting the field properly. After having all the quantities available for both the current and the original design, the costs were calculated in about 30 minutes. The square footage of the original design was 15,050 Sq.Ft and for the current design 9,019 Sq. Ft. Quantities were multiplied by the cost of the material and labor, resulting in an original design total of $ $ 1,019,261 compared to the current design which is **$ 610,811.78.**

After speaking to the Project manager (David Wysong), he provided me with the current curtain wall design cost which is approximately $ 622,000.00. It was difficult for David to provide me with the original design estimate since it was never used during construction. The percent cost difference between the actual cost provided to me by Truner and the traditional estimation cost is 7.8%. The percent cost difference between the actual cost and the 3D Revit quantity schedule estimation cost is 1.7%. This high percentage is due to the lack of experience using the 3D Revit quantity schedule and not having access to the actual square footage material cost used on this project. The percent difference between both methods is drastic due to the high human error used in the traditional 2D estimation method.

In addition to the percent cost difference in both estimates, the time it took to prepare the traditional 2D estimate was more than three times as long as what it took to prepare the estimate using the Revit quantity scheduling. And the estimator's labor hours is the additional percent cost difference between both methods. And on average, an entry level estimator's hourly salary in Washington, DC is $25 dollars.

When using the 2D estimation method, some estimation errors occur in the details. Using a ruler it was difficult to get the exact length and width of each piece. In addition, when calculating the original design using only the current construction documents, an assumption was made in having 2 curtain wall faces per precast panel removed. Last but not least, when counting the faces of curtain wall around the perimeter of the building, it was very easy to have missed a couple of faces included within the structure. All of the errors mentioned above were eliminated when using the 3D Revit quantity schedule.

	Estimation Time (Minutes)	Original Design Cost	Current Design Cost
Manual Takeoff	90	$1,260,769	$574,173
Revit Schedule	10	$1,019,261	$610,812
PM Estimate	60	N/A	$ 622,000
Difference from Manual to PM Estimate	30	N/A	$47,827
Difference from Revit Schedule to PM Estimate	50	N/A	$11,188
Difference from Manual to Revit Schedule	80	$241,508	$36,639
Percentage Difference from Manual to Revit Schedule	89 %	24%	6%

INDUSTRY POINT OF VIEW

DPR- Sutter Medical Center Castro Valley - Rob Leicht

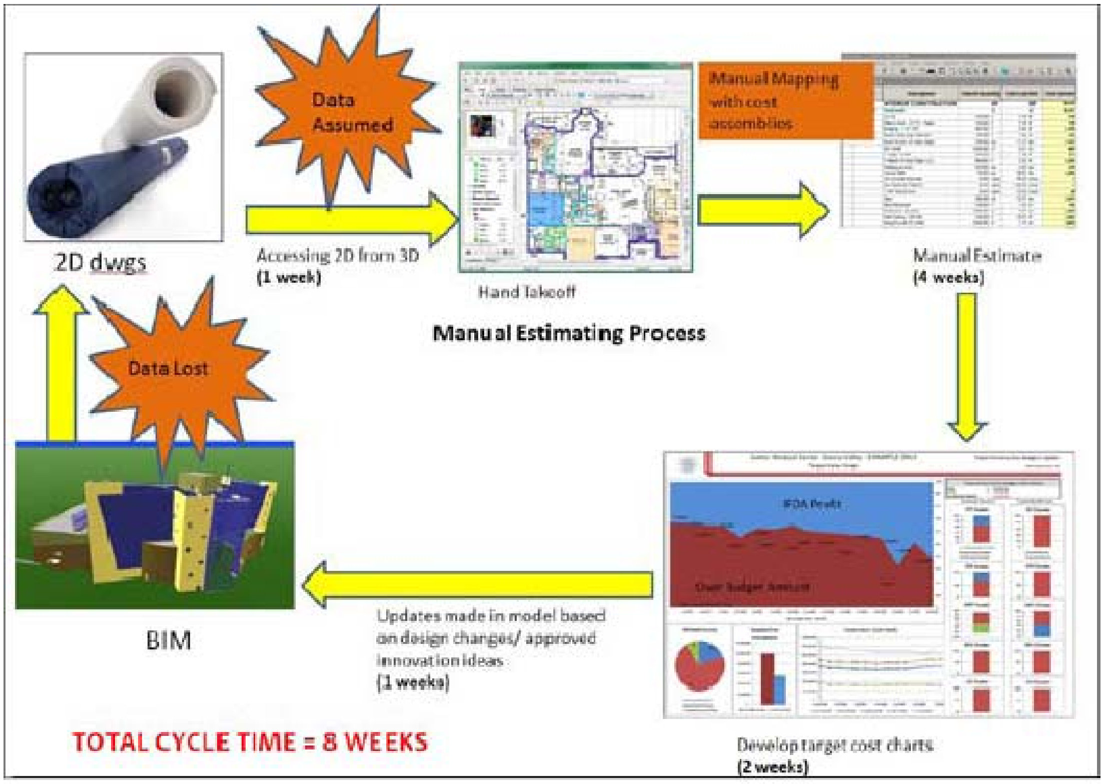
Sutter Medical Center Castro Valley project is a $320 million, six-story, 130-patient bed replacement hospital in Castro Valley, CA. Sutter Health adopted Lean Project Delivery for all its projects in early 2003 and has been promoting the use of the Integrated Form of Agreement (IFOA) as the contract method for project delivery. The IFOA approach is similar to the Integrated Project Delivery (IPD) framework promoted by the AIA. DPR Construction is the general contractor and one of 11 members of this IFOA/IPD team for the SMCCV project. DPR was selected as the builder and part of the IPD team. The IPD team used BIM tools for MEP coordination, quantity extraction and estimating to support this process.

Figure 31 – Sutter Medical Center Castro Valley Project

WHY MODEL-BASED COST ESTIMATING

In a target estimation process, cost should be an input to design. There has been a lot of research in the past year on how to make this happen. Cost feedback based on a BIM has been suggested as a potential option to rapidly decrease the time spent through the design stages.

"Model- based cost estimating is the process of integrating the object attributed from the 3D model of the designer with the cost information from database of the estimator. Model-based estimating has proved to be a leaner approach compared to traditional 2D drawing-based estimating. Using the 3D model to estimate rather than the 2D drawings utilizes the object attribute of the 3D model rather than "assuming" the same, based on flattened 2D drawings. The process is not only quicker but also eliminates scope for errors and omissions. Figure 32 compares the two processes and shows how the cycle time is reduced from 8 weeks to 3 weeks on this project."



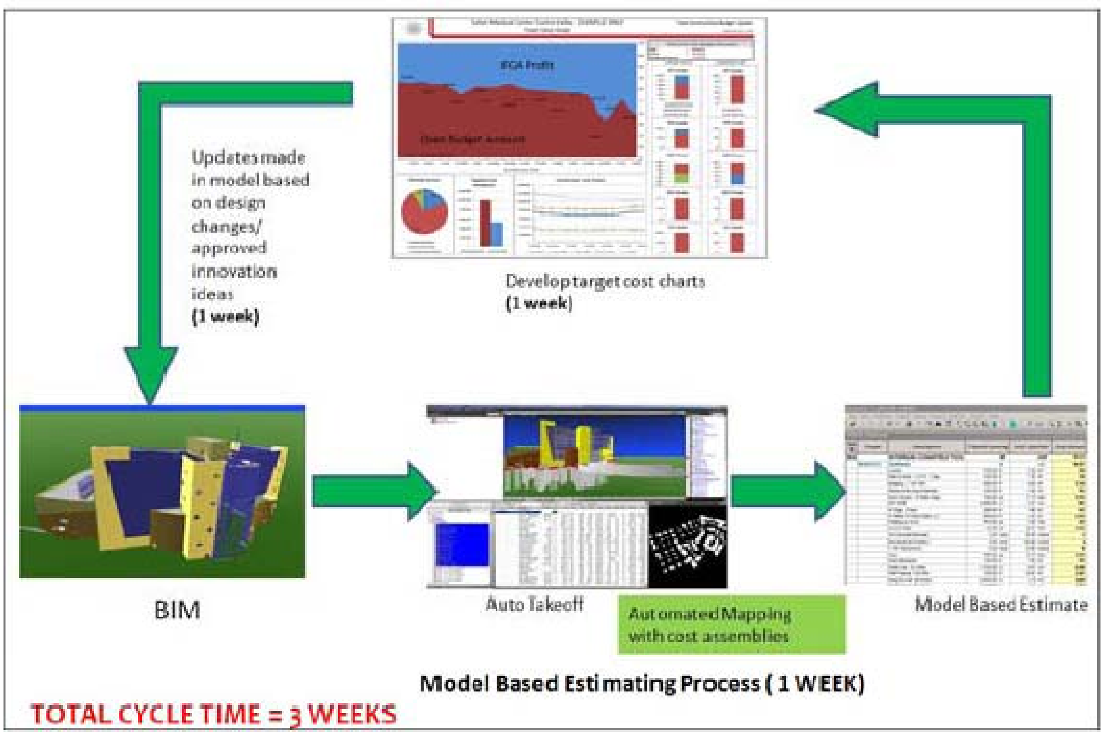


Figure 32- Comparing 2D and 3D estimation process

AECbytese "building the future" Article

The issue is that, to date there has not been many implementations of cost estimating on a large project to accomplish target costing goals. The SMCCV project provided the opportunity to implement model-based cost estimating since one of the requirements during the preconstruction phase on the project was to give the team real-time input on constructability and cost feasibility and provide timely cost feedback on design alternatives and changes on a regular basis. As a result, the SMCCV project team developed a rapid, repetitive and consistent mechanism for evaluating design against the budget and the target values of the client. By adopting the leaner model-based estimating approach, the cycle time of cost feedback—beginning at incorporating design changes in the 3D model to updating cost status of design due to the changes—was dramatically reduced, as shown in the above figure 32.

Model-Based Cost Estimation For Each Trade on SMCCV

Trades	3D Model Tool	Current Model based Cost Estimating Tool	Model based Cost Estimating Tool *(Exploring)*
Architectural	Revit Architecture	Innovaya/Timberline	
Structural	Revit Structure/Tekla	Innovaya/Timberline	Tocoman (for Tekla)
Mechanical	CAD-Duct	None	CAD Est
Electrical	AutoCAD MEP	None	Innovaya
Plumbing	CAD-Pipe	None	CADEst
Fire Protection	AutoSprink	None	None

Figure 33 - The software being used for 3D modeling and model-based cost estimating on the SMCCV project.
AECbytese "building the future" Article

Challenges in Implementing Model-Based Cost Estimating

The challenges of model-based estimating go beyond finding appropriate software solutions. To transition from manual estimating processes to a model-based estimating process takes substantial effort, time and cost. In DPR's experience, the easier part is the purchase of new programs and transferring the estimating database from one source to another. The more difficult part is the cultural shift and training required. Estimators must be thoroughly trained in the software and run test cases to make sure that the information coming out of the model is accurate and can be trusted. At first, the model-based estimating process may also take more time than their traditional way of estimating. However, after time and greater proficiency using the software, the new method should take less time than the older method, achieving results like the SMCCV project. In addition to the cultural shift and "buy-in" challenge, there is also the question of who will pay for the transition from one software to another. Should it be the owner of the project interested in adopting model-based estimating or should it be the design-assist subcontractor, who will benefit from the set up repeatedly on other projects?

Model-Based Cost Estimating For SMCCV in an Integrated Delivery Method Contract

Collaboration between the following was very crucial:

- Architects and structural engineers, who were developing the model.

- DPR self-perform work estimators, who have the estimating knowledge and database.
- DPR Virtual Building Group BIM engineers, who are experienced in both areas and know how to integrate the two.

> *"We believe that the key to collaboration is bringing in a crossfunctional team of designers, general contractor and subcontractors early with an incentive to collaborate and optimize on the whole project*."
>
> *DPR Constrcution*

" When this does not happen, accomplishing the same results becomes challenging for a variety of reasons, both technical and organizational. On some other projects, it has been challenging for DPR to persuade architects to make changes to their models for estimating purposes, because the contractual agreement between the owner and the architect does not stipulate that one of the intents for the 3D model is cost estimating. On other projects, we have seen issues with the interoperability between the BIM authoring system and estimating database because of the fact that team members were invited to join the design process after Detailed Design was completed and this issue was not identified until late in the process. To benefit from the time savings of model-based cost estimating, it is important for the owner to clearly state the intent of 3D modeling in a contractual format when awarding the project to different participants.
It took approximately 3 months of setup time for the cross-functional team of the architects, engineers, self-perform work estimators, and BIM engineers to automate the cost-estimating process on the SMCCV project and generate fortnightly cost estimate updates on design changes. This is outlined in Figure 34.

> "*This early collaboration in the IPD approach has resulted in significant time savings, taking one estimator in each self-perform work group just two days to generate an updated model-based cost to meet the "once every two weeks" cost estimating cycle."*

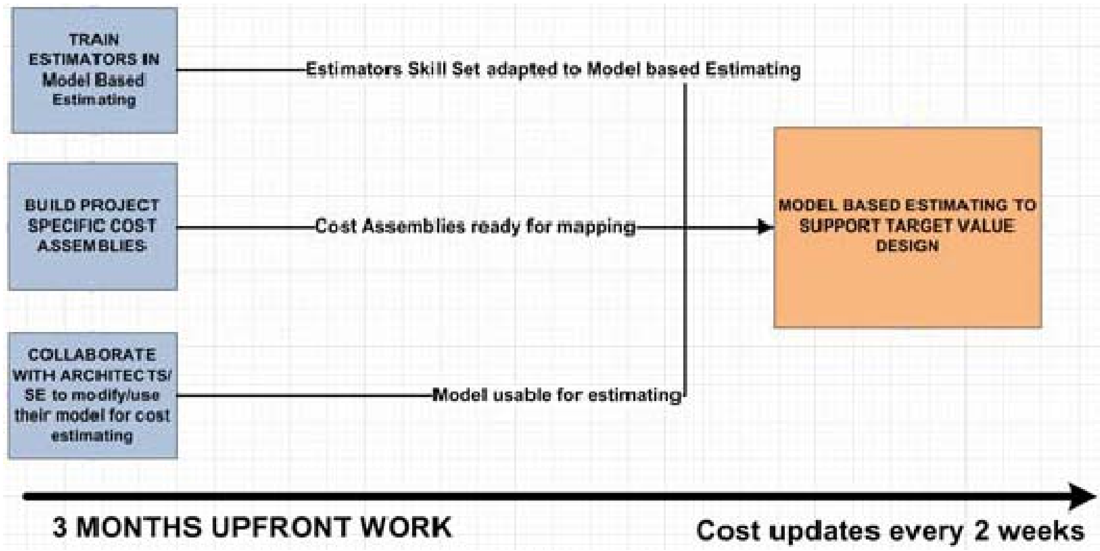


Figure 34 – the upfront work required to automate the cost estimating process
AECbytese "building the future" Article

LESSONS LEARNED USING MODEL-BASED ESTIMATION ON SMCCV PROJECT

" SMCCV is truly a ground-breaking project, as DPR has taken model-based cost estimating to the maximum extent possible. As a result, there have been a number of lessons learned, as listed below. Most of the lessons are process and organization related; some of them are also software related.

- Senior Company Management buy-in of model-based cost estimating: If the senior company management sees the value in the model-based cost estimating process and endorses it, it is much easier to implement within the company. This is one of the major reasons why some of the trades are still generating traditional estimates as there is still resistance to move away from traditional estimating practices.

- Contractual language of the project to support collaborative work environment: Compared to non-IPD projects, it has been easier to work with designers and get requests of model modifications entertained because of the IFOA contractual setting. The IFOA leverages a collaborative work environment by providing incentives, such as a Common pool of profit.
- Not all cost estimates can be model-based: Some of the items in the estimate cannot be quantified or formulated from the existing 3D elements in the model. Items like construction joints in slabs are means and method items, which need to be manually quantified. Also, there are time-based cost elements (e.g., man lifts, temporary power, trailers, etc.), which are estimated by how long they are on the jobsite and cannot be easily quantified from the 3D model.

- Transitioning traditional estimates to model-based estimates: A visual record in the form of marked up drawings of what was a part of the hand takeoff is important to have, so that quantities can be compared easily with the model quantities. A new software tool does not always perform the way you expect it to: Implementation of new technology is not always successful the first time. A lot of collaboration with the software developer is required to make it work to give you the desired result.

- Always check the quantities from the model at least once: Some of the elements might have been modeled using a tool that does not give you the right quantities. In case of SMCCV project, there were irregular shared pile caps whose quantities were not read correctly. Taking another example, Revit gives you the flexibility of modeling certain elements in different ways but quantification does not work with all of them. For example, openings can be modeled using an "edit profile" tool or "opening tool" or an "opening family" or a "void extrusion." The only way openings get quantified is if they are modeled using opening tool or by using the opening family.

- Model-based cost estimating is not a click of a button process: As you may have grasped by now, there is a lot of pre-requisite work in preparing the cost assemblies, preparing the model, training the estimators, etc. All of these steps are required to make this process work successfully.

- Start the process early by the end of conceptual design phase: The earlier the teams start this process in the preconstruction phase, the more in sync the model will be for cost estimating, and the more time design will have in the design development phase to react to the regular cost updates to attain Target Value Design."

ALTERNATIVE DESIGN – PRECAST CONCRETE PANELS TO CENTURY-WALL ARCHITECTURAL INSULATED METAL WALL PANEL SYSTEM

The model-based cost estimating process can also be used during the Value engineering process to evaluate the cost of design and construction alternatives. An alternative wall panel system was investigated compared to the current 7" thick precast concrete panels used in conjunction with the curtain wall system on the northwest side of the building. This analysis compares the precast concrete panels to the Century-Wall Architectural Insulated Metal Wall Panel System shown in figure 35.

Figure 35- AR-12 Accent Panels

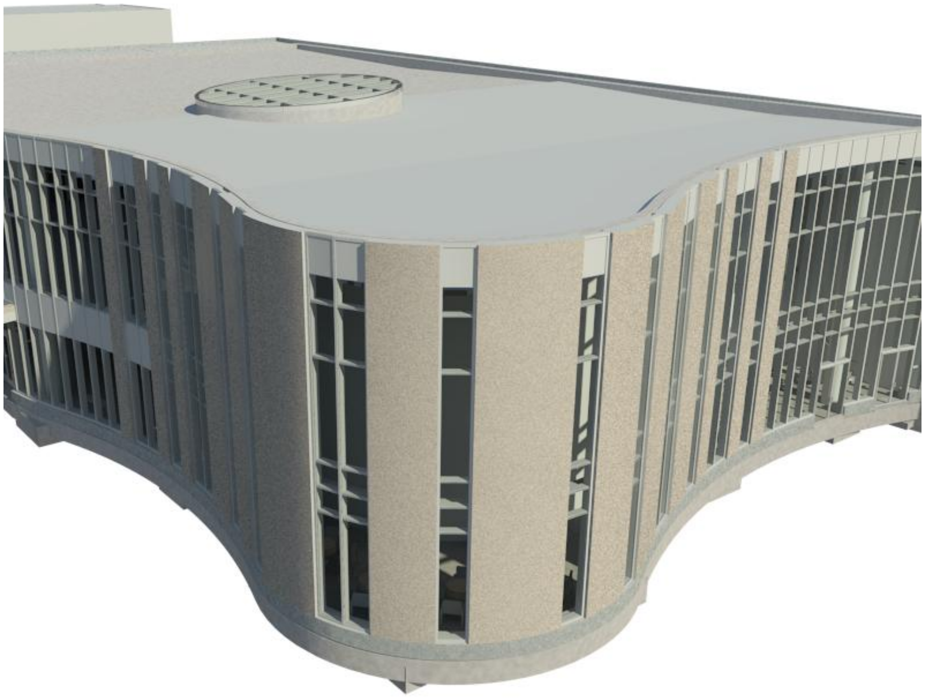


Figure 36 – 3" Thick Insulated Metal Panels

The potential benefits into using Insulated Metal Panels are:

- A much lighter system which requires a lighter weight foundation system for the dead load.
- a breakthrough in construction providing aesthetic, cost effective and thermally efficient buildings;
- a complete unitized façade solution with a choice of façade finishes;
- an off-site façade that just requires the façade finish to be on-site; or
- just the steel framework components for fabrication on-site.
- These systems are key to achieving lifetime energy efficient, low carbon (CO2) buildings.

