PROPOSAL

UNIVERSITY ENGINEERING BUILDING
UNIVERSITY, MID ATLANTIC REGION, UNITED STATES

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Executive Summary

The University Engineering Building is located at a Mid-Atlantic University and will be the new landmark engineering building for the University. It features laboratory and office space, separated into wings, with a state-of-the-art clean room located in the basement. This proposal outlines the construction analyses and breadths that will be researched during the Spring 2014 semester.

There are current constructability issues with the roof system that has the project team desiring a different system be implemented. Analysis 1 will focus on whether the current system can be re-sequenced in the schedule to avoid the problems associated with cold weather construction or if an alternative system will be more effective. The alternate systems will be analyzed based on cost, schedule and cold weather constructability. Another deciding factor is whether the owner would approve of the change based on aesthetics and quality. This analysis will allow me to perform a structural breadth.

Analysis 2 will focus on the delivery of information between the construction manager and the facility manager. The UEB is a highly complex building featuring detailed MEP systems and custom made equipment, so finding ways to efficiently deliver the information the facility manager needs to operate and maintain the building is key to its success in terms of research. This area will also be the focus of a current industry topic.

The third analysis will focus on the clean room, mainly coordination between Hodess Construction and Massaro. This situation is unique since Hodess Construction has a contract directly with the University and not Massaro, so the need to determine the relationship between the two companies is crucial to complete the clean room without any issues. This analysis will also focus on prefabrication of the MEP system in the clean and possibly the laboratory spaces of the UEB. The MEP systems are highly complicated and being able to prefab main runs would greatly reduce cost, time and alleviate congestion within that area. This analysis will allow me to perform a mechanical breadth.

The final analysis will explore the underground spring located underneath the foundation of the building. This spring went undetected during the geotechnical evaluation and caused critical path delays during the excavation and foundations phase of construction. The analysis will focus on alternative systems for removal of the water aside from the permanent sump pump that was already installed by the project team. This analysis is important due to the fact that the underground spring, if left unchecked, could cause future problems with the foundation.

Each analysis was selected based on its importance during construction and after the building has been turned over. The results of the analyses will be compared to the original solutions where applicable, with the expected outcome being that the proposed solutions will provide increased quality without increasing cost and schedule on the project.

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Analysis 1: Roof System Analysis

Problem Identification

As stated in Technical Report 3, Massaro Construction discussed the desire to use a built-up roof system instead of the self-adhered, single-ply TPO membrane system, which is called out in the drawings and specifications. The reason behind this is as the winter months and colder weather is approaching the constructability of the TPO membrane becomes more difficult due to temperature requirements for the materials. Saving time and money were behind the decision on Massaro's part, especially time, due to the need to gain time back after delays during the excavation and foundation phase of construction. This analysis will determine whether the schedule can be re-sequenced/accelerated to make the TPO membrane system feasible or if an entirely new roof system is necessary in regards to cost and schedule.

Background Research

Once this problem was identified, background research was conducted to determine the feasibility of this analysis. First research was conducted on the TPO membrane system that is currently being used on the building to determine problem areas that would affect constructability and possibly delay this activity on the schedule. One area of concern brought up by Massaro is the temperature during installation, in which the materials for the TPO system must be installed with the temperature at 40°F or greater. Reference figure 1 for the projected start and completion dates for both the lab and office roof systems.

