TECHNICAL ASSIGNMENT 3

November 15, 2013

SOUTH HALLS RENOVATION: EWING-CROSS

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Construction Option

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SOUTH HALLS RENOVATION: EWING-CROSS

EXECUTIVE SUMMARY

Technical Assignment 3 investigates the specific areas of the South Halls Renovation that are good candidates for research and further analysis. This includes the examination of the project's critical path and schedule acceleration scenarios, value engineering, and critical industry issues. Through the analysis of these areas, several ideas for technical analysis can be derived.

After analyzing the critical path for the Ewing – Cross renovation, it was determined that the critical path could be divided into seven main categories. Each category was analyzed to see if there was any room for potential acceleration. The North side first floor meeting room and the ground floor mechanical rooms pose the largest obstacles to the project's completion. It was found that simplest solution to accelerating the schedule would be to accelerate the follow-on finishes in these two areas. This would be accomplished through the use of increased manpower and overtime.

Some of the value engineering ideas that were implemented on Ewing – Cross include the use of a two pipe heating/cooling system for student rooms, using recycle rubber and plastic slate shingles, the limestone veneer panels, and the meeting room air handling units. Although a majority of the value engineering on Ewing – Cross sought to reduce cost while maintaining quality, there were some ideas that increased the cost of the project but also increased the quality, such as the addition of the overflow lounge. There were also several value engineering ideas that were considered but not implemented, such as the bathroom tile and the use of vertical fan coil units.

Critical industry issues were discussed with industry professionals at the 22nd annual PACE Roundtable Meeting. The event gave students an understanding of some of the current industry trends and several possible areas for further research. The breakout sessions covered information management for the workforce and planning on retrofit projects.

Technical Assignment 3 concludes with the feedback from the industry roundtable, where students were provided with the opportunity to meet in small groups with an industry professional. This small group meeting generated several research opportunities for students to pursue that dealt with the topics discussed at the PACE Roundtable.

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SCHEDULE ACCELERATION SCENARIOS

The Ewing-Cross Renovation construction began on May 14, 2013, and is set to conclude on January 14, 2014. The first phase of the South Halls Renovation, Haller-Lyons, took twelve months to complete and served as a baseline for the future phases, which are scheduled at seven month construction periods each. The construction schedule stands as the biggest risk to the project team, with the substantial completion being particularly important. This section will discuss the construction project's critical path, along with the associated risks, and potential schedule acceleration areas.

CRITICAL PATH

The critical path encompasses several construction activities during a seven month period, or essentially, the entire construction duration. These construction activities can be grouped into 7 main activities or areas, which can be seen in Figure 1. There are two main areas that drive the construction of Ewing – Cross; the North meeting room and the ground floor mechanical spaces. Both of these areas are on the critical path, meaning that any delays in these areas could potentially push back the completion date for construction.

In addition to the critical path, substantial completion is also a top priority for Penn State. Students are scheduled to move back into Ewing – Cross in early January 2014, and the owner will need as much time as allowable for cleaning as well as owner fixtures, furniture, and equipment.

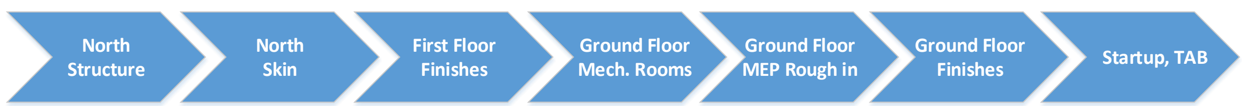

Figure 1: Critical Path

RISKS TO COMPLETION

As can be seen in the detailed construction schedule from Technical Assignment 2, the North structure and skin mainly includes the construction of the North Meeting Room. The North Structure begins with the new foundations for the columns and slab of the North meeting room. Upon completion of the foundations, the superstructure follows and includes the steel columns and beams for the meeting room and wrap around porch. The North skin follows the structure, as observed on the critical path, and includes the masonry and storefront glazing to enclose the meeting room. The North structure and skin is followed directly by the first floor finishes, because the meeting room needs to be structurally complete and enclosed prior to the finish installation in this area. When looking at the detailed construction schedule, the first floor rough-in and finishes takes 91 days, while upper floors only take 73 days; this is due to the fact that the meeting rooms only exist on the first floor, and makes the total footprint of the first floor larger than the upper floors. This puts the first floor on the critical path for two reasons: the construction follows a top-down sequence, and the total duration for the first floor is longer than the upper floors.

Some of the risks associated with the completion of the meeting room and North side structure and skin could be delays due to material deliveries. There have been several delays due to the acquisition of limestone veneer panels for the stone panel projections. The coordination of installing the limestone panels and the other exterior facades is critical; delays in the installation of the limestone panels affect the rest of the building's skin because there is limited area for laydown, sequencing, and mobilization. If the limestone panel installation is pushed back by two weeks and overlaps with the installation of the cornice and masonry at the North meeting room, then the entire critical path of the North side facade has the potential to be pushed back.

Concurrent with the North structure, skin, and finishes, the ground floor mechanical room and ground floor finishes are also on the critical path. Work on the ground floor begins with the mechanical room(s) fit out, which takes approximately 60 days for each mechanical room. The mechanical room(s) fit out puts nearly every other activity on the ground floor on the critical path; which includes the MEP in-wall and overhead rough in, as well the ground floor finishes.