Option	Advantage	Disadvantages	Cost
Precast Concrete Panels	• Strength • Ductility • Volume change accommo-dation • Blast rating = level 3 • Durability • Fire resistance	• Thermal Performance • Moisture Protection • Forms required • Requires a crane for placement • R-Value = 6 • Heavy Weight – harder to install and requires a deeper foundation • Not aesthetically soothing	$55.00 per Linear Feet

AR-12 Insulated Accent Metal Panels	• Thermal Performance helps lower Energy Cost -R-value = 23 • Highest Insulating Value per Inch • Rear sealed system - Vapor tight • Lightwieght (3.10 PSF) • Quick and easy to install • Designs Vary according to design, Wide range of colors, textures and finishes. • Concealed Attachment	• Non blast protected. • Security	$ 25.00 per square foot

The product which was chosen for an alternate system is AR-12 Accent Panel using Kingspan Manufacturer Company.

Design Features:

- Creates architectural highlights within a horizontal flat panel wall system
- Two or three bold asymmetric ribs per 12” module create extremely unique linear accents
- Fully integrates with all other CWP panel profiles
- Consistent joint profile and depth provide continuity in vertical and horizontal joint reveals as well as wall system R-value
- Available with factory-folded corner panels (choice of notched and bent or welded and painted to match your project’s budget and design needs)
- Lightweight Panels area ideal for use in multi-story construction. Easily adaptable to curtain wall type designs.
- Trimless ends and aluminum extrusions are readily available for those finishing touches.

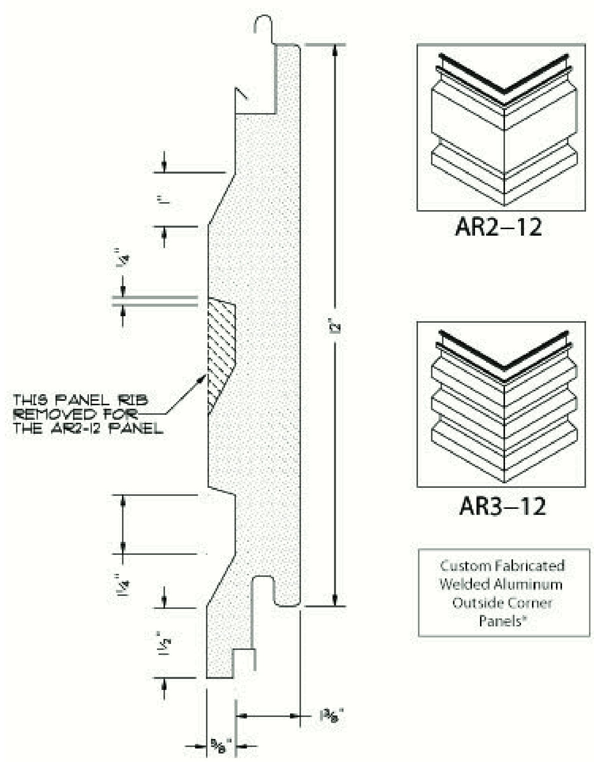


Figure 37- 3" thick AR2-12 Accent Panel

Insulated Metal Panels Structural Design:

Product Specifications:

Panel Width	12"
Panel Thickness	3"+ Metal studs and finishes = 11-3/8"
Panel Length	12'-11" x 3 panels = 38'-9"
R-Value by ASTM C236	23
Dead Wight	3.10 per SF
Deflection Limit	L/180 or 1" Maximum
Joint Configuration	Interlocking Tongue and Groove
Insulation Material	Laminated Urethane modified isocyanurate with nominal density of 2.0-2.6 lbs/ft^3
Accessories	Flashings, sealants, fasteners and painted aluminum extrusions are available.
Panel Exterior	Standard is 22 ga. Stucco embossed G-90 galvanized steel. Custom options include .040 aluminum (must be used with .032 aluminum liner).
Panel Interior	Standard is 26 ga. Stucco embossed G-90 galvanized steel. Also available in 24 and 22 gauge facings. Standard finish is PPG Durafin 2000™, USDA accepted and suited for most wash down environments. PPG Duranar PVDF can also be used.

Assumptions:

- The number of panels = 25 panels – 12” length
- Wind load approxiamtly = 25 psf
- Single Span
- 22 GA / 26 GA
- 3” core thinkness
- Spans shown are simple and limited by deflection under uniform load only. Spans may be governed by other factors including deflection due to temperature differentials, multiple spans, negative wind pressure and connection points required for fasteners. Consult Metecno-API for specific project applications.
- Weight per square foot for the AR2-12 Accent Panel 3” thick with 22GA / 26GA = 3.10 per sf

Span Used

3” Core Thickness	WALL PANEL SPAN IN FEET (L/180)			
	22 GA / 22 GA		22 GA / 26 GA	
Wind Load in PSF	Single Span	Double Span	Single Span	Double Span
20	16’-7”	15’-0”*	14’-4”	15’-0”*
25	15’-1”	15’-0”*	12’-11”	15’-0”*
30	13’-11”	15’-0”*	11’-11”	14’-7”
35	13’-0”	15’-0”*	11’-0”	13’-6”
40	12’-3”	15’-0”*	10’-4”	12’-6”

AR2-12

LBS per SF

	WEIGHT PER SQ FT (LBS)	
	22 GA / 22 GA	22 GA / 26 GA
PANEL THICKNESS		
2”	3.53	2.94
2½”	3.61	3.02
3”	3.69	3.10

PRECAST CONCRETE STRUCTURAL DESIGN:

Product Specifications:

Panel Width	12”
Panel Thickness	7”
Panel Length	38’-9”

Blast Resistance	Level 3
R-Value	6
Deal Load	Normal Weight Concrete = 150 lbs/ ft^3

Figure 38 – Precast Concrete Panels

Wall Schedule 2					
Family	Type	Volume	Width	Length	Area
NICoE-Base at Curtainwall 2nd fl: 3					
NICoE-ScreenWall Precast					
Basic Wall	NICoE-ScreenWall Precast	140.80 CF	1' - 3 3/4"	2' - 10 9/16"	108 SF
Basic Wall	NICoE-ScreenWall Precast	147.15 CF	1' - 3 3/4"	3' - 0 1/8"	113 SF
Basic Wall	NICoE-ScreenWall Precast	147.15 CF	1' - 3 3/4"	3' - 0 1/8"	113 SF
Basic Wall	NICoE-ScreenWall Precast	294.29 CF	1' - 3 3/4"	6' - 0 1/4"	226 SF
Basic Wall	NICoE-ScreenWall Precast	294.29 CF	1' - 3 3/4"	6' - 0 1/4"	226 SF
Basic Wall	NICoE-ScreenWall Precast	434.56 CF	1' - 3 3/4"	8' - 10 11/16"	342 SF
Basic Wall	NICoE-ScreenWall Precast	289.71 CF	1' - 3 3/4"	5' - 11 1/8"	228 SF
Basic Wall	NICoE-ScreenWall Precast	434.56 CF	1' - 3 3/4"	8' - 10 11/16"	342 SF
Basic Wall	NICoE-ScreenWall Precast	289.71 CF	1' - 3 3/4"	5' - 11 1/8"	228 SF
Basic Wall	NICoE-ScreenWall Precast	144.85 CF	1' - 3 3/4"	2' - 11 9/16"	114 SF
Basic Wall	NICoE-ScreenWall Precast	294.27 CF	1' - 3 3/4"	6' - 0 1/4"	226 SF
Basic Wall	NICoE-ScreenWall Precast	294.27 CF	1' - 3 3/4"	6' - 0 1/4"	226 SF
Basic Wall	NICoE-ScreenWall Precast	147.14 CF	1' - 3 3/4"	3' - 0 1/8"	113 SF
Basic Wall	NICoE-ScreenWall Precast	147.14 CF	1' - 3 3/4"	3' - 0 1/8"	113 SF
Basic Wall	NICoE-ScreenWall Precast	147.14 CF	1' - 3 3/4"	3' - 0 1/8"	113 SF
NICoE-ScreenWall Precast: 15					

Please see detailed structural Calculation in Appendix E

STRUCTURAL IMPACT

The original design system using precast concrete panels has a much higher weight than the insulated metal panels due to two aspects:

1. Total thickness :
    a. Precast concrete panels = 1’-3” as shown in figure 39
    b. Insulated metal panels = 0’-11 3/8”
2. The total weight :
    a. Precast concrete panels = 21,900 LBS per panel
    b. Insulated metal panels = 120 LBS per panel

Lateral Load:

The lateral load is being transferred using a HSS beam which simply transfers the load onto the round columns shown in figure 39. Very minimum of the lateral load is being held by the foundation and the roof system. This lateral load will not change since the surface area is not being changed when using the insulated metal panel system. Therefore the columns and the HSS will be affected very minimally and therefore will not be redesigned.

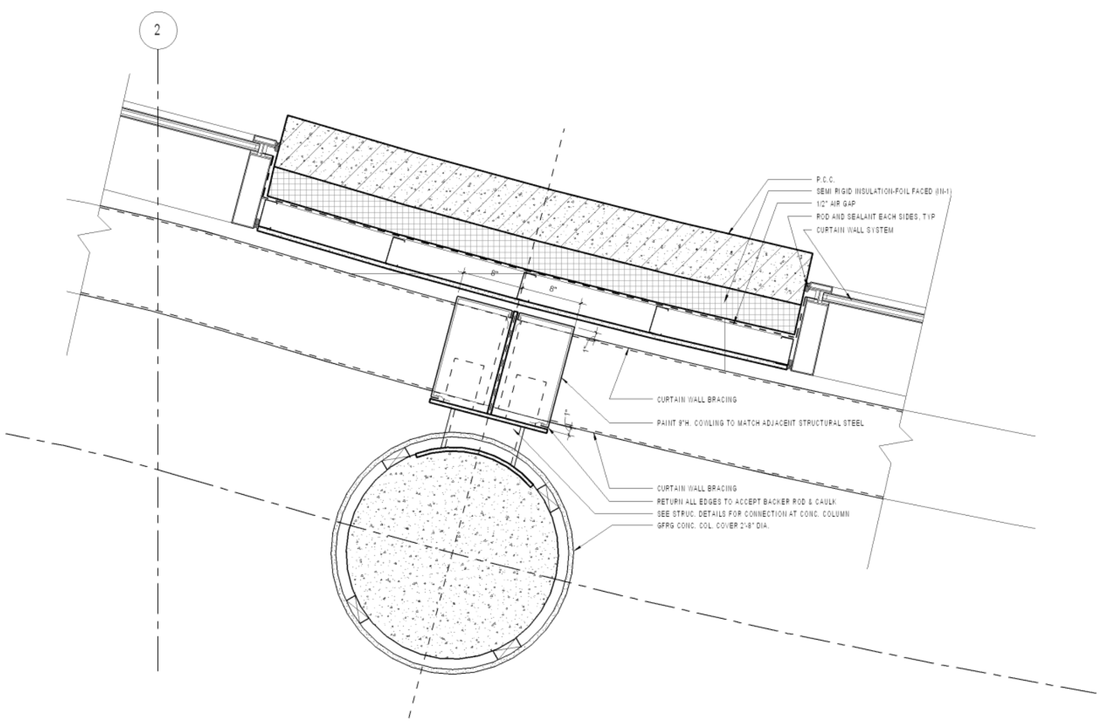


Figure 39- Precast Conc. Panel Detail

Dead Load:

Most of the dead load of the precast concrete panels is being transferred to the reinforced pier on the spread footings shown in figure 40. A typical footing will be redesigned according to the insulated metal panels dead load in appendix E.

As for the connections / anchors at the very top of the precast panels, tying the panels back to the roof structure, will not be effected since they are simply preventing the panels from over turning.

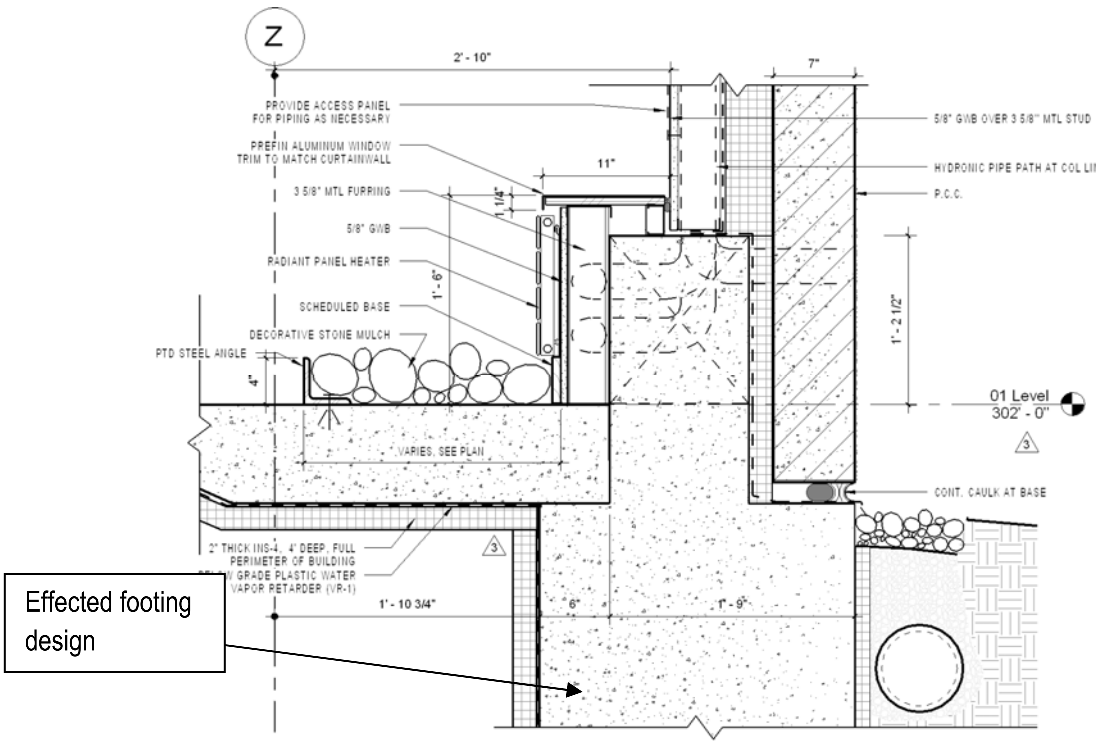


Figure 40 - Precast Conc. Panel Footing Detail

Cost Analysis

	Precast Wall Panels	AR2-12 Accent Insulated Metal Wall Panels
Material Cost (Per S.F)	$32.00/S.F * 969S.F= $31,008	$18.75/S.F * 969S.F= $18,168
Installation Cost (Per S.F)	$15.00/ S.F * 969S.F=$14,535	$6.25/S.F * 969S.F = $6,056
Total	$45,543	$24,225

Conclusion

The insulated metal panels can be a great alternative to both the owner and this facility if blast rating can be altered. This decisions is made by the owner but can still be presented due to the many benefits it has for both the owner and the environment.

THE BENEFITS OF 3D ESTIMATION WHEN CONSIDERING DESIGN ALTERNATIVES

During the design of the alternative system, Revit was used to calculate the quantity of the precast panels currently used. When suitable cost data estimation software is being directly linked to the systems, during the Value engineering process, systems can be evaluated according to the cost of design and construction alternatives as shown in figure 41.

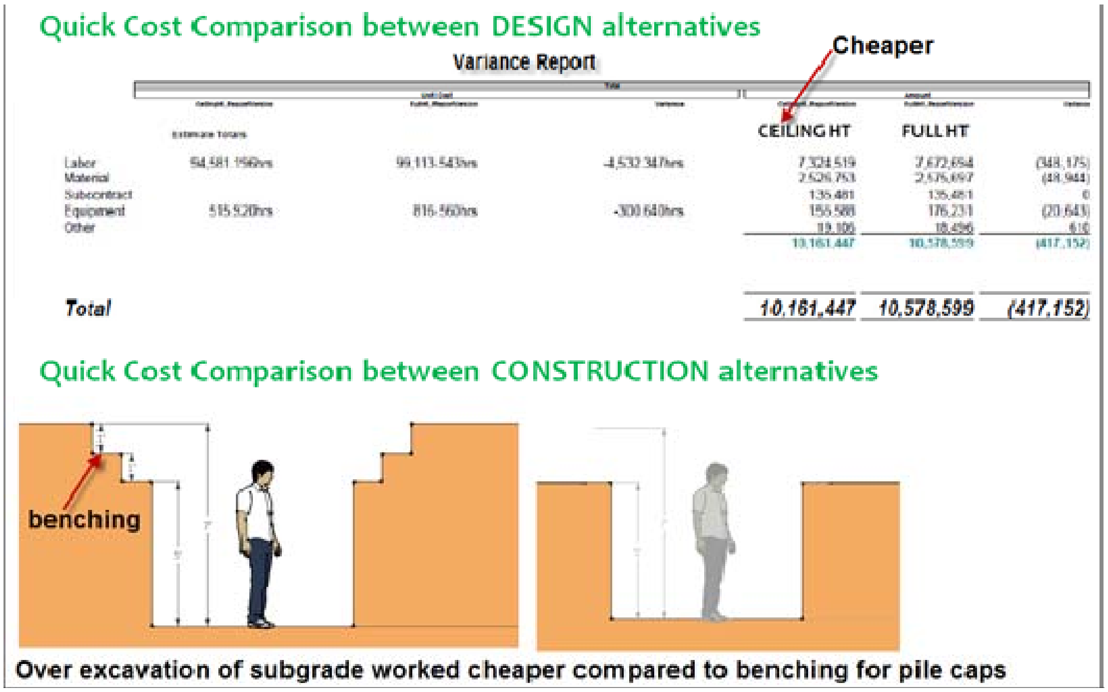


Figure 41 – Cost comparison of design/construction alternatives
AECbytese "building the future" Article

CONCLUSION:

When using BIM it is importan to take advanatage of all its benefits and uses by the project team. One of it's great cost and time saving benefits BIM has is its ability to be used as a cost-based model. As mentioned above there is a high initial cost due to traning, planning, and organizing the data required to be linked within the continouse working model. Additionaly, a design-build project has the benefits of having a collobrative estamting team from both the designer and the construction manager to work together to maintain a model that can be used for both estimation reasons and building system design alternatives.

