TECHNICAL REPORT 3

UNIVERSITY BUILDING
UNIVERSITY, MID ATLANTIC REGION, UNITED STATES

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EXECUTIVE SUMMARY

Technical report 3 focuses on two main topics: an interview with the project manager and takeaway from this year's PACE roundtable event. The breakdown for the report includes schedule acceleration scenarios and value engineering topics based on the interview with the project manager and feedback and potential research topics from breakout sessions and industry professional feedback from the roundtable.

Schedule Acceleration Scenarios

The University Engineering Building (UEB) has already seen construction delays caused by inclement weather and unforeseen soil issues. A list of items on the critical path has been provided in order to gain a better grasp on the project sequencing. Measures have already been taken to accelerate the critical path in order to get the project back up to speed, which will be discussed within this report. Also an analysis of possible risks was made in order to determine what areas could affect the project completion date. Some of the risks have already occurred on the project, such as underground utility issues, excavation and foundation issues, but also covered are future risks that are currently being monitored by the project team. Those issues include mainly building enclosure and the incoming cold weather as it affects all interior work and could delay the key components of the critical path. Finally this section concludes with potential areas where schedule acceleration can be achieved. The hope is on this project interior rough-in work will go smoothly due to coordination with a 3D model and the fact that the schedule has allowed for some extra time to complete work.

Value Engineering Topics

All value engineering that occurred on the UEB, did so prior to the general contractor, Massaro, being brought on board after the bid phase. Value engineering came down to two main requirements in order to determine it was feasible and should be implemented. Those requirements were cost and standards and quality, where cost differences meant implementation and standard and quality changes meant not implementing the changes. Implemented changes include reduction in building size, building façade and roofing changes and interior space changes. Items that were not implemented dealt with mechanical, electrical and plumbing systems and the stair towers.

Critical Industry Issues

At this year's annual PACE roundtable, students were required to attend two breakout sessions based on leading industry topics and use the discussion to find possible areas for research. The discussion topics were tied-in to the UEB based on relevancy. The final session was a sit-down with an industry professional that provided feedback on research ideas based on the breakout sessions. The attended sessions covered in this report are: "Safety – Prevention through Design" and "Efficient Delivery of Facility Management Information." The industry professional was John O'Keefe of Clark Construction.

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SCHEDULE ACCELERATION SCENARIOS

Since the University Engineering Building is a university project, the schedule, mainly the substantial completion date is extremely important to the project team. The current tentative completion date is December/January 2015. The key date in this equation is January 12th, 2015 which is the first day of classes for the Spring 2015 semester, according to the University's academic calendar. This section of the report discusses the critical path for the UEB, risks and potential acceleration areas.

Critical Path

The critical path for the UEB involves main phases of construction as well as key areas that will ensure the successful completion of the project within the given timeframe. The first main group of activities on the critical path revolves around the installation of underground utilities. Currently the sanitary and acid waste pipes are being installed and have taken longer than expected. The details surrounding this risk will be discussed in the next section. This also threatens to add the slab on grade to the critical path if it is not resolved soon. As of right now the building enclosure is the driving factor on the critical path, due to the cold winter months here. The risks involved with this issue will be discussed also in the next section. The building must be enclosed in order to begin interior work which is temperature sensitive. Once the building is enclosed, rough-ins and the clean room are the driving factors in order to reach the commissioning and testing phase. The clean room is the key feature of the building, so its quality is of top concern, but also to ensure it will be completed on time and pass commissioning in order allow for researchers to move into the space.

The next sections delve deeper into the risks that have occurred and could potentially occur that would affect the project completion date, along with ways to accelerate the schedule to make up for lost time.