Building Roof & Exterior Enclosure		133	133		11-Nov-13	19-May-14
Lab		133	133		11-Nov-13	19-May-14
Lab - Roof		61	61		12-Dec-13	10-Mar-14
Lab-30000	Roof Blocking - Lab Roof	5	5	0%	12-Dec-13	18-Dec-13
Lab-30010	Roof Drains - Lab Roof	4	4	0%	13-Dec-13	18-Dec-13
Lab-30020	Roofing System - Lab Roof	15	15	0%	11-Feb-14	03-Mar-14
Lab-30030	Lightning Protection - Lab Roof	5	5	0%	04-Mar-14	10-Mar-14
Lab-30035	Install Roof Crane	5	5	0%	04-Mar-14	10-Mar-14
Office		101	101		25-Nov-13	17-Apr-14
Office - Roof		30	30		07-Jan-14	17-Feb-14
Off-30000	Roof Blocking - Office Roof	5	5	0%	07-Jan-14	13-Jan-14
Off-30010	Roof Drains - Office Roof	4	4	0%	08-Jan-14	13-Jan-14
Off-30020	Roofing System - Office Roof	20	20	0%	14-Jan-14	10-Feb-14
Off-30030	Lightning Protection - Office Roof	5	5	0%	11-Feb-14	17-Feb-14

Figure 1: Lab & Office Roof Durations

To get a better understanding of the weather issue, the weather history for the University's location was researched. As of December 11th, 2013, the average mean temperature, from Weather Underground, is 39°F. Historical data also has shown, that typical December's hover around 40°F and lower and for January and February, the temperatures drop even more, see Appendix B. With construction extending as far as March, the need for temporary heating and temporary enclosure has been expressed by the project team.

Preliminary researched was also conducted on multiple different roofing systems to determine their feasibility for a variety of factors. These factors include constructability in cold weather situations, cost, schedule and owner approval. The roof systems chosen for analysis are built-up, proposed by Massaro, polymer-modified bitumen sheet membranes and thermoset membranes (EPDM).

Potential Solutions

The key in determining potential solutions for the roof analysis comes down to two main factors. The first factor involves schedule changes for the TPO membrane system. The other factor is the cost and time effectiveness, along with constructability and owner approval of the other systems. The following solutions were realized from the two factors:

- The TPO membrane system was deemed acceptable, due to schedule re-sequencing/acceleration to avoid cold weather construction.
- Another roof system, any of those listed above, was deemed more cost and time effective than the TPO membrane, have easier constructability in the cold weather months and would be approved by the owner.

Analysis Methodology

To complete a detailed and thorough analysis of the roof systems to determine the feasibility of the two potential solutions, the following steps must be taken.

- Analyze the project schedule, for possible re-sequencing and/or acceleration of the roof activities.
- Conduct interviews with the project team to verify that the schedule changes are feasible.
- Re-sequence the schedule accordingly based on the two above steps.
- Research each alternative roof system based on the following criteria:
    - Cold weather constructability
    - Contractor familiarity with alternative systems
    - Cost – Savings or Increases
    - Schedule – Savings or Increases
    - Owner Approval
- Conduct interviews with the project team and owner representatives as part of the research on the alternative systems.
- Determine which alternative system is the most feasible of the three.
- Comparison between the results of the TPO analysis with the results of the alternative system analysis.

Expected Outcome

Even after preliminary research, the most logical outcome is successfully re-sequencing the TPO system activities to avoid cold weather construction. At this time, with very little to go on in terms of cost and durations, but based on past interviews with the project team, the only other outcome would be substituting the TPO system with the built-up roof system. The original design was for a built-up roof in accordance with University standards, but was later value-engineered out during later design phases because of cost savings with the TPO system. With this, the built-up system is still very much possible, but a slight advantage to the TPO at this time.

See Appendix A for Structural Breadth

Analysis 2: Information Delivery from CM to FM

Problem Identification

The University Engineering Building features state-of-the-art laboratory space, including a highly detailed clean room, all operated via an extremely complex MEP system. In order to properly maintain and service the building and its equipment, the information provided to the facility manager, the owner, must be detailed enough and accessible enough for all personnel to understand and use. The problem lies in the fact that currently, there are not any real standards or guidelines for facility management information delivery. The need for this material is more important on the UEB since it is above all else a laboratory/research building.