ANALYSIS IV: HEAT RECOVERY SYSTEMS

Background:

The original design of 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. It is one of the effects of not having the MEP trades involved earlier on with the project. This system had been designed 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 the field erection decision, has resulted in a much higher cost and more time required on the project schedule for the erection of the unit. Therefore, during the beginning phases of the construction services, Turner suggested to redesign an alternative air handling unit system which would be a better fit for this facility. Limback Company (MEP) came up with an alternative AHU that is currently used in this facility.

This system is a much better fit than the original design but lacks the energy efficiency due to the lack of heat recovery systems. Electricity and gas cost could be saved for the owner when using a heat recovery within the AHU systems.

Goal:

There are many heat recovery systems that can be as high as 90% efficient used along with the AHU system. These heat recovery systems include a flat plat heat recovery systems or enthalpy wheals. The goal of this analysis is to research the heat recovery system that is appropriate for the AHUs used for this facility. Analyzing the energy cost saving compared to the initial cost of the heat recovery systems.

Preliminary Resources and Tools:

- ASHRAE standard 62.1 & 90.1
- Hoval – Heat recovery heat systems
- Xetex Selection Program Version 1.1.14

ORIGINAL AIR HANDLING UNIT SYSTEM

Before the VE period had begun, SmithGroup had originally designed an AHU which serves 100,000CFMs supply air along with 100% outdoor air. After the building was cut in size during the VE period from 84,000sq.ft to the current 72,000sq.ft it was time to look into alternative AHU systems. An alternative AHU system was redesigned by SmithGroup, resulted in having two air handling unit systems, each serving one floor of the building.

Please see Appendix F for the alternative AHUs data sheet.

Taking into consideration the usage of this facility, the alternative Variable Air Volume air handling units were redesigned to each serve 37,000CFM supply air with approximately 37% (13,690 CFM) outside air. Although this system has obviously saved the owner massive amounts of money compared to the original system, it is also important to look into other options that would possibly improve the efficiency of this system and perhaps have some additional initial cost but at the same time will have a high rate of return.

For this analysis two alternative systems were considered for the purpose of increasing the efficiency, lowering the energy cost of the facility, and producing an energy conservative system.

Air Handling Unit Calculations

This analysis began with calculating the minimum outside air required. This was done using ASHRAE standard 62.1 & 90.1. An excel sheet was produced based on each of the required CFMs in each of the spaces in the facility, totaling 25,000CFM outside air / ventilation rate required.

Please see Appendix F for AHU calculations

After the outside air CFMs were calculated it was important to calculate the inside air required to heat and cool the building. Using some of the industries' rule of thumb procedures, it was calculated a total of 49,000CFM inside air required. Totaling both outside air and inside air, a total of 74,000 CFM s supply air/cooling load is required for this facility.

Next, heating and cooling calculations were done to calculate the required tones to cool the building according to the require design day condition for Bethesda, MD. Using the an *annual cooling, dehumidification, and enthalpy design condition* from ASHRAE handbook, along with the set inside air temperature of 52 degrees, the cooling loads were calculated based on the hottest month of the year (July). This resulted in having 265.73 tons of cooling load required.

It was important to calculate the tones of cooling load required in order to make sure these requirements are met when researching for systems that can increase the efficiency of the AHUs used in this facility.

Variable Air Volume w/ Heat Recovery Systems

The current air handling unit consists of 37% outside air, which means 13,690 CFM is being relieved to the outside and a fresh 13,690 CFM outside air is being delivered to the inside. Therefore, out of the 37% outside air which is being relieved to the outside, 0% is being recovered for possible reuse. Since this facility is more of a clinical use than an actual hospital, there is a possibility for the use of a heat recovery Therefore, this analysis will focus on two different heat recovery systems which can improve the efficiency of the alternative air handling unit s used for this facility.

Benefits of Heat Recovery Systems

A heat recovery ventilator (HRV) can help make mechanical ventilation be more cost effective by reclaiming energy from exhaust airflows. HRVs use heat exchangers to heat or cool incoming fresh air, recapturing 60 to 80 percent of the conditioned temperatures that would otherwise be lost. They filter the air coming into your building and also while removing the warm stale air - they recover the heat energy that is normally wasted to the atmosphere. This ensures the supply of clean fresh air and also saves you money on your energy bills.

Efficiency of Heat Recovery

Heat recovery from extract air is the most efficient way to save energy in ventilation plants. Heat exchangers transfer the heat (or cold) of the extract air to the fresh air; in this way, energy is recovered and used in multiple ways.

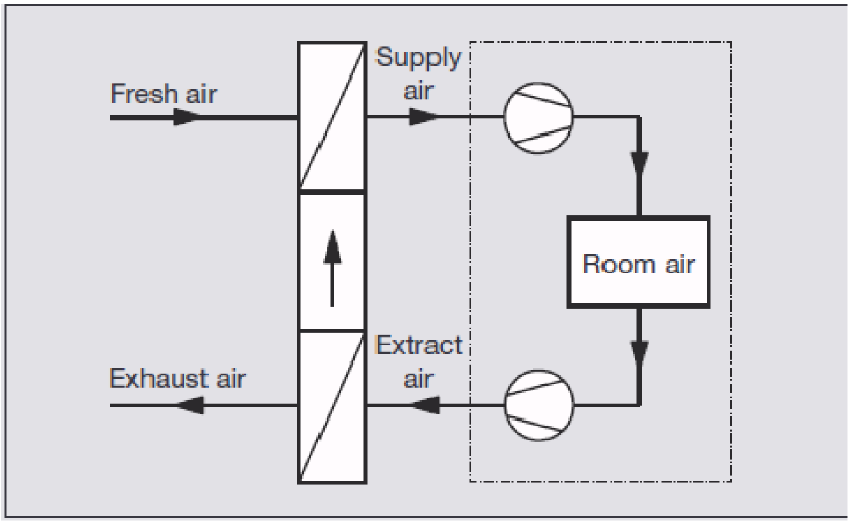


Figure43 – The process of a Heat Recovery System
Source: Hoval, heat recovery systems at a glance

Heat recovery is environmentally Friendly

Through heat recovery, the pollutants emitted during the generation of heat are reduced. This is due to extractions, transport, and storage of the primary energy carriers. In the heat exchanger the warm extract air and the cool fresh air, pass each other in cross-flow. No mixing of the two air streams takes place. Therefore, the transmission of dirt, odors, bacteria, etc. is impossible. Heat is transmitted from extract air to fresh air purely by conduction as a result of the temperature difference between the two air streams. The warm extract air is cooled down and the cool fresh air is heated.

Cost Reduction of heat Recovery Systems

Fresh Air Make-up: Increasing amounts of fresh air ventilation are required to satisfy state and local building codes. Heating and cooling these large amounts of ventilation air can be extremely expensive and, in some cases, cost prohibitive. Heat Changers is the solution, bringing in the required amount of ventilation air at up to an 80% reduction in energy costs.

This investment pays off in several ways:

- Lower energy consumption.
- Lower investment for heat generation and distribution.
- Less damage to the environment.
- Lower the primary energy (oil) and the connected capital.

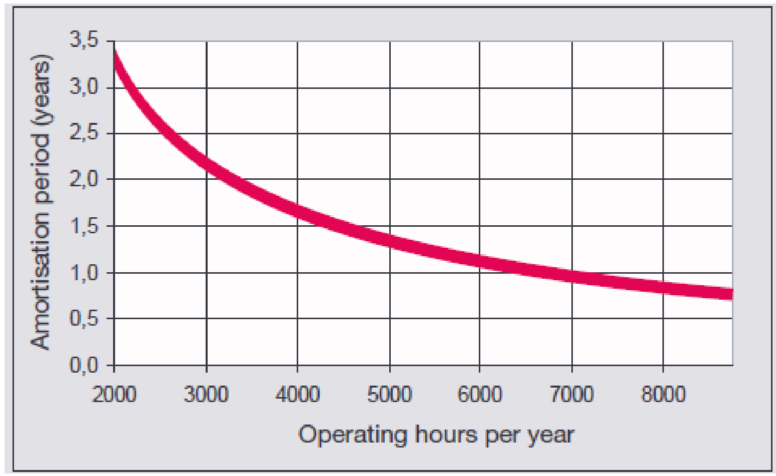


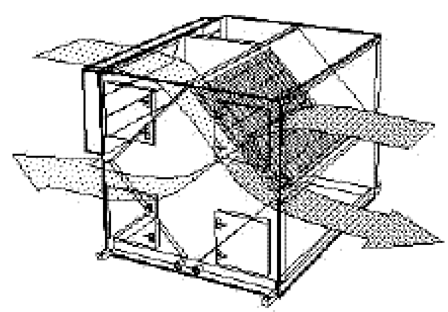
Figure44– the paying-back period compared to the operating hours per day.
Source: Hoval, heat recovery systems at a glance

Process Heat Recovery

Heat exchangers can be custom-built to fit almost any process application, recovering exhaust heat and saving valuable energy dollars. Optional materials and coatings are available for high temperature or corrosive environments.

HEAT RECOVERY USING A FLAT PLATE HEAT EXCHANGER

For this analysis Xetex heat recovery system's manufacturer was used to compare and select the appropriate system.



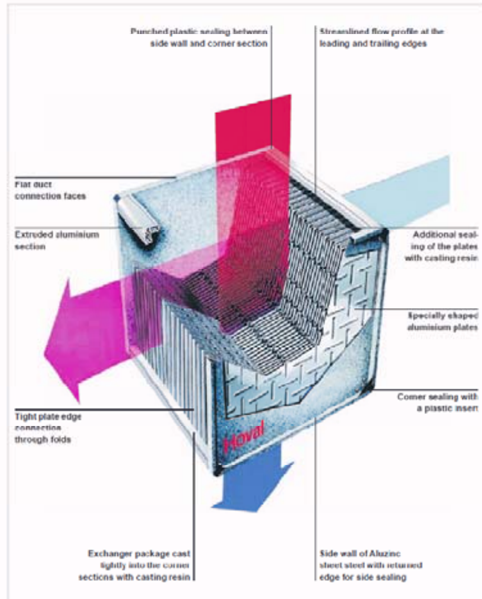
Flat Plate Heat exchangers are one way of allowing the transfer of heat from exhaust air to ventilation air. Since the heat is transferred through a medium like aluminum, the clean air and dirty air never come in contact. Consequently up to 90% of the heat is recovered and placed in clean, healthy ventilation air.

Advantages to Flat Plat Heat Exchangers

- Highest Efficiency in the Industry
- Counter-flow heat exchanger performance providing up to 90% effectiveness.
- Laminar air flow for reduced pressure drop and lower energy costs.
- Engineered air channels for even airflow distribution over the entire cell.
- Close rib spacing & rigid construction nearly doubles the transfer surface and maximizes cell rigidity.
- Standard Operating Temperatures from -40oF to 250oF
- Certified Performance by an Independent Test Lab

- Vertical or Horizontal Mounting Capability
- Optional Materials and Coatings Available for Special Requirements

Function



Fresh air passes through one side of the plate and contaminated air passes on the other side. Multiple plates are joined together in a special configuration to form the heat exchanger. Heated contaminated air flows through one set of air passages while the cold fresh air flows at a right angle through alternate, intervening passages. Heat is transferred from the contaminated air to the fresh air but the contamination remains in the contaminated air and is exhausted.

Heat exchangers have become increasingly popular due to their:

- Reliable Operation
- Separate Fresh & Contaminated Air Paths
- High Energy Recovery (Effectiveness)
- Low Energy Usage (Low Pressure Drop)
- Low Cost

Temperature Effectiveness

Effectiveness (Temperature Efficiency) is a measure of the amount of heat available in the contaminated air that can be recovered in the heat exchanger. The heat that would be exhausted is re-used by heating the fresh air without purchasing additional fuel. Effectiveness is expressed as a percentage of the maximum amount of heat available. This percentage varies between 45% and 85% (for a single-pass exchanger) depending on application and selection. Effectiveness is increased by selecting heat exchangers with large face areas (lower face velocities for longer dwell time), closer plate spacing (larger heat transfer surface) and double pass airflow (counterflow heat transfer).

Additionally, moisture in the exhaust airstream also increases effectiveness. When outdoor supply air temperature is low, moisture in the exhaust air will condense on the plates. Latent heat will then be transferred to the supply air. This heat transferred into the supply air is sensible heat (temperature rise heat only) but exhaust latent heat (changing from vapor to water without temperature change) is useful to increase effectiveness.

Temperature Efficiency is defined as the temperature change of the supply airstream divided by the temperature difference between the inlet exhaust air temperature and inlet supply air temperature.
Effectiveness %= Efficiency%=Eff.=

Supply SCFM (Outlet Temp - Inlet Temp)
(Exhaust Inlet Temp - Supply Inlet Temp)

Flat Plate Selection Procedure – Xetex Selection Program Version 1.1.14

Next for my analysis I contacted Ben Fisher from Xetex recovery Systems Manufacturer. He provided me with a system selection program which helped with selecting the right system for both air handling units used in NICoE based on their O/A CFMs and E/A CFMs.

After using this system the model required for each of the AHU used is XLT(P)-50I-96 Shown in Appendix G. Using this system will have the following results:

Energy recovery in the summer: 99,327 BTU/Hr = 29.1KW-hr

Energy recovery in the winter: 373,041 BTU/Hr= 109.4KW-hr

Energy Cost Savings

Gas savings in the winter:

373,041 BTU/Hr = 3.657 CCF * $1.68 CCF = $ 6.144 Per Hour
(1CCF=102,000 BTU)

Total = $147.45 per 24 hours

Electric savings in the summer:

On-Peak = 29.1KW-Hr x 8 Hr x $0.1148 KW-H = $ 26.73

Off-Peak = 29.1KW-Hr x 4 Hr X $0.09184 KW-H = $10.69

Total = $37.415 per 24 hours

Total electricity savings per year = $26,542 (winter) + $6,734 (summer) = $33,276 Per Year

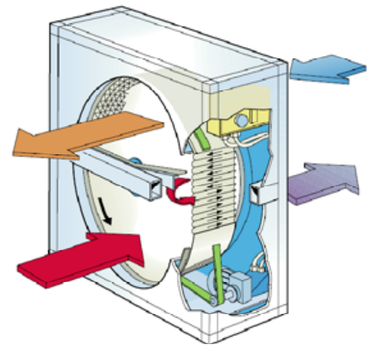
Construction of Heat Recovery Flat Plates

"The standard Heat-X-Changer unit is constructed of alternately oriented channels of high grade aluminum. These channels are secured with an adhesive sealant applied between plates to produce an exchanger cell that is extremely rigid and virtually "crush-proof." This unique process eliminates exposed joints and provides a tight, leak-resistant seal. Cross contamination of supply and exhaust air is virtually eliminated."

Indoor Installation

- Units may be directly mounted on the Floor, suspended on a platform, or hung from solid threaded rod attached to the unit shipping support brackets.
- Installation must be in accordance with standard air handling structural weight and vibration isolating procedures and requirements.

HEAT RECOVERY SYSTEM USING ENTHALPY WHEELS



For this analysis Xetex heat recovery system's manufacturer was used to compare and select the appropriate system.

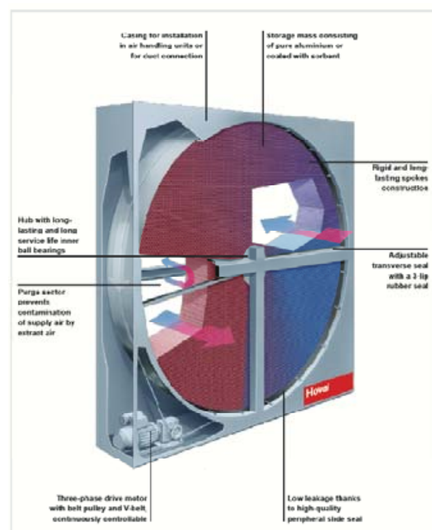
The rotary heat exchanger operates on the air-to-air principle of heat transfer. It provides a way of recovering air conditioning energy in hot, humid climates. Heat Wheels provide a solution for hot climates where there is a need to recover the energy expended in air conditioning. Using a desiccant (water absorbing) coating on a rotating metal wheel, heat and moisture are absorbed from the incoming hot humid outdoor air and transferred to the exhaust airstream.

Advantages to Heat Recovery Wheel

- Total energy recovery efficiencies as high as 90%.
- Rotor has smooth air channels to ensure a low pressure drop and reduce the risk of fouling.
- Rotor surface is manufactured absolutely smooth allowing for tight fitting seals between airstreams.
- Available with electronic speed control for variable rotor capacity.
- Hygroscopic rotor provides latent and sensible heat recovery.

Function

Cool, dry, exhaust air enters one side of the rotating Heat Wheel, chilling the wheel and drying the desiccant coating. This cool and dry part of the wheel then rotates into the supply air where it absorbs heat and humidity from the incoming fresh air before the air is mechanically cooled to room temperature. The Heat Wheel can reduce the ventilation air-conditioning load by up to 90%, which saves energy and reduces the size of required air-conditioning equipment.



Construction of Heat Recovery Wheel

"The RVA heat recovery unit is constructed from a rigid steel welded frame, with insulated galvanized sheet metal cover plates and hatches. The frame is reinforced to prevent deflect of the rotor from static pressure drops to less than 0.003 inches.

The rotor is assembled from alternate layers of flat and corrugated thin sheet aluminum. The smooth channels formed by this construction ensure that the air flow is laminar, thereby ensuring that the pressure drop is low and minimizing the risk of fouling by dirt or dust. Dry particles up to 900 microns shall pass freely through the rotor without clogging the media. The rotor media can be cleaned with low temperature steam without degrading unit performance.

The hygroscopic rotor equally transfers both sensible and latent heat. Moisture is transferred between airstreams in the vapor stage so media remains dry and no drain pan is required.

The rotor, which may be removed from the frame, is mounted in sealed permanently-lubricated spherical ball bearings. The bearings can be serviced or replaced without removing the rotor from the case.

The exchanger is sealed with brush seals between airstreams and around the perimeter of the rotor. Because of the smooth rotor surface, the brush seals provide an extremely effective seal with very little contact pressure, resulting in extended service life.

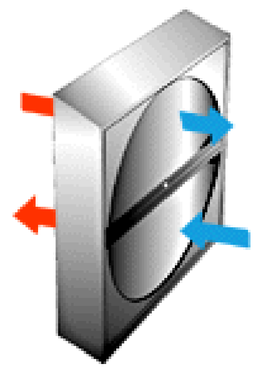
An adjustable purging sector is provided to ensure continuous cleaning of the rotor and to virtually eliminate cross-contamination between the exhaust air and the supply air.

The standard AIRotor heat recovery unit is supplied with a perimeter self adjusting belt and worm drive for on/off operation.

For installations where there is a requirement for controlling heat recovery capacity and/or rotor frost control, the heat recovery unit is equipped with an electronic control unit that varies rotor speed from maximum speed down to an automatic purge cycle of 1/20 rpm. "

Heat Wheel Recovery Systems Lab performance Results

"An independent evaluation of the performance of the XeteX AIRotor Total Energy Recovery Wheel was conducted under both summer and winter operating conditions. Heat transfer performance was obtained using ASHRAE Standard 84-1991 procedures and ARI Standard 1060-80 conditions. For equal air flow rates on the exhaust and supply sides of the wheel, the maximum summer sensible effectiveness was found to be 80.9%. When the wheel was operated with the exhaust flow rate greater than the supply flow rate, the measured sensible effectiveness exceeded 92%. A special wintertime condition was also tested, for which the maximum sensible effectiveness under equal flow rates was 84.5%."



