Kaiser Permanente Largo Medical Office Building – Largo, MD

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Technical Assignment 3

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Executive Summary

The project team on the Kaiser Permanente Largo Medical Office Building has had several challenges to overcome throughout construction. Schedule has been the biggest obstacle as there has always appeared to be too little time for work to physically get done. This third technical report goes into much more detail of schedule challenges and problems that can be analyzed to accelerate this schedule. Other items researched for this report include a thorough LEED analysis, value engineering topics, the PACE Roundtable discussions, and identification of project problems to possibly be further analyzed.

Being that this project is not LEED certified, completing a LEED scorecard was quite challenging as there is currently no material tracking that's necessary for the different accreditation. Sustainability was a key focus for designers and engineers on this project, but reaching the certification requirements were not necessarily a goal. Even though the goal wasn't to get certified, it is believed that Kaiser Permanente's goals to improve the overall experience for the people occupying this facility will be met. 24 points have been achieved with a possible of 41 credits that may be achieved, and finally 45 credits are unachievable. Currently, the building would not qualify for LEED certification. At a maximum, the building could reach 65 points, or LEED Gold, but LEED Silver would most likely be the highest certification attainable.

As mentioned above, schedule has been the biggest obstacle on this project. The following section, Schedule Acceleration Scenarios, goes into detail about the limited areas that were able to be accelerated. Doing work out of sequence was a common occurrence on site as change orders would stop trades' progress in one area. Third floor operating rooms is one example of a way the schedule was accelerated, as a second crew was added to divide the work in half and reduce the overall duration. Another example discussed is the change order crew, a group that wears blue vests indicating their dedication specifically to change order work.

There were limited opportunities for value engineering on this project as preconstruction services were not performed by DPR. The tight schedule rarely permitted the project team the time to discover and justify potential areas to apply value engineering. Some areas the experienced team was able to implement value engineering included replacing roof deck spray-on fireproofing with exterior fire-rated gypsum board and eliminating unnecessary waterproofing from underneath the building slab.

Industry members from multiple states attended the PACE Roundtable discussions to learn more about critical industry issues. Improving efficiency through innovation was the theme. Sessions attended included measuring collaboration and modularization. Both discussions were very informative and interesting, while providing ideas for areas to analyze relating to this project. Some possible ideas that stemmed from these discussions were modularization of different systems to try to make construction more efficient. Also, a key discovery was the lack of integration on this project. As preconstruction services were not purchased from DPR, all sections of this report discuss the missed valuable input from healthcare-experienced team members. Closely related to that is the amount of changes required on this job. So many change orders have caused several problems, making the change order management process a feasible candidate for further research as an alternative process could possibly be beneficial.

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LEED Evaluation

Although this project is not going to be LEED Certified, there are several sustainable concepts incorporated into the design. The LEED Scorecard is separated into a total of seven subcategories. The evaluation focuses on design aspects of the three-story addition. Because the project is not LEED Certified, justifying credits achieved for the renovation (that is still in planning) would be very difficult. This evaluation focuses on the following categories; Sustainable Sites, Water Efficiency, Materials & Resources, and finally Indoor Environmental Air Quality. Energy & Atmosphere, Innovation & Design Process, and Regional Bonus Credits will be briefly discussed in minor detail.

Sustainable Sites

Credits 1 through 4.2 aren't applicable as this project consists of an addition and renovation to an existing building for reasons such as already having public transportation access. Credit 4.3 is addressed because charging stations for low-emitting and fuel efficient vehicles are provided in the parking garage. The garage was necessary for this addition.

Figure 1 - The stormwater management pond protection can be seen in the lower left of the image. This area has been protected throughout construction and the pond will be completely restored upon completion of the project. Image courtesy of DPR Construction.

Credit 5.1 and 5.2 are both addressed as the stormwater management pond (SWM) will be protected during construction and restored fully after completion. This pond and its protection can be seen to the right in Figure 1. The black fencing put in place cuts off access to this area and prevents any debris from falling down the bank and into the pond. Stormwater design has been taken into account as there are several bio-retention areas located on site, but whether or not related credit requirements will be achieved is undetermined.

Credits 7.1 and 7.2 have been taken into account as precautions have been made to prevent heat island effect. The parking garage was necessary as the new addition footprint removes a large amount of parking spaces. The four-story garage has 713 spaces, with roughly 75% of them being on the first three levels. This credit is achieved by having 50% of parking spaces covered with a roof with a solar reflectance index (SRI) of at least 29. The parking garage is concrete, which achieves the SRI requirement. It can also be seen in Figure 1 that the roofing material is white. Roofing is comprised of a durable, white, thermoplastic membrane intended to reflect light and absorb as little heat as possible, thus preventing the heat island effect. The final credit, credit 8, is the last Sustainable Site credit achieved as lighting fixtures with low light spillover have been selected to reduce light pollution.

Water Efficiency

Credit 1.1 and 1.2 are both satisfied through the landscaping design. Plantings with indigenous characteristics have been chosen because they don't typically require any more water than the natural environment provides. As water for landscaping is rarely going to be needed, no irrigation system is used on this project. Water use reduction credits have not been included as the actual amount of water reduction cannot be determined with the provided information. Some plumbing fixtures, not all, are sensor-operated. The ratio of men to women necessary to perform an accurate flush-usage calculation is unkown; therefore, it is indeterminate if water reduction credits are achieved.

Materials & Resources

Building Reuse, Material Reuse, and Recycled Content were the most difficult items to determine. For the renovation, it is best assumed that there are at least 75% of the existing walls, floors, and roof that will be maintained; therefore, credit 1.1 is achieved. It is also estimated that reuse of 50% of interior non-structural elements are going to remain in place. These credits are subject to change, however, as there are major scope amends expected for the renovation. Figure 2 is a prime example why Materials & Resources are difficult credits to determine. In the image below, the color purple represents areas where contract work is specified. Renovation areas highlighted green are places where work has been determined necessary, but are not included in the original scope. Renovation was expected to affect roughly a third of the 129,000 SF existing building, however that is expected to significantly increase.