Background Research

The background research performed for this analysis was done primarily at this year's PACE Roundtable event. Some main ideas about information management were taken from the breakout session dealing with this topic. One of the keys is personnel training and ways to go about it, also including the ease of accessing the information. Further research pertaining specifically related to the UEB leads to different possibilities for training the personnel on the different systems and equipment and their maintenance and operation. Those methods include, training during construction, allowing the personnel to get a better understanding of how the systems tie together and work with the equipment. Also, personnel can be trained how to navigate the 3D MEP model that was created for the project. Finally, the last piece of training involves bringing in manufacturer representatives to train the personnel with the equipment, especially the air-handling units.

A meeting with John O'Keefe at the PACE Roundtable provided even more crucial information in regards to information delivery. He stated that one must analyze the building, not from the energy efficiency perspective, but to look at the functionality of the building. Since it is a laboratory/research building, energy efficiency can be ignored for the most part, since the most important aspect is making sure the building continues to operate and the systems and equipment function properly at all times. This leads to the next key area of analysis, determining what information the University needs to successfully operate the building. This will require further interviews with university representatives to acquire more information on the information they need and how they want it delivered.

Potential Solutions

After research and deliberation, only one solution seems feasible, being creating a set of guidelines for the University for information delivery on the UEB and future buildings. Since the University, doesn't have a system in place currently, they only have experience to go, the final result of this analysis could be used by the University and potentially others if it can be deemed successful. The potential for different outcomes is apparent in that the University would either try implementing the guidelines or

using parts of the guidelines or continuing to use the system currently in place for facility management and information delivery.

Analysis Methodology

To successfully create a set of guidelines for facility management information delivery the following steps must be taken:

- Conduct interviews with University representatives and the future facility management personnel to determine what information they need and want Massaro to turnover along with the completed building.
- Interview members of Penn State OPP for insights on how they manage buildings and the information they look for to properly manage the laboratory/research buildings at the University Park campus.
- Compile the results of the interviews along with research conducted on how the industry is dealing with this topic.
- Conduct further interviews with the project team and operations personnel from the University on the possible methods of training to be implemented and the types of training the personnel feel would be most beneficial.
- Compile the results of these interviews to create training guidelines.
- Combine the results of the information and training portions of this analysis and create a final set of guidelines that the University can use when handling facility management information delivery.

Expected Outcome

This outcome is more difficult to predict than the other analysis topics due to the nature of the research. I feel that the University will look at the research and suggestions that result from this analysis, but as for fully integrating the guidelines that will be created will be more difficult and less likely to occur. The hope is with this research to provide a start for further research in the issue of information delivery and finding potential means and methods to improve the problems associated with it.

Critical Industry Research

Currently, one of the leading topics of discussion and research in the construction industry is effective information delivery for facility management. Since buildings are becoming more complicated via building systems, equipment and technology, the need for proper information on the part of facility managers is growing. There currently exists a gap between construction managers and certain owners, who are not experienced enough to know what information they need to properly maintain and operate a new building. The purpose of this research is to discover what information facility managers on a university level need from construction managers in order to maintain and operate their buildings. Also the goal is to discover what training methods are most beneficial for operations personnel to maximize the efficient use of the information provided. To reach these goals, I will conduct interviews with University personnel, both operations personnel and higher ups, along with Penn State OPP to get a

different perspective on facility management. The BIM guide for owners will also be used a research tool to gather more information. A list of sample interview questions is provided in Appendix B.

Analysis 3: Clean Room Coordination and Prefabrication

Problem Identification

The most important feature of the University Engineering Building is the clean room, but at the same time is also one of the most confusing aspects from the construction management standpoint. A separate contractor has the scope for all clean room construction, leaving Massaro to manage them, like any other subcontractor. The problem lies in that Hodess Construction, the clean room contractor, has a contract with the University and not Massaro, making it difficult to distinguish the chain of command and who has the authority to override the other.