Xetex Rotary Wheel Selection Procedure

Continuing in using the selection system given by Ben fisher, from Xetex recovery Systems Manufacturer,

After using this system the model required for each of the AHU used is RXA-2250 Shown in Appendix G. Using this system will have the following results:

Energy recovery in the summer: 266,863 BTU/Hr = 78.2 KW-hr

Energy recovery in the winter: 582,870 BTU/Hr= 170.8 KW-hr

Energy Cost Savings

Gas savings in the winter:

582870 BTU/Hr = 5.714 CCF * $1.68 CCF = $ 9.59 Per Hour
(1CCF=102,000 BTU)

Total = $230.16 per 24 hours

Electric savings in the summer:

On-Peak = 78.2KW-H x 8 Hr x $0.1148 KW-H = $71.82

Off-Peak = 78.2KW-H x 4 Hr X $0.09184 KW-H = $57.45

Total = $130 per 24 hours

Total electricity savings per year = $41,428 (winter) + $ 23,400(summer) = $64,828 Per Year

COMPARISION BETWEEN BOTH HEAT RECOVARY SYSTEM

Looking over both heat recovery systems it is recommended to use the heat recovery Enthalpy wheel since it has almost twice as much energy savings as the Flat Plate heat recovery. It is also much more energy efficient since it has the capability of capturing both latent and sensible heat.

COST ANALYSIS

	XLT-(P)-50I-96 (FLat Plate)	RXA-2250 (Enthalpy Wheel)
Material Cost	$9,880	$11,450
Installation Cost	$2,470	$2,862
Total	$12,350	$14,312

CONCLUSION

NICoE has undergone many design changes throughout the lifetime of the project. In a traditional delivery method, when the construction has begun with a guaranteed budget in mind, and the design begins to change, the quality and efficiency of the systems begins to be an unfavorable aspect to the project team. When the MEP package was decided to be given as a MEP design/build project the schedule was already in process and waiting for long lead items such as the AHU to be delivered. This creates pressure on the MEP contractor and therefore does not produce the best valuable product as seen above.

Heat recovery systems can help make mechanical ventilation more cost effective by reclaiming energy from exhaust airflows. HRVs use heat exchangers to heat or cool incoming fresh air, recapturing 60 to 80 percent of the conditioned temperatures that would otherwise be lost. These heat recovery systems are used in many construction projects due to their low life cycle cost.

Conclusion And Recommendations

Although there were some minor glitches throughout the design and construction of The National Intrepid Center of Excellence, it has been a very successful project for both the project team and the owner, the Fishermen house foundation. Some of these issues were based upon the process in which this project was undertaken.

These issues began with the miscommunication when using BIM between involved parties in which it affected the owner, the contractor, and the designer's bottom line. The efficient use of BIM is critical for the benefits it has on the design and construction of the project. With some earlier planning of a BIM execution plan along with an organized collaborative project team, the benefits of BIM should increase dramatically.

BIM has many other benefits along with coordination and collaboration efforts. 3D estimation methods can be used to fasten the process of the design alternative ideas suggested by the project team. 3D estimation is also has just begun to be used by some contractors; therefore it has many challenges. It is well worth the initial training and the 2 – 3 month planning efforts. This method has clearly increased DPR's profit line and has given them an added incentive from other contractors. In addition, when suitable cost data estimation software is being directly linked to the systems, during the Value engineering process, systems can be evaluated according to the cost of design and construction alternatives.

SmithGroup has spent a tremendous amount of time designing a building which will be the next signature building of the National Naval Medical Center in Bethesda, MD. This design came well above the owner's expectation and had to be redesigned multiple times with the help of the Construction Manager. Having a Construction Manager on board as late as 60% into design completion has not been very beneficial for the project. There were many challenges for both the construction manager, who does not have a contractual obligation for the design of the building, and the designer to come up with a signature building which both meets the eyes of the owner and the budget of the funds available.

It has been proven in many aspects of the building industry that it is very important to move towards and integrated project delivery method in this current industry. Design-build delivery method has the potential to eliminate many of the problems faced by the project team and at the same time save on both the building cost and the timeline of the project.

Under a design-build delivery method BIM can be used more efficiently since one of the main requirements of this new cutting edge technology (BIM) is having more of a collaborative team on both the design and the construction phases. In addition, when using a design-build delivery method, it is possible to involve many of the specialty contractors in order to get the best and most sufficient value system earlier on when money is not as tight as it is when the contractors are on board. When contacting a specialty contractor and asking for their help on some design ideas on how to make the current mechanical system more environmentally efficient on a LEED certified project, it was suggested to invest in heat recovery systems which have a very low life cycle cost.

In conclusion, after having gone through the analysis included within this project, it is recommended that each one of them should be looked upon as a means of possible recommendation to both the owner and the project team to have a more successful, efficient, and profitable project.

RESOURCES

1. http://www.cascadepolicy.org/bgc/build.htm - Timothy D. Hovet is Director of Real Estate Development with Sycan B Corporation in Springfield, Oregon. Mr. Hovet has used both Design/Bid/Build and Design/Build in construction projects.
2. Model Based Estimating, Target Value Design: AFCbytes "Building the Future" – DPR Construction
3. http://designbuild.construction.com/opinions/MarketTrends/archive/0511_feature5.asp
4. http://cmaanet.org/files/risk_in_cm_at_risk.pdf
5. http://www.design-buildsolutions.com/process/design-build-process.html
6. http://www.schiffhardin.com/binary/designer_led_adv_draw.pdf
7. http://www.constructionsoftwarereview.com/learning_center/buyers_guides/introduction-bim-building-information-modeling/how-does-pre-constructi
8. http://www.kingspanpanels.us/TechnicalData.aspx
9. http://www.kingspanpanels.ca/products/specs/index_KS42SL.htm
10. http://www.reedconstructiondata.com/bim/

APPENDIX A – DETAILED PROJECT SCHEDULE

ID	Task Name	Duration	Start	Finish
1	**Precon Award**	**0 days**	**Tue 7/1/08**	**Tue 7/1/08**
2	**Design Phase**	**204 days**	**Wed 10/15/08**	**Fri 7/24/09**
3	**Owner Notice to Proceed**	**0 days**	**Mon 3/2/09**	**Mon 3/2/09**
4	**Contractor Mobilize**	**5 days**	**Mon 3/2/09**	**Fri 3/6/09**
5	**Site Utilities**	**140 days**	**Mon 3/2/09**	**Thu 9/10/09**
8	NAVFAC-make available Temp power from 1200A Tr.	0 days	Mon 3/2/09	Mon 3/2/09
9	NAVFAC-Water Avaliable-Domestic,Portable, F	0 days	Mon 3/2/09	Mon 3/2/09
10	NAFAC-Make available Perm Power from 3000A Tr.	0 days	Wed 6/10/09	Wed 6/10/09
11	Underground Utilities	15 days	Wed 6/17/09	Tue 7/7/09
12	NAFAC-Steam available for heating	0 days	Mon 8/10/09	Mon 8/10/09
13	NAFAC-Sanitary line from S of NICOE to exist	11 days?	Thu 8/27/09	Thu 9/10/09
14	NAVFAC-Telecom line from S of NICOE to vault	11 days?	Thu 8/27/09	Thu 9/10/09
15	NAVFAC-18" RCP storm line from SE of NICOE	11 days?	Thu 8/27/09	Thu 9/10/09
16	**Site work/Excavation/underpin**	**239 days**	**Thu 3/12/09**	**Mon 2/8/10**
17	NAVFAC-Realign/lower existing 12" line south o	0 days	Thu 3/12/09	Thu 3/12/09
18	NAFAC-Realign/lower gas line south of s palm	0 days	Thu 3/12/09	Thu 3/12/09
19	Set Erosion & Sediment Control	5 days	Tue 4/28/09	Mon 5/4/09
20	Cut to Grade	10 days	Tue 5/5/09	Fri 5/15/09
21	Build Temp. road from G-1 to A-10	5 days	Tue 5/5/09	Sun 5/10/09
22	Excavate for footings and foundation	20 days	Tue 5/5/09	Fri 5/29/09
23	Install foundation Drain System	1 day	Thu 5/21/09	Thu 5/21/09
24	Site Restoration	40 days	Tue 12/29/09	Mon 2/22/10
25	Asphalt Paving	30 days	Tue 12/29/09	Mon 2/8/10
26	**Substructure**	**41 days**	**Thu 5/14/09**	**Thu 7/9/09**
27	FRP footings & found walls -CL 10-7	10 days	Thu 5/14/09	Wed 5/27/09
28	Erect tower crane @ Cl 5-6 and E1-F	12 days	Tue 5/19/09	Wed 6/3/09
29	Backfill	30 days	Tue 5/26/09	Mon 7/6/09
30	FRP Footings 7 Found walls - Cl 7-4	10 days	Fri 5/29/09	Thu 6/11/09
31	FRP footings and Found walls - CL4-1 Including C	12 days	Fri 6/12/09	Mon 6/29/09
32	**Superstructure-Cast-in-Place**	**87 days**	**Wed 6/17/09**	**Thu 10/15/09**
33	Supply Embeds from Curtain wall sub	10 days	Tue 5/5/09	Fri 5/15/09
34	Slab-on-grade	20 days	Wed 6/17/09	Tue 7/14/09
35	Form & Pour -Level 2	25 days	Wed 7/1/09	Tue 8/4/09
36	Form & Pour- Low Roof	20 days	Thu 7/30/09	Wed 8/26/09
37	Strip-Level 2	25 days	Wed 8/5/09	Tue 9/8/09
38	Form & Pour -High Roof	20 days	Mon 8/17/09	Fri 9/11/09
39	Form & Pour - Clerestory Curb	10 days	Fri 8/21/09	Thu 9/3/09
40	Strip-Low Roof	20 days	Tue 8/25/09	Mon 9/21/09
41	Strip-High Roof	25 days	Thu 9/3/09	Wed 10/7/09
42	Remove Tower crane @ Cl 5-6 and E1-F	3 days	Tue 9/15/09	Thu 9/17/09
43	Tower crane removed	0 days	Thu 9/17/09	Thu 9/17/09
44	FRP Concrete at Crane Void	20 days	Fri 9/18/09	Thu 10/15/09
45	**Façade-Precast Concrete**	**28 days**	**Fri 9/11/09**	**Tue 10/20/09**
46	Supply Embeds from the elevator Sub	4 days	Tue 4/14/09	Fri 4/17/09
47	Supply Embeds from curtain wall sub	10 days	Tue 5/5/09	Fri 5/15/09
48	Precast Setting A line	5 days	Fri 9/11/09	Thu 9/17/09
49	Weld & patch-Ready Windows-A line	2 days	Fri 9/18/09	Mon 9/21/09
50	Precast setting 10 line	4 days	Fri 9/18/09	Wed 9/23/09
51	Precast setting F line	6 days	Thu 9/24/09	Thu 10/1/09
52	Weld & Patch -Ready Windows-10 line	3 days	Thu 9/24/09	Mon 9/28/09
53	Weld & Patch-Ready Windows-F line	3 days	Fri 10/2/09	Tue 10/6/09
54	Precast Setting 1 line	3 days	Fri 10/2/09	Tue 10/6/09
55	Weld & Patch -Ready Windows-1line	3 days	Wed 10/7/09	Fri 10/9/09
56	Precast along Curtain wall (z line)	5 days	Fri 10/9/09	Thu 10/15/09
57	Weld & Patch at Curtain Wall (z line)	3 days	Fri 10/16/09	Tue 10/20/09
58	**Unit masonry - Layout/Installation**	**32 days**	**Thu 9/10/09**	**Sat 10/24/09**

Project: DetailedprojectSchedule.mpp
Date: Sun 10/25/09

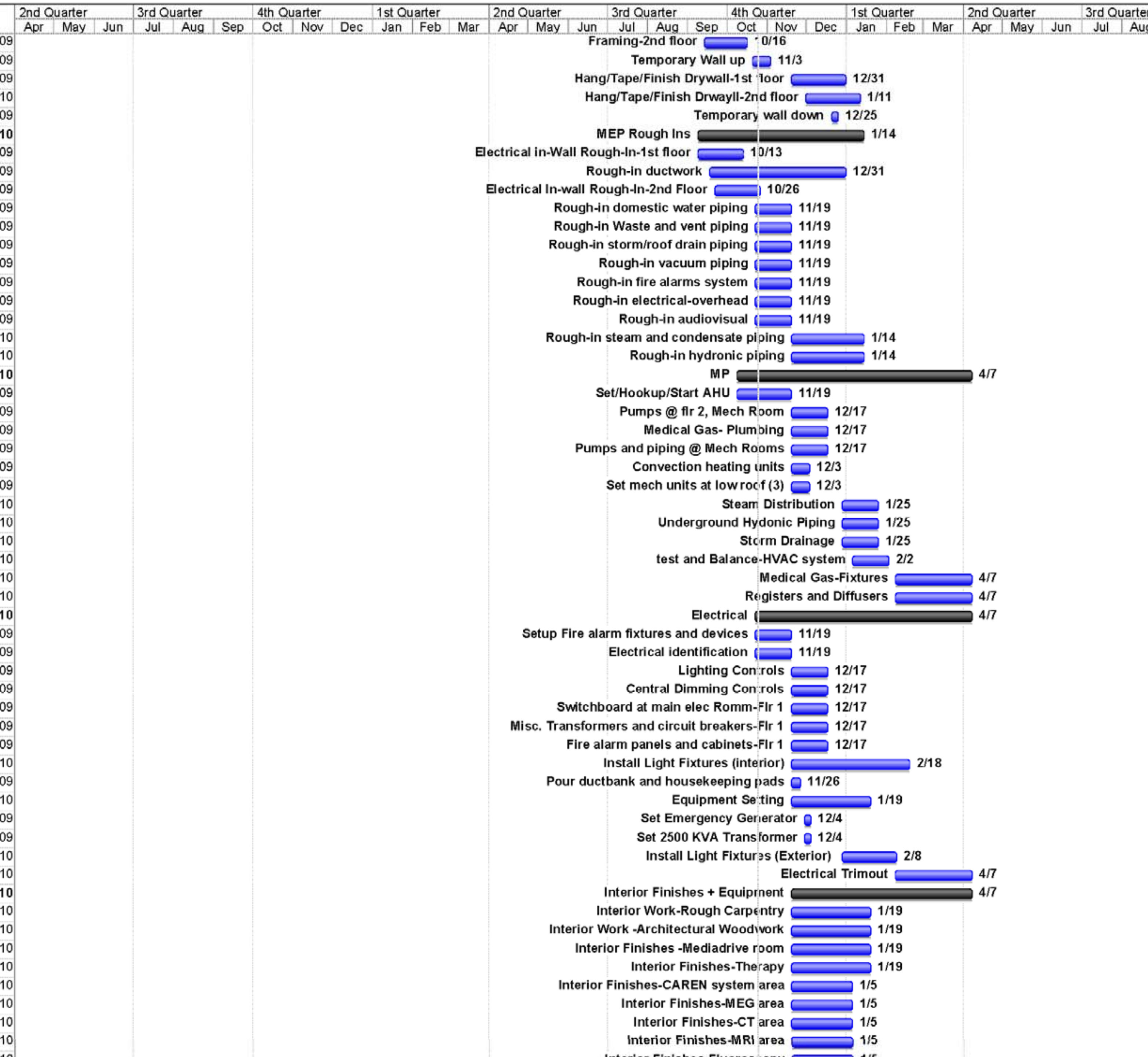
Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | Deadline

ID	Task Name	Duration	Start	Finish
59	**Façade-Curtain wall Glass & Glazing**	**89 days?**	**Tue 9/15/09**	**Fri 1/15/10**
60	Weather-tight protection above skylight	3 days	Tue 9/15/09	Thu 9/17/09
61	Punch Window A	3 days	Tue 9/22/09	Thu 9/24/09
62	Install Curtain wall-frame and glaze NE to SW	60 days	Fri 9/25/09	Thu 12/17/09
63	Punch Window 10	5 days	Tue 9/29/09	Mon 10/5/09
64	Set skylight	15 days	Tue 9/29/09	Mon 10/19/09
65	Install Interior framing & Glazing	5 days	Tue 10/6/09	Mon 10/12/09
66	F&I Interior aluminum & Glass Doors	50 days	Tue 10/6/09	Mon 12/14/09
67	Punch Window F	8 days	Wed 10/7/09	Fri 10/16/09
68	Install Clerestory Curtain wall	20 days	Fri 10/9/09	Thu 11/5/09
69	Aluminum Entrance and storefronts	10 days	Fri 10/9/09	Thu 10/22/09
70	Punch Window 1	2 days	Mon 10/19/09	Tue 10/20/09
71	Detailing @ skylight	5 days	Tue 10/20/09	Mon 10/26/09
72	F&I metal panel cladding at employee entrance	50 days	Fri 10/30/09	Thu 1/7/10
73	F&I metal panel cladding at loading dock	50 days	Fri 10/30/09	Thu 1/7/10
74	F&I exterior aluminum glass doors	50 days	Fri 10/30/09	Thu 1/7/10
75	Detailing @ clerestory curtain wall	10 days	Fri 11/6/09	Thu 11/19/09
76	F&I metal panel cladding at main entrance	20 days	Mon 12/21/09	Fri 1/15/10
77	**Roofing**	**108 days?**	**Wed 6/24/09**	**Fri 11/20/09**
78	Flash, Caulk precast panels at footing	1 day	Wed 6/24/09	Wed 6/24/09
79	Install waterproofing at elevator pit	1 day	Thu 7/16/09	Thu 7/16/09
80	Low roofing	20 days	Mon 9/14/09	Fri 10/9/09
81	High roofing	20 days	Tue 9/15/09	Mon 10/12/09
82	Install Metal Coping at Low Roof parapet	5 days	Mon 10/12/09	Fri 10/16/09
83	Install Roofing at East service canopy	5 days	Tue 10/13/09	Mon 10/19/09
84	Install metal coping at high roof parapet	5 days	Tue 10/13/09	Mon 10/19/09
85	Install roofing on 2nd floor mech space	5 days	Tue 10/13/09	Mon 10/19/09
86	install roofing at West service canopy	5 days	Mon 10/19/09	Fri 10/23/09
87	Install roof scuppers	5 days	Mon 10/19/09	Fri 10/23/09
88	Provide traffic deck coating at mech rooms	1 day	Fri 11/20/09	Fri 11/20/09
89	**Fire Protection - RI Sprinkler**	**20 days**	**Fri 10/23/09**	**Thu 11/19/09**
90	**Waterproofing -Interior Work-Firestopping**	**22 days**	**Fri 12/18/09**	**Mon 1/18/10**
91	**Misc metals & Ornamental Iron**	**62 days?**	**Thu 8/6/09**	**Fri 10/30/09**
92	Install overhead bridge suppt in Fluor Room	5 days	Thu 8/6/09	Wed 8/12/09
93	Furnish abrasive metal strips for conc. stairs	5 days	Thu 8/27/09	Wed 9/2/09
94	Install Stair railings at Loading Dock	5 days	Thu 8/27/09	Wed 9/2/09
95	Install Railings for interior stair towers	5 days	Thu 8/27/09	Wed 9/2/09
96	Install Elevator Pit Ladders, Div Beams, Hooks	5 days	Thu 8/27/09	Wed 9/2/09
97	Install Misc Metals at Roof incl ship ladder	25 days	Tue 10/13/09	Mon 11/16/09
98	Provide Steel for Op partition in Auditorium	5 days	Mon 10/19/09	Fri 10/23/09
99	Install Ships ladder at CAREN Room	5 days	Mon 10/26/09	Fri 10/30/09
100	Provide support steel in CAREN Room	5 days	Mon 10/26/09	Fri 10/30/09
101	**Elevators**	**150 days?**	**Wed 7/1/09**	**Tue 1/26/10**
102	Provide/install Sleeves for Firestopping	5 days	Wed 7/1/09	Tue 7/7/09
103	Provide Elevator Guid Rails	5 days	Thu 7/30/09	Wed 8/5/09
104	Layout Elevator installation	10 days	Tue 8/4/09	Mon 8/17/09
105	Furnish Access doors for Inst by Drywall Sub	5 days	Wed 8/26/09	Tue 9/1/09
106	Install elevator Items for wall roughin	5 days	Wed 9/9/09	Tue 9/15/09
107	Build Elevator incl cab finishes (E1 and E2)	43 days	Fri 11/20/09	Tue 1/19/10
108	Install Aluminum Entrance sills	5 days	Fri 1/15/10	Thu 1/21/10
109	Provide testing plan for elevators	5 days	Fri 1/15/10	Thu 1/21/10
110	Commission Elevators	5 days	Wed 1/20/10	Tue 1/26/10
111	**Drywall & Acoustic Ceilings**	**91 days?**	**Fri 8/21/09**	**Fri 12/25/09**
112	Layout Top Track-1st floor	25 days	Fri 8/21/09	Thu 9/24/09
113	Framing-1st floor	25 days	Mon 8/31/09	Fri 10/2/09
114	Layout Top Track-2nd floor	25 days	Thu 9/3/09	Wed 10/7/09