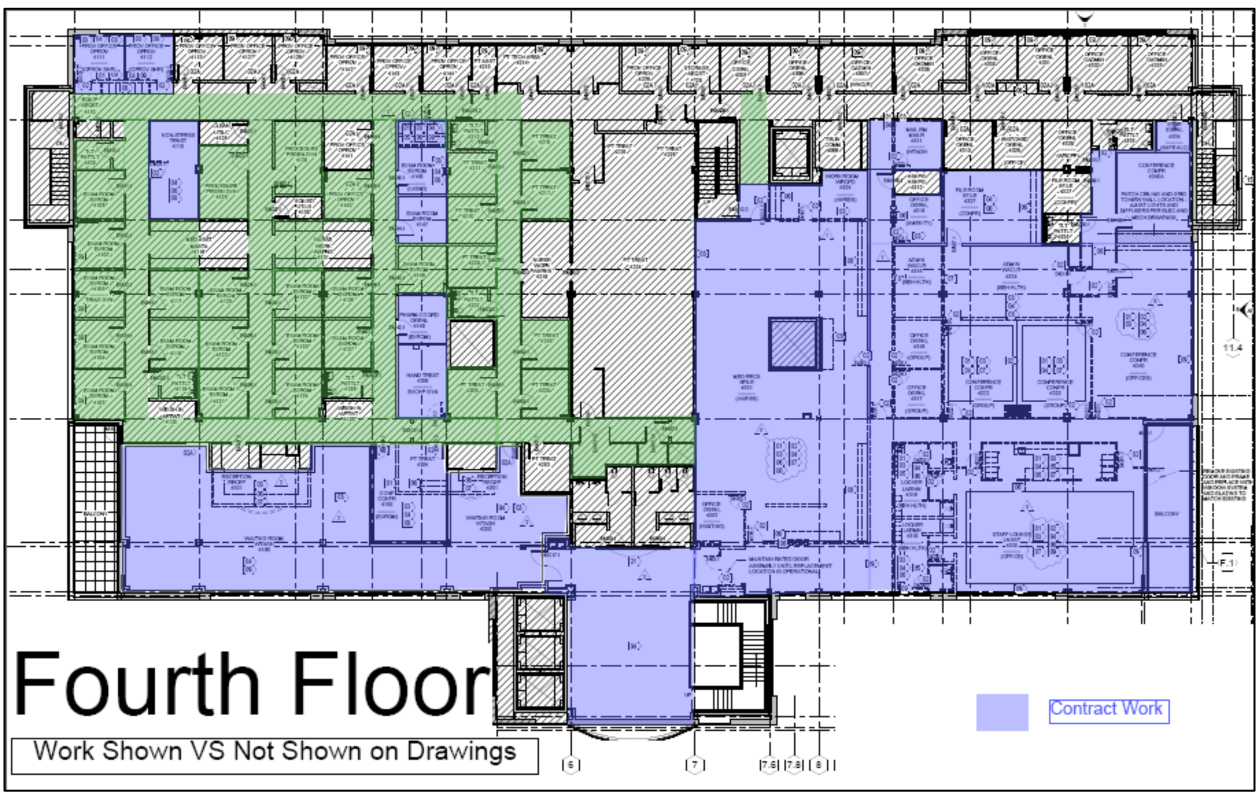

Figure 2 - Image of the existing building's fourth floor. Renovation areas in purple represent work to be done included in the original contract. Green areas represent spaces where work has been deemed necessary, but are not included in the original contract scope and are subject to change possibly altering the Materials & Reuse section of the LEED evaluation drastically.

Credits 2.1 and 2.2 are being achieved; it is a project goal to have at least 50% of discarded material recycled. Comingled dumpsters have been used throughout construction; so once filled, they are removed from site and separated into trash or recyclables. To date, less than 10% of materials has been taken to a landfill. As long as this pattern continues, a minimum of 75% of material will be diverted from disposal.

Materials have not been tracked to know whether enough items used are post-consumer or pre-consumer materials. Also, locations of suppliers and manufacturers were unable to be obtained for each building material to determine the percent of local material, so regional material percentages could not be determined. No use of rapidly renewable materials and certified wood has been specified.

Indoor Environmental Quality

Credit 1 is included as permanent monitoring equipment has been installed to indicate if a space is occupied and can decrease output to reduce energy usage if the space is vacant. Credit 3.1 and 3.2 were not applicable as there wasn't a specific management plan required to be put forth, although precautions have been taken as all mechanical ductwork delivered to site was sealed until installation to keep ductwork clean along with other safeguards. Credits 4.1 through 4.3 have all been addressed as low-emitting volatile organic compounds (VOC) have been selected. Along with low-emitting adhesives and paints, rubber flooring produced by nora flooring, Inc. has been chosen for its durable and low-emitting qualities. Because very few composite wood & agrifiber products could be determined, credit 4.4 is unknown.

Because the Building Automation System (BAS) controls all of the thermal systems, credit 6.2 is achieved. This is the final of the IEQ credits that can be determined. Even though a large amount of façade is glass or windows, the building's large footprint doesn't provide daylight and views to 75% of the total space. Although sustainable measures have been taken, enough detailed information is neither available for all systems nor adequate enough to determine if credit requirements are met.

Energy & Atmosphere

Energy & Atmosphere includes the fundamental commissioning of the building energy systems and minimum energy performance which are prerequisites; however, energy performance optimization percentages have not been calculated nor is there on-site renewable energy. The Enhanced Refrigerant Management credit is possible as a non-CFC/HCFC, "ozone safe" refrigerant is used, but other refrigerants are used so this credit has not been determined.

Energy & Atmosphere is the category worth the most towards the overall score, with 35 total points available. An example of the scorecard can be seen on the following page, in Figure 3. This section has the most potential because of the 19 available points for optimizing energy performance. Unfortunately, the energy usage in the addition or renovation won't be known which leaves 19 points unknown.

Yes	?	No		Energy & Atmosphere	35 Points
0	24	11			
Y			Prereq 1	**Fundamental Commissioning of the Building Energy Systems**	Required
Y			Prereq 2	**Minimum Energy Performance:** 10% New Bldgs or 5% Existing Bldg Renovations	Required
Y			Prereq 3	**Fundamental Refrigerant Management**	Required
	?		Credit 1	**Optimize Energy Performance**	1 to 19
				12% New Buildings or 8% Existing Building Renovations	1
				16% New Buildings or 12% Existing Building Renovations	3
				20% New Buildings or 16% Existing Building Renovations	5
				24% New Buildings or 20% Existing Building Renovations	7
				28% New Buildings or 24% Existing Building Renovations	9
				32% New Buildings or 28% Existing Building Renovations	11
				36% New Buildings or 32% Existing Building Renovations	13
				40% New Buildings or 36% Existing Building Renovations	15
				44% New Buildings or 40% Existing Building Renovations	17
				48% New Buildings or 44% Existing Building Renovations	19
		N	Credit 2	**On-Site Renewable Energy**	1 to 7
				1% Renewable Energy	1
				5% Renewable Energy	3
				9% Renewable Energy	5
				13% Renewable Energy	7
		N	Credit 3	**Enhanced Commissioning**	2
	?		Credit 4	**Enhanced Refrigerant Management**	2
	?		Credit 5	**Measurement & Verification**	3
		N	Credit 6	**Green Power**	2
Yes	?	No			

Figure 3 - The Energy & Atmosphere section taken from the LEED scorecard. This section has the most points available. 11 credits are certainly not achieved, but the building has the potential to earn anywhere between 1 and 24 points, mostly depending on its energy performance.

There is no way to know for sure if the necessary verification for credit 5, Measurement & Verification, will take place. Innovation & Design Process and Regional Bonus Credits are not applicable as LEED certification was not achieved, but there was a LEED accredited professional on this project.

To the best of my ability, it has been determined that 24 points have been achieved. There is a possible of 41 credits that may be achieved, with 45 credits unachievable. Currently, the building would not qualify for LEED certification. At a maximum, the building could reach 65 points, but LEED Silver would most likely be the highest certification attainable. Although this project is not going to be LEED certified, the sustainability factors incorporated into the design are appropriate for the owner's goals. The main purpose of this project, other than expanding and improving the existing facilities to meet future healthcare demands, is to create an environment that improves the overall experience for the people in this facility. The interior space created has been designed to bring in as much natural light as possible where allowed and to provide outdoor views. Also, energy saving measures have been taken, as described above, to make the addition an environmentally friendly building.

Schedule Acceleration Scenarios

Time has been a factor since before construction was able to begin. As the owner provided building permit was received much later than anticipated, work started off behind schedule before it ever started. Due to this and weather that significantly delayed excavation and foundation work, many activities lost the little float built into the original schedule. This led to the much of the sequencing changes that were implemented throughout construction as discovered in Technical Assignment 2. An example of an activity done out of order includes roof construction starting before exterior framing could be installed on the upper floors. Steps such as this were necessary in order to keep construction flowing when unexpected challenges or delays arose. As Substantial Completion has already been changed from October 1, 2012 to the current February 11, 2012, the critical path has changed numerous times throughout construction.