From the constructability side of coordination, the MEP systems within the clean room are extremely complicated and clustered. To reduce the amount of congestion during construction and introduce potential savings, prefabrication of certain main MEP runs could be a possibility. Utilizing prefabricated rack systems would combine the different systems that occupy the same space saving time and money as well as requiring more coordination between the subcontractors and Massaro.

Background Research

On the management side of coordination, research was done for technical report 1 on the project delivery method, which included creating an organizational chart outlining coordination between the different team members, a version can be seen in figure 2. After speaking with members of Massaro's project staff, it became apparent that the situation with Hodess Construction and coordination was unique. Originally Hodess was to have a contract with Massaro, but the University later decided against that and made a contract with Hodess directly.

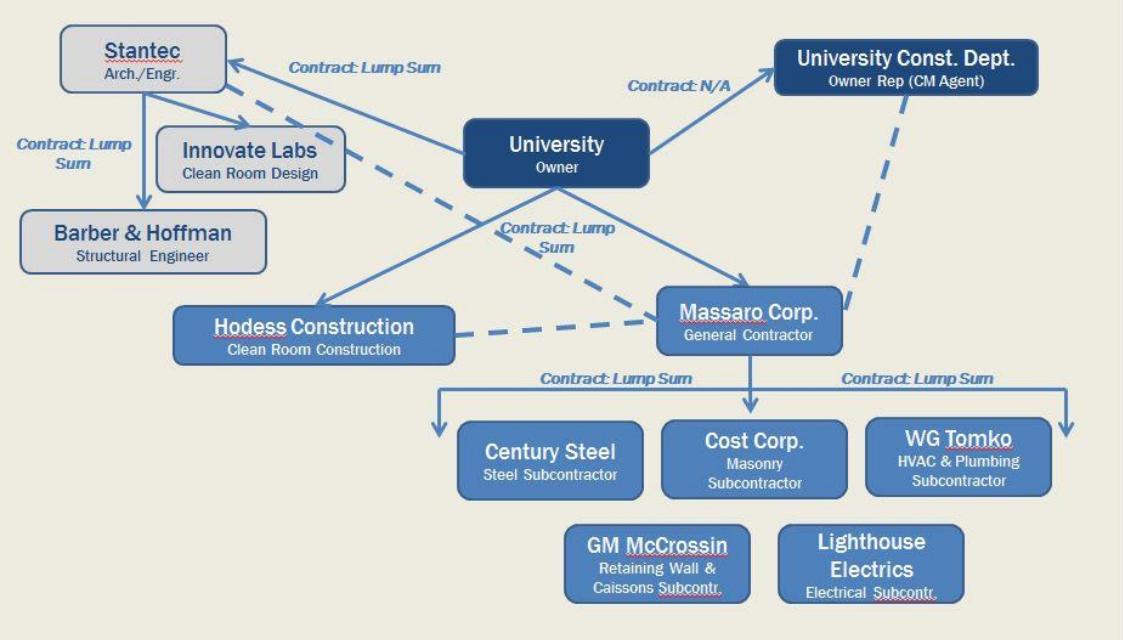

Figure 2: Project Organization Chart

In regards to MEP prefabrication, preliminary research was performed for technical report 2 when analyzing those systems to perform assemblies estimates. The mechanical and plumbing floor plans were studied to determine whether there is sufficient overlap to warrant prefabrication of runs in order to look at cost and time savings along with increased coordination between trades. Those floor plans can be seen in figures 3 and 4. It was deemed that there is enough overlap in key areas to warrant the further research of prefabricated rack systems and the implementation on the clean and potentially the laboratory spaces.