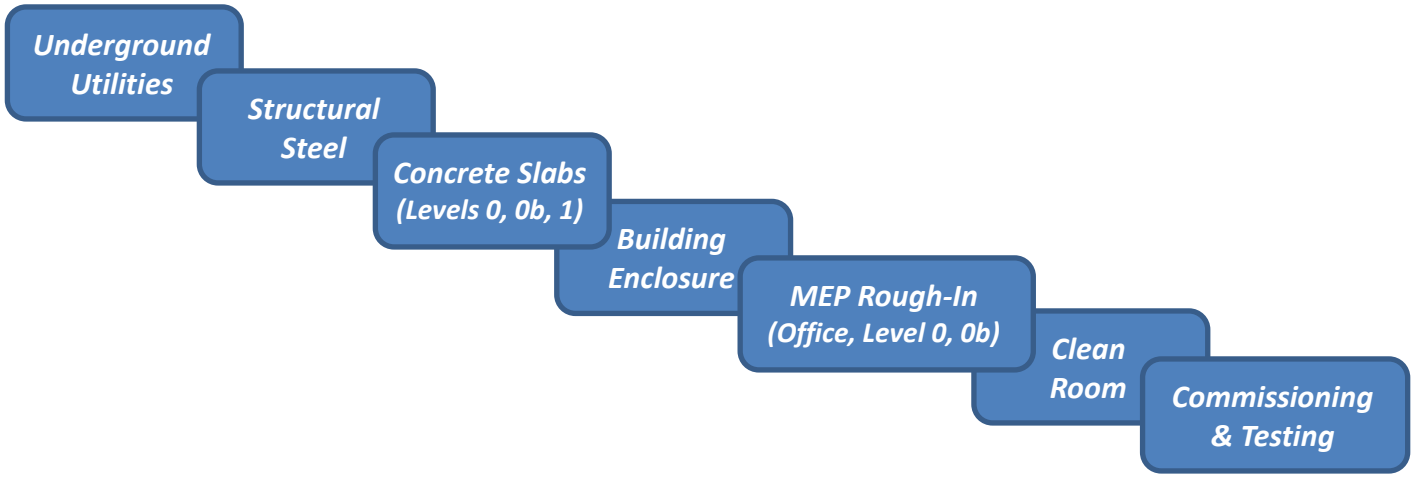

Figure 1: Critical Path (Courtesy of Massaro)

Risks

As with any project, there are risks that could affect the building's completion date and the University Engineering Building is no different. With the owner being the University, one item the project manager discussed, which he felt was unlikely at this point in construction, was the addition or change in scope of the project, or possible design changes added by the owner. Not only would these items affect the completion date of the project by pushing it back but also increase the cost of the project.

Massaro has already encountered situations where the project completion date was affected. As previously discussed in technical report 2, there were issues with the excavation and foundation phase of construction caused by an undetected underground spring and weather that delayed foundation concrete pours and affected formwork and rebar cages. These issues alone delayed the start of structural steel erection by almost five weeks. Beginning the structural that much later than planned would cause all kinds of problems for the critical path, mainly delaying building enclosure. This would have been a major issue because most of the equipment and materials installed in the interior of the building along with concrete pours need to remain at constant temperatures to avoid freezing or voiding warranties. Since the cold winter months are already here the need for temporary heated has greatly increased and adds to general conditions costs for Massaro. But, Massaro has already found ways to accelerate the schedule, which will be discussed in the next section of this report.

Another risk that currently has the potential to affect the project completion date, involved the underground sanitary and acid waste pipe. The pipe used for the acid waste is a fused PVC product. This product is unique in that the fused portion has copper strands throughout it and is fused together using electric current. The problems arose when testing the pipe, where pieces began falling apart and leaks occurred in multiple places. Originally the plumber had a two week buffer in the schedule to complete his work, but now the issues have delayed the completion of this work by three weeks, one week past the scheduled completion date. This directly affects pouring the slab on grade, which is not currently a problem because the slab on grade is not on the critical path, but further delay in the underground piping would push the slab on grade onto the critical path, thus affecting the project completion date.

Future risks that the project manager feels could affect the critical path focus on building enclosure and the roofing system. The cold and winter weather are the reasons driving the need to accelerate the installation of the building skin. Interior work is directly affected by the building enclosure, where relatively constant temperatures must be kept for proper material storage, installation and maintenance. The air-handling units are one piece of equipment that must be kept at constant temperatures; otherwise the warranty could be voided causing major problems that would back up the entire project, since the UEB is basically built around these units and the mechanical system.

The other major building system that could affect the project completion date because of the cold and weather is the roof system. The roof system used on the University Engineering Building is a self-adhered TPO membrane, shown in figure 2 below.

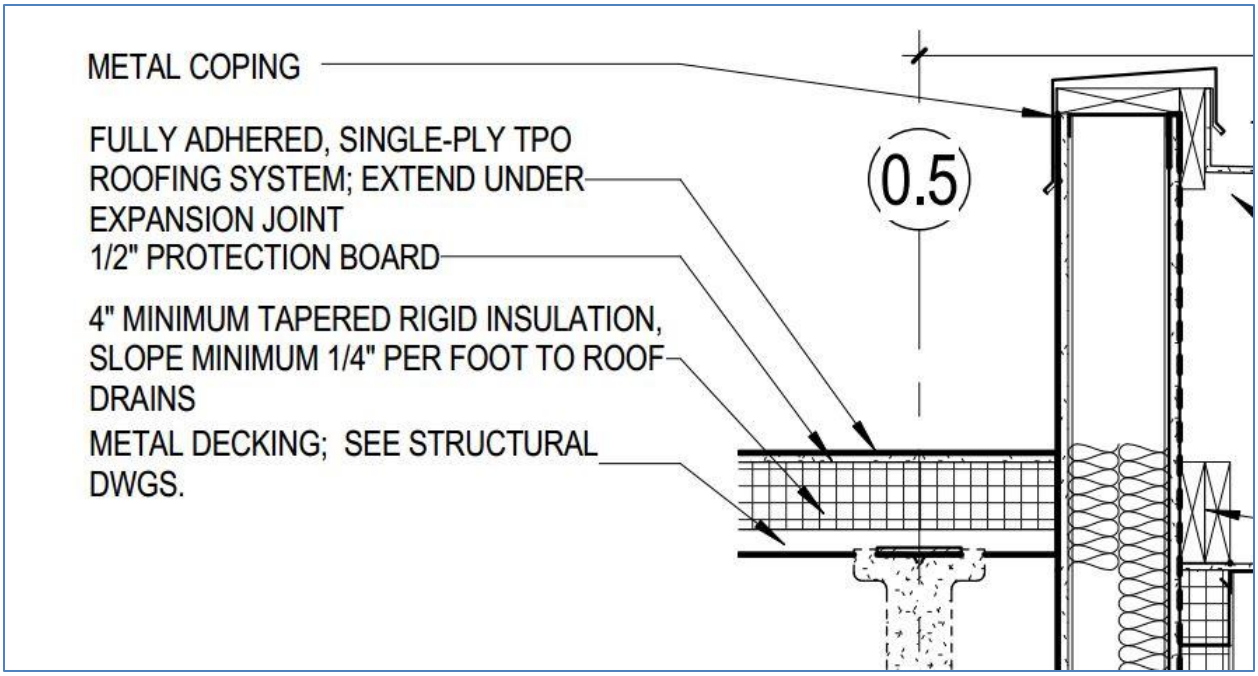

Figure 2: Roof Detail (Courtesy of Stantec)

The problem arises with the installation of the TPO membrane, where the material must be kept at 40°F or higher in order to be installed and function properly. A built-up roofing system was originally proposed during the design phase, which will be discussed in the value engineering section of the report, that the project manager would have preferred because of the ease of installation in cold weather situations.

Costs that affect the building enclosure and roofing system include temporary enclosure structures as well as temporary heating, in this instance large air velocity heaters. It is currently being discussed and research whether a temporary roof will be needed if the cold weather inhibits the installation of the roofing system.

Potential Acceleration

While assessing the current and future risks, areas have been analyzed for schedule acceleration. Due to the weather delays during excavation and foundation, there was an owner change order that was approved that added 20 extra working days to the schedule to account for lost time that was out of the control of Massaro. Also time has been made up from those delays during the slab deck phase. Steel decking installation and detailing allowed for the project team to make up time as well as during the concrete pours. The concrete pours were supposed to be completed early January 2014, but will now be completed a couple weeks earlier, prior to Christmas 2013. The costs associated with these activities were mostly overtime for the workers due to finishes for the concrete decks that required the workers to put in some ten to twelve hour days for a few weeks in order to properly finish the concrete and prep it for curing.

Massaro feels that once the building is enclosed, they will be able accelerate the schedule to get back on track. On past projects they have seen how BIM and model coordination can smooth the transition from drawings to installation and hope that the time put in at the beginning of the project will pay off and limit problems and delays during the rough-in and interiors phases. The hope is also that the rough-in and framing is sequenced correctly by the project manager to achieve efficient installation. The sequencing is reflected in the schedule and will be altered as necessary to best manage the work being done.

The last resort in order to make up time and accelerate the schedule as much as possible is overtime and weekend work. So far, Massaro has been able to avoid forcing workers to work overtime for the most part and wish to continue this trend to avoid slumps in work and possibly quality.

VALUE ENGINEERING TOPICS

The value engineering that was performed on the University Engineering Building during the design phases, prior to Massaro being brought on after the bid phase. During the design phase, major decisions were discussed by both the design team and the University in order to value engineer the project to decrease costs while maintaining the standard of quality expected.

Early during the design phase, the UEB was originally 120,000 SF with a different building foot print but after a budget analysis and schematic estimate, the size of the building was value engineered to roughly 100,000 SF by redesigning the building footprint and cutting height on the mezzanine level. The floor to floor height was cut by enough that it didn't directly affect any of the equipment housed on that level. This was directly related to costs because the funding for the project was limited. The owner and the College of Engineering were fine with this change because the end project still provides the goals and spaces needed.

Building Façade & Roofing System

The building façade was a main area of value engineering, mainly due to cost restraints. Originally the façade was cast stone, meant to appear as limestone, and typical red brick masonry, but an analysis was performed focusing on function and cost and it was determined that it would be cost effective without sacrificing quality to switch to metal panels for the exterior façade. This change saved the owner roughly $200,000.

The university has building standards set that call for their buildings to use built-up roof systems. The original plan for the University Engineering Building was to have a built-up roof, in accordance with university standards, but cost restraints required an analysis into another roofing system. The alternate choice, as determined by the owner's rep and the design team was a self-adhered TPO membrane, which can be seen in detail in figure 2. An exact cost savings for this system change was not provided by the project manager for the owner's rep.

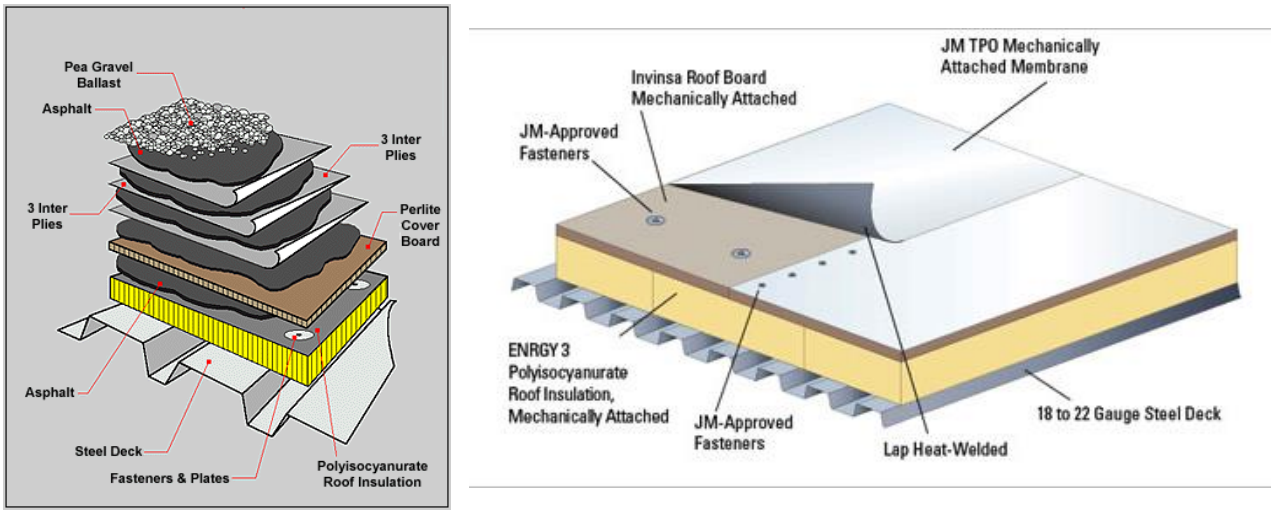

Figure 3: Built-Up Roof vs. TPO Membrane Roof
(Courtesy Google Images)

Interior Lab Space

The primary function of the UEB is for laboratory and research purposes. The original design of the lab spaces included one floor of shelving space for storage needs. The College of Engineering felt this was not sufficient space and requested that more shelving be added to the second floor lab space. The design was then value engineered to add additional shelving space on the second floor lab to accommodate the owner's requests. The owner's rep also did not provided a cost change for this design alteration.

Proposed Value Engineered Items

Along with the many items that were value engineered on the UEB project, more change proposals were presented but not implemented. All of the proposed changes were rejected due to quality control and quality standards established by the owner for university buildings. One proposed change was using PVC pipe instead of cast iron piping, but was rejected because the university standard calls for cast iron to be used in particular applications. Another rejected value engineered item was to eliminate the redundancy in the mechanical system, by removing the hot water pump, but the university felt this was necessary and decided against this change. A change to the electrical conduit material was also denied, with the change from metal conduit to mc cable. This was denied because of university standards as well.

The stair towers were a source of considered value engineering that was later not implemented. One of the proposed changes was using metal panels in lieu of brick but this was decided against for safety and quality reasons. Another stair tower related change was to value engineer out stair pressurization. This was immediately denied because in order to accomplish this required a signed authorization form by the local fire marshal approving of the measure and this approval would have cost $50,000.

CRITICAL INDUSTRY ISSUES

The annual PACE (The Partnership for Achieving Construction Excellence) Roundtable was held on November 7, 2013 at the Penn Stater Conference Center with the topic of "Whole Project Delivery." This event brought together industry professionals, Penn State faculty and fifth year Architectural Engineering students.

The roundtable consisted of two sets of breakout sessions focused around personnel and integration. The point of these breakout sessions was for industry professionals and students to discuss the topics while being moderated by Penn State faculty members. The information gained from these discussions is to be used by the students to formulate research topics for their senior thesis projects. At the end of the roundtable a few students were paired with an industry professional to discuss and gain key feedback from the breakout sessions to better formulate research topics.

This section of the report details the discussion and how it relates to the University Engineering Building from the breakout sessions attended, as well as the feedback provided by John O' Keefe of Clark Construction.

Breakout Session #1: Safety – Prevention through Design

The main focus of this breakout session involved the concept of safety within the design community. Most of the participating industry professionals agreed that the design community is not as aware, or focus on safety as much as they should. This is partially due to the design community's belief that the builder is the safety expert and their insistence on not taking on any liability for possible construction accidents.

The conversation then turned towards ways of creating a safety first culture within the mindset of design professionals. A leading issue is in contract language, where it is not directly spelled out regarding safety and the designer. Patrick Harrison, the guest lecturer, emphasized the need for a safety first culture, not matter whether it's the owner, the design team or the construction team. The idea was proposed of design professionals taking on liability for safety, but it was debated whether they would ever do so between industry professionals, with the final consensus being unless they are directly at fault for any injuries or deaths, the design community would not take on any liability. The direction of the discussion changed again, where the thought was proposed on having some type of design safety regulatory entity, similar to that of OSHA for the construction industry. This entity would have generic guidelines to enforce designers would take safety into account when designing buildings and systems. Issues with this solution included; how exactly would an entity be able to regulate design, how would the guidelines be created and how would they be generic enough to apply to every design project.

Branching off the regulatory idea, a student brought up the idea of creating a point system, similar to LEED, in which points or a checklist would be used to determine whether safety is prevalent in design. Again, similar problems arose on the creation and implementation of the point system.

The takeaway from the breakout session is that the most effective way to introduce safety during the design phase is to have early collaboration during design between the design team and the construction team. This way the construction team can give feedback for what they feel should be changed or might be a safer alternative. Also utilizing prefabrication and site logistics as ways to minimize the amount of possible safety hazards on a job site would be beneficial where applicable.

Safety is key on any project, but more so on a university project, such as the University Engineering Building, where the safety of students is the sole priority. Identifying and solving any potential safety hazards early in the design stages or early during construction help to ensure the safety of the workers, students and other members of the general public. Overall the discussion topic was board in the sense of applying safety in design, but as discussed during the industry professional feedback, design could mean methods and designs used by the owner and construction team to solve safety issues at different stages of the project. One area where safety through design is beneficial on the UEB project is the east side of the building which is closely located to the Plants/Soils Building. Designing systems that minimize congestion and time spent on that area of the building minimizes the possible dangers to the general population. This is apparent with crane picks and the swing radius of the crane, as it could pass near the occupied building posing a safety hazard for people in the building at that time.

Breakout Session #2: Efficient Delivery of Facility Management Information

The afternoon breakout session dealt with the concept of facility management and the transfer of information between the contractor and the facility manager. This discussion presented many challenges that project teams face when turning over a building. Those challenges include owners not knowing what they want, or what to do with the information they receive, competency of the facility management staff, face time between the CM and FM and not placing an emphasis on building turnover.

In order to create a successful transition of information, the owner must first know what need once they receive the building and the contractor must understand those needs. Ways to achieve that were discussed include having facility management personnel on site for one-on-one interactions with the construction team, determining what parts of the building are assets and are the most and least important to the owner and looking at long-term maintenance aspects, such as total cost of ownership (initial + maintenance + replace + loss of use).

Examples were provided by industry professionals about how they have handled by the facility manager. One example was a courthouse Clark Construction built in California where the contract made them the facility manager and owner of the building for thirty-five years and how Clark has tackled maintenance and the need for particular information in order to properly maintain the building.

Keys to a successful delivery of information were discussed and the list created by the participants includes: making the information usable, assessing staff time and frustration and differentiating between the different areas of facility management, asset and space management, energy, engineering, rennovations, BAS/controls.

The session ended with industry professional presenting topics they felt needed further research in the future. The topics presented were analyzing the lifecycle of an asset, studying and possibly creating end-user interfaces, looking at energy audits and how FM information plays a role and finally optimizing time and money for building turnover.

Since the owner and end-user of the UEB is the University and its faculty and students, ensuring the facility management team has the necessary information is crucial to operate and maintain the building. The lab spaces are especially important since any maintenance downtown means wasted time and money and in the world of scientific research, even a short time such as minutes or hours could mean the failure of an experiment. Failed research and experiments would cost the university possibly millions in money and grants and possible future grants. A good research topic would be to analyze and prepare a method for a smooth transition of building information from Massaro to the facility management staff and make sure they know how to find the information and operate any necessary programs.

Industry Professional Feedback: John O' Keefe, Clark Construction

The final session of the roundtable involved a small group of students meeting with an industry professional and discussing possible research topics based on the sessions attended earlier in the day.

My meeting was with John O'Keefe of Clark Construction where we discussed how safety through design and facility management information delivery could be applied to the University Engineering Building. When looking at safety through design, the idea was thrown around of not just thinking of design as the architects and engineers but also as the contractor, where they can design safety hazard solutions during construction to increase site safety. He used the example of a system implemented by Clark where fall nets are embedded in or attached to columns where there are floor openings to prevent material and workers from falling through and sustaining injuries. We also discussed the use of site utilization plans in conjunction with University alerts to plan crane picks, walkways, deliveries and other activities that create potential safety issues.

When discussing the second breakout session, which he also attended, Mr. O'Keefe talked about looking at the function of the building when figuring out the transfer of information. Since the building is mostly lab space and used for research, don't concern the facility manager with efficiency and other energy savings but to focus on functionality and keeping the building up and running. We also discussed ways of training and teaching the operations personnel to use programming and with maintaining the equipment. I posed the idea of using a system where you could scan the pieces of equipment and the information would be displayed on an iPad or able to be uploaded to a laptop. He then came up with the idea of having that information stored in the BIM model and the personnel would only need to navigate the model enough to click on the equipment to bring up the information. He also informed me on the program Maximo and how it can be used to ease the use by the operations personnel use, but is time consuming and difficult to get to that end stage. Overall, I feel that our discussion produced some interesting research ideas for the next semester.

APPENDIX A – PACE ROUNDTABLE SUMMARY SHEETS

22nd Annual PACE Roundtable Summary

Session #1: Safety – Prevention through Design

Research Ideas:

1. How can the University affect the safety culture for the project from the onset
    a. University's safety plan collaborating with Massaro's safety plan
    b. Maintaining that safety culture once construction has begun
2. Creation of an alert system the University can use to notify students of upcoming events
    a. Construction activities and associated safety hazards
    b. Email, Text system, similar to what Penn State uses
    c. Costs associated with this
    d. Notification of walkway detours, other items that directly affect students

Session #2: Efficient Delivery of Facility Management Information

Research Ideas:

1. The transition of the building from CM to FM
    a. Information complexities
    b. Training
    c. What exactly to turnover that is beneficial
    d. Programs that would be beneficial (Maximo)
2. Ways to allow for easy access of information
    a. Custom Equipment, that requires detailed information sheets
        i. Having the information available by clicking on the item in the BIM model
        ii. Creating a scanning program where the equipment can be scanned and would be directed to information via iPad
    b. Teaching the operations managers on how to use software
        i. Costs and Time associated

Industry Member: John O'Keefe – Clark Construction

Key Feedback:

Breakout Session #1:

- Look at safety through design by contractor and owner, not just design team
  - Contractor designs for safety features, fall protection, trip hazards, etc.
- Create Site Utilization Plans with the heavy focus on factors that affect the general public
  - Crane picks
  - Vehicles/Deliveries
  - Walkways, Paths

Breakout Session #2:

- Improve the handoff between CM and FM due to the building's complexity
- Don't look at it as maintaining and monitoring the building's energy efficiency
  - Since it is a lab building used for research the focus is on functionality, not efficiency
- Information and training associated with the handoff and ease of access to information, whether electronic or hardcopy
- MOP
  - Proceedure: Construction – Commissioning – Turnover – Maintenance

Suggested Resources:

Facility Managers

OPP at Penn State – Dr. Dubler, Dr. Gannon

Project Team and Owner for Safety

Penn State's BIM Guide for Owners – ties into facility management