Site utilities, footings and perimeter foundations, and structural steel were all on the critical path at the start of the project. Challenges with getting the building enclosed, which will be discussed more in the Problem Identification and Technical Analysis Options section, quickly put masonry work on the critical path and had its affect on other trades. Roofing, along with the façade, was on the critical path so the watertight milestone could be reached on September 20, 2012. Laying out and framing walls; and overhead and in-wall rough-ins were the critical activities moving from different building areas to different floors. Major finishing activities before final walkthroughs could take place that dictated work flow were installation of drywall and mechanical/electrical trim out.

Third floor operating room suites moved onto the critical path. Elevators have recently been readjusted to have zero float falling on the critical path. The critical path is completely different from what it was just a few weeks ago and has been updated almost daily for the last several weeks. Site work has actually been removed from the critical path, even though landscaping needs to be done before full winter affects cause the ground to freeze and prevent vegetation from being planted.

Change of work sequence was typically due to delays caused by untimely change orders. It was the goal of the superintendents to not let work stop altogether which meant moving on to another part of the building if necessary to keep work flowing. Even though there might not have been another way of doing things, possible alternative analyses to accelerate the schedule will be discussed later in this report. The rest of this section will describe some of the major risks to the schedule and ways that the project team has chosen to deal with challenges.

One of the biggest risks currently on the critical path includes the ConMed conduit and operating rooms (OR's). 2" ConMed conduit is used throughout each of the six major operating rooms on the third floor of Area C, shown in Figure 4. Each surgical room has roughly 20 outlets requiring this 2" conduit. ConMed conduit is necessary for the communication system. Systems are closely monitored by the nursing staff during surgeries and can be checked at nurse stations in this area of the building. A major issue putting the schedule at risk is the lack of detailed responses to past requests for information (RFI's). Due to insufficient coordination information involving the ConMed conduit details, rough-ins are behind schedule because outlet locations are not detailed or coordinated with other systems.

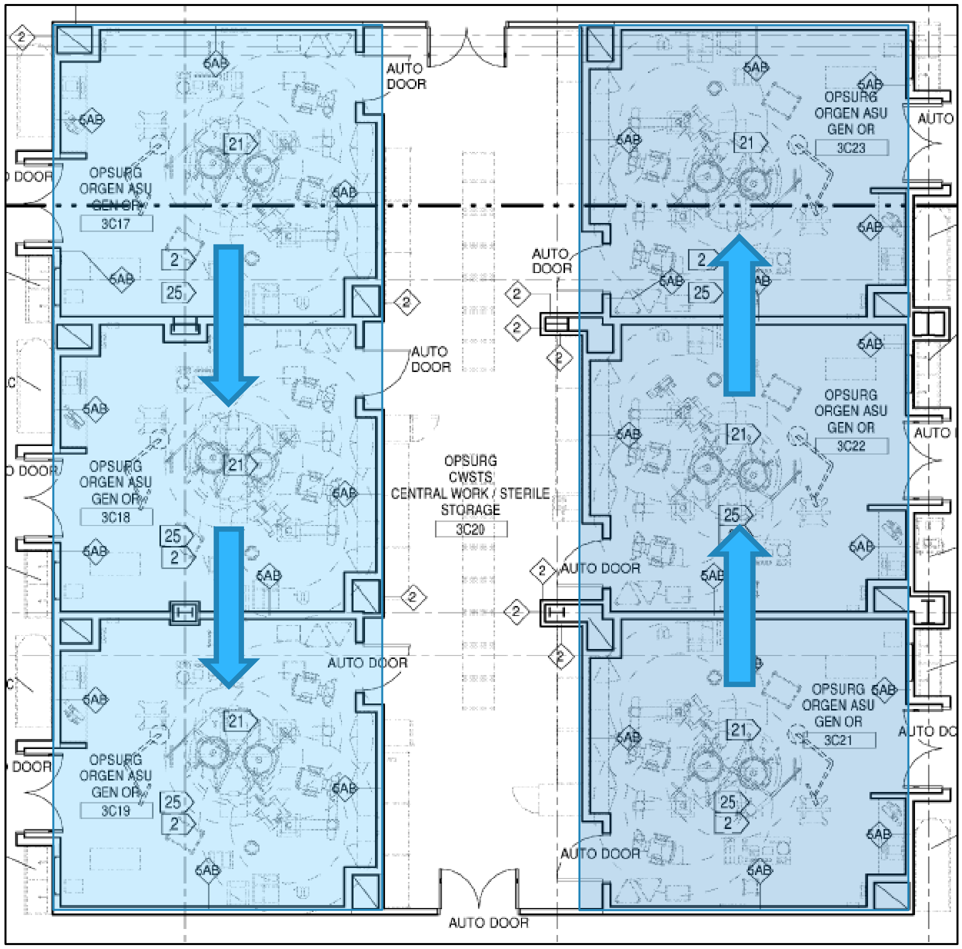

Figure 4 - Operating rooms on the third floor of Area C. It can be seen two colors represent separate crews have been established in order to save time and improve efficiency of work in this critical area. Image courtesy of Ellerbe Becket.

Plenty of other work is required in these OR rooms. Because they're on the critical path and each room requires such a large amount of work, the decision has been made to change from having one crew in these rooms to having two separate crews as shown in Figure 4. Time to complete the OR rooms is expected to be half of what was originally anticipated.

A major risk throughout the project has been the tight schedule from very early on. Reaching completion dates were expected to be a challenge, keeping the project team at risk. Finding areas to accelerate the schedule have proven to be very difficult as described previously. As delays have come about before and throughout construction, float has virtually been removed from nearly all activities that still remain to be put in place. For example, obtaining the building permit about 45 days later than expected set everything behind, but subcontractors have not budgeted working premium time or larger crews into their contract. Both would be required to accelerate the schedule; but without an issued change order, subcontractors were not responsible for accelerating work beyond the agreed contract.

It has come down to there being three months remaining until Substantial Completion, with roughly $3,000,000 necessary to be put in place each month, or $750,000 per week. With the large amount of work needed to be put in place, the size of the project comes into effect. There are physical limitations to how much work can be completed in a given space. Although this is a large medical office building, the amount of work required is still extreme for a building that is 106,700 square feet. To make Substantial Completion achievable, crews needed to be expanded along with extra work hours.

Currently, major trades have brought on a second shift and are working 16 hours a day, seven days a week. There is currently no other alternative to accelerate the schedule at this point. A unique aspect is that there are entire crews dedicated to change order work. The purpose of the different color vests is to help everyone involved have a better understanding who is working on what, especially as the site is more congested for longer periods every day. Electricians and plumbers both have these change order crews working seven 10-hour shifts which are being paid premium time out of contingency.

Owner Furnish, Contractor Install (OFCI) equipment brings a large risk, also. Especially as there is little to no float, equipment is needed punctually for timely installation. Another schedule risk, as $3,000,000 of work is being done inside the building, is the exterior work. With February 11th being Substantial Completion, site work has to be done; including planting shrubs and trees, and placing asphalt and concrete. Even though these activities have until February 11th, it's necessary to do this type of work by early December due to inherent winter weather and the ground freezing.

Value Engineering

Schedule was the key driver on this project. As work started going into place, several changes that developed created lost time. Taking time to look for areas value engineering could be implemented was never a real possibility for the project team. Providing value engineering was more difficult because DPR had very little involvement in preconstruction. It was challenging to come up with ideas to change systems, especially as major MEP coordination was taking place throughout construction, and typically completed in a specific area of a building only a week or two before rough-ins were scheduled to start in that area. That being said, there were some decisions made that did add value to the project as well as reduce unnecessary cost as well.