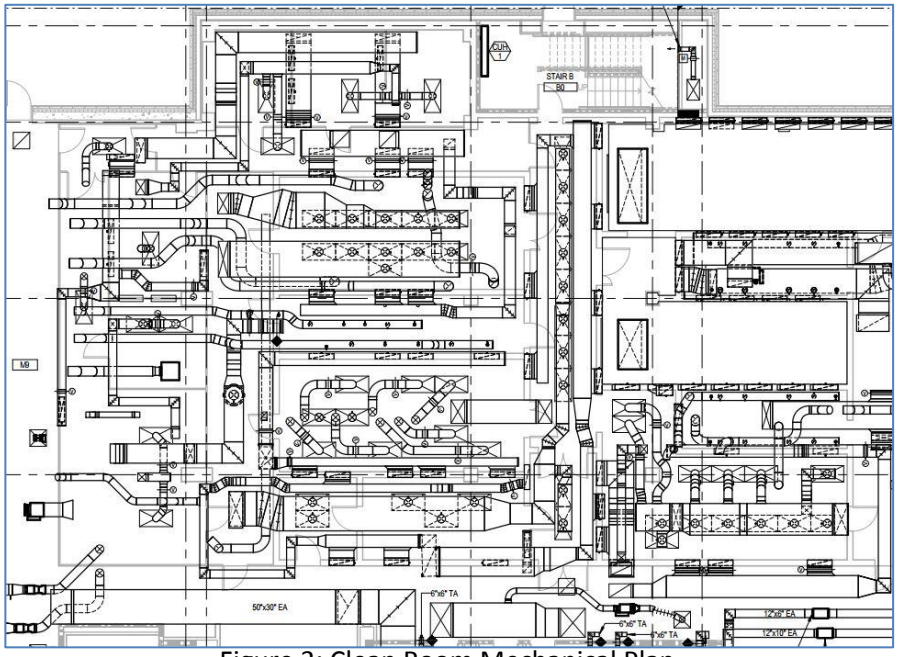

Figure 3: Clean Room Mechanical Plan

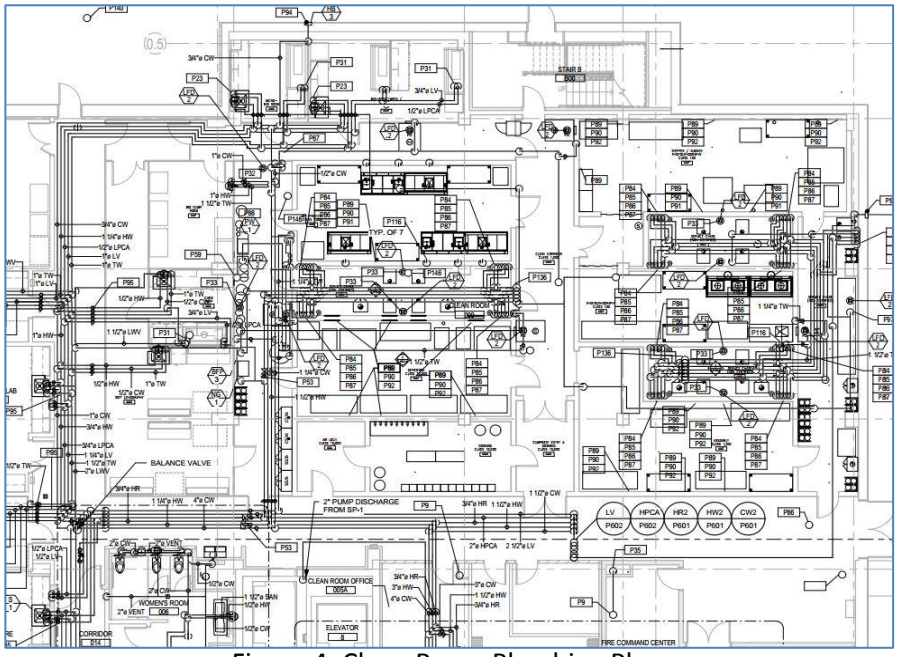

Figure 4: Clean Room Plumbing Plan

Potential Solutions

Based on the research that will be conducted management coordination will have two potential solutions, which are the following:

- Hodess, even with a contractor directly with the owner, answers to Massaro for construction issues and coordination.
- Hodess answers directly with to the University and coordinates with Massaro as equal members of the project team with an indirect relationship.