Project: DetailedprojectSchedule.mpp
Date: Sun 10/25/09

Task · Split · Progress · Milestone · Summary · Project Summary · External Tasks · External Milestone · Deadline

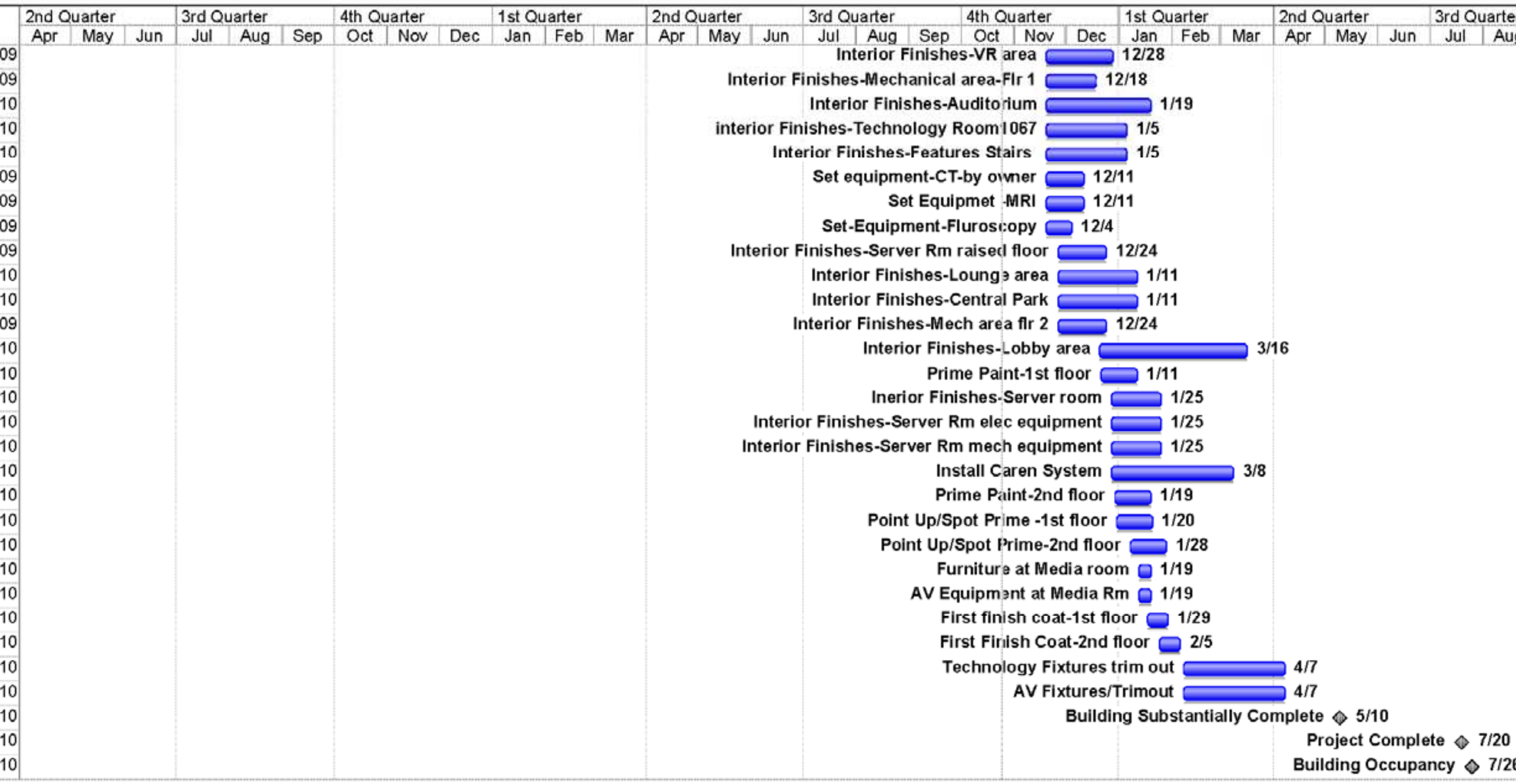
ID		Task Name	Duration	Start	Finish
115		Framing-2nd floor	25 days	Mon 9/14/09	Fri 10/16/09
116		Temporary Wall up	10 days	Wed 10/21/09	Tue 11/3/09
117		Hang/Tape/Finish Drywall-1st floor	30 days	Fri 11/20/09	Thu 12/31/09
118		Hang/Tape/Finish Drwayll-2nd floor	30 days	Tue 12/1/09	Mon 1/11/10
119		Temporary wall down	5 days	Mon 12/21/09	Fri 12/25/09
120		**MEP Rough Ins**	**92 days?**	**Wed 9/9/09**	**Thu 1/14/10**
158		Electrical in-Wall Rough-In-1st floor	25 days	Wed 9/9/09	Tue 10/13/09
157		Rough-in ductwork	75 days	Fri 9/18/09	Thu 12/31/09
159		Electrical In-wall Rough-In-2nd Floor	25 days	Tue 9/22/09	Mon 10/26/09
153		Rough-in domestic water piping	20 days	Fri 10/23/09	Thu 11/19/09
154		Rough-in Waste and vent piping	20 days	Fri 10/23/09	Thu 11/19/09
155		Rough-in storm/roof drain piping	20 days	Fri 10/23/09	Thu 11/19/09
156		Rough-in vacuum piping	20 days	Fri 10/23/09	Thu 11/19/09
160		Rough-in fire alarms system	20 days	Fri 10/23/09	Thu 11/19/09
161		Rough-in electrical-overhead	20 days	Fri 10/23/09	Thu 11/19/09
162		Rough-in audiovisual	20 days	Fri 10/23/09	Thu 11/19/09
163		Rough-in steam and condensate piping	40 days	Fri 11/20/09	Thu 1/14/10
164		Rough-in hydronic piping	40 days	Fri 11/20/09	Thu 1/14/10
165		**MP**	**129 days**	**Fri 10/9/09**	**Wed 4/7/10**
166		Set/Hookup/Start AHU	30 days	Fri 10/9/09	Thu 11/19/09
167		Pumps @ flr 2, Mech Room	20 days	Fri 11/20/09	Thu 12/17/09
168		Medical Gas- Plumbing	20 days	Fri 11/20/09	Thu 12/17/09
169		Pumps and piping @ Mech Rooms	20 days	Fri 11/20/09	Thu 12/17/09
170		Convection heating units	10 days	Fri 11/20/09	Thu 12/3/09
171		Set mech units at low roof (3)	10 days	Fri 11/20/09	Thu 12/3/09
172		Steam Distribution	20 days	Tue 12/29/09	Mon 1/25/10
173		Underground Hydonic Piping	20 days	Tue 12/29/09	Mon 1/25/10
174		Storm Drainage	20 days	Tue 12/29/09	Mon 1/25/10
175		test and Balance-HVAC system	20 days	Wed 1/6/10	Tue 2/2/10
176		Medical Gas-Fixtures	43 days	Mon 2/8/10	Wed 4/7/10
177		Registers and Diffusers	43 days	Mon 2/8/10	Wed 4/7/10
178		**Electrical**	**119 days**	**Fri 10/23/09**	**Wed 4/7/10**
179		Setup Fire alarm fixtures and devices	20 days	Fri 10/23/09	Thu 11/19/09
180		Electrical identification	20 days	Fri 10/23/09	Thu 11/19/09
181		Lighting Controls	20 days	Fri 11/20/09	Thu 12/17/09
182		Central Dimming Controls	20 days	Fri 11/20/09	Thu 12/17/09
183		Switchboard at main elec Romm-Flr 1	20 days	Fri 11/20/09	Thu 12/17/09
184		Misc. Transformers and circuit breakers-Flr 1	20 days	Fri 11/20/09	Thu 12/17/09
185		Fire alarm panels and cabinets-Flr 1	20 days	Fri 11/20/09	Thu 12/17/09
186		Install Light Fixtures (interior)	65 days	Fri 11/20/09	Thu 2/18/10
187		Pour ductbank and housekeeping pads	5 days	Fri 11/20/09	Thu 11/26/09
188		Equipment Setting	43 days	Fri 11/20/09	Tue 1/19/10
189		Set Emergency Generator	5 days	Mon 11/30/09	Fri 12/4/09
190		Set 2500 KVA Transformer	5 days	Mon 11/30/09	Fri 12/4/09
191		Install Light Fixtures (Exterior)	30 days	Tue 12/29/09	Mon 2/8/10
192		Electrical Trimout	43 days	Mon 2/8/10	Wed 4/7/10
193		**Interior Finishes + Equipment**	**99 days?**	**Fri 11/20/09**	**Wed 4/7/10**
194		Interior Work-Rough Carpentry	43 days	Fri 11/20/09	Tue 1/19/10
195		Interior Work -Architectural Woodwork	43 days	Fri 11/20/09	Tue 1/19/10
126		Interior Finishes -Mediadrive room	43 days	Fri 11/20/09	Tue 1/19/10
127		Interior Finishes-Therapy	43 days	Fri 11/20/09	Tue 1/19/10
128		Interior Finishes-CAREN system area	33 days	Fri 11/20/09	Tue 1/5/10
129		Interior Finishes-MEG area	33 days	Fri 11/20/09	Tue 1/5/10
130		Interior Finishes-CT area	33 days	Fri 11/20/09	Tue 1/5/10
131		Interior Finishes-MRI area	33 days	Fri 11/20/09	Tue 1/5/10
132		Interior Finishes-Fluoroscopy	33 days	Fri 11/20/09	Tue 1/5/10



Project: DetailedprojectSchedule.mpp
Date: Sun 10/25/09

Task | Progress | Summary | External Tasks | Deadline
Split | Milestone | Project Summary | External Milestone

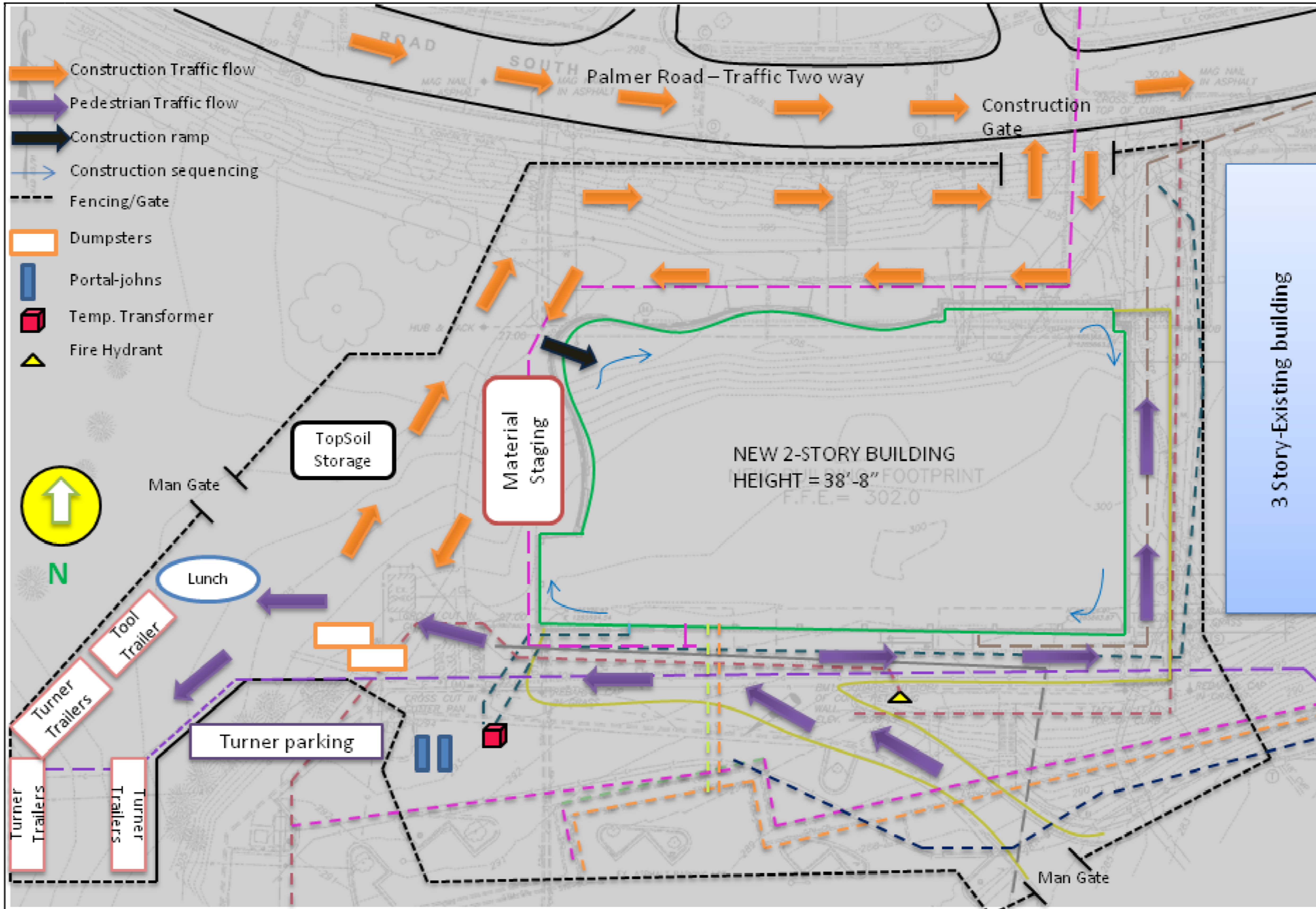
ID	Task Name	Duration	Start	Finish
133	Interior Finishes-VR area	27 days	Fri 11/20/09	Mon 12/28/09
134	Interior Finishes-Mechanical area-Flr 1	21 days	Fri 11/20/09	Fri 12/18/09
135	Interior Finishes-Auditorium	43 days	Fri 11/20/09	Tue 1/19/10
136	interior Finishes-Technology Room1067	33 days	Fri 11/20/09	Tue 1/5/10
137	Interior Finishes-Features Stairs	33 days	Fri 11/20/09	Tue 1/5/10
138	Set equipment-CT-by owner	16 days?	Fri 11/20/09	Fri 12/11/09
139	Set Equipmet -MRI	16 days?	Fri 11/20/09	Fri 12/11/09
140	Set-Equipment-Fluroscopy	11 days	Fri 11/20/09	Fri 12/4/09
141	Interior Finishes-Server Rm raised floor	20 days?	Fri 11/27/09	Thu 12/24/09
142	Interior Finishes-Lounge area	32 days	Fri 11/27/09	Mon 1/11/10
143	Interior Finishes-Central Park	32 days	Fri 11/27/09	Mon 1/11/10
144	Interior Finishes-Mech area flr 2	20 days	Fri 11/27/09	Thu 12/24/09
145	Interior Finishes-Lobby area	62 days	Mon 12/21/09	Tue 3/16/10
146	Prime Paint-1st floor	15 days	Tue 12/22/09	Mon 1/11/10
147	Inerior Finishes-Server room	21 days	Mon 12/28/09	Mon 1/25/10
148	Interior Finishes-Server Rm elec equipment	21 days	Mon 12/28/09	Mon 1/25/10
149	Interior Finishes-Server Rm mech equipment	21 days	Mon 12/28/09	Mon 1/25/10
150	Install Caren System	51 days?	Mon 12/28/09	Mon 3/8/10
121	Prime Paint-2nd floor	15 days	Wed 12/30/09	Tue 1/19/10
122	Point Up/Spot Prime -1st floor	15 days	Thu 12/31/09	Wed 1/20/10
123	Point Up/Spot Prime-2nd floor	15 days	Fri 1/8/10	Thu 1/28/10
6	Furniture at Media room	5 days?	Wed 1/13/10	Tue 1/19/10
151	AV Equipment at Media Rm	5 days	Wed 1/13/10	Tue 1/19/10
124	First finish coat-1st floor	10 days	Mon 1/18/10	Fri 1/29/10
125	First Finish Coat-2nd floor	10 days	Mon 1/25/10	Fri 2/5/10
7	Technology Fixtures trim out	43 days?	Mon 2/8/10	Wed 4/7/10
152	AV Fixtures/Trimout	43 days	Mon 2/8/10	Wed 4/7/10
196	**Building Substantially Complete**	0 days	Mon 5/10/10	Mon 5/10/10
197	**Project Complete**	0 days	Tue 7/20/10	Tue 7/20/10
198	**Building Occupancy**	0 days	Mon 7/26/10	Mon 7/26/10



Project: DetailedprojectSchedule.mpp
Date: Sun 10/25/09

Task	Progress	Summary	External Tasks	Deadline
Split	Milestone	Project Summary	External Milestone	

APPENDIX B – TYPICAL PROJECT SITE PLAN



Appendix C – CII Project Delivery Methods Alternatives

PDCS Number	PDCS Name	Description
PDCS 01	**Traditional Design-Bid-Build**	Serial sequence of design and construction phases; procurement begins with construction; Owner contracts **separately with designer and constructor**.
PDCS 02	**Traditional with early procurement**	Serial sequence of design and construction phases; procurement begins during design; Owner contracts **separately with designer, constructor, and supplier**.
PDCS 03	**Traditional with Project Manager**	Serial sequence of design and construction phases; procurement begins with construction; Owner contracts separately with **designer and constructor; PM (Agent)** assists Owner in managing project.
PDCS 04	**Traditional with Construction Manager**	Serial sequence of design and construction phases; procurement begins with construction; Owner contracts separately with **designer and constructor; CM (Agent)** assists Owner in managing project.
PDCS 05	**Traditional with early procurement and CM**	Serial sequence of design and construction phases; procurement begins during design; Owner contracts separately with **designer and constructor; CM Agent** assists Owner in managing project.
PDCS 06	**CM @ Risk**	Overlapped sequence of design and construction phases; procurement begins during design; Owner contracts separately with **designer and CM @ RISK** (constructor).
PDCS 07	**Design-Build or EPC**	Overlapped sequence of design and construction phases; procurement begins during design; Owner contracts with **Design-Build (or EPC)** contractor.
PDCS 08	**Multiple Design-Build or EPC**	Overlapped sequence of design and construction phases; procurement begins during design; Owner contracts with **two Design-Build (or EPC)** contractors, one for process and one for facilities.
PDCS 09	**Parallel Primes**	Overlapped sequence of design and construction phases; procurement begins during design; Owner coordinates separate contracts with **designer and multiple constructors** (or D-B contractor(s)).
PDCS 10	**Traditional with Staged Development**	**Multi-stage**, serial sequence of design and construction phases; **separate contracts for each stage**; procurement begins with construction; **Project Manager (Agent)** assists Owner with project management.
PDCS 11	**Turnkey**	Overlapped sequence of design and construction phases; procurement begins during design; Owner contracts with **Turnkey** contractor.
PDCS 12	**Fast Track**	Overlapped sequence of design and construction phases; procurement begins during design; Owner contracts separately with designer and constructor.