An opportunity was noticed associated with fireproofing on the roof deck. Spray fireproofing was used throughout the building; on columns, beams, and other steel members, as it was to be used on the roof deck. In order to apply fireproofing to the lower side of the decking, metal lathing would be necessary. It was decided that exterior grade fire-rated gypsum board could be used on the roof. This alternate ended up costing roughly $20,000, compared to the original $115,000. A $44,000 credit back to the owner from the fireproof installer was the final result. Metal lathe never had to be purchased. At the same time, this change saved a few weeks of the fire proofer's scope.

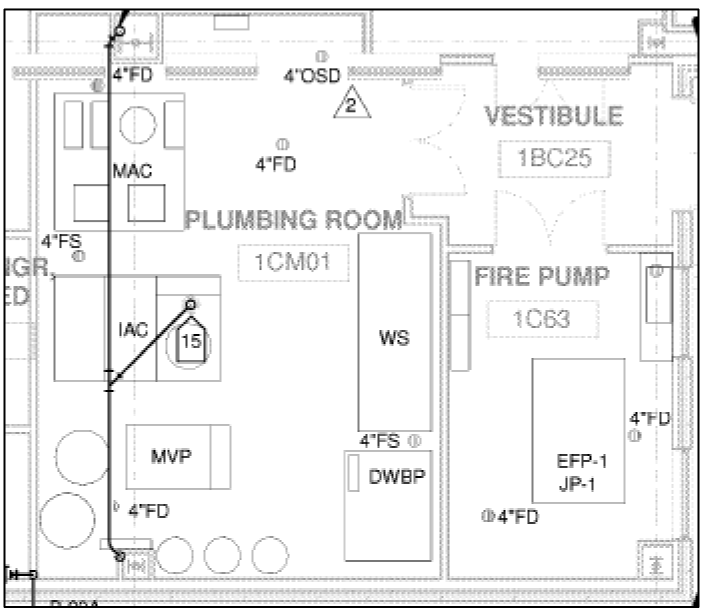

Figure 5 - Mechanical and plumbing room located in the southwest corner of the building in Area C. These spaces have been laid out slightly different than on the drawing shown above, due to the necessary space requirements between equipment. The exact savings cannot be known for sure, but eliminating the need of a change order, rework, and lost time was agreed to be saved by both DPR and the subcontractor. Image courtesy of Ellerbe Becket.

Another value engineering decision made by the project team was to change the layout of the mechanical and fire pump rooms, seen in Figure 5. These rooms are located in the southwest of Area C on the first floor. Specific spacing is required between different pieces of equipment, which is not adequate as shown on these drawings. With this layout, both rooms would have to have an increase in square footage. Adjustments were made as necessary between the general contractor and subcontractor. This required some extra time, but no extra cost and was a definite benefit to the project. Instead of stopping work in these rooms, a logical solution was found that didn't require the stagnant time that is typically associated with design questions, redesigning, and change orders. All spacing requirements were met and maintenance access is easier than it would have been if laid out as shown in Figure 5, while no walls needed to be moved to provide extra space.

Safety is always the number one concern on a construction project. There came a point on this project when it seemed safety was not top priority as the amount of injuries was quickly becoming significant.

There were several recordable injuries, and a couple of those were lost time injuries. To try to counter this problem, safety incentives were created. Safety audits were conducted by all DPR team members on top of the usual safety supervision. These audits include awarding raffle tickets to those subcontractors performing work safely and making sure to not create any unsafe hazards for other trades. Overall, this idea has been very successful as there have been no recordable injuries since additional safety audits have been started; over a two-month period of no injuries and raising awareness on site. Although it's not something the owner sees directly, it has added an increased value to the project that cannot be measured. No one can argue or disagree with its success and it has been implemented at no extra cost to the owner.

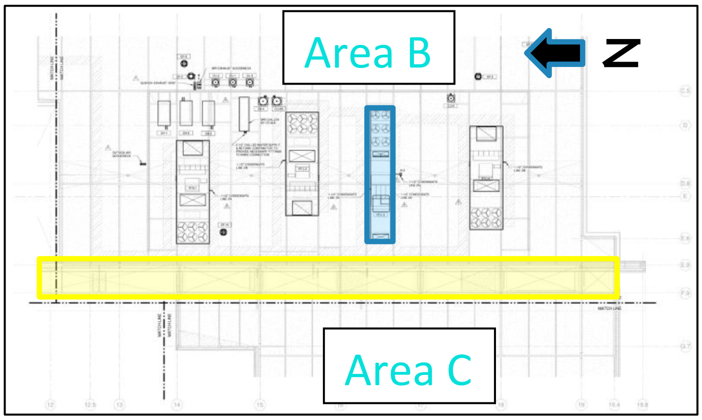

Figure 6 - Roof plan of Area B showing each of the building's rooftop mechanical units. Highlighted in blue is RTU-3, which serves only the third floor operating rooms in Area C, requiring mechanical ductwork to cross a clerestory space, highlighted yellow, separating Area B and Area C. Image courtesy of Ellerbe Becket.

An example of value engineering that was desired, but not implemented, can be seen in Figure 6. Rooftop Unit 3 (RTU-3) was brought to the project team's attention by the mechanical engineer. RTU-3 serves only the operating rooms (OR's) on the third floor of Area C.

Significant ductwork was required to travel the extra distance compared to being directly above the areas that it serves. Because the ductwork had to cross between Area B (where RTU-3 is located) and Area C (where operating rooms RTU-3 serves are located), ductwork had to pass through the clerestory corridor space, highlighted yellow above in Figure 6.

Figure 7 shows the amount of ductwork that is necessary to run from Area B to Area C and how much open space is protruded by crossing supply and return duct. This ductwork could have been eliminated had RTU-3 been placed above the OR's in Area C.

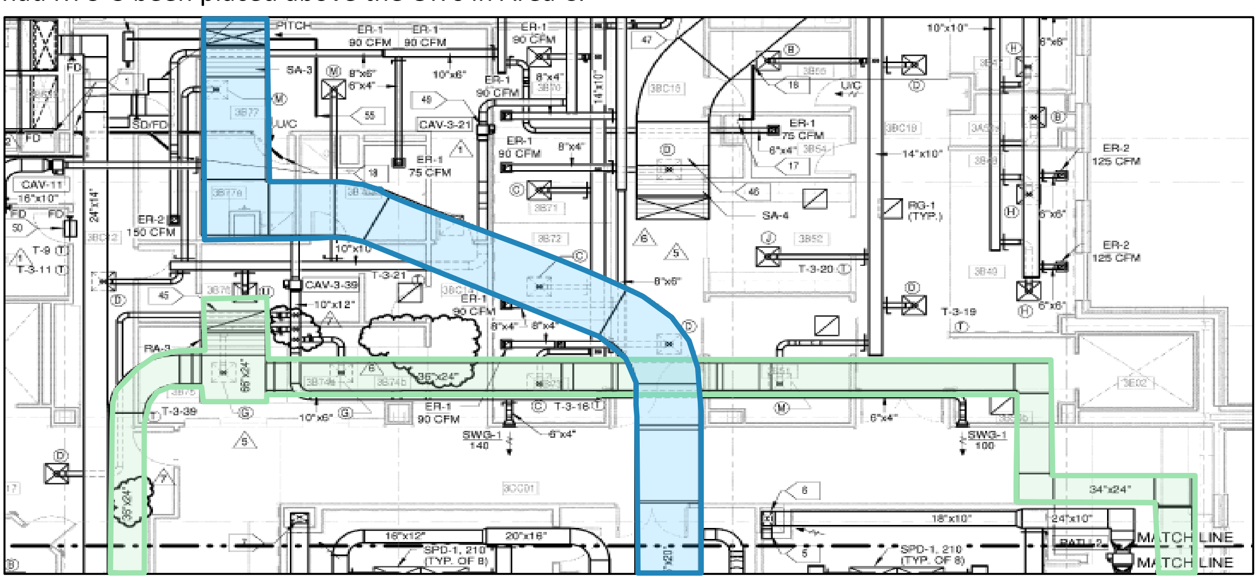

Figure 7 - Ductwork from RTU-3 is shown passing through clerestory corridor spaces are shown. Supply duct is highlighted blue and return duct is highlighted green. Image courtesy of Ellerbe Becket.