There are several potential risks associated to completing the mechanical rooms on time, the largest one being a delay in the installation of equipment. Any delays in material or equipment deliveries would trickle down to effect the entire critical path. If the mechanical equipment is not installed on time, the MEP rough-ins cannot be fully tied into the systems and completed. If the rough-ins cannot be completed, then the finishes on the ground floor would in turn, be delayed. All of these delays would add up to result in lost productivity and a lot of wasted manpower, potentially increasing labor costs.

The entire critical path comes down to the closeout activities, which includes the startup of mechanical equipment, testing and balancing, and commissioning. All of this leads into the turnover of Ewing – Cross to Penn State for the spring 2014 semester. If the ground floor mechanical spaces and the North meeting room are not completed on time, it would cause delays in the startup of mechanical equipment, which in turn, could potentially push back substantial completion and turnover to the owner.

POTENTIAL ACCELERATION

As previously mentioned, there are two main areas which are on the critical path; the North meeting room and the ground floor mechanical rooms. These two areas have the biggest impact on the project schedule, and as such, both are started at the beginning of the project. Overall, the schedule is driven by the desire to get the mechanical equipment up and running. If there were delays in the schedule due to activities on the critical path, there are a few areas that could be accelerated to ensure the project is still delivered on time.

To make up time lost due to delays in the critical path, there is a potential to accelerate the follow-on finish activities, such as the framing, insulation, and drywall. The framing and drywall specialty contractor would do this by increasing manpower and working weekends and overtime. This is the best area for potential acceleration because their work occurs towards the end of the critical path and by working after normal hours or during weekends, it would ensure that the site does not become over-congested with laborers, resulting in decreased productivity.

A unique potential for acceleration on South Halls resides in the turnover itself. Typically on smaller sized renovation projects such as Ewing – Cross, the building is turned over to the owner once construction has reached substantial completion. Due to the fact that the construction schedule is only seven months long, a phased turnover schedule was looked at to allow Penn State to have certain floors before the rest of the building would be complete with construction. There are a multitude of logistical and coordination challenges that come with phasing the turnover of a building. As previously stated, Ewing – Cross follows a top-down construction, which means that the upper floors (4, 3, 2) will be finished prior to the lower floors (first and ground). This essentially results in the owner having to traverse through an active jobsite to reach the upper floors. In addition, the deliveries of owner FF&E will need to be coordinated in such a way that those deliveries do not interfere with the project team or any of their deliveries. If these obstacles weren't enough, student belongings, located in the next phase of the South Halls project (Cooper – Hoyt), will need to be relocated to Ewing – Cross. An overlap between turning over Ewing – Cross and mobilizing for construction at Cooper – Hoyt creates another layer.

Despite the challenges of turning Ewing – Cross over in phases, it would still allow for a quicker completion of the project than if the project team were to wait until substantial completion to turn over the building to Penn State. Over a ten week period, the project team plans to phase the punching out of floors to allow the owner to start moving into the building while construction continues to wrap up. This approach has the potential to ensure that the project is still delivered on time, even if there were delays due to the critical path because the project team could wrap up construction on the first floor (meeting room) and the ground floor (mechanical room) while Penn State starts their cleaning and move-in on the upper floors.

VALUE ENGINEERING

Throughout the design and construction of the South Halls Renovations, value engineering has been implemented in various ways. What is unique about the South Halls project is the fact that it essentially involves renovating the same building four times; this means that there is potential for improvement and implementation of lessons learned from the construction of previous phases. Value engineering is a method used to reduce the cost of a portion of the project, while maintaining the same level of quality. It can also be used to improve the quality without increasing the cost. Value engineering is often misunderstood and used simply as a means to cut costs, for the sake of maintaining the budget. However, on South Halls, the contractor, design team, and the owner worked together to analyze the various systems that had potential cost savings, all the while maintaining the high level of quality that Penn State demands.

Student Rooms

The first way that value engineering was implemented in the student rooms was by redesigning the wireless keycard entry. During the initial design for the South Halls Renovation, Penn State wanted to put wireless keycard entry to each student room, as opposed to a traditional key and lock. Utilizing keycard entry for student rooms would have allowed Penn State to eliminate the need to distribute additional keys, as each student is already required to have a student ID. However, it was determined that the cost to implement wireless card entry would have resulted in exceeding Penn State's budget, due to the sheer number of card swipes needed, as well as additional in-wall wiring. The project team instead opted to use lock and keys, in line with what Penn State typically uses in residence halls. This somewhat detracted from Penn State's goals, but was ultimately deemed necessary due to budget constraints.

The second way that value engineering was implemented in the student rooms was through the design of the mechanical system. All student rooms are conditioned through the use of fan coil units, which are supplied by a two-pipe system. Using the two-pipe system in the student rooms, as opposed to a four-pipe system like the rest of the building, effectively cut the lineal feet of piping to student rooms in half. A two pipe system is capable of only supplying either hot or chilled water, while a four-pipe system can supply both heating and cooling simultaneously; this means a four-pipe system would have a wider range of temperatures. The owner determined that use of the two-pipe system was acceptable because full temperature control was not necessary.

Building Skin

In regards to the building's skin, there are two main areas where value engineering was used. The first is in the roofing material selected. Traditionally, Penn State uses slate shingles because they are very durable and have the high level of quality that Penn State expects from the products they choose. However, for the South Halls renovation, EcoStar shingles were looked at as a viable alternative to slate shingles. EcoStar shingles are made from recycled rubber and plastic, and are made to look like actual slate shingles, as can be seen in Figure 2 below.