In terms of MEP prefabrication for the clean room and potentially the laboratory spaces, there are also two potential solutions, those being:

- Prefabrication of certain MEP runs is deemed cost and time effective and eases constructability and congestion in the clean room and will be substituted for traditional system construction.
- Prefabrication of those systems was not deemed a viable alternative and will stick with traditional construction on the MEP systems in the clean room and laboratory spaces.

Analysis Methodology

In order to perform the feasibility study for this analysis topic the following steps will taken:

Management:

- Conduct interviews with members of both Massaro and Hodess to get a better understanding on what they do for coordination and how they are related via contractual obligations and work scope and various other factors.
- If permitted, review the contracts for scopes of work and any language pertaining relationships between Massaro, Hodess Construction and the University.
- Identify solutions to solve any coordination concerns and issues for construction of the clean room by the two parties.

Prefabrication:

- Highlight key areas where fabrication of the MEP systems can occur.
- Identify various vendors within the region that can perform prefabrication and speak with them in regards to cost, travel and other logistical factors.
- Perform a cost and schedule analysis to determine any potential savings or increases.
- Create a logistics plan for bringing the prefabricated racks to the site, storage and eventually installation.
- Compare this with cost, schedule and logistics for traditional system construction, with information received from the project team.

Expected Outcome

Based on knowledge gained from classes, such as AE 476 and others, the prefabrication can potentially produce savings for the project, making it the expected outcome for the MEP system coordination. Some areas of the clean room and the other areas of the building not analyzed will require traditional construction because of the complexity of the systems and the tight spaces in the clean room to fit the duct, piping and electrical lines. For the management aspect of this analysis, the expected outcome will be that even though Hodess has a contract directly with the owner, they must still answer to Massaro, since Massaro is the general contractor on the project. Hodess can't begin their work until the subcontractor's under Massaro have completed theirs and the area is ready, so Hodess must rely on Massaro for coordination in order to successfully complete the clean room.

See Appendix A for Mechanical Breadth

Analysis 4: Underground Spring Analysis

Problem Identification

During the excavation and foundations phase of construction on the University Engineering Building, an underground spring was discovered that was previously not found on during the geotechnical evaluation. This spring in conjunction with poor weather caused delays in foundations pours and affected the formwork and rebar cages for the grade beams and other components of the foundation wall. These delays pushed the critical path back, causing Massaro to seek and receive a change order to add an extra 20 working days to the schedule. The project team's solution to the underground involved installing a sump pump that will become a permanent feature of the building.

Background Research

This was one of the topics of analysis in technical report 2 regarding constructability challenges experienced on the project. The information on the issues dealt with because of the underground spring were provided by the project manager for Massaro and described in the problem identification. To determine possible solutions for this analysis, I had a conversation with Dr. Walt Schneider to discuss possible alternatives for dealing with the underground spring. He described two systems that would fit with the building and be alternative to the actual solution of installing a permanent sump pump. The first solution is to determine where the flow of the underground spring begins and if found the spring can be piped and fed to another area away from the building. The next solution involved installing a French drain system that drained the water in the spring to a collection tank and from the tank and sump pump would be used to pump the water out of the tank. He also discussed building in redundancy for the sump pump system because they have to be continuously operating and the second pump would kick on if the first pump were to fail or die.

These alternatives would be analyzed based on cost of the system, schedule impact and feasibility based on the site and neighboring areas, which includes a logistical plan for removal of the water.

Potential Solutions

Given the research that will be performed, two potential solutions stand out, which are:

- The actual solution, permanent sump pump, will suffice, with the possible addition of another pump to add redundancy.
- One of the proposed alternate systems will be a more effective solution based on the factors outlined above and would warrant replacing the permanent sump pump.

Analysis Methodology

The following steps will be taken to determine the best possible solution for the underground spring issue:

- Conduct another interview with Dr. Walt Schneider to gain a better understanding of the alternate systems and how underground springs can affect building foundations.
- Perform a cost analysis for each alternate system and for including redundancy to the actual system in use.
- Analyze the schedule and make necessary adjustments based on time needed for installation of the alternate systems.
    - The durations will require discussions with the project team and others to get a better grasp on how long these activities would take.
- Create site logistics plans to determine the area needed at the site to install these systems and whether the area of the site would need to increase.
- Perform a final comparison on the actual system being used and the alternatives to determine which is the most effective and logical solution based on the results from the previous steps.

Expected Outcome

Based on preliminary research and a discussion with Walt Schneider, the expected outcome would be to add redundancy to the permanent pump already installed. This would benefit the building if the current pump were to breakdown and stop working the backup would kick in and continue to pump the water out. This is necessary since the clean room is located in the basement of the building and having water affect the foundation could potentially ruin research, costing the University money.

Conclusion

Since the UEB is a university building, the overriding factor affecting all analysis topics is the project schedule. The building has to be completed prior to the Spring 2015 semester in order to begin making the building profitable. Another key to the success of this project is the operations and maintenance of the building to ensure a long life-cycle with very little cost impact decades after construction has completed. My analyses revolve around these factors to provide quality results that would benefit the University and possibly impact future projects they have. Analysis 1 deals with both factors since the roof system must withstand years of weathering along with not affecting the critical path and delaying the schedule. Analysis 2 focuses on the building life-cycle because of the necessity to properly operate and maintain the building. Analysis 3 deals again with both factors as the clean room is the key feature of the UEB and needs to be coordinated and constructed within the given schedule time in order to begin commissioning to turn the final product over to the University. Analysis 4 has affected and will continue to affect the building and providing a cost effective solution would benefit all parties involved. It is my belief that all of these analyses will provide beneficial results that will improve quality while reducing schedule and cost.

Appendix A

Breadth Topics

Structural Breadth

Performing a roof analysis lends itself naturally to a structural breadth analysis. Potentially changing the roof system adds a variety of issues involving the structural system. Issues include whether the structural system can handle a heavier system, also would structural members and decking need to be changed to account for the load changes. This breadth will focus on the loads on the structural system caused by the different roof systems, along with re-sizing any structural members and metal decking based on the load calculation results. Each system, including the alternatives will be part of breadth analysis.

Mechanical Breadth

The purpose of a clean room is to keep everything inside, inside and everything outside, outside. With the future research that will take place in the clean room at the UEB, the need for air tightness is more important than anything else. The mechanical breadth will focus on the wall materials that make up the shell of the clean room and their air and moisture properties. Also areas for potential leaks will be highlighted and analyzed providing solutions for how to handle them.

Appendix B

Interview Questions

University Questions

- Being a University, what information are you looking for in order to successfully operate and manage your buildings?
- Are there particular methods of delivery that you prefer, if so what are they?
- How have you integrated technology in the operations and maintenance of your buildings?
- Would a set of guidelines be useful for future projects to prepare general contractors on what information they need to provide you?
- What conversations have you had with Massaro in regards to information delivery?

Penn State OPP Questions

- Having the AE department and PACE, how have they affected how you manage buildings from an industry trends perspective?
- What do you expect out of general contractors when working with them on a project in regards to information on the building and systems and equipment?
- How has BIM for Owners affected information delivery?

General Contractor Questions

- What training methods do you provide operations personnel for building information that you turnover along with the building to the owner?
- Do you feel that meeting/working directly with operations personnel is more beneficial to determine what they need?
- What discussions do you have with owners in regards to the information they need and what you can provide them?

Appendix C

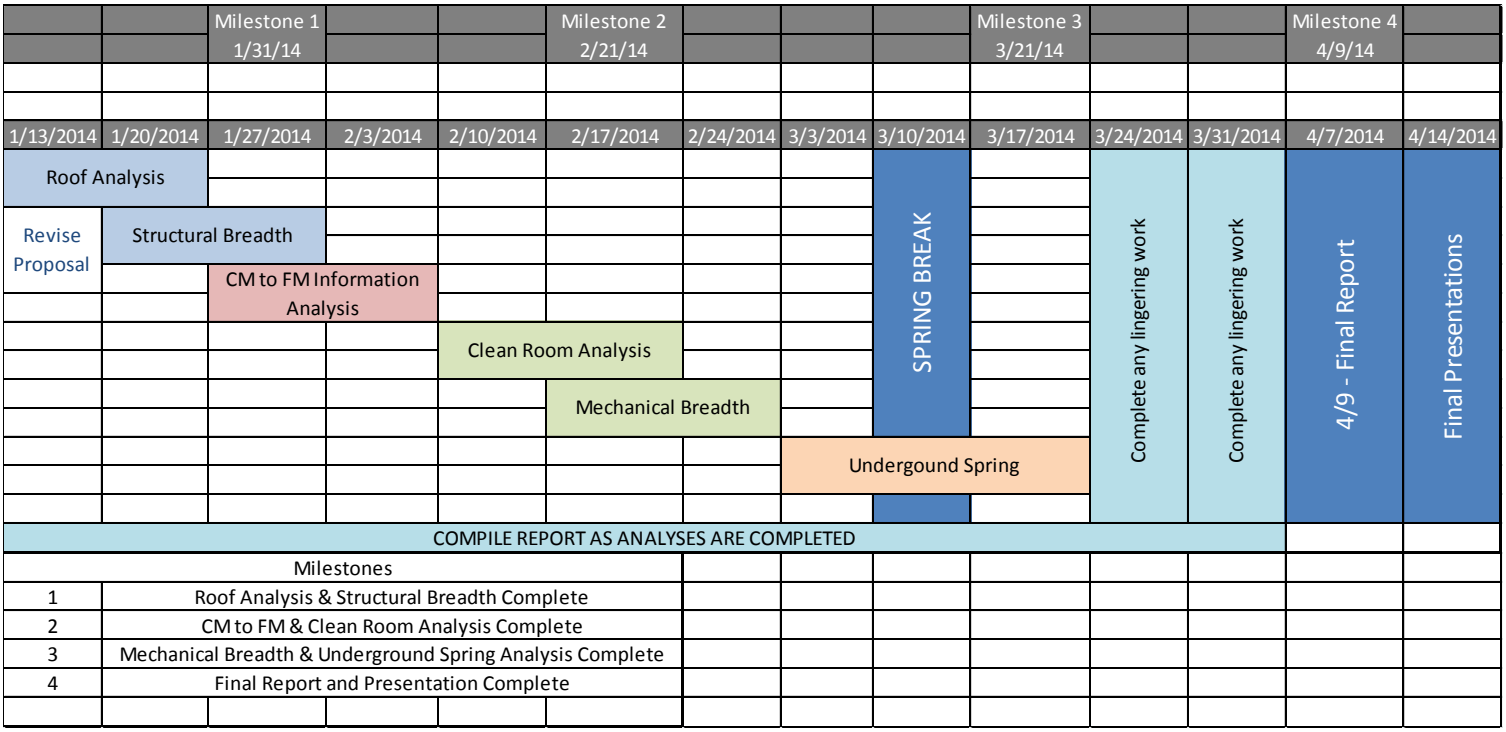

Figure 5: Spring 2014 Milestone Schedule

Table 1: Weight Matrix

Description	*Critical Industry Research*	*Value Engineering Analysis*	*Constructability Review*	*Schedule Reduction/ Acceleration*	Total
Roof Analysis		5%	10%	5%	20%
CM to FM Delivery	30%				30%
Clean Room Coordination		10%	10%	10%	30%
Underground Spring		5%	10%	5%	20%
Total	**30%**	**20%**	**30%**	**20%**	**100%**