Figure 8 - View of corridor space in Area B on the third floor looking south. Ductwork can be seen crosing this space running from Area B to Area C along with the clerestory window in the upper right of the image. Personal photograph taken by Chris Pozza.

A big reason this idea was proposed, other than to save a large amount of ductwork, was for aesthetic reasons. As shown in Figure 8, ductwork can be seen crossing through open space. This is not ideal, especially with the clerestory windows above, which will create shadows in the corridor space.

It was decided by the architects not to change the original design for two reasons. The first reason is that steel would have been redesigned to carry the extra load. Even though RTU-3 is the smallest rooftop unit, it still adds a significant amount of weight that would require heavier reinforcement to support it. The second reason the idea of moving RTU-3 wasn't accepted was for vibration reasons. Although the rooftop units are placed on pate curbs with sound and vibration reduction measures taken, the risk of vibrations affecting surgeries in the OR's was not worth redesign or the extra ductwork that's required by the original design.

None of the value engineering decisions implemented detracted from the owner's goals, if anything; they were advantageous to overall goals. Producing the best overall product in a timely manner has only been made more possible by making the changes described above. Smart decisions made by experienced team members can only have an overall positive impact on the project as a whole and help improve relationships. Value was added traditional ways and untraditional, including making work around the entire site safer and reducing the number of recordable injuries, which is something everyone benefits from.

Critical Industry Issues

Industry professionals from several states attended this year's Partnership for Achieving Construction Excellence (PACE) Roundtable event. "Improving Efficiency through Innovation" was the 2012 theme as all discussions throughout the daylong event related back to this concept. With the economy still recovering from the Great Recession, budgets and schedules have only grown to be more challenging as owners want the best product with the latest technology, and at the same time finding ways to save money while adding value. This combination has made efficiency more necessary than ever before. As industry leaders are getting to the point where processes can't become much more efficient than they already are, innovation is going to drive future changes the industry needs to keep moving forward.

After the morning kick-off session, Bob Holland gave an interesting presentation describing how Penn State is providing opportunities to students that promote collaboration. Between Building Information Modeling (BIM) Studio available for undergraduate students and the BIM thesis that students can partake in for an entire year, Penn State is definitely the leading academic institution that promotes the most interaction with industry professionals while providing the closest simulation to real-world experience.

Academic institutions traditionally promote diverse and successful programs, but what surprised me most in the morning session was to listen to the student panel discussion. I did not expect to see a virtual role reversal, where students who participated in both the BIM studio and BIM thesis were questioned by the industry professionals in attendance. It was great to see fellow students represent our university well and hear their perspective on educational experiences. I believe that was beneficial to industry professionals to have a better understanding of what these opportunities are like.

The student panel discussion was something I think would have been most beneficial for third and fourth year students to attend. These conversations would be a benefit for younger students to get a better understanding of what's to come later in the architectural engineering program and possibly influence future decisions. This session wasn't as much of a benefit for the current fifth years because decisions related to educational possibilities to pursue cannot be changed at this point in our college careers, although it was definitely interesting to see what professionals wanted to know about these programs. I do think that there should be a stronger encouragement for younger students to attend the PACE Roundtable and teachers should persuade students, providing excuse from class to take advantage of this valuable opportunity.

The afternoon break-out sessions all dealt with different variations of ways to improve efficiency. Break-out sessions available are shown below in Table 1.

A. Supply Chain	B. Efficient Delivery of Services	C. Operations and Maintenance
Session 1A: Integrating strategies and technologies	Session 1B: Measuring Effective Collaboration	Session 1C: Energy and BIM
Session 2A: Modularization	Session 2B: Efficient Use of Integrated Design	Session 2C: Model Handover

Table 1 - Break-out session topic summaries available for professionals and students to attend.

The first session that I attended was Efficient Delivery of Services: Measuring Effective Collaboration. There are a few things related to that session that really caught my attention. First, as mentioned previously, Penn State offers a lot of collaborative opportunities for students. At the same time, the industry is constantly trying to become more effective and efficient. As part of this effort, collaboration seems to be getting strongly promoted from within organizations in order to make better decisions earlier; regardless of the type of process or project. Collaboration and integration are vague words. How can work be checked if it's being done collaboratively and how can that be measured? That is the second and biggest reason why I wanted to attend this session. I wanted to learn if, based on my school and limited professional experience, what I have been involved with has actually been collaborative, what it takes to be truly collaborative, how industry professionals perceive this topic, and their knowledge of what's being done in the industry.

There were a lot of great interactions, questions, and points made throughout the conversation. One of the first things discussed was integration requirements and what hinders it. We all know that teamwork leads to a better result; but if it were that easy, everyone would be doing it already. We first discussed things that hinder integration before it could be develop properly. They include:

- Lack of trust
- Risk management
- Contracts
- Changing roles

These are key concepts that, individually or combined, prevent true collaboration from occurring. Some companies aren't capable of taking on too much risk, don't know how to deal with the necessary adjustments and changes, or don't allow themselves to trust other companies on which they would depend. It seems more companies are starting to overcome these barriers, but it has and will remain to take significant time to become more collaborative.

Major necessities for collaboration include clearly defined responsibilities, a shared understanding of processes, and a strong purpose statement. Team members need to know how their decisions affect others, including lead/lag time and decision making processes; not just construction processes. A strong purpose statement should be developed early. I believe lack of a strong purpose is one of the reasons why the collaborative concept is taking so long to catch on. Owners often want to see a more collaborative contract and that contract make team members work collaboratively, which is often not the case. If team members don't feel comfortable or don't know how to work different from how they're used to, it will be impossible to jump into a project and take on more risk especially if work is being attempted a traditional way. Realizing the purpose for the project's integration early on by the entire team is absolutely necessary. Doing this will help stakeholders realize the importance of interaction between different teams, that everyone is dependent on each other, and align everyone's goals. Aligning goals is difficult to do. If not done properly, an individual member can easily end up hurting the project team if not committed.

The most surprising thing, which was at the same time the most informative, dealt with what's needed for integration and signs of true integration. As mentioned above, clearly defined responsibilities are necessary for integration. The difference between the signs of integration and responsibilities were provocative at first. There were a few points discussed that show there is true integration:

- Consistent work flow
- State of mind
- Roles aren't as traditionally defined

The first two made immediate sense as work should better flow due to better team decisions being made earlier and less bumps that would hinder work are discovered along the way. This combination should build stronger relationships that are easier maintained along the way. Roles that are not traditionally defined really stood out; especially as clearly defined responsibilities are something that's needed to be working truly collaboratively. How can there be clearly defined responsibilities without traditionally defined goals? The realization was that when everyone is working together, exact titles aren't necessary to get work done. Solutions are sought by more than just the people directly involved with an issue and sometimes it's hard to know who is specifically responsible for something when everyone is working toward the same goals. In parallel, responsibilities need to be clearly defined so that everyone knows what is needed to be done. The clearly defined responsibilities need to be established early in order to prevent things from falling through the cracks and potential problems going unnoticed. For example, early coordination for a long lead-time item taking place when needed; thus preventing a scramble to get it done once it's too late. Each person doesn't necessarily need to be assigned a responsibility before work starts, but leaders of different trades or activities should develop to champion different tasks or work.

Looking further into the details of the Kaiser Permanente Medical Office Building, I would have liked to see more collaboration from the beginning. Had DPR's preconstruction services been purchased, there would have been more people questioning assumptions by the design team, while team members would have had shared more co-ownership of the project design. That feeling of co-ownership tends to create co-learners working together throughout the entire project which most likely leads to much more diverse experiences shared and learned; compared to traditional paths where silos are often created and team members depend on one person to be responsible for a specific activity or trade throughout construction.

Had preconstruction services been purchased, BIM could have been utilized much more efficiently and earlier than what it had actually been. Design and coordination could have been done before construction began, preventing major challenges from developing further down the road. BIM coordination ended up taking approximately 100 days longer than expected. This was because, at one point, design was caught by coordination and systems were going in place faster than their design was still being finalized. As modeling and coordination were occurring at the same time, the overall process became much less efficient than doing just one of the two.

The second session was Supply Chain: Modularization. I chose this conversation for several reasons. After discussing modularization in several classes throughout the last few semesters, it appears to have an increasing demand. Because products are assembled in more idealistic conditions (inside a prefabrication shop), quality is often times better as work can be done in a comfortable environment the easiest possible way it can be done. Coupled with that, because safety is always a major concern, the more work that's done in a shop, the safer the site and putting work in place should be.

I wanted to learn more about modularization and what it takes to have done on a project. It appears ideal as it should benefit to the project as a whole, but I wanted to get a better idea of why it's not for everyone. Modularization can take designers and builders both out of their comfort zone.

Three major requirements necessary for successful modularization discussed were:

- Upfront thought process and early involvement
- Owner input to the design team
- Solid delivery method

Major planning is necessary and often coordination becomes a challenge. A few of these challenges include thinking through site logistics, how modules will be transported and put in place, and to have modules appear aesthetically pleasing; not look like a module. It is often not realized how much work is needed to be done well in advance in order to account for long lead times typically involved and to have materials delivered just in time. Owners have to understand that their timely input and responses are absolutely necessary, or modules could never be fabricated in time. Also, the project delivery method is crucial because procurement of subcontractors and suppliers early in this process is so important.

Cost relationships are something to investigate. Even at the breakeven point between modular and non-modular systems, many other things besides direct costs need to be considered. Labor time, site congestion, and waste are all reduced with module construction. All three have a major impact on the overall logistics and cost of the project.

There is potential to have several systems and components prefabricated in a medical office building. Because Kaiser Permanente has a strict set of specific standards that creates redundancy all over their facilities, this could provide the best locations to have modules built. It is possible, if finding logical systems to prefabricate, to build the components that are going to remain the same regardless of the point at which the design is and let the things that could possibly be changed remain uninstalled until a later point of construction. Regardless of the amount of work still required for the modules, savings will be made for the reasons mentioned above related to cost relationships.

Throughout the day, I have met several industry professionals that I will most likely be referring to for more advice on specific topics. As Southland and Truland are both major leaders in prefab and modularization, related questions will be directed to Andy Rhodes, Chuck Tomasco, along with John Messner. Collaborative and preconstruction questions will be directed to David Riley and John Bechtel from Penn State. John Bechtel can also be a valuable source to find out how Penn State deals with change orders to help move forward finding alternative change order management processes. Also involving any preconstruction, prefabrication, and concrete work will be directed towards Bill Moyer and Bryan Nuspall from Davis, Ray Sowers from Penn State, and Will Lazration from Clark Concrete.

Problem Identification and Technical Analysis Options

Change Order Management: Change order management has proved to be a big challenge throughout construction. It takes significant time to receive answers from the owner as there is an internal review process that is required by KP for each change. Several problems found, related to the BIM model, have led to a number of bulletins and change orders. During the time typically taken to respond, work affected by that change is put on hold until answers are received. An example of work hindered due to the change order process includes sleeves on the third floor. On this level only, no pipe sleeves or rain leaders were placed when pouring the any of the slab on the entire floor. Because it took too long to respond to an RFI and issue a change order, all slab penetrations needed to be core drilled after this level's concrete was placed.

It is evident there are major problems being caused by the current way change orders are being managed by looking at the number of blue vests on site. Blue vests, as described in the Schedule Acceleration Scenarios, are required for all personnel dedicated to working on change orders. The steps taken to respond to change orders can be investigated further with the proposal of possible alternatives to review changes differently potentially speeding up this overall process. Something that can stem from this challenge is analysis of payments reaching subcontractors. Work continues but subcontractors aren't paid until work is put in place, so looking into how different trades have been affected by delays and changes is possible. Payment schedules of different trades that have been on site for an extended period of time can be checked to view the effect on cash flow throughout construction along with interviewing their respective project managers.

It would be best to consult with faculty members for ideas of how to approach a technical analysis of an alternate way to manage change orders. There is potential to accelerate the schedule if time wasted waiting for responses can be shortened and subcontractors can maintain a steady cash flow receiving payments instead of having claims be issued.

Direction to proceed from the construction manager has proven to be a similar, but separate, challenge. When DPR has proposed solutions for design or coordination errors, approval and direction to proceed is needed by the CM. Much like the change order management process, more efficient responses could have created significant savings. Dates that information was requested and sent can be documented along with the dates of received approval to proceed. This will most likely not be an analysis topic to further study as other analysis options of more interest will be attempted first.

Other owner related delays have proved to be a challenge, even from the start of construction. The owner provided building permit was issued roughly 45 days late, putting construction behind before it was able to start. Another example is the permanent power. The owner is responsible for establishing a connection for permanent power with the utility provider; however, this was done behind schedule. Temporary generators were required because of this, as temporary heat has been necessary for finishes already in place as of November. Casework being in place puts DPR at risk as the building runs on temporary electricity and casework is susceptible to cold temperatures. There doesn't seem to be an alternative to this problem other than making it clear to the owner that timely decisions are necessary, therefore, it is more likely that an analysis related to change order management will be conducted.

Preconstruction Services Benefits: One of the major challenges discussed in each technical report was the challenging schedule. As work fell behind, sequencing had to be done differently than what was originally expected. The BIM coordination itself became extremely important as modeling and coordination for a specific area was being completed only a week or two before the drawings for that area was absolutely necessary. Had preconstruction services been performed by DPR, perhaps much more value engineering options could have been discovered and implemented. Without DPR's involvement, healthcare-experienced team leaders were not able to influence any of the design or constructability of systems.

Case studies can be compared between similar projects that did and did not include the general contractor's preconstruction services while the amount of changes and budgets can be compared. Taking a different approach, the timing of events throughout construction that could have otherwise been avoided if DPR was involved in preconstruction could be studied. An example of this is the 3D coordination. BIM took over three months longer than expected due to the design and coordination happening simultaneously. How timing affected trades could also be investigated. For example, sprinklers couldn't be installed due to a delay which turned out to be after all of the other trades had work roughed-in. Pipes had to go in place around all of the MEP systems, greatly reducing efficiency for this trade.