The benefits of using EcoStar rubber shingles are really three fold. In regards to cost, the shingles are significantly cheaper than actual slate shingles. In addition, the rubber shingles are installed much in the same manner as traditional asphalt shingles; the shingles simply need to be nailed down to the roof sheathing. This results in a simplified installation, when compared to slate shingles, and translates to a reduced cost in labor. There are also schedule benefits to using the rubber shingles; the total roofing duration can be reduced because the process for installing the rubber shingles is much quicker than slate shingle installation. Finally, because the rubber shingles are made from 80% post-industrial rubber and plastic, the shingles are sustainable, and help the South Halls renovation in achieving LEED points in the Materials and Resources category. Overall, the use of EcoStar rubber shingles in lieu of slate shingles stays in line with Penn State's goals because the shingles still meet their quality expectations, while reducing the cost and schedule of the project.

vs.

Figure 2: Slate Shingles vs. Rubber Shingles | images courtesy of Google images

Value engineering was also implemented in the use of the limestone veneer stone panel systems, as opposed to using full limestone panels. The stone panel systems for the wall projections consist of 1/4 in. limestone veneer on metal backing, which is secured to the 5/8 in. exterior sheathing, and the sheathing is backed by 6 in. metal studs. The limestone veneer stone panel systems allow for a much lighter façade, which can be manually lifted and placed by workers. The lighter façade system also means that the structural system for the building skin carries less load; had full limestone panels been used, the structural system may need to be stronger to carry the increased load. The limestone veneer stone panel system also helps to accelerate the schedule of the building skin; because the limestone panels are lighter than traditional limestone façade, the panels can be lifted and placed by laborers only using hydraulic scaffolding. This cuts down on the amount of crane time needed for the building façade as well. However, the cost of the limestone veneer stone panels is significantly higher than that of traditional full thickness limestone panels. The cost increase was deemed acceptable because it allowed for the building skin schedule to be shortened. Overall, the use of the limestone veneer stone panel systems stayed in line with the owner's goals because the schedule was reduced while still maintaining the look and quality of full limestone panels.

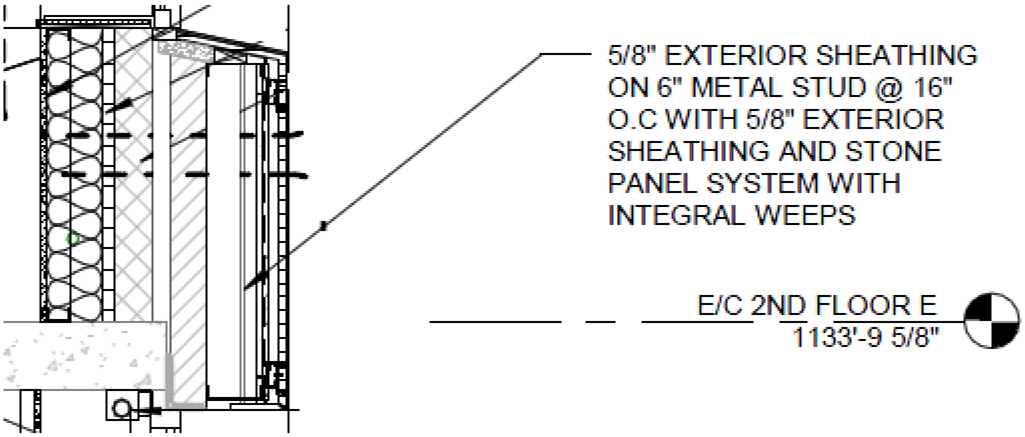

Figure 4: Building Facade Section | AE 321

Figure 4: Limestone Panel System | Quaid Spearing

Overflow Lounge

Initially, the overflow lounge on the ground floor (see Figure 5) was intended to be a storage space. However, during the design phase, it was suggested that this area be used as a common lounge/overflow bedroom. By converting the storage space in an overflow bedroom, Penn State was able to gain six (6) additional beds. This may not sound like much, but when on-campus housing is pushing maximum capacity each year, every bed counts. Adding the overflow bedroom to the scope of the project increased the total cost, because the finish level for a bedroom space exceeds the level of quality for a storage space. However, the increased cost is offset by the increased payback from increasing the bed capacity. Even though the project's cost was increased, implementing the overflow bedroom stayed in line with Penn State's goals by increasing the return on their investment, and it also allowed them to better meet the demand for student housing on campus.