PROJECT SELECTION FACTORS

Factor Number	Selection Factor	Factor Description for Comparing Delivery Systems	Factor Action Statement
Cost-related factors			
1	Completion within original budget is critical to project success.	Delivery System facilitates control of cost growth	Control cost growth
2	Minimal cost is critical to project success	Delivery System ensures lowest reasonable cost	Ensure lowest cost
3	Owner's cash flow for the project is constrained.	Delivery System delays or minimizes rate of expenditures	Delay or minimize expenditure rate
4	Owner critically requires early (and reliable) cost figures, to facilitate financial planning and business decisions.	Delivery System facilitates accurate early cost estimates	Facilitate early cost estimates
5	Owner assumes minimal financial risk on the project.	Delivery System reduces risks or transfers a high level of cost and schedule risks to the contractor(s)	Reduce risks or transfer risks to contractor(s)
Schedule-related factors			
6	Completion within schedule is highly critical to project success.	Delivery System facilitates control of time growth	Control time growth
7	Early completion is critical to project success	Delivery System ensures shortest reasonable schedule	Ensure shortest schedule
8	Early procurement of long lead equipment and/or materials is critical to project success.	Delivery System promotes early design and purchase of long lead equipment or materials	Promote early procurement
Other factors			
9	An above normal level of changes is anticipated in the execution of the project.	Delivery System promotes ease of incorporating changes to the project scope during detailed design and construction	Ease change incorporation
10	A below normal level of changes is anticipated in the execution of the project.	Delivery System capitalizes on expected low levels of changes.	Capitalize on expected low levels of changes
11	Confidentiality of business/engineering details of the project is critical to project success.	Delivery System protects secrecy of business objectives and proprietary technology	Protect confidentiality

12	Local conditions at project site are favorable to project execution.	Delivery System capitalizes on familiar project conditions	Capitalize on familiar project conditions
13	Owner desires a high degree of control/influence over project execution.	Delivery System increases owner's role in managing design and construction	Maximize Owner's controlling role
14	Owner desires a minimal level of control/influence over project execution.	Delivery System minimizes owner's role in managing design and construction	Minimize Owner's controlling role
15	Owner desires a substantial use of its own resources in the execution of the project.	Delivery System promotes greater owner involvement in detailed design and construction	Maximize Owner's involvement
16	Owner desires a minimal use of its own resources in the execution of the project	Delivery System minimizes owner involvement in detailed design and construction	Minimize Owner's involvement
17	Project features are well defined at the award of the design and/or construction contract.	Delivery System capitalizes on well defined project scope prior to award of design and/or construction	Capitalize on well defined scope
18	Project features are not well defined at the award of the design and/or construction contract.	Delivery System efficiently utilizes poorly defined project scope prior to award of design and/or construction	Efficiently utilize poorly defined scope
19	Owner prefers minimal number of parties to be accountable for project performance.	Delivery System minimizes the number of parties under contract directly with the owner	Minimize number of contracted parties
20	Project design/engineering or construction is complex, innovative or non-standard.	Delivery System facilitates efficient coordination and management of non-standard project design/engineering and/or construction.	Efficiently coordinate project complexity or innovation

Effectiveness Values of Project Delivery Selection Alternatives with Respect To Selection Factors

	Cost Related Factors					Schedule Related Factors			
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8	
	Control cost growth	Ensure lowest cost	Delay or minimize expenditure rate	Facilitate early cost estimates	Reduce risks or transfer risks to contractor(s)	Control time growth	Ensure shortest schedule	Promote early procurement	
PDCS 01	80	90	100	0	80	20	0	0	PDCS 01
PDCS 02	50	100	70	20	50	50	50	90	PDCS 02
PDCS 03	80	70	90	10	60	20	10	0	PDCS 03
PDCS 04	80	70	90	10	60	20	0	0	PDCS 04
PDCS 05	50	60	60	20	20	50	40	90	PDCS 05
PDCS 06	60	40	40	70	70	70	80	100	PDCS 06
PDCS 07	90	80	10	90	90	90	100	100	PDCS 07
PDCS 08	70	80	30	80	80	80	90	100	PDCS 08
PDCS 09	0	0	50	20	10	0	90	80	PDCS 09
PDCS 10	0	0	60	0	0	0	60	50	PDCS 10
PDCS 11	100	80	0	100	100	100	100	100	PDCS 11
PDCS 12	40	40	100	60	0	80	100	100	PDCS 12

	Other Factors								
	Factor 9	Factor 10	Factor 11	Factor 12	Factor 13	Factor 14	Factor 15	Factor 16	
	Ease change incorporation	Capitalize on expected low levels of changes	Protect confidentiality	Capitalize on familiar project conditions	Maximize Owner's controlling role	Minimize Owner's controlling role	Maximize Owner's involvement	Minimize Owner's involvement	
PDCS 01	100	0	90	0	90	10	80	20	PDCS 01
PDCS 02	80	20	90	50	100	0	90	10	PDCS 02
PDCS 03	100	0	70	0	70	30	80	20	PDCS 03
PDCS 04	100	0	70	0	80	20	80	20	PDCS 04
PDCS 05	70	30	70	40	80	20	80	20	PDCS 05
PDCS 06	60	40	70	70	60	40	40	60	PDCS 06
PDCS 07	10	90	0	100	10	90	10	90	PDCS 07
PDCS 08	0	100	40	90	20	80	30	70	PDCS 08
PDCS 09	20	80	100	80	90	10	100	0	PDCS 09
PDCS 10	40	60	60	10	50	50	30	70	PDCS 10
PDCS 11	0	100	0	100	0	100	0	100	PDCS 11
PDCS 12	70	30	80	70	100	0	100	0	PDCS 12

	Other Factors				
	Factor 17	Factor 18	Factor 19	Factor 20	
	Capitalize on well defined scope	Efficiently utilize poorly defined scope	Minimize number of contracted parties	Efficiently coordinate project complexity or innovation	
PDCS 01	0	100	70	70	PDCS 01
PDCS 02	20	80	60	60	PDCS 02
PDCS 03	0	100	50	50	PDCS 03
PDCS 04	0	100	40	40	PDCS 04
PDCS 05	30	70	40	40	PDCS 05
PDCS 06	40	60	70	70	PDCS 06
PDCS 07	100	0	90	100	PDCS 07
PDCS 08	90	10	80	80	PDCS 08
PDCS 09	80	20	0	0	PDCS 09
PDCS 10	60	40	80	0	PDCS 10
PDCS 11	100	0	100	90	PDCS 11
PDCS 12	60	40	70	80	PDCS 12

APPENDIX D – NICOE BIM EXECUTION PLAN – COMMUNICATION AND COLLABORATION PROCESS

National Intrepid Center of Excellence   February 03, 2010

BIM PROJECT EXECUTION PLAN
VERSION 1.1
FOR
National Intrepid Center of Excellence
DEVELOPED BY
Rose Abousaid

This template is a tool that is provided to assist in the development of a BIM project execution plan as required per contract. The template plan was created from the buildingSMART alliance™ (bSa) Project "BIM Project Execution Planning" as developed by The Computer Integrated Construction (CIC) Research Group of The Pennsylvania State University. The bSa project is sponsored by The Charles Pankow Foundation (http://www.pankowfoundation.org), Construction Industry Institute (CII) (http://www.construction-institute.org), Penn State Office of Physical Plant (OPP) (http://www.opp.psu.edu), and The Partnership for Achieving Construction Excellence (PACE) (http://www.engr.psu.edu/pace). The BIM Project Execution Planning Guide can be downloaded at http://www.engr.psu.edu/BIM/PxP.

This coversheet can be replaced by a company specific coversheet that includes at a minimum document title, project title, project location, author company, and project number.

BUILDING INFORMATION MODELING PROJECT EXECUTION PLAN
VERSION 1.1
1

BIM PROJECT EXECUTION PLAN
VERSION 1.1
FOR
National Intrepid Center of Excellence
DEVELOPED BY
Rose Abousaid

TABLE OF CONTENTS

SECTION H: BIM AND FACILITY DATA REQUIREMENTS

1. **Final Building Information Model Definition Output Matrix:**

Select the column that best describes the type of information that will be delivered to the client in each division of the CSI Uniformat II structure.. Below are descriptions of the columns:
3D w/ facility data – 3D graphical representation with associated intelligent attribute data.
2D w/ facility data – 2D graphical representation with associated intelligent attribute data.
2D w/o facility data – 2D graphical representation without associated intelligent attribute data.
Resp. Party – the party responsible for complete that section of the model element breakdown
Description – Additional information used to explain facility data.

MODEL ELEMENT BREAKDOWN	3D W/ FACILITY DATA	2D W/ FACILITY DATA	2D W/O FACILITY DATA	RESP. PARTY	DESCRIPTION
A SUBSTRUCTURE					
A10 - Foundations					
Standard Foundations	YES			A/E	
Special Foundations	YES			A/E	
Slab on Grade	YES			A/E	
A20 - Basement Construction	**N/A**			**N/A**	
Basement Excavation					
Basement Walls					
B SHELL					
B10 - Superstructure					
Floor Construction	YES			A/E	
Roof Construction	YES			A/E	
B20 - Exterior Enclosure					
Exterior Walls	YES			A/E	
Exterior Windows	YES			A/E	
Exterior Doors	YES			A/E	
B30 - Roofing					
Roof Coverings	YES			A/E	
Roof Openings	YES			A/E	
C INTERIORS					
C10 - Interior Construction					
Partitions	YES			A/E	
Interior Doors	YES			A/E	
Fittings	YES			A/E	
C20 - Stairs					
Stair Construction	YES			A/E	
Stair Finishes		YES		A/E	
C30 - Interior Finishes					
Wall Finishes	YES			A/E	A/E may capture this in the object's properties
Floor Finishes	YES			A/E	A/E may capture this in the object's properties
Ceiling Finishes	YES			A/E	A/E may capture this in the object's properties
D SERVICES					
D10 - Conveying Systems					
Elevators & Lifts	YES			A/E	
Escalators & Moving Walks	-			-	
Other Conveying Systems	-			-	
D20 - Plumbing					
Plumbing Fixtures	YES			A/E	
Domestic Water Distribution	YES			Pipe Sub	
Sanitary Waste	YES			Pipe Sub	

MODEL ELEMENT BREAKDOWN	3D W/ FACILITY DATA	2D W/ FACILITY DATA	2D W/O FACILITY DATA	RESP. PARTY	DESCRIPTION
Rain Water Drainage	YES			Pipe Sub	
Other Plumbing Systems	YES			Pipe Sub	
D30 - HVAC					
Energy Supply	YES			Mech Sub	
Heat Generating Systems	YES			Mech Sub	
Cooling Generating Systems	YES			Mech Sub	
Distribution Systems	YES			Mech Sub	
Terminal & Package Units	YES			Mech Sub	
Systems Testing & Balancing	YES			Mech Sub	
Other HVAC Systems & Equipment	YES			Mech Sub	
D40 - Fire Protection					
Sprinklers	YES			FP Sub	
Standpipes	YES			FP Sub	
Fire Protection Specialties	YES			FP Sub	
Other Fire Protection Systems	YES			FP Sub	
D50 - Electrical					
Electrical Service & Distribution	YES			Elec Sub	
Lighting and Branch Wiring	YES			Elec Sub	
Communications & Security	YES			Elec Sub	
Grounding Systems	YES			Elec Sub	
Other Electrical Systems	YES			Elec Sub	
E EQUIPMENT & FURNISHINGS					
E10 - Equipment					
Commercial Equipment					
Institutional Equipment	YES			Vendor	
Vehicular Equipment	YES			A/E	
Other Equipment	YES			Vendor	Medical Equipment
E20 - Furnishings					
Fixed Furnishings	YES			A/E	
F SPECIAL CONSTRUCTION & DEMOLITION					
F10 - Special Construction					
Special Structures	YES			A/E	
Integrated Construction	-		-	-	
Special Construction Systems	-		-	-	
Special Facilities	-		-	-	
Special Controls & Instrumentation	YES		-	MECH	Automatic blinds. Etc.
F20 - Selective Bldg Demo	**N/A**			**N/A**	
Building Elements Demolition					
Hazardous Components Abatement					

MODEL ELEMENT BREAKDOWN			3D W/ FACILITY DATA	2D W/ FACILITY DATA	2D W/O FACILITY DATA	RESP. PARTY	DESCRIPTION
G	BUILDING SITEWORK						
	G10 - Site Preparation						
		Site Clearing	YES			Civil Eng	
		Site Demolition & Relocations	-			-	
		Site Earthwork	YES			Civil Eng	
		Hazardous Waste Remediation	YES			Civil Eng	
	G20 - Site Improvements						
		Roadways	YES			Civil Eng	
		Parking Lots	YES			Civil Eng	
		Pedestrian Paving	YES			Civil Eng	
		Site Development	YES			Civil Eng	
		Landscaping	YES			Civil Eng	
	G30 - Site Civil/Mech Utilities						
		Water Supply & Distribution Systems	YES			Civil Eng	
		Sanitary Sewer Systems	YES			Civil Eng	
		Storm Sewer Systems	YES			Civil Eng	
		Heating Distribution	YES			Civil Eng	
		Cooling Distribution	YES			Civil Eng	
		Fuel Distribution	YES			Civil Eng	
		Other Civil/Mechanical Utilities	YES			Civil Eng	
	G40 - Site Electrical Utilities						
		Electrical Distribution	YES			Elec Sub	
		Site Lighting	YES			Elec Sub	
		Site Communications & Security	YES			Elec Sub	
		Other Electrical Utilities	YES			Elec Sub	
	G90 - Other Site Construction		N/A			N/A	
		Service Tunnels					
		Other Site Systems & Equipment					

SECTION I: COLLABORATION PROCEDURES

1. Collaboration Strategy:

Describe how the project team will **collaborate**. Include items such as **communication methods**, document management and transfer, and record storage, etc.

Interactive Collaboration:

- In person, meetings at site. Collision detection is projected on wall or movie screen. Communication is via FTP sites, or video conference calls.
- Modeling is being performed by Designers, necessary consultants, contractors, subcontractors, and required vendors.
- The required subcontractor, project manager, superintendent, architect, necessary engineer, necessary consultant, and the BIM coordinator is required to be at all weekly coordination meetings.
- All weekly coordination meetings location are on site in the iRoom using a smart board, GoToMeeting, and video conference calling.
- All architectural, structural, mechanical, electrical, plumbing, and sprinkler models are required to be updated with each paper revision, with major changes occur, and are to be submitted for approval within 4 business days, unless otherwise specified.
- All file formats are acceptable but limited to their compatibility with Navisworks software for collaboration purposes.

Model Breakdown, File Naming, & File Sharing:

- The MEP coordination process will take place per floor level and per the 4 zones within each of the floors.
- The model is to be broken down by floor and by each of the 4 zones.
- All submitted files are to be shared within the project team using FTP.
- All updated submitted files are to be named according to the following format:
    - Project name, Responsibility, Trade, Floor Level, Zone, version, date, and time.

Level of Detail & Model Inclusion/Exclusion

- All model updates should include: Insertion axis, Grid lines, Room Numbers, and RCP.
- The level of detail is ¼" rigid or larger.
- All Access space, insulation, hangers, and subcontractors equipment are to be modeled accordingly.
- Use the original architectural model developed by SmithGroup as the base model.

2. **MEETING PROCEDURES:**

The following are examples of meetings that should be considered.

MEETING TYPE	REQUIRED PER CONTRACT	PROJECT STAGE	FREQUENCY	PARTICIPANTS	LOCATION
BIM REQUIREMENTS KICK-OFF	Yes	Schematic Design & Precon.	Precon: After sub has won the bid	A/E, Owner, CM, Subs, BIM Cord.	On Site
BIM EXECUTION PLAN DEMONSTRATION	Yes	Schematic Design & Pre-bidding stages	A/E: SD Subs: Prebidding	A/E, Owner, CM, Subs, BIM Cord	On Site
DESIGN COORDINATION	Yes	DD & Precon.	Weekly	A/E, CM, Subs, BIM Cord	On Site
CONSTRUCTION OVER-THE-SHOULDER PROGRESS REVIEWS	Yes	Construction.	Weekly	PM, Superintendent, PE	On site/ On the Field
ANY OTHER BIM MEETINGS THAT OCCURS WITH MULTIPLE PARTIES	Yes/ Major Changes to Design	Construction	As Required	A/E, CM, Subs, BIM Cord	On Site
ANY OTHER BIM MEETINGS THAT OCCURS WITH MULTIPLE PARTIES	YES	Model Turnover	Once	A/E,CM,Owner	On Site

3. **MODEL DELIVERY SCHEDULE OF INFORMATION EXCHANGE FOR SUBMISSION AND APPROVAL:**

Document the information exchanges and file transfers that will occur on the project.

INFORMATION EXCHANGE	FILE SENDER	FILE RECEIVER	ONE-TIME or FREQUENCY	DUE DATE or START DATE	MODEL FILE	MODEL SOFTWARE	NATIVE FILE TYPE	FILE EXCHANGE TYPE
DESIGN AUTHORING TO 3D COORDINATION	Structural Engineer	FTP POST) (COORDINATION LEAD)	Weekly (12 noon, b/f coord.Mtg)	After origin. Arch. Model is delivered	STRUC	CAD Structural	.IFC	DWG
	Mechanical Engineer	FTP POST) (COORDINATION LEAD)	Weekly (12 noon, b/f coord.Mtg)	After origin. Arch. Model is delivered	MECH	CAD Mech	DWG	DWG
	Electrical Engineer	FTP POST) (COORDINATION LEAD)	Weekly (12 noon, b/f coord.Mtg)	After origin. Arch. Model is delivered	ELEC	ACAD MEP	DWG	DWG
	Fire Suppression	FTP POST) (COORDINATION LEAD)	Weekly (12 noon, b/f coord.Mtg)	After origin. Arch. Model is delivered	FP	CAD Pipe	DWG	DWG
	Architectural A/E Firm	FTP POST) (COORDINATION LEAD)	One-Time	After orgin. Arch. Model is delivered	ARCH	Revit	.rvt	DWG

4. Interactive Workspace

The project team should consider the physical environment it will need throughout the lifecycle of the project to accommodate the necessary collaboration, communication, and reviews that will improve the BIM Plan decision making process. Describe how the project team will be located. Consider questions like "will the team be collocated?" If so, where is the location and what will be in that space? Will there be a BIM Trailer? If yes, where will it be located and what will be in the space such as computers, projects, tables, table configuration? Include any additional information necessary information about workspaces on the project.