Contacting the project team in order to understand the preconstruction services that would have been performed would be necessary. More specifically, the areas that have proved to be the biggest challenges are why team members would have liked to be more involved early on. Knowing what issues would have been dealt with earlier and what the possible benefits could have been can be compared to what the actual result was of having such little preconstruction involvement. Here, possibly several major changes, rework, and time spent waiting for answers could have been eliminated. Schedule and budget costs could be estimated to further analyze this option.

Besides contacting the project team, subcontractors can be contacted for their opinions of the project. The point at which subcontractors are able to get involved can have a significant impact on the project. Earlier subcontractor involvement allows for earlier problems to be discovered and answered, and also increases the opportunity to use prefabrication while finishing coordination much earlier. John Bechtel would also be a viable contact to learn more from an owner's perspective on contractor involvement in preconstruction.

Construction of Masonry Façade: Getting the building enclosed was a constructability issue discussed in Technical Assignment 2. Drawing details specifying flashing and air/vapor barrier connections, especially around windows, were difficult to interpret and held up construction of the façade as answers to these questions were being sought. The watertight milestone was delayed because of the façade falling behind schedule. Because the building was not watertight, elevators could not be installed, and no elevator access meant that materials still had to be hoisted to the upper levels using all-terrain forklifts. Until late October, the building still had an opening for materials. Once it got to the point when the building had to be closed up, material had to be hoisted to upper levels in bulk to provide a supply lasting a week. More specifically, the required week was the time it took for the elevator to be completed before it could be used to transport material.

An analysis idea supported by the entire project team is the alternative installation of the masonry façade or use of precast panels for the façade. Weather delays that held up masonry work early on, along with difficult façade details mentioned previously, required answers that take valuable time. Had an alternative been used, time and space could have been saved. Site congestion was becoming a problem as more trades were arriving on site and requireing more laydown space that was being taken up by brick, as shown in Figure 9. This problem could have possibly been eliminated with just-in-time delivery of precast or brick panels. Full understanding of the installation process, lead/lag time involved, associated costs to use for comparison, and manufacturers local to the Maryland/DC Metro area are all necessary to learn more about these types of systems. Alternative systems can also be investigated. For instance, Thin Brick is a type of façade system that uses bricks that are the same length and width as traditional bricks, but much thinner and weigh about 1/6th of traditional bricks. It might not have been possible to use a Thin Brick system here, but that can't be determined without futher investigation.

Figure 9 - Fraco Lifts which didn't allow work to be done underneath along with large amounts of brick taking up valuable laydown space for an extended period of time can be seen here. Personal photo taken by Chris Pozza.

The use of brick panels or precast panels would require supporting analyses. Steel members would possibly be required to take more load and therfore involve redesign. In order to do this, assumptions made by the structural engineer with more knowledge about this buidling and location would be needed. Connections to the existing building, loads created by alternative systems, time to install, methods of installation and cost will all need to be investigated.

As mentioned above, the connections of the panels to the steel members would require redesign. Details including support angles and clips to transfer load to the steel structure would also be necessary with an alternative façade system. Consultation from manufacturers of wall panels and structural engineers would be necessary in order to ensure a sufficient design was reached and all issues were addressed. It would have to be determined whether the waterproofing and air/vapor barrier used would be compatible with the new connections.

Modularization of Systems: Many of the major coordination issues could have been prevented early had DPR been able to be involved with execution planning. If the model was coordinated months ahead of time, spool drawings could have been created. Spool drawings could have led to major changes in the way work was put in place. Currently, there is so much work to be done on site while only so much can physically be done in this 106,700 SF building. Items such as headwalls or mechanical and plumbing systems would have been a benefit to have been prefabricated. Most trades working inside the building deal with headwalls at some point and several components of mechanical and plumbing systems could have been pieced together before arriving on site.

A different possibility would be modularizing systems that are repetitious. This is a logical possibility as Kaiser Permanente standardizes all of their facilities to be as similar as possible. It can be investigated what items or systems are standardized by KP to potentially prefabricate larger systems than just the ones mentioned. Systems that are repetitious but have changing components nearby can be left out to be installed in the field; saving major time as less work would need to be sequenced or re-sequenced.

Kaiser Permanente standards would be necessary for this analysis. Owner representatives who know these facilities would be a valuable source to find these standards and discuss what items have the potential to be prefabricated. Tradesmen would probably be an important point of contact as they would know best what items they have installed repeatedly, what items took the most time, and how prefabrication would best benefit their production. Depending on the systems selected, lead times would be necessary to determine when information exchanges would be necessary, how modules would be transferred to site and then be put into place.

From the PACE Roundtable discussions, contacting industry professionals would be necessary. Chuck Tomasco from Truland and Andy Rhoades from Southland Industries would be the best people to contact as they deal with prefabrication of electrical and mechanical systems routinely.

Use of Virtual Mock-Ups: A major challenge presented as discussed with the masonry façade was the detail connecting the addition to the existing building. The way the original drawings portrayed these connections, neither DPR nor Calvert Masonry could not have guaranteed the quality or ensured that the system would physically work. This is an area where use of virtual mock-ups could have been created and benefitted the design team and contractors.

Virtual mock-ups of a typical operating room, patient room, an office, complicated details, and other virtual mock-ups were initially expected to be created. These mock-ups were never produced as the design and coordination were taking place simultaneously with construction allowing no time before systems were being installed; at that point, rendering mock-ups useless. As the original drawings presented a system that nobody involved with the project had ever seen before or knew how to install, a benefit could have been from mocking up facades where tying into the building.

Speaking with the design team to understand their original intentions and expectations for such connections or spaces would be necessary. To learn more about virtual mock-ups, Matt Hedrick, the BIM champion on this project would be a valuable resource to learn what is needed to make a mock up come to life.

Appendix A

LEED Scorecard

LEED for New Construction and Major Renovation 2009 Project Scorecard

Project Name:
Project Address:

Yes	?	No			
8	1	17		**Sustainable Sites**	**26 Points**
Y			Prereq 1	**Construction Activity Pollution Prevention**	Required
		N	Credit 1	**Site Selection**	1
		N	Credit 2	**Development Density & Community Connectivity**	5
		N	Credit 3	**Brownfield Redevelopment**	1
		N	Credit 4.1	**Alternative Transportation,** Public Transportation Access	6
		N	Credit 4.2	**Alternative Transportation,** Bicycle Storage & Changing Rooms	1
Y			Credit 4.3	**Alternative Transportation,** Low-Emitting & Fuel-Efficient Vehicles	3
		N	Credit 4.4	**Alternative Transportation,** Parking Capacity	2
Y			Credit 5.1	**Site Development,** Protect or Restore Habitat	1
Y			Credit 5.2	**Site Development,** Maximize Open Space	1
	?		Credit 6.1	**Stormwater Design,** Quantity Control	1
		N	Credit 6.2	**Stormwater Design,** Quality Control	1
Y			Credit 7.1	**Heat Island Effect,** Non-Roof	1
Y			Credit 7.2	**Heat Island Effect,** Roof	1
Y			Credit 8	**Light Pollution Reduction**	1

Yes	?	No			
4	4	2		**Water Efficiency**	**10 Points**
	?		Prereq 1	**Water Use Reduction,** 20% Reduction	Required
Y			Credit 1.1	**Water Efficient Landscaping,** Reduce by 50%	2
Y			Credit 1.2	**Water Efficient Landscaping,** No Potable Use or No Irrigation	2
		N	Credit 2	**Innovative Wastewater Technologies**	2
	?		Credit 3.1	**Water Use Reduction,** 30% Reduction	2
	?		Credit 3.2	**Water Use Reduction**, 40% Reduction	2

Yes	?	No			
0	24	11		**Energy & Atmosphere**	**35 Points**
Y			Prereq 1	**Fundamental Commissioning of the Building Energy Systems**	Required
Y			Prereq 2	**Minimum Energy Performance:** 10% New Bldgs or 5% Existing Bldg Renovations	Required
Y			Prereq 3	**Fundamental Refrigerant Management**	Required
	?		Credit 1	**Optimize Energy Performance**	1 to 19
				12% New Buildings or 8% Existing Building Renovations	1
				16% New Buildings or 12% Existing Building Renovations	3
				20% New Buildings or 16% Existing Building Renovations	5
				24% New Buildings or 20% Existing Building Renovations	7
				28% New Buildings or 24% Existing Building Renovations	9
				32% New Buildings or 28% Existing Building Renovations	11
				36% New Buildings or 32% Existing Building Renovations	13
				40% New Buildings or 36% Existing Building Renovations	15
				44% New Buildings or 40% Existing Building Renovations	17
				48% New Buildings or 44% Existing Building Renovations	19
		N	Credit 2	**On-Site Renewable Energy**	1 to 7
				1% Renewable Energy	1
				5% Renewable Energy	3
				9% Renewable Energy	5
				13% Renewable Energy	7
		N	Credit 3	**Enhanced Commissioning**	2
	?		Credit 4	**Enhanced Refrigerant Management**	2
	?		Credit 5	**Measurement & Verification**	3
		N	Credit 6	**Green Power**	2

Yes ? No

Yes	?	No				
6	5	3		**Materials & Resources**	**14**	**Points**
Y			Prereq 1	**Storage & Collection of Recyclables**	Required	
Y			Credit 1.1	**Building Reuse,** Maintain 75% of Existing Walls, Floors & Roof	2	
		N	Credit 1.2	**Building Reuse,** Maintain 95% of Existing Walls, Floors & Roof	1	
Y			Credit 1.3	**Building Reuse,** Maintain 50% of Interior Non-Structural Elements	1	
Y			Credit 2.1	**Construction Waste Management**, Divert 50% from Disposal	1	
Y			Credit 2.2	**Construction Waste Management**, Divert 75% from Disposal	1	
Y			Credit 3.1	**Materials Reuse,** 5%	1	
	?		Credit 3.2	**Materials Reuse,** 10%	1	
	?		Credit 4.1	**Recycled Content,** 10% (post-consumer + ½ pre-consumer)	1	
	?		Credit 4.2	**Recycled Content,** 20% (post-consumer + ½ pre-consumer)	1	
	?		Credit 5.1	**Regional Materials,** 10% Extracted, Processed & Manufactured Regionally	1	
	?		Credit 5.2	**Regional Materials,** 20% Extracted, Processed & Manufactured Regionally	1	
		N	Credit 6	**Rapidly Renewable Materials**	1	
		N	Credit 7	**Certified Wood**	1	

Yes	?	No				
5	7	3		**Indoor Environmental Quality**	**15**	**Points**
Y			Prereq 1	**Minimum IAQ Performance**	Required	
Y			Prereq 2	**Environmental Tobacco Smoke (ETS) Control**	Required	
Y			Credit 1	**Outdoor Air Delivery Monitoring**	1	
		N	Credit 2	**Increased Ventilation**	1	
	?		Credit 3.1	**Construction IAQ Management Plan,** During Construction	1	
	?		Credit 3.2	**Construction IAQ Management Plan,** Before Occupancy	1	
Y			Credit 4.1	**Low-Emitting Materials,** Adhesives & Sealants	1	
Y			Credit 4.2	**Low-Emitting Materials,** Paints & Coatings	1	
Y			Credit 4.3	**Low-Emitting Materials,** Flooring Systems	1	
	?		Credit 4.4	**Low-Emitting Materials,** Composite Wood & Agrifiber Products	1	
	?		Credit 5	**Indoor Chemical & Pollutant Source Control**	1	
	?		Credit 6.1	**Controllability of Systems,** Lighting	1	
Y			Credit 6.2	**Controllability of Systems,** Thermal Comfort	1	
	?		Credit 7.1	**Thermal Comfort,** Design	1	
	?		Credit 7.2	**Thermal Comfort,** Verification	1	
		N	Credit 8.1	**Daylight & Views,** Daylight 75% of Spaces	1	
		N	Credit 8.2	**Daylight & Views,** Views for 90% of Spaces	1	

Yes	?	No				
1	0	5		**Innovation & Design Process**	**6**	**Points**
		N	Credit 1.1	**Innovation in Design:** Provide Specific Title	1	
		N	Credit 1.2	**Innovation in Design:** Provide Specific Title	1	
		N	Credit 1.3	**Innovation in Design:** Provide Specific Title	1	
		N	Credit 1.4	**Innovation in Design:** Provide Specific Title	1	
		N	Credit 1.5	**Innovation in Design:** Provide Specific Title	1	
Y			Credit 2	**LEED® Accredited Professional**	1	

Yes	?	No				
0	0	4		**Regional Bonus Credits**	**4**	**Points**
		N	Credit 1.1	**Region Specific Environmental Priority:** Region Defined	1	
		N	Credit 1.2	**Region Specific Environmental Priority:** Region Defined	1	
		N	Credit 1.3	**Region Specific Environmental Priority:** Region Defined	1	
		N	Credit 1.4	**Region Specific Environmental Priority:** Region Defined	1	

Yes	?	No				
24	41	45		**Project Totals (Certification Estimates)**	**110**	**Points**

Not Certified

Certified: 40-49 points **Silver:** 50-59 points **Gold:** 60-79 points **Platinum:** 80+ points

Appendix B

PACE Roundtable Notes

Student Name Chris Pozza

Session #1

Topic: Delivery of Services: Efficient use of Integrated Design

Research Ideas:

(1) Preconstruction - overlap
- DPR precon services were not purchased
- More people question assumptions
- Collection of co-learners
- Co-ownership of project

(2) BIM implementation / impacts
- Design and coordination took place simultaneously
- Earlier / More integration would've saved time/money

Integration barriers: Trust, Risk Management, Contracts, Change
- Need clearly defined responsibilities
- Shared understanding of processes

Signs of Integration: state of mind, consistent work flow
- roles aren't as traditionally defined

Purpose Statement - Function - Being - Motivation

Session #2

Topic: Modularization

Research Ideas: Prefab Headwalls

(1) Interview trades to see where best implementation could be

(2) How do companies ~~[illegible]~~ train prefab
- who is at the table?
- what does process look like?
- what does it take to design to support modularization

* Hospital in Ohio to check out

Modularization Requires:
- Upfront thought process / early involvement
- Design team / owner input
- Solid delivery method - procurement issues

Look at cost relationship
Even at break even point, labor time, site congestion, waste are all reduced

Challenges - Preconstruction Planning / Coordination
Site Logistics
Size of modules - require crane? / Extra support?

Industry Panel: Differentiation in a Down Economy

Research Ideas:

(1)

(2)

Industry Member Discussion

Key Feedback:

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

Modularization of headwall units, labor
indirect savings - waste, shipping

Panelized Facade.

Move RTU 3 to Area C - only area it serves

Precon Involvement.

Prefab mechanical/plumbing systems

Energy Recovery System.

Suggested Resources:

What industry contacts are needed? Is the information available?

Southland/Ireland - indirect costs

Mechanical Engineer - why selection was chosen - RTU's all on Area B (3rd Fl. OR's)
possible energy recovery system

Early involvement / BIM during Precon → could've lead to spool drawings