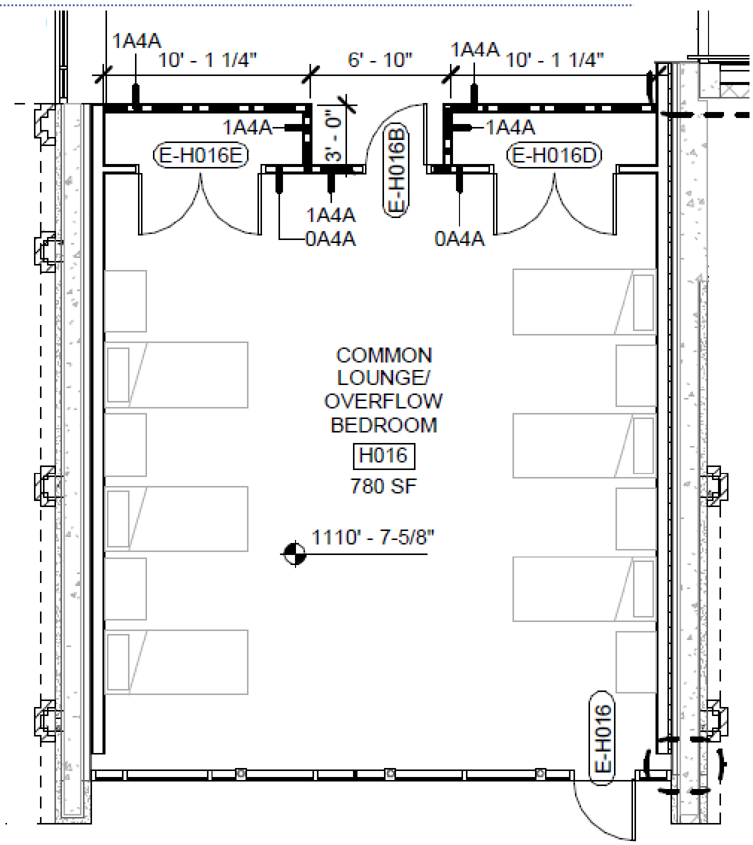

Figure 5: Overflow Lounge | AE 110

Meeting Rooms

During the early design of the mechanical systems, the energy recovery ventilation (ERV) units were intended to serve the two first floor meeting rooms. However, it was determined that there was a potential for cost savings if the two meeting rooms were supplied with their own, 1,700 CFM air handling units (AHU). By implementing separate AHUs for the meeting rooms, the supply ductwork from the ERVs on the ground floor to the first floor meeting rooms was entirely eliminated. This decreased a significant portion of sheet metal needed for the job, which more than offset the increased cost for the two air handling units. By using the AHUs, there were also schedule savings; installing ductwork is labor intensive, and by reducing the overall length of ductwork needed on the project, the project team was able to save time and money on the mechanical system. Utilizing separate air handling units for the meeting rooms kept in line the owner's goals because they still maintained the same level of environmental control, while achieving some savings in cost and schedule.

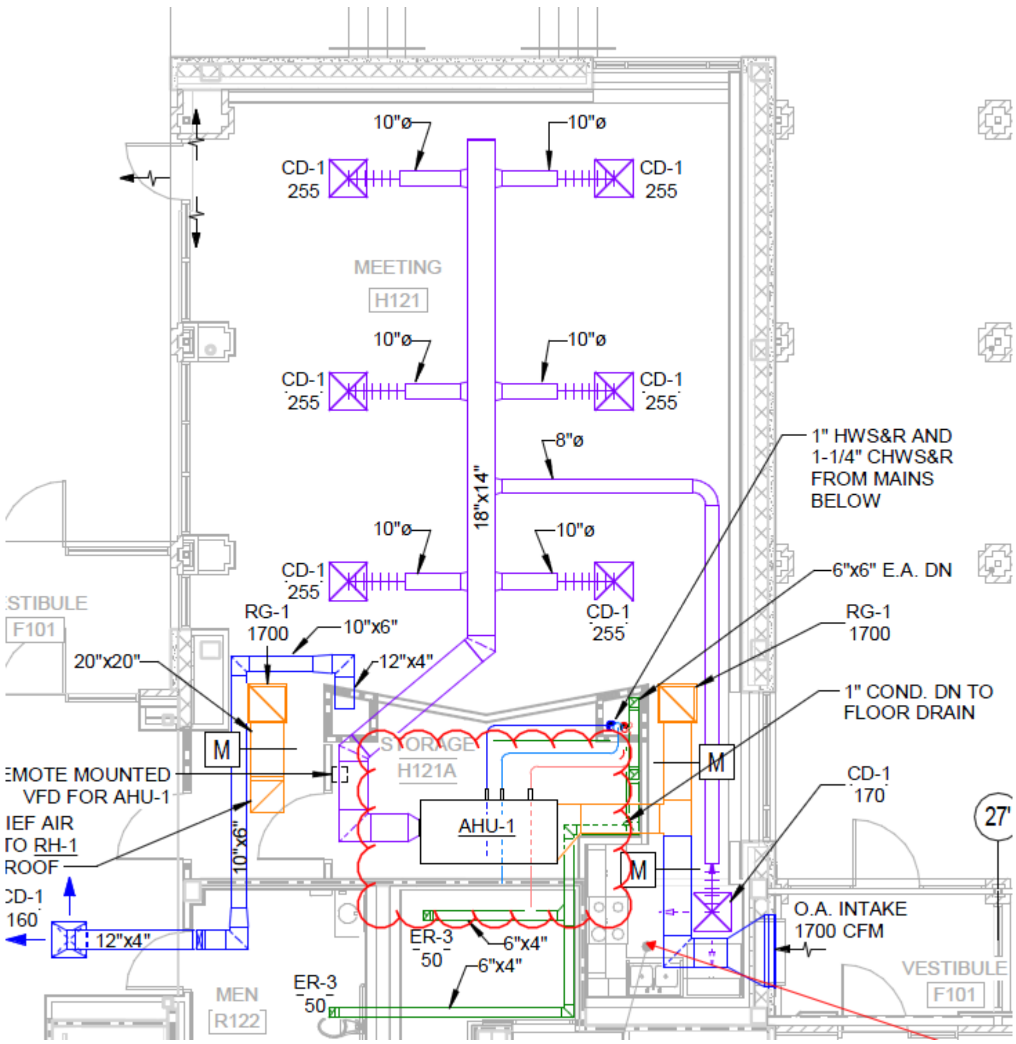

Figure 6: AHU at Meeting Room | MH 111

VALUE ENGINEERING IDEAS NOT IMPLEMENTED

While there is a plethora of value engineering ideas that were implemented on Ewing-Cross, there are also a few ideas that were not applied. Early in the design phase, the project team considered using vertical fan coil units to heat the student rooms, as opposed to the horizontal units which were used. Using vertical FCUs would have reduced the total length of horizontal piping required by placing the units in series vertically. However, the owner did not like the look of the vertical units, when compared to the horizontal units, which sit underneath the windows. In addition, the vertical units would be placed in a corner, resulting in an asymmetrical room layout; Penn State tries to keep the student room layout symmetrical so as to allow the two students who share a room to have an equal amount of space. Ultimately, Penn State felt that room layout was more important than the cost savings in using vertical fan coil units.

Another area where value engineering ideas were not implemented was in the bathrooms. The wall tiles in the bathrooms are full height, and are installed at a 45 degree angle. The 45 degree angle achieves the aesthetic look that the owner desires, but it also makes tile installation much more difficult, when compared to a 90 degree installation. Installing tiles at full wall height is also much more costly than just installing to half height. However, having the tiles cover the entire wall increases the durability and quality of the bathroom walls, and makes cleaning and maintenance significantly easier. While choosing a simpler installation method and only using tiles to half wall height would reduce the cost for material and labor, the owner felt that increased costs were justified to achieve the look and level of quality that they wanted.

Typical of Penn State projects, quality is of the upmost importance. While a wide variety of value engineering ideas were implemented throughout the construction at South Halls, if a VE idea decreased the quality of the project, they were not implemented. Although some value engineering ideas increased the project cost, they improved the quality of the project or helped to reduce the construction schedule, which is the other critical aspect of the project. Generally, the project team implemented ideas that decreased the cost of the project, while maintaining the level of quality that the owner expects. Overall, the value engineering ideas implemented on Ewing-Cross proved to be a success by maintaining or even increasing the quality of the project.

CRITICAL INDUSTRY ISSUES

The 22nd annual PACE (Partnership for Achieving Construction Excellence) Roundtable Meeting was held on November 7th, 2013 at the Penn Stater Conference Center. This year's PACE Roundtable focused on Whole Project Delivery. The meeting began with an introduction of some of the research and projects that Penn State is working on, followed by two breakout sessions, a guest lecture presentation, and concluded with focus groups, to allow students to get feedback on research topics. The breakout sessions covered three main areas: Sustainability, Information Technology, and Integrated Processes. The two breakout sessions attended gave students and industry professionals the opportunity to discuss some of the leading construction industry trends. They also served as a way for students to gather information and ideas for potential thesis research topics. The guest lecture was given by Patrick Harrison and he discussed how ideas and systems integration from rail projects can be implemented in the commercial building industry. The final small group meetings allowed students to meet with an industry member and discuss and gain feedback on what they had learned at the breakout sessions they attended throughout the day. The following sections focus on the two breakout sessions and the focus group discussions.

BREAKOUT SESSION 1-B: INFORMATION MANAGEMENT FOR THE WORKFORCE

The first breakout session that was attended was "Information Management for the Workforce". The session was led by Dr. Messner, and the session began with a discussion about what information the workforce actually needed to put work in place.

The initial discussion centralized around the idea that more often than not, the right information isn't put into the hands of the people putting the work in place. Several industry members discussed the wide variety of information that is provided on drawings, and how much of that information is not value adding to the project. Since the implementation of CAD drawings, there has been a shift to provide as much information as possible, even if that information is not necessarily useful during construction. The designers need to find better ways to represent the information that they are providing. The group then shifted focus to discuss information within the design model; can information be obtained directly from the model, rather than always relying on the drawings? This then begs the question of how reliable the model is. Often, the exact dimensions and other crucial information are not built into the model; they are typically overlaid on the 2d plans. If all the trades used the model for information gathering, rather than drawings, then each trade would need access to the central model, rather than a copy. If everyone had access to the model, then subcontractors could see live changes. This would greatly speed up the process of changing a part of the design in the model, updating the drawings, and then issuing the updated drawings. There seemed to be a consensus among the group that the industry is slowly heading towards more use of the model, but it will be difficult with the way contracts are set up; even with drawings designed directly from a 3d model, the information obtained from the 2D drawings still outranks the information gained directly from the model.

The group discussed how the construction industry has a plethora of tools, yet there are few that can talk to each other through a shared interface. This leads to a lot of model redesign for a project team to obtain the information they need. It was brought up that smartphones have a wide variety of apps that all work differently, but are still able to communicate with each other through the device's operating system. Another issue is that many construction companies use their own custom tools for tracking information such as RFIs and submittals. This makes it difficult to implement other tools that can communicate across the board. In addition, most of the companies that utilize custom tools have invested a lot of time in developing those tools, which leads them to strongly resist implementing newer and better tools.

In looking at Penn State as an example, they have implemented their own facility management team within the Office of Physical Plant (OPP) that handles integrating all of the O&M information into the 3D models from the major construction projects on their campuses. At the time that Penn State started using 3D models for facility management, there was not a lot of software available, so they started customizing their own. Now that the industry has caught to where Penn State is, with respect to facility management, it could be more beneficial to allow the contractors and architects build the facility management model; the project team fully understands the model and the as-built structure, and could integrate the facility management information for Penn State. There is a potential to research how Barton Malow would perform the modeling for the facility management, as opposed to OPP making the model. Analysis could be completed to see how efficient the contractor would be, compared to the owner, and if there is a potential for cost savings by having the contractor own the facility management model within their scope.

In discussing the problems with tools being interfaced, the session shifted focus to the topic of many workers not knowing how to use the technology. There has been a cultural shift to use electronic information in the field, but many of the superintendents and foreman on projects still prefer paper drawings. Often, recent graduates join a construction company and learn the industry practices from older project managers and superintendents. One industry member brought up the concept of reverse mentoring; educating young engineers to be effective mentors to employees with less technical background. This is an interesting concept that could help in reducing the technological gap between generations of workers.

Another issue that was discussed during the session was who should model which items; when should design-assist subcontractors take over modeling from the architect/engineer? Often, an A/E will model a particular system, perhaps the ductwork, only to later find out that the way they laid the ductwork out will have too many coordination issues with other trades. If the design-assist subcontractor knows the best way to lay out the job, and will need to remodel the architect's work, there is a significant amount of time wasted on design iteration. One industry member brought up the point that it becomes difficult to allow the subcontractors to develop the models, because then the architect feels that he is losing part of his scope of work. In addition, the cost to the owner can vary, depending on who models the various scopes of work. The type of project delivery method also has an impact on who handles which parts of the model; design-build and IPD projects bring the subcontractors onto a project early, so there is potential to allow the whole project team to work together in developing the model. Given that South Halls is a design-build 'IDP-like' project, an interesting research opportunity would be to analyze how effective the project team divided the scope of work for modeling. It could be investigated to determine if there was any waste due to design iteration, and how efficiently work was transferred from the architect-engineer to the design-assist specialty contractors. It would also be relevant to analyze the contracting strategies to determine if the contract itself hindered the project team parties from modeling certain work.

BREAKOUT SESSION 2-A: PHASING ON RETROFIT PROJECTS

The second breakout session, led by Dr. Leicht, focused on the Phasing on Retrofit Projects. The session began with the group brainstorming some key challenges that arise when phasing a building for retrofit work. One of the key challenges to phasing on retrofit projects is ensuring that the owner and building occupants fully understand the impact of the construction. The owner and building occupants need to communicate their expectations and fully understand the level of inconvenience that they will experience; often, because most owners do not fully understand the construction process, they underestimate the inconvenience that will occur during a retrofit. Another challenge to phasing on retrofit projects is the continuity of workflow. A lot of thought process goes into planning how the work will be phased, while maintaining the facility operations. Scott Mull, with Barton Malow, mentioned that on the South Frear renovation project, there were a multitude of challenges with phasing the construction, while the laboratory facilities were still occupied. Site logistics can be challenging because the contractor needs to ensure that public safety and awareness is maintained; this can prove to be particularly problematic on a project where the site logistics changes every few months, as is the case at South Halls.

The session then shifted focus as the group discussed the drivers of a project's schedule duration. Like a typical project, milestones often drive the schedule. However, the group discussed several other factors that need to be considered in retrofit projects. For starters, the number of phases will be a schedule driver. On a university project, the academic calendar strongly dictates the phasing, especially if certain work can only occur during the summer, or when student residents will not be on campus. The schedule could also be driven by the locations of work; if there are particular sections or wings of a building that generate more revenue for an owner, the schedule may have to be built around getting those areas online as quickly as possible. It is crucial to engage the owner in determining the phasing schedule; while the project team understands the construction and how to do the work, they may not fully understand which areas/sections of a building are the most important to the owner.

An interesting topic that was discussed concerned how the retrofit construction's impact on the building occupants could be reduced. Doug Workman, with Alexander construction, explained how they are building isolated, temporary hallways on their renovation project at the Mount Nittany Medical Center; these temporary corridors allow the hospital staff to traverse between the construction areas without having to actually travel through the construction zone. Another way to reduce the impact on the building occupant is through the use of interstitial spaces, or buffer floors between the occupied spaces and the construction zones.

The discussion ended with the group determining the owner drivers for phasing on retrofit projects. These could include the number of moves that an owner needs to make during the construction, the amount of revenue that they stand to lose while they are unable to occupy their space, and possibly their budget. Phasing a project can prove to be beneficial to an owner because it allows them to spread the cost of the project out over several fiscal years, rather carrying the financial burden all at once.

Similar to the first breakout session, the Phasing on Retrofit Projects session gave students several ideas for potential research. In respect to South Halls, there is a potential to analyze how the project was phased, and what factors led to Penn State deciding upon renovating South Halls, as opposed to entirely new construction. An analysis of the cost and schedule differences could be performed to determine if new construction would be a viable option. Chace hall could be used as a model to get an idea of how the cost and schedule would be for the other four halls.

FEEDBACK FROM INDUSTRY ROUNDTABLE

The final activity at the PACE Roundtable was a small group meeting between three students and Dr. Craig Dubler, a Penn State professor. Dr. Dubler has several years of industry experience and currently works for the Office of Physical Plant at Penn State. The discussion began with each student summarizing what they had learned from the two breakout sessions that they attended and how some of those concepts could be applied to their thesis projects. Dr. Dubler and the students spent a large portion of the time talking about the needs of the client and/or building occupants, as all three students had projects that involve a portion of the building, or project area, being occupied during construction. The group discussed the pros and cons of retrofitting/renovating a building, as opposed to constructing new. Dr. Dubler also suggested that the students interview current building residents to analyze how the construction is affecting them or their daily operations. For the South Halls project, it could be beneficial to speak with residents who reside in Chace Hall and the first renovation, Haller-Lyons. This could provide an understanding of what the students like about the renovations and what areas could possibly be improved.

After discussing Phasing on Retrofit Projects with Dr. Dubler, the students had a good understanding of a few potential thesis research areas. Overall, the 22nd Annual PACE Roundtable was a successful event that provided a wide expanse of research topics to the students. Students were able to gain valuable feedback from industry professionals, as well as contacts for future research.

APPENDIX A: PACE ROUNDTABLE SUBMISSION FORM

SESSION 1: INFORMATION MANAGEMENT FOR THE WORKFORCE

Research Ideas:

1. How efficient was the design model handoff between the architect-engineer and the design-assist subcontractors?
    a. Could the design scope have been turned over to the DA subs earlier to reduce remodel work? How much of what the A/E modeled was converted to actual work put in place?
    b. What are the cost impacts of having different trades perform the modeling?
2. Is there a potential to decrease the amount of RFIs and change orders by involving the DA subcontractors early in the design process?
    a. How can the right information get put into the hands of the people who put the work into place early in the planning, as opposed to getting them information through multiple RFIs?

SESSION 2: PLANNING ON RETROFIT PROJECTS

Research Ideas:

1. Look into the possibility of building entirely new residence halls, as opposed to renovating.
    a. Perform a cost/benefit analysis of new construction vs. renovation
    b. Could interview current residents at Chace & Haller-Lyons Halls to determine what is liked and/or disliked about those residence halls.
    c. Could use Chace Hall as a model to determine the cost and schedule for building new
2. Look into the possibility of re-sequencing the construction at South Halls
    a. What would be the cost difference of building a lager new dormitory upfront and then renovating all four dormitories at once?
    b. Would there be a potential for schedule and general conditions savings by not phasing the renovation of the four halls?
    c. Would the owner have the potential to fill up a larger new residence hall, as well as four renovated halls?

INDUSTRY MEMBER DISCUSSION: CRAIG DUBLER – PENN STATE UNIVERSITY

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

1. Phasing on Retrofit Projects – Specifically analyzing the possibility of building new vs. renovating
    a. Cost Difference to build new v. renovate
    b. Would Maintenance be reduced?
    c. Integrating new MEP systems with existing systems
    d. Improved floor to ceiling heights at South Halls
        i. Research how the facilities could be improved
2. Phasing on Retrofit Projects – Could the project have been phased differently?
    a. Simultaneous renovations (2 or 4)
    b. Research how much money/schedule could be saved by adjusting the project phasing
    c. What would be the increase to the size and cost of the project management team?
    d. Would the new construction (Chace Hall) need to be larger to accommodate displaced students?
        i. Future Renovations at Penn State (East and Pollock Halls) a factor?

Suggested Resources: What industry contacts are needed? Is the information available?

1. Barton Malow – They have experience with retrofit and renovation projects.
    a. Scott Mull – Project Manager
    b. Nick Umosella – Project Engineer
2. Penn State Professors – Familiar with the owner's goals and needs.
3. Office of Physical Plant – Familiar with future projects at Penn State, fully understand the client's needs and the impacts of construction and phasing.
    a. Rich O'Donald – Project Manager

APPENDIX B: PROBLEM IDENTIFICATION AND TECHNICAL ANALYSIS OPTIONS

PROBLEM IDENTIFICATION AND TECHNICAL ANALYSIS OPTIONS

Although the South Halls Renovation has been a successful project thus far, there are several areas of the project that have room for potential improvement. These problematic sections will serve as the potential candidates for further analysis. Furthermore, the analyses performed for Ewing-Cross can be implemented on the remaining phases of the project, as Cooper-Hoyt and Hibbs-Stephens are nearly identical to Ewing-Cross.

BATHROOM SLAB STRUCTURAL SYSTEM

As described in previous technical assignments, the bathroom slabs take up a considerable portion of the project at 48 days. This can be accounted to the fact that the existing delaminated slabs need to be removed and then shoring for each new slab. In addition, tying in the new slabs into existing slabs was challenging. The restrooms are on their own critical path, so any schedule reductions would allow the restroom follow-on work to begin sooner. This would be very beneficial to the project because as it stands, all four floors are restroom finishes are working simultaneously, making it more difficult to coordinate manpower and maintain the level of quality the owner expects.

Rather than the bathroom structural slabs being cast-in-place, an analysis exploring the use of a precast concrete system will be performed. Redesigning the bathroom structural system would involve a structural breadth to ensure that all strength and load requirements are met using a precast system. Using precast concrete slabs would also involve removing the columns that are located in the restrooms. The analysis will focus on creating a self-supported structure for the restrooms, in an attempt to eliminate tying reinforcement bars from the existing structure into the new slabs.

In addition, a cost and schedule analysis will need to be performed to compare the precast structural system to the original cast-in-place system. The constructability of the precast system will be analyzed to identify if the alternative design eased the coordination and reduced the overall schedule of the bathrooms.

MODULARIZATION OF BATHROOM UNITS

Through an analysis of the bathroom structural system, another potential research area arises in the use of modularized bathroom units. The use of a precast concrete slab would create tighter tolerances and reduced variability in floor sloping and slab thickness than a cast-in-place slab allows for. There have been numerous quality concerns with the bathrooms, especially with the finishes, such as the tile work. This is in part because all because all four floors of restrooms are working simultaneously. By removing the construction of the bathrooms from the jobsite and placing them in a factory setting, there is potential improve the quality of the finishes. Modularization of the bathrooms would allow for a finalized unit to be installed, which would help to alleviate some of the rush to finish the bathrooms.

A technical analysis comparing the schedule, cost, quality, and constructability of a modularized bathroom unit versus the traditional stick-built would provide insight into the potential use of modularization at South Halls. Research would be required to understand the different levels of modularization and which level would be best for implementation on this project. The schedule would also be analyzed to see how modularization would affect the overall bathroom construction duration.

TWO-PIPE FAN COIL UNIT DESIGN

Early in the design of the South Halls Renovations, it was decided that a two-pipe system would be used to supply heating and cooling to student rooms. The main purpose for this decision was to reduce the cost of the mechanical system, as the other areas of the dormitory buildings are on a four-pipe system. While the two-pipe system was initially cheaper, it created other problems. For starters, the two-pipe system and fan coil units are not on the BAS. Because the two-pipe system uses the same supply and return piping for both heating and cooling, it becomes difficult for the system to quickly switch between heating and cooling, as the temperature fluctuates throughout the day. This type of problem is of particular concern during the spring and fall, or the transitional periods between the heating and cooling seasons. In looking at the first renovation, Haller-Lyons, there are a large number of students who have their windows open during the day because the mechanical system is still supplying heating because it was cooler the night before. This results in a lot of wasted energy literally being thrown out windows.

In order to alleviate this issue, a technical analysis looking at the redesign of the two-pipe mechanical system could be performed. This would involve analyzing the replacement of the two-pipe system with a four-pipe system, and the cost, schedule, and quality impacts of doing so. Obviously, a four-pipe system would cost more because it is essentially twice as much piping; however, a four-pipe system would be on the BAS and would better condition the student rooms.

The analysis will offer the opportunity for a mechanical breath, and will primarily focus on designing a four-pipe system that meets the heating and cooling load requirements and codes. A cost and schedule analysis will also be performed to compare the four-pipe system to the existing two-pipe design. Discussion with the owner would be performed to determine if the use of four-pipe system better aligns with their goals and needs.

CONSTRUCTION PHASING OF RENOVATIONS

The current phasing of the South Halls project sees the first renovation, Haller-Lyons, taking twelve months to complete, with the remaining three buildings taking seven months each to complete. This puts the total construction duration at approximately 33 months, from May, 2012 to January, 2015. Each of the renovated dormitories will house approximately 248 students. As such, the sooner that Penn State can have each dormitory back online, the more revenue they stand to generate. Having the project completed even one semester quicker would allow them to start their payback period that much sooner.

An analysis looking at the phasing of the South Halls renovation would be performed to determine if it would be feasible to accelerate the schedule by simultaneously renovating the dormitories. Research would be required to determine the best sequencing of construction; i.e. two buildings at a time, all four at once, etc. Renovating more than one building at a time would inadvertently affect several other aspects of the project that would then need to be analyzed. The cost would need to be analyzed to determine if and by how much the construction management and general conditions costs would increase, and if the additional revenue gained would offset increased management costs. The schedule would also need to be thoroughly analyzed to determine how much the total construction schedule could ultimately be reduced.

In addition, it would be beneficial to interview the owner because they would fully understand the flexibility that they have to house students in other dormitory complexes at Penn State. Re-sequencing the South Halls Renovation could ultimately tie into future projects that Penn State has planned, such as the East and Pollock dormitory renovations. If it were necessary to build a larger new dormitory at the beginning of the project to allow for renovating simultaneous buildings, this could then alleviate the burden of future renovations by creating more flexibility in student housing. Renovating multiple building would obviously increase site congestion; this analysis could be tied into the bathroom analyses, because utilizing a pre-cast structural system and modularized bathroom units would help in reducing site congestion by moving some of the construction offsite.

LIMESTONE PANEL FAÇADE

The limestone veneer panels used for the façade at South Halls are an alternative to using full sized limestone panels. The veneer panels used in lieu of traditional limestone panels because of their low weight and ease of installation. Each projection at Ewing-Cross can fully clad in limestone with caulking in five days. This is much quicker than traditional limestone panels, but the veneer panels are also more costly. A technical analysis comparing the cost, schedule and quality of traditional limestone panels versus the limestone veneer panels used would identify if the traditional panels would be a better alternative. The schedule would need to be closely analyzed to determine if the use of traditional panels would put the building’s façade on the critical path. Due to the fact that full sized limestone panels have a higher dead load when compared to the veneer panels, a structural analysis would need to be performed to determine if the structural system would need to be redesigned; the limestone veneer panels are currently backed by 6 inch metal studs and plywood sheathing.