Turner Construction will be providing a BIM coordination room within one of their trailers on site. A BIM coordinator will also have an office in the same location, where he/she will be available approximately 2-3 days a week including the weekly coordination day required.

The collision detection meetings will therefore be conducted by the CM. Any design challenges discovered during the impacting collision detection meeting will be resolved immediately since CM, architect, required engineers, required consultant, and the involved subcontractor is involved within all meetings.

During the coordination meetings, the parties involved will be the following:

- The architect and any of his/her required consultants – Physically in the meeting / Video Conference.
- Specific engineer if required – Physically in the meeting / Video Conference / Phone Conference call.
    - Turner's Project Manager – Physically in the meeting
    - Turner's Superintendent – Physically in the meeting
    - Turner's Project Engineer – Physically in the meeting
    - Subcontractor's Project Manager – Physically in the meeting/Video Conference
    - Subcontractor's Superintendent – Physically in the meeting
    - Specific Vendor is required – Physically in the meeting/ Phone Conference call.

Included in the BIM coordination room (IRoom) is :

2 smart boards, 2 projectors, 1 available desktop computer, a conference table that includes 9 receptacles for laptop hookups, 1 conference telephone.

5. ELECTRONIC COMMUNICATION PROCEDURES:

(Note: File Naming and Folder Structure will be discussed in Section L: Model Structure).
The following document management issues should be resolved and a procedure should be defined for each: Permissions / access, File Locations, FTP Site Location(s), File Transfer Protocol, File / Folder Maintenance, etc.

FILE LOCATION	FILE STRUCTURE / NAME	FILE TYPE	PASSWORD PROTECT	FILE MAINTAINER	UPDATED
FTP SITE: ftp://ftp.****.com/***/****	ROOT PROJECT FOLDER	FOLDER	YES ***********	Daniel Fernados	ONCE
	Arch. Root Folder	FOLDER		Daniel Fernados	ONCE
	ARCH-11111-BL001.rvt	.rvt		Daniel Fernados	DAILY
FTP SITE: ftp://ftp.****.com/***/****	ROOT PROJECT FOLDER	FOLDER	NO		ONCE
Project Management Software www.*****.com	None				

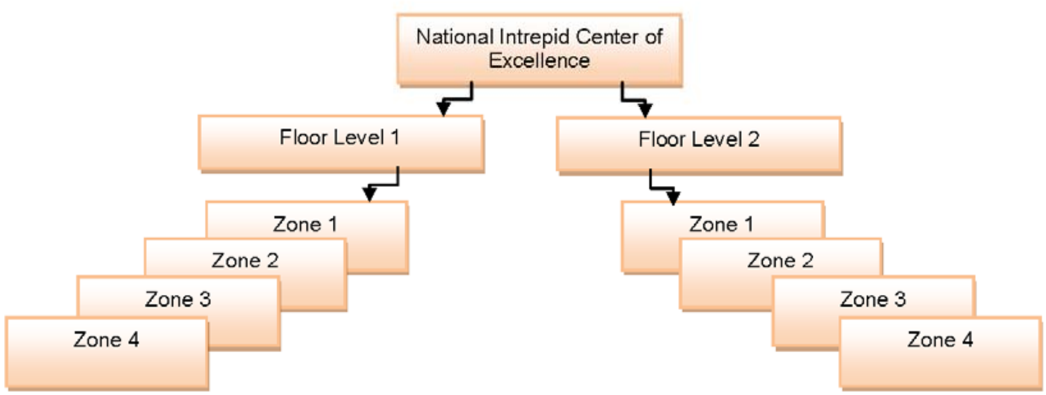
SECTION L: MODEL STRUCTURE

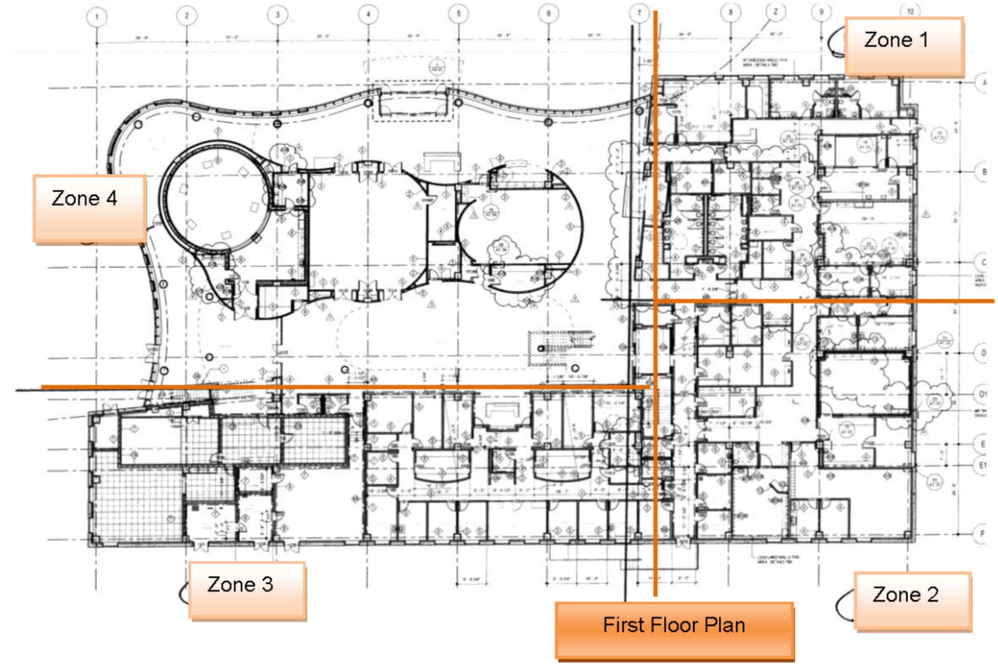
1. **File Naming Structure:**
Determine and list the structure for model file names.

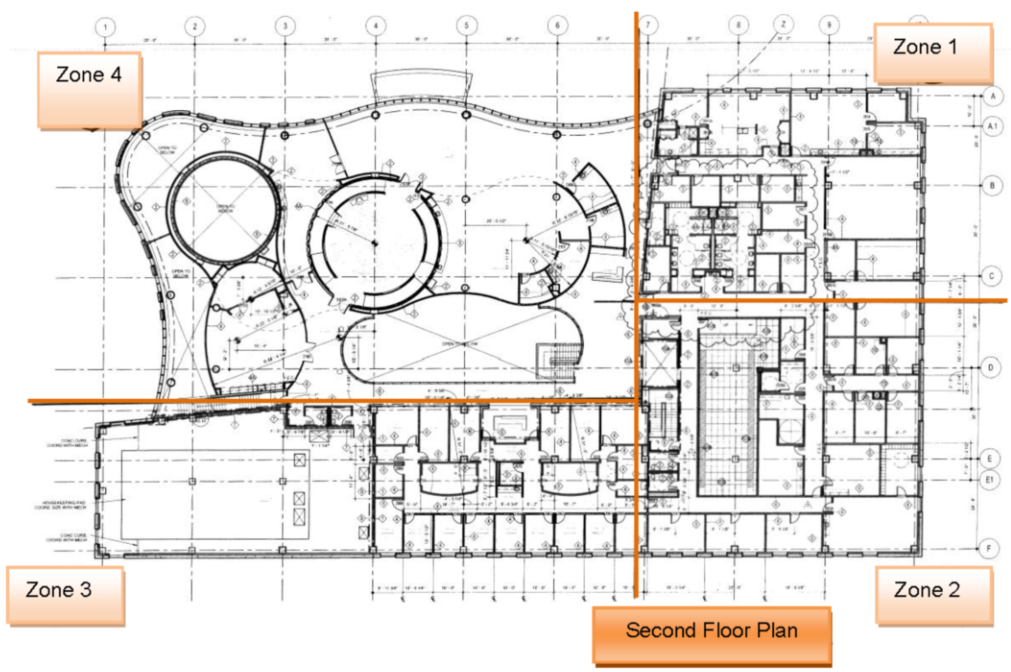
FILE NAMES FOR MODELS SHOULD BE FORMATTED AS:	
DISCIPLINE – Project, Responsibility, Trade, Floor Level, Zone, Version, Date, Time	
ARCHITECTURAL MODEL	ARCH- NICoE, SmithGroup, level1, zone 1, version 111, March 21, 2009, 1:20PM
CIVIL MODEL	CIVIL- NICoE, American Infrastructure, level1, zone 1, version 121, March 30, 2009, 2:30PM
MECHANICAL MODEL	MECH- NICoE, Limb Back Inc., level1, zone 1, version 321, April 21, 2009, 2:30PM
ELECTRICAL MODEL	ELEC- NICoE, Truline Electrical., level1, zone 1, version 122, April 2, 2009, 3:20PM
STRUCTURAL MODEL	STRUCT- NICoE, Cagley and Association. , level1, zone 1, version 21, March 30, 2009, 1:30PM
ENERGY MODEL	ENERGY- NICoE, Limb Back Inc., level1, zone 1, version 321, April 21, 2009, 2:30PM
CONSTRUCTION MODEL	CONST- NICoE, Turner Construction, level1, zone 1, version 18, April 21, 2009, 2:30PM
COORDINATION MODEL	COORD- NICoE, SmithGroup, level1, zone 1, version 321, April 21, 2009, 6:30PM

2. **Model Structure:**
Describe and diagram how the Model is divided up. For example, by building, by floors, by zone, by areas, and/or discipline.

Model is divided by floors, zones, and geographic location (north, center, south, etc.)




Zone 1
Zone 4
Zone 3
Zone 2
First Floor Plan


Zone 1
Zone 4
Zone 3
Zone 2
Second Floor Plan

3. **MEASUREMENT AND COORDINATE SYSTEMS:**

Describe the measurement system (Imperial or Metric) and coordinate system (geo-referenced) used.

Measurement system is in Imperial units. Coordinate system is not geo referenced but simply file based (uses models standard 0,0,0 origin.

4. **MODEL ACCURACY AND TOLERANCES:**

Models should include all appropriate dimensioning as needed for design intent, analysis, and construction. Level of detail and included model elements are provided in the Information Exchange Worksheet.

PHASE	DISCIPLINE	TOLERANCE
DESIGN DOCUMENTS	ARCH	ACCURATE TO +/- 0.5" OF ACTUAL SIZE AND LOCATION
SHOP DRAWINGS	MECH CONTRACTOR	ACCURATE TO +/- 0.5" OF ACTUAL SIZE AND LOCATION

APPENDIX E – STRUCTURAL LOAD CALCULATIONS – REDESIGN OF SPREAD FOOTINGS

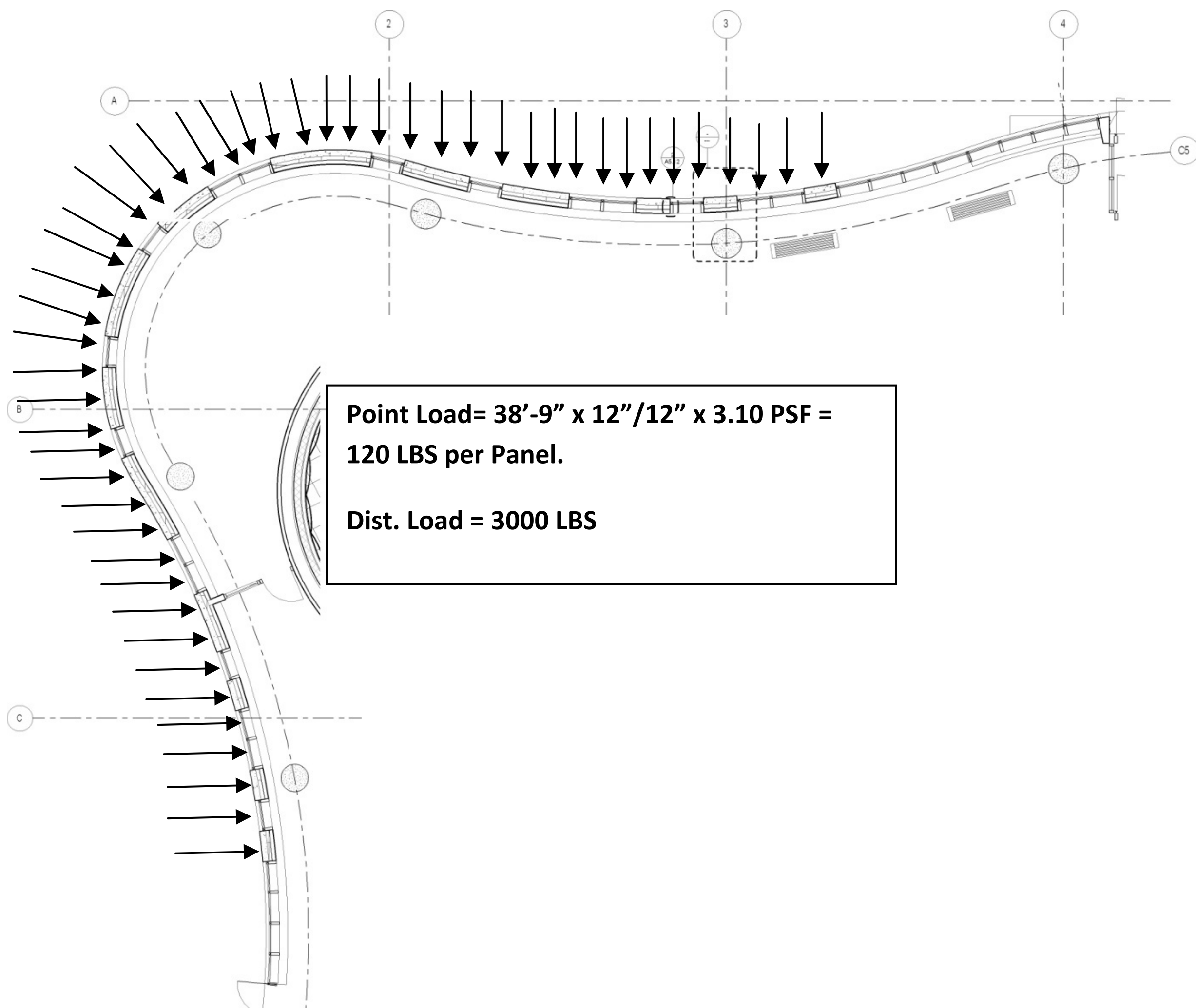
Most of the dead load of the insulated metal panels will be transferred to the reinforced pier on the spread footing shown as shown above in figure 40. The spread footing will be reduced in size according to the new structural system used:

Precast concrete wall panels Dead load =

Point Load = 146 CF x 150 LB/CF = 21,900 LBS per Panel

Dist. Load = 146CF *150Lb/CF *25panels = 547,500 LBS

Insulated Metal Panels Distributed Dead Load =



Point Load= 38'-9" x 12"/12" x 3.10 PSF = 120 LBS per Panel.

Dist. Load = 3000 LBS

REDESIGN FOOTING F7.5

BEARIN CAPACITY = 3000 psf = q

COLUMN LOAD = 94^k → FROM COLUM SCHEDULE

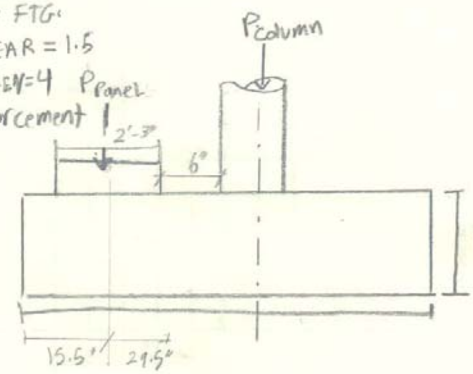
$P_{INS. Metal Panels} = 120^{lbs} = 0.12^k$

SOIL TYP = Gravel, Sandy Gravel, well Graded (GW)

$C = 0$ → compacted
$\phi = 40°$
$\gamma = 130$ pcf

ASSUMPTION:

- $D_f = 36"$
- PIER EXISTANCE DUE TO TIE IN PRECAST WALL ∴ WILL BE REMOVED DUE TO LEIGHTER WEIGH
- P_{Column} = SERVICE LOAD
- Square FTG.
- $F_{SHEAR} = 1.5$
- $F.S_{GEN} = 4$
- Neglect Reinforcement



SOL:

$$q = \frac{P_{col}}{A} + \frac{P_{Panel}\,e}{S}$$

$$3KSF = \frac{94k}{B^2} + \frac{0.120\left(\frac{29.5"}{12"}\right)^{kft}}{B^3/6}$$

$$3ksf = \frac{94k}{B^2} + \frac{1.77^{kft}}{B^3}$$

$$3B^3 = 94B + 1.77$$

$$B \geq 5.61'$$

<u>USE B = 6'</u>

$$q = \frac{P_{col}}{A} + \frac{P_{panel}\, e}{\frac{6(L)^2}{6}}$$

$$3^{ksf} = \frac{94^{k}}{6L} + \frac{0.12\left(\frac{29.5'}{12''}\right)}{\frac{6(L)^2}{6}}$$

$$3^{ksf} = \frac{15.67}{L} + \frac{0.295}{L^2}^{ksf}$$

$$3L^2 = 15.67L + 0.295$$

$$L \geq 2.29$$

USE $L = 3'$

SHEAR FALIUR CHECK

$C_1 = 0$ $\quad \phi = \tan^{-1}\left(\frac{\tan\phi}{F.S}\right) = \tan^{-1}\left(\frac{\tan 40}{1.5}\right) = 29.2° \approx 30°$

$N_c = 30.14$ $\quad q = D_f\,\gamma = 36''(130) = 390\ psf$

$N_q = 18.4$

$N_\gamma = 22.4$

$$q_u = 1.3\,cN_c + q\,N_q + 0.4\,\gamma B N_\gamma$$

376480

$$\frac{94.12^{k}(4)}{B^2} = (390)\,18.4 + 0.4\,(130)(22.4)B$$

$$\frac{376480}{B^2} = 7176 + 1164.8B$$

$$376480 = 7176B^2 + 1164.8B^3$$

$$B \geq 5.38' \longrightarrow B = 6' \quad \text{ok}$$

APPENDIX F – CFM CALCULATIONS

$Q_{BTU/HR}$ = 1.08 CFM ΔT

$Q_{BTU/HR}$ = 1.08 (74,000 CFM) (91.9˚ – 52˚) = 29,30560 / 12,000 = 244.2 Tons

Outside CFM = 25,000 CFM

Inside CFM = 49,000 CFM

$Q_{BTU/HR}$ = 1.08 (25,000 CFM) (91.9˚ – 52˚) = 1077300 / 12,000= 89.8 Tons

AHU DATA SHEETS

SPECIFIED: AIR HANDLING UNIT SCHEDULE

TAG	CFM	ESP	TSP	BHP	MOTOR HP	FAN	RPM	FILTERS	HEATING COIL						
									EAT °F	LAT °F	MBH	GPM	WPD FT	EWT	LWT
AHU-1	3700	3.5	6.65	57	75	36" DWDI-AF	1215	MERV 8 PREFILTER / 12" CARTRIDGE MERV 14	50	900	900	45	1.7	180	140
AHU-2	3700	3.5	6.65	57	75	36" DWDI-AF	1215	MERV 8 PREFILTER / 12" CARTRIDGE MERV 14	50	900	900	45	1.7	180	140

TAG	COOLING COIL							
	EAT DB/WB	LAT DB/WB	MBH TOTAL	BHH SENSIBLE	WPD	GPM	EWT °F	LWT °F
AHU-1	81/67.5	53/	1700	1142	201	280	44	56
AHU-2	81/67.5	53/	1700	1142	201	280	44	56

SUBMITTED: AIR HANDLING UNIT SCHEDULE

TAG	CFM	ESP	TSP	BHP	MOTOR HP	FAN	RPM	FILTERS	HEATING COIL						
									EAT °F	LAT °F	MBH	GPM	WPD FT	EWT	LWT
AHU-1	3700	3.5	7.16	59.25	75	36.5" DWDI-AF	1306	MERV 8 PREFILTER / 12" CARTRIDGE MERV 14	50	69.3	779	50	4	180	148.8
AHU-2	3700	3.5	7.16	59.25	75	36.5" DWDI-AF	1306	MERV 8 PREFILTER / 12" CARTRIDGE MERV 14	50	69.3	779	50	4	180	148.8

TAG	COOLING COIL							
	EAT DB/WB	LAT DB/WB	MBH TOTAL	BHH SENSIBLE	WPD	GPM	EWT °F	LWT °F
AHU-1	81/67.5	52.5/52.3	1712	1152	13.8	280	44	56.2
AHU-2	81/67.5	52.5/52.3	1712	1152	13.8	280	44	56.2

VISION AIR HANDLING UNIT FAX SHEET

Date Saved : 30/06/2009

JOB NAME	RSA106(XX.000)	REP. OFFICE	Havtech (DC)
JOB DESCRIPTION	NICoE Limbach	SALESPERSON	DS
MODEL NUMBER	CAH080GDAC	ENGINEER	
UNIT TAGGING	AHU-1 37000 cfm	VERSION	9.01

Unit configuration	Inline horizontal	
Supply external dimensions	(HxW) ins	98 x 136
Exhaust external dimensions	(HxW) ins	

FAN PERFORMANCE		SUPPLY	RETURN / EXHAUST
Air volume	cfm	37000	
Altitude	ft.	0	
Turning loss	in WC	0.00	
External static	in WC	3.50	
Total static	in WC	7.17	
Fan diameter / type	ins	36.50 / AF	
Fan power	HP	59.25	
Motor power	HP	75.00	
Motor voltage	V/Hz/P	460/60/3	

COIL PERFORMANCE	IN ORDER OF AIR FLOW	1st COIL	2nd COIL	3rd COIL	4th COIL
Coil model		5WB0801B	5WM1206C		
Total capacity	Btu/hr	779760	1712959		
Sensible capacity	Btu/hr	-	1152411		
Entering db / wb	F	50.0 / -	81.0 / 67.5		
Leaving db / wb	F	69.3 / -	52.5 / 52.3		
Face area	sqft	70.00	71.75		
Face velocity	fpm	529	516		
Air pressure drop	in WC	0.10	1.41		
EWT / LWT	F	180.0 / 148.8	44.0 / 56.2		
Flow rate	gpm	50.00	280.00		
Glycol type / %		- (0 %)	- (0 %)		
Water pressure drop	ftHD	4.00	13.80		
Suction temp / Refrig	F	-	-		
Steam pressure	psig	-	-		

FILTER DATA		STAGE 1	STAGE 2	STAGE 3
Type		Pleated (MERV 8)	Pleated (MERV 8)	Varicel SH cartridge
Efficiency		70	70	95
Face area	sqft	80.1	78.2	78.2
Face velocity	fpm	462	473	473

COMPONENT SUPPLY	APD (in WC)	WEIGHT (lbs)	COMPONENT RET/EXH	APD (in WC)	WEIGHT (lbs)
Mixing Box	0.08	273.45			
Panel Filter	1.00	137.72			
Hot Water Coil	0.10	390.46			
Access section	0.00	6.75			
Chilled Water Coil	1.41	2420.33			
Fan Section	0.00	3128.37			
Diffuser	0.15	67.43			
Combination Filter	0.91	514.15			
Plenum section	0.02	0.00			

** Denotes a component static pressure based on the fan air volume rather than the individual component air volume.

SHIPPING SECTION DETAILS	Length (ins)	Weight (lbs)		Length (ins)	Weight (lbs)
Section 1	74	2163			
Section 2	62	3573			
Section 3	86	4733			
Section 4	52	1519			
Section 5	48	1156			
TOTALS (Lower level total length, entire unit total weight)				322.00	13144

UNIT SOUND	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
Radiated	91	93	90	80	74	65	49	40
Unit discharge	98	100	99	94	87	77	68	53
Unit return	97	99	99	93	89	83	77	75

NOTES

Page 1 of 2

McQuay Air Conditioning

VISION AIR HANDLING UNIT TECHNICAL DATA

Date Saved : 30/06/2009

JOB NAME	RSA106(XX.000)	**REP. OFFICE**	Havtech (DC)
JOB DESCRIPTION	NICoE Limbach	**SALESPERSON**	DS
MODEL NUMBER	CAH080GDAC	**ENGINEER**	
UNIT TAGGING	AHU-1 37000 cfm	**VERSION**	9.01

Unit configuration	Inline horizontal		
Drive (handing) location	Right		
	SUPPLY	**RETURN / EXHAUST**	
Air volume	37000		s cfm
Altitude	0		ft
Turning loss	0.00		in WC.
External static	3.50		in WC.
Total static	7.17		in WC.
External H x W	98 x 136 (Not including base rails)		ins

CASING DETAILS	
Outer panel	Standard G90 galv steel (unpainted)
Liner	Galvanized steel (Unless noted per section)
Insulation	R-13 Injected Foam (Unless noted per section)
Frame	2 ins
Base	8" formed channel
Sound baffles	None (unless noted per section)
Tread Plate floor liner	None (unless noted per section)

1 MIXING BOX(50 ins) — SECTION 1

Drip pan	None	Drip side	-
	OUTSIDE AIR	**RETURN AIR**	
Length x Width	46.00 x 132.00	46.00 x 132.00	ins
Location	End	Top	
Dampers	UltraSeal Low Leak	UltraSeal Low Leak	
Actuation	-	-	
Rated cfm	37000	37000	cfm
Air pressure drop	0.08		in WC
Quantity	1	1	

DOOR DATA

Door location	Drive side		Window size	None
Door width	30	ins	Light	None
Door opening	Outward			

SPECIAL

Rusking CD60 Dampers

Tread Plate floor liner	None			
Liner	(As casing details)			
Insulation	(As casing details)			
Sound baffles	None			
Special static pressure	-	ins WC	Filter Gauge	None

Standard ASHREA 62.1 CFM Requirements

Room Design Information		ASHRAE Standard 62.1-2007								
Room Name	Area (SF)	Type of Occupancy	People	Design Occup	CFM / PERSON	CFM / SQ FT	Occ OA	Area OA	OA CFM Req'd	Design OA CFM
Break Out	923.6	Lobbies (Public Assembly)		139	5	0.06	695	56	751	755
Caren System	1422.05	Operating rooms		29	30	0	870	0	870	870
lobby	8023.24	Lobbies (Public Assembly)		1204	5	0.06	6020	482	6502	6505
Reception	933.25	Reception areas		28	5	0.06	140	56	196	200
Rec therapy	1699.76	Physical therapy		34	15	0	510	0	510	510
Equipment Storage	760.43	Storage rooms		0	0	0.12	0	92	92	95
patient Prep.	437.34	Patient rooms		5	25	0	125	0	125	125
vestibule	400.5	Lobbies (Public Assembly)		61	5	0.06	305	25	330	330
Business center	132.87	Reception areas		4	5	0.06	20	8	28	30
Auditorium	1463.52	Auditoriums -Public Assembly		220	5	0.06	1100	88	1188	1190
Chapel	117.45	Legislative chambers		6	5	0.06	30	8	38	40
Media Div Room	948.32	Operating rooms		19	30	0	570	0	570	570
Coffee	145.18	Cafeteria/fast food dining		15	8	0.18	113	27	140	140
Control Room	707.33	Medical procedure rooms		15	15	0	225	0	225	225
Fats/Gold	496.15	Medical procedure rooms		10	15	0	150	0	150	150
VR Lab	754.78	Medical procedure rooms		16	15	0	240	0	240	240
VR prep.	171.22	Medical procedure rooms		4	15	0	60	0	60	60
Main Electrical Room	208.21	Computer lab		6	10	0.12	60	25	85	85
EM Electrical	186.44	Computer lab		5	10	0.12	50	23	73	75
Eng. Equip. Room	87.07	Storage rooms		0	0	0.12	0	11	11	15
Work area	638.24	Office space		4	5	0.06	20	39	59	60
Mechanical Room	809.37	Computer lab		21	10	0.12	210	98	308	310
VEH/SIM	301.1	Operating rooms		7	30	0	210	0	210	210
M.Toilets	870.79	Dayroom		27	5	0.06	135	53	188	190
F.Toilets	343.7	Dayroom		11	5	0.06	55	21	76	80
Psych	717.18	Medical procedure rooms		15	15	0	225	0	225	225
Consult/Eval	1034.64	Conference/meeting - General		52	5	0.06	260	63	323	325
Exam Room	295.72	Medical procedure rooms		6	15	0	90	0	90	90
Interior Corridor	3019.42	Corridors		0	0	0.06	0	182	182	185
Teaming Area	242.7	Conference/meeting - General		13	5	0.06	65	15	80	80
POC	29.7	Medical procedure rooms		1	15	0	15	0	15	15
Intake	225.78	Conference/meeting - General		12	5	0.06	60	14	74	75
Quiet	253.96	Barracks sleeping areas		6	5	0.06	30	16	46	50
Electrical Room	210.01	Computer lab		6	10	0.12	60	26	86	90
HSKP	117.82	Medical procedure rooms		3	15	0	45	0	45	45
Recycle	128.49	Storage rooms		0	0	0.12	0	16	16	20
Stair #3	209.08	Main entry lobbies (Office)		3	5	0.06	15	13	28	30
Elevator #2	87.92	Main entry lobbies (Office)		1	5	0.06	5	6	11	15
Elevator #1	87.79	Main entry lobbies (Office)		1	5	0.06	5	6	11	15
Elevator Control Room	73.46	Computer lab		2	10	0.12	20	9	29	30
Gas Cylinder	98.01	Medical procedure rooms		2	15	0	30	0	30	30
Communication	124.57	Medical procedure rooms		3	15	0	45	0	45	45
Soiled/Imaging	183.53	Medical procedure rooms		4	15	0	60	0	60	60
Blood Lab	182.98	Medical procedure rooms		4	15	0	60	0	60	60
Clean Supply Equipment	262.93	Storage rooms		0	0	0.12	0	32	32	35
pharm office	134.69	Pharmacy (prep. area)		2	5	0.18	10	25	35	35
Work/Viewing/Imaging	184.51	Medical procedure rooms		4	15	0	60	0	60	60
Test prep.	67.33	Medical procedure rooms		2	15	0	30	0	30	30
Fluoroscopy	386.33	Medical procedure rooms		8	15	0	120	0	120	120
Holding /Exam	120.66	Medical procedure rooms		3	15	0	45	0	45	45
Office	320.9	Office space		2	5	0.06	10	20	30	30
Research/Tech	557.87	Medical procedure rooms		12	15	0	180	0	180	180
MRI	588.29	Operating rooms		12	30	0	360	0	360	360
Dose	143.68	Medical procedure rooms		3	15	0	45	0	45	45
Hot Lab	195.91	Medical procedure rooms		4	15	0	60	0	60	60
Uptake	137.28	Computer lab		4	10	0.12	40	17	57	60
PT/CT	568.76	Operating rooms		12	30	0	360	0	360	360
MEG/Control/Patient prep.	568.76	Patient rooms		6	25	0	150	0	150	150
Sleep/Eeg	411	Barracks sleeping areas		9	5	0.06	45	25	70	70
Imaging Check-in	403	Reception areas		13	5	0.06	65	25	90	90
Dress	92	Bedroom/living room - Hotel		1	5	0.06	5	6	11	15
US/Exam	118	Medical procedure rooms		3	15	0	45	0	45	45
Case Manegement	592	Office space		3	5	0.06	15	36	51	55
Board Room	605	Conference/meeting - General		31	5	0.06	155	37	192	195
Office	3787	Office space		19	5	0.06	95	228	323	325
Interior Corridor	2858	Corridors		0	0	0.06	0	172	172	175
Copy center	68	Copy, printing rooms		1	5	0.06	5	5	10	10
Admin/research	227	Reception areas		7	5	0.06	35	14	49	50
Conference	176	Conference/meeting - General		9	5	0.06	45	11	56	60
Electrical Room	217	Computer lab		6	10	0.12	60	27	87	90
HSKP	123	Medical procedure rooms		3	15	0	45	0	45	45
Staff Loung	541	Booking/waiting		28	8	0.06	210	33	243	245
Toilet	851	Multi-purpose assembly (Hotel)		103	5	0.06	515	52	567	570
Server Room	1234	Computer lab		31	10	0.12	310	149	459	460

Storage	462	Storage rooms		0	0	0.12	0	56	56	**60**
VOC Rehab	341	Medical procedure rooms		7	15	0	105	0	105	**105**
Group Room	336	Conference/meeting - General		17	5	0.06	85	21	106	**110**
Classroom	847	Lecture Classroom		56	8	0.06	420	51	471	**475**
Locker rooms	473	Storage rooms		0	0	0.12	0	57	57	**60**
Sleep Group	269	Barracks sleeping areas		6	5	0.06	30	17	47	**50**
Clean Work	180	Storage rooms		0	0	0.12	0	22	22	**25**
ADL	532	Recovery and ICU		11	15	0	165	0	165	**165**
Snoezlen	216.8	Recovery and ICU		5	15	0	75	0	75	**75**
Family Lounge	889	Booking/waiting		45	8	0.06	338	54	392	**395**
Child Play	257	Daycare (through age 4)		7	10	0.18	70	47	117	**120**
Central Park	1473	Dayroom		45	5	0.06	225	89	314	**315**
Art/Music	831	Art Classroom		17	10	0.18	170	150	320	**320**
PT (lobby)	2818	Lobbies (Public Assembly)		423	5	0.06	2115	170	2285	**2285**
OT	679	Operating rooms		14	30	0	420	0	420	**420**
PT/Eval	148	Operating rooms		3	30	0	90	0	90	**90**
PT Work	139	Medical procedure rooms		3	15	0	45	0	45	**45**
Central Therapy Info	389	Physical therapy		8	15	0	120	0	120	**120**
OT Work	250	Medical procedure rooms		5	15	0	75	0	75	**75**
Waiting	1143	Booking/waiting		58	8	0.06	435	69	504	**505**
Therapy Waiting	655	Booking/waiting		33	8	0.06	248	40	288	**290**
Total:	60,651		0	3163	1010	4.92	21589	3247	24836	24970
Note 1: BASED ON ASHRAE 62.1-2004 OFFICE MAIN ENTRY LOBBY										
Note 2: AIRFLOW ADJUSTED BASED ON ASHRAE TIME CALC: MAX OCC ONLY 37.5 MIN										
Note 3: ASHRAE 62-2004 KITCHEN EXHAUST RATE: .70 / SF										

APPENDIX G – HEAT RECOVERY SYSTEM DESIGN

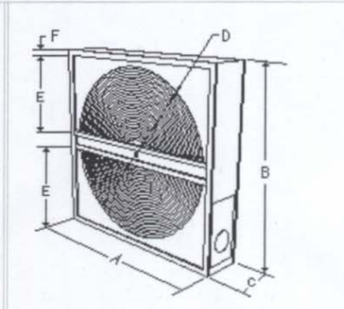
XETEXSELECTION PROGRAM VERSION 1.1.14 FOR ENTHALPY WHEELS

XeteXSelection Program version 1.1.14 3/16/2010 5:03:04 PM

AIROTOR

Job Name: National Intrepid Center of Exellence
Model Selected: RXA-2250

				A	88.6	in
		Outside CFM	14560.00	B	88.6	in
Supply Airflow	14560	Exhaust CFM	14560.00	C	17.3	in
Return Airflow	14560	Purge CFM	0	D	81.1	in
Purge PD	N/A	Sup/Exh Ratio	1.00	E	40.8	in
Voltage	230/1/60	Watts	500	F	2.4	in



		Summer		Winter	
		Supply	Return	Supply	Return
Entering Temp DB	(F)	85	75	30.4	68
Entering Temp WB	(F)	73.6	63.7	23.8	54.8
Entering Rel. Humidity		58.79%	53.96%	31.74%	42.24%
Entering Enthalpy	(Btu/lb)	37.18	29.01	8.49	23.03
Leaving Temp DB	(F)	77.86	82.14	56.96	41.44
Leaving Temp WB	(F)	68.51	69.01	44.52	37.40
Leaving Enthalpy	(Btu/lb)	32.81	33.20	17.39	14.05
Actual Face Velocity	(FPM)	909.70	904.89	846.24	864.79
Actual Pressure Drop	(in. WC)	0.92	0.91	0.85	0.87

Elevation: 318 ft

	Effectiveness	Energy Recovered (Btu/h)	Effectiveness	Energy Recovered (Btu/h)
Sensible	71.37%	112232.17	70.65%	417719.18
Latent	42.55%	154631.07	46.21%	165150.9
Total	53.41%	266863.24	61.22%	582870.08

Note: 'Effectiveness' as defined by ASHRAE standard 84 and ARI Standard 1060.

Comments:

Selection By efficiency

XeteX, Inc.

Phone:
Fax:
E-Mail:

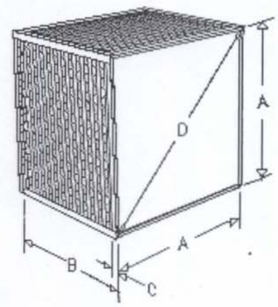
XETEXSELECTION PROGRAM VERSION 1.1.14 FOR FLAT PLATES

XeteXSelection Program version 1.1.14 3/16/2010 5:01:57 PM

Heat - X - Changer Commercial

Job Name: National Intrepid Center of Exellence
Model Selected: XLT(P)-50I-96

A	47.2	in
B	96.0	in
C	1.5	in
D	66.8	in
E	N/A	in
F	N/A	in



Supply Airflow	14560
Return Airflow	14560

		Summer Supply	Summer Return	Winter Supply	Winter Return
Entering Temp DB	(F)	85	75	30.4	68
Entering Temp WB	(F)	73.6	63.7	23.8	54.8
Entering Rel. Humidity		58.8%	54.1%	31.6%	42.2%
Entering Enthalpy	(Btu/lb)	37.2	29.0	8.5	23.0
Leaving Temp DB	(F)	78.8	81.3	53.8	44.7
Leaving Temp WB	(F)	71.7	65.6	37.5	44.3
Leaving Enthalpy	(Btu/lb)	35.5	30.4	14.1	17.3
Actual Face Velocity	(FPM)	528	525	490	503
Actual Pressure Drop	(in. WC)	0.92	0.91	0.84	0.88
Energy Recovered	(Btu/hr)	99327		373041	
Sensible (Supply) Effectiveness		62.0%		62.2%	
Water Condensed (lb/hr)			0.0		0.0

Elevation: 318 ft

Comments:

Selection By efficiency

XeteX, Inc.

Phone:
Fax:
E-Mail: