Technical Assignment 3

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Table of Contents

Executive Summary 2

Schedule Acceleration Options 4

- Critical Path of Project 4
- Potential Risks 5
- Accelerations Opportunities 5

Value Engineering 6

- Key areas implemented 6
- Areas not implemented 6

Constructability Challenges 8

BIM Use Evaluation 11

- Existing BIM Uses 11
- Potential BIM Uses 12

Critical Industry Issues 14

- IPD Panel 14
- Innovative Design 14
- Incentivizing Team Performance 15
- Feedback from Industry Roundtable 16

Appendix 17

Executive Summary

Technical Assignment three contains a more qualitative assessment of the Health Sciences Facility III in Baltimore, Maryland to help understand opportunities for analysis in the spring semester. This assignment consists of an interview with the project manager where the topics of project schedule, value engineering and constructability were discussed. Also, a level one building information modeling use list evaluates the current implementation of BIM as well as other potential beneficial uses of BIM. Finally, a reflection of the topics discussed at the PACE roundtable are included at the end of this report.

During the interview, many items were discussed that embody the three categories mentioned above. The critical path of the 55 month duration schedule was explained and there were several suggestions for analysis in the schedule, specifically in the sequencing of the façade. The critical path is mainly driven by the cash flow on the project, which makes the acceleration on the project not a desired goal of the owner. Aside from the cash flow, the current critical path shows the schematic design of the fast track construction, the stages of demolition, excavation, and structure up to the fourth floor. Following this is the first two floors of exterior envelope, the east elevation masonry, and the MEP rough-in of floors 7-10. Finally, the building flushout and commissioning follow the critical path to the building's substantial completion in September 2017. The biggest risk on this project is the sequencing of the skin, and there is not much interest in accelerating the schedule due to the funding sources, but there could be some potential to sequence the envelope in another way to better accommodate the schedule.

Value engineering on this project was extensive and the project team performed multiple iterations to help with controlling the cost on the project. Some of the items listed that had a major impact on the project include the removal of the monorail system, the change in the fire door manufacturer, and changing to MC cable from the terminal boxes to the device. All of these items fall in line with the owner's goals and do not detract from the vision of the building in any large way. Other items not implemented include the deletion of the north collaboration tower, the deletion of the atrium bridges and the removal of the tunnel from the scope of the project. All of these items rejected would detract from the vision of the building, both functionally and visually. The three constructability issues concern the performance mockup details, the installation of the MRI suite and a lack of performance of the waterproofing in the basement. These elements are critical in the project and have potential to change the project on a larger scale. They each bring their own unique challenge to the project and the project team has either fleshed out the issue or is still discovering ways to solve these challenges.

The next major piece within this report is the evaluation of BIM uses on the project. HSF has implemented several methods already to the advantage of the project. Some of those include 3D coordination, 4D scheduling, and virtual mockups. Other items that could be of great use to the project include record modeling and cost estimation.

Finally, the PACE roundtable offered insight to popular topics in the industry. The IPD panel discussed the changing roles of the project manager and some of the challenges and benefits involved with an IPD project. The first breakout session involved innovative design and how to promote innovation both within design and construction. There are also many drivers that influence innovation on a project. In the second breakout session, the discussion revolved around incentivizing team performance. This topic led to establishing motivations behind incentives and how to measure the success of different incentives.

Schedule Acceleration Options

Critical Path of Project

An abridged version of the critical path can be seen in figure 1. First, the schematic design, site mobilization, demolition and excavation of the project all fall within the critical path. This is common element within the critical path because the next stages of the project must wait for these steps to be fully complete before initiating sequencing. One exception to this rule is the top down method, which is not a chosen method on this project. This fast track type of a project removes the other stages of design from the critical path; however, it could have become an issue if the designs were delayed in some way. The beginning of schematic design to the completion of excavation took about four months to complete.

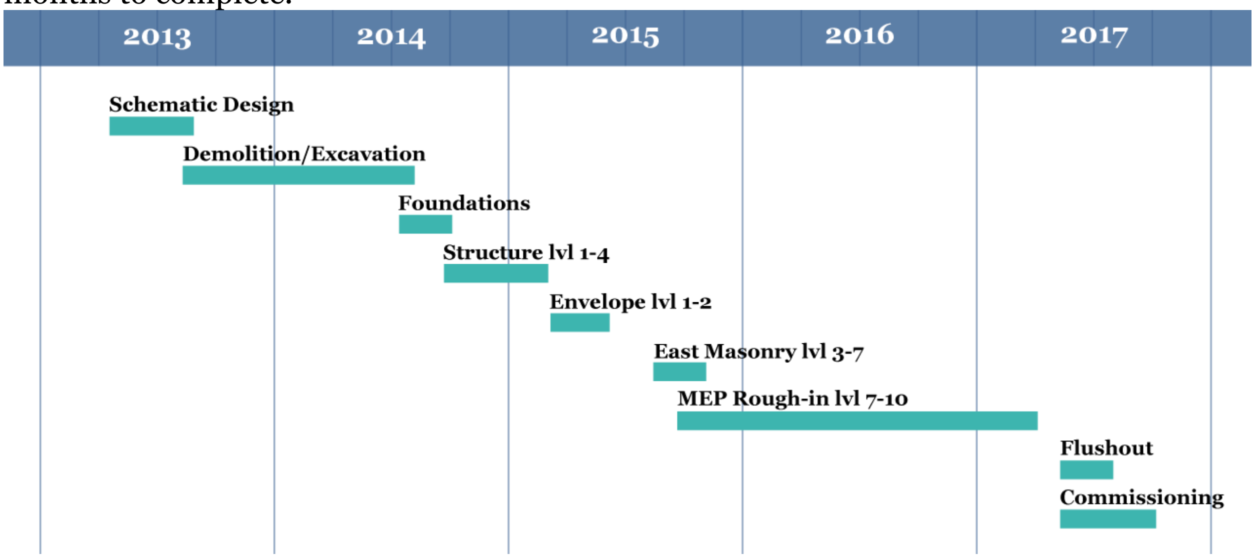

Figure 1 Critical Path of HSFIII

Succeeding the excavation stage in the critical path are the concrete pours for the foundation and structure up to the fourth floor. The entire concrete package is slated to take approximately nineteen months, from foundations to topping out. After the fourth floor, the exterior work begins on the first floor. This work must wait until after the fourth floor is poured to both allow the safety nets to be erected on the fourth floor and give sufficient lead-time for the concrete contractor. This ensures that multiple trades are not in the same spaces and slowing productions. Several parts of the façade on the north tower fall on the critical path. Among those include the first floor granite, the second floor storefront, and the east masonry. This is because the interior finishes must wait for those floors to be dried in to begin installing temperature dependent items. Also, the east elevation of masonry from floors three through seven is the last elevation to be installed, making it a critical item to close up each floor for the interior work.

The next item on the critical path is the overhead rough-in of floors seven through nine. Most interior work of the tenth floor also lies on the critical path. Other work in the mechanical spaces have enough float that don't land them on the critical path; this helps with the long lead items and major equipment that needs to be installed for the building commissioning. Sitework does not fall on the critical path because the interior work and building commissioning have a longer duration both before and after this item. Also, it is not tied to the interior work and has some freedom as to when it can be performed, preferably in good weather.

Potential Risks

The cash flow is one of the major schedule drivers on this project. The owner only receives a certain amount of funding each year for the project. To help with this challenge, the revised schedule delayed the interior trades by a couple of months as well as the purchasing of some major equipment like the MRI and other mechanical equipment. There will still be a steady flow of manpower and production, but it will happen in a more linear manner than formerly anticipated.

Another high-risk area in the project is the sequencing of the envelope. Each face has a different material, most of which require the tower crane for erection. The project team is currently investigating a second operator to use in two shifts to complete this work in the allotted time frame. The façade on the first two floors will also conflict with the concrete pours of the tower crane on the upper floors, potentially requiring double shift or Saturday shift to accommodate the schedule.

Accelerations Opportunities

It is not necessarily in the project's best interest to accelerate the schedule because of the cash flow. There is opportunity to investigate the sequencing of the skin, as previously mentioned. The current schedule has multiple trades working on multiple elevations at once, which will cause congestion on an already tight site. If the project is looking to draw out certain trades to help the cash flow, then the skin is an area to take advantage of this. The caveat to this is the interior work. It has already been delayed in the schedule by a couple of months. If it continues to be delayed, then other trades such as the mechanical and electrical contractors who have been on site since the end of excavation will have to reduce or potentially remove their on-site presence. This is because they will start to run out of work for the trades without the building being dried in. This is not an ideal situation, especially from a production management standpoint.

Value Engineering

Key areas implemented

Listed in table 1 are some major value engineering items both implemented and rejected on the project. To start, the owner has accepted a change in the fire door manufacturer for a substantial savings of 200k. This is an accepted change, but there are some design alterations required to move forward with this change. The door tracks are different than originally specified, moving the handrails about two feet further into the lobby. The fire marshal does not like this change because moving the handrails cause the furniture to potentially block the entrance. One potential solution to this is to place a sensor that detects when furniture is in the way of the door.

Table 1: Value Engineering Items

Proposed VE Description	Amount	Y/N
Remove monorail system	(177k)	Y
Change fire door manufacturer	(200k)	Y
Use standard thermistor temp sensors ILO platinum rtds	(83k)	Y
Revise conduit to MC cable from terminal box to device	(233k)	Y
Remove tunnel and leave loading dock as is	(383k)	N
Delete atrium bridges	(197k)	N
Precast panels first floor instead of brick and granite	(72k)	N
Delete north collaboration tower	(552k)	N
Total Accepted VE	**(693k)**	

Other items in the accepted category are small changes made to the project that realize significant savings due to the scale of the activity. For example, changing to MC cable on just one terminal box is a small dollar amount, but when it is multiplied across all of the terminal boxes in the building, it becomes a more significant number. This exercise of changing small things that repeat several times in the building is where a good portion of the value engineering was found. Another example of this not shown in the table is the change from aluminum frames to hollow metal for wood door, which realized a savings of about $17k. The total value engineering exercises performed throughout design saved the project over one million dollars.

Areas not implemented

One major item listed that was not implemented is the removal of the tunnel that connects the dental school to the new school of medicine. The school of dentistry has a room in the new school of medicine to service the janitorial staff for the dental school. Without the tunnel, it would be difficult to access this space and it would not make as much sense to provide funding to a building that would not benefit the school of dentistry. The tunnel will also allow for the MRI to be installed out of sequence, so it is a crucial element to the construction of HSF.

The MC cable is a good example of a value engineering item that does not detract from the owner goals. The choice of cable here is a cheaper solution that provides the best value to the owner at the best price. Many of the rejected value engineering items are items that could potentially shift the goals of the owner. For example, the atrium bridges are not only unique visual elements within the building, but they serve as a connection between the north and south tower. Without these bridges, users will have to walk all the way to the core to access the north tower. This changes how users navigate through the space, which shifts the purpose of the space. Also, the tunnel that connects the dental school and school of medicine is an important element for the dental school. It holds the only major connection that the dental school has to the building. As for the north collaboration tower, this visual piece breaks up the wall on the north side and provides relief to the otherwise monotonous precast façade. Removing this would change the building visually.

Constructability Challenges

During the kickoff meeting of the envelope subcontractors, it was discovered that there was discretion between the alignment of the exterior seals of the head, jamb and sill detail. The jamb detail shows two beads of sealant, neither one of which align with the larger sealant bead at the head. A virtual mockup of this condition was drawn in Sketchup to better understand the situation and propose a solution, seen in figures 2-4. This misalignment can cause water and other foreign objects to enter into the cavity and destroy the thermal barriers around the window.

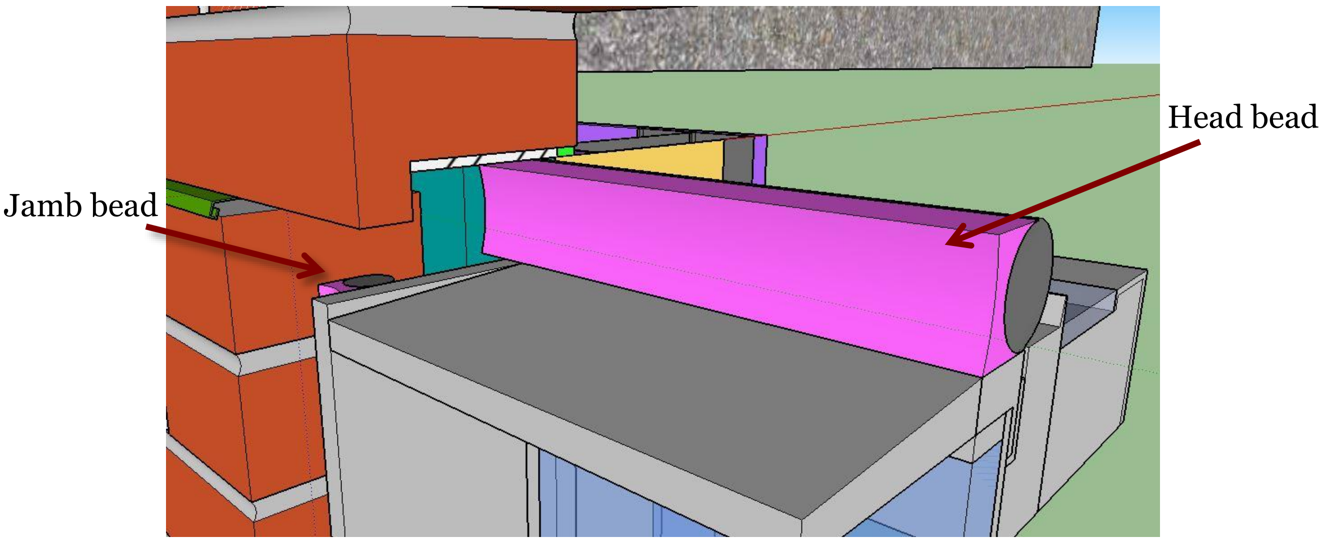

Figure 2 Sketchup model of head and jamb detail

Based on conversations between the subcontractors, the interior bead (not shown in above picture) was aligned with the head bead while the exterior jamb bead acts as an architectural bead. This can be seen in the two details below; the red text box indicates the two beads of sealant now in alignment.

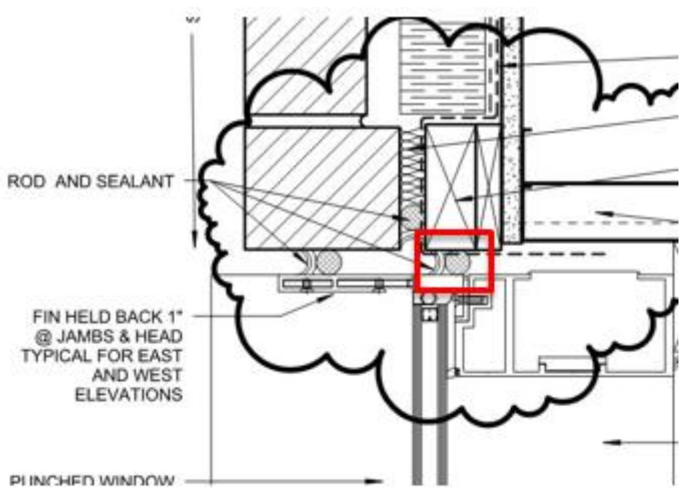

Figure 3 Jamb Detail

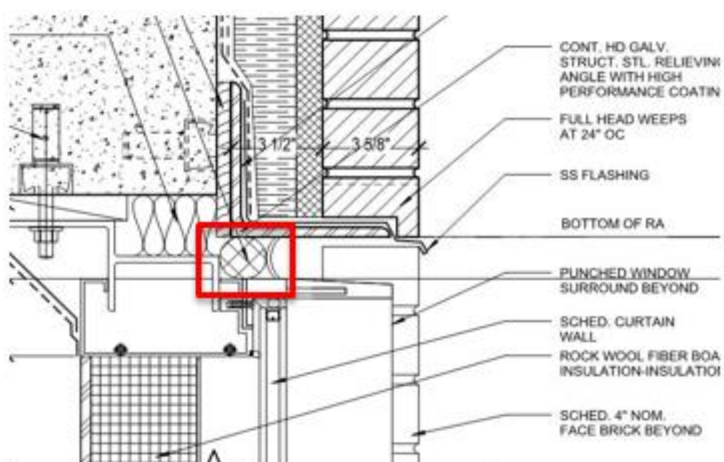

Figure 4 Head Detail

The MRI suite is located in the lower basement of HSFIII. After multiple discussions on the design of this room, it was decided that the MRI equipment would be installed out of sequence once the equipment model has been chosen. This poses multiple problems with the room. First, there needs to be a pathway to install this equipment at the appropriate time. One advantage to the design of this access is the ability for the MRI suite to be maintained and potentially replaced in the future. The disadvantage is that this pathway cannot be finished within the sequencing of interiors because it would run a higher risk of damages to the finished space. Without the equipment in the MRI suite specified, the sizing of the room and rough in for the equipment is difficult to establish.

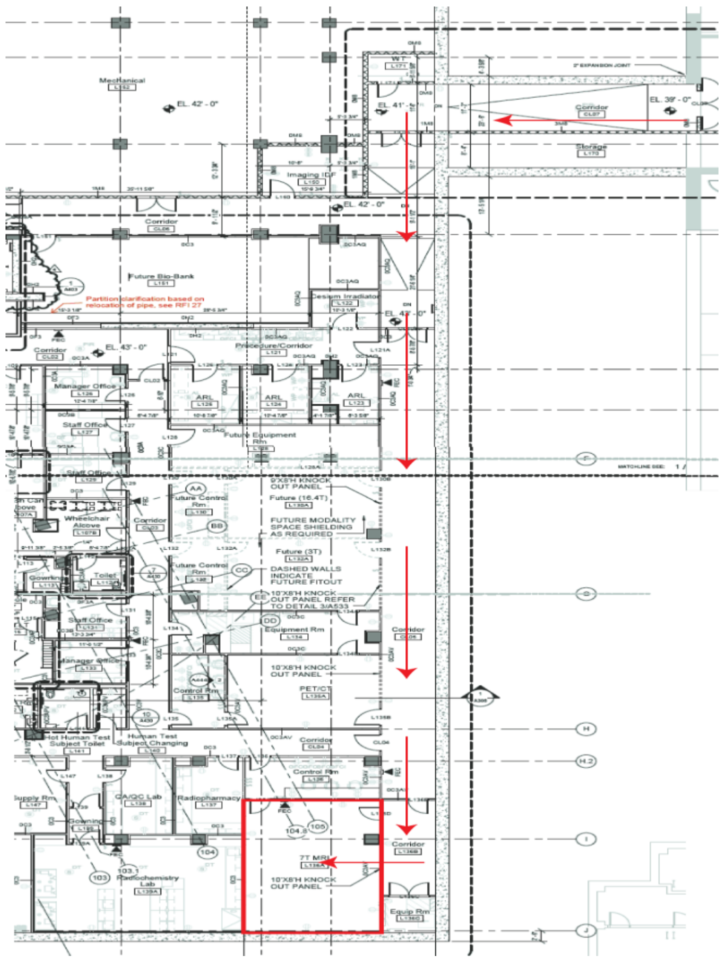

Figure 5 MRI Pathway

Figure 5 shows the current pathway for the installation of the MRI. There is a tunnel between the dental school and the new HSF building that connects to the loading dock of the dental school which will serve as the entrance for the MRI into the building. The project is still in the superstructure phase, so it has not yet encountered the sequencing issues involved with this, but an appropriate amount of space has been designed for this room. Currently one of the walls in the corridor is designed to be removed for the installation of the MRI.

The third major constructability challenge is in the waterproofing of the building. The foundation is design like a bathtub that will use its own weight to keep the building in place. Surrounding the mat foundation and structure below grade is a waterproofing membrane. This membrane serves as the only line of defense to stop the penetration of water into the building. Figure 6 shows the layout of the membrane. The lagging is

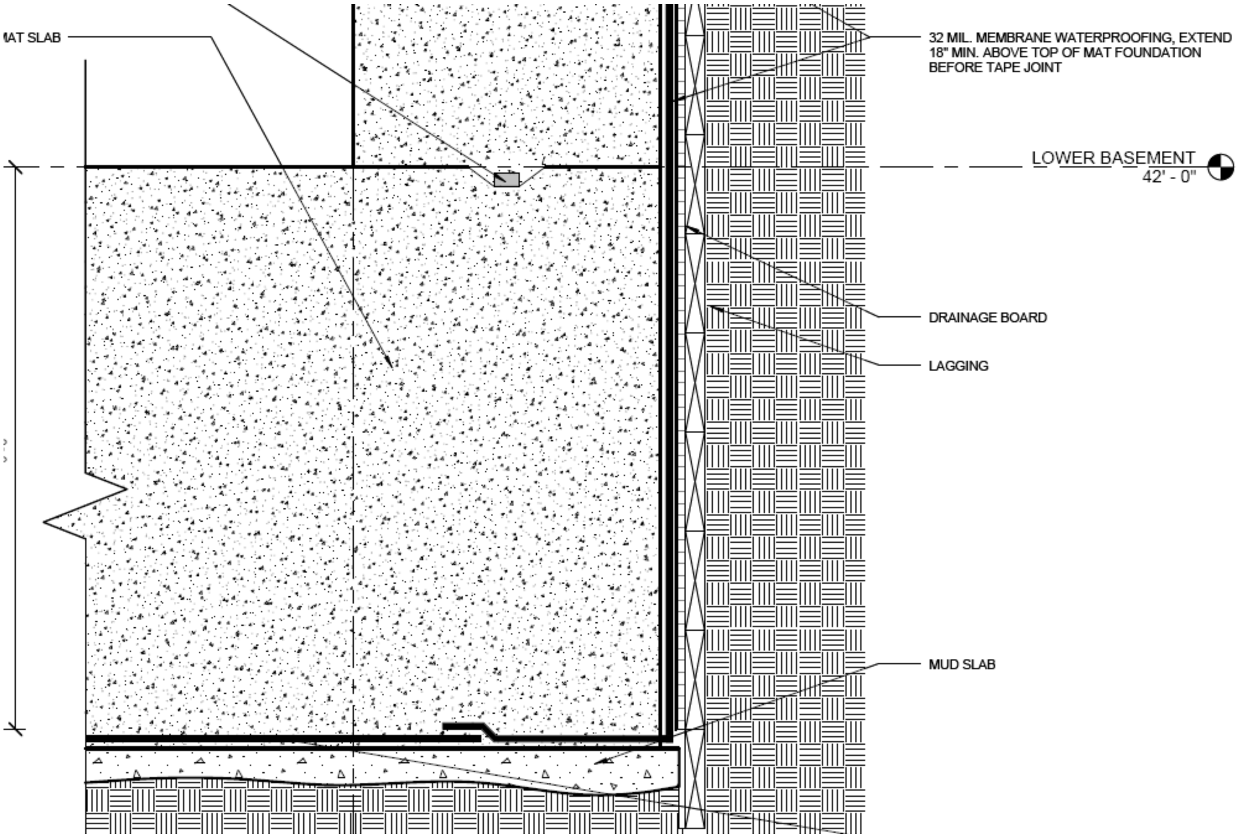

Figure 6 Waterproofing for Foundation

directly against the soil with no drainage system. Between the lagging and waterproofing is a drainage board that does not continue past the mud slab, trapping the water between the mud slab and the waterproofing below the mat slab. Despite these waterproofing efforts, water is seeping into the basement and the source has yet to be discovered. There are a lot of details that are involved in this membrane installation that could have potentially failed. The membrane had to be dry to adhere to itself, but the site was fairly difficult to keep dry at plan bottom, which could have foiled the efforts to adhere the membrane when dry. Also, the lapping of the membrane has yet to be complete and could potentially be a source of failure for the waterproofing.

The project team is investigating some sort of grouted jets to surround the area, but this is an expensive solution to the project and they are hoping for another alternative once the source of the water has been discovered.

BIM Use Evaluation

Existing BIM Uses

The project team for Health Sciences Facility III is taking advantage of several Building Information Modeling (BIM) uses throughout the project. Figure 7 represents the tools utilized on the project to date. The three items highlighted in teal are potential BIM uses suggested for the project. The owner understands the value of using BIM on the project and has mandated many uses through contracts with the designers and contractors. With the construction and design phases overlapping, the design team can work with the construction manager and enhance the value of the BIM use. This is best seen through the design reviews. One challenge involved with this fast track schedule is the reduced time frame to perform the BIM uses. For example, a 4D model should wait for the design to be complete because it takes a lot of time to create and alterations to the design will subsequently cause rework in the model. At HSF, the design reached 100% in July in the middle of the pouring of the foundation. This only left a few weeks between the complete of design and the kickoff meeting for all of the façade subcontractors.

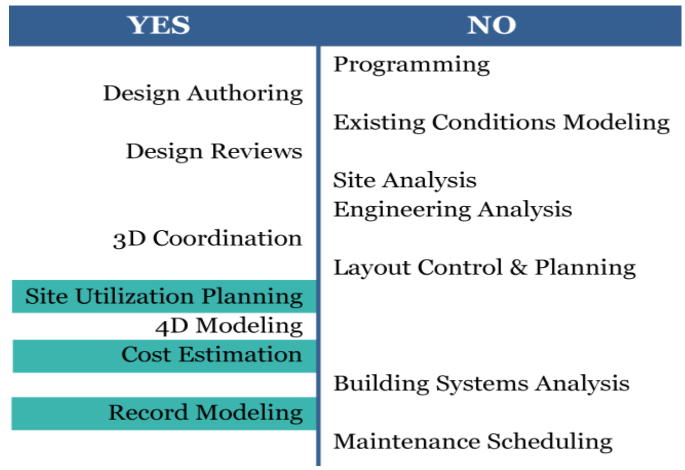

Figure 7 BIM Uses Summary

3D Coordination

With a lab building that has several mechanical systems, coordination is crucial to reduce clashes in the field and to increase productivity on the project. BIM is one of the most useful tools to push the clashes into the design phase and to involve multiple parties on the project. With design assist subcontractors, they are responsible for performing these clash detection sessions and resolving conflicts in the model before it reaches the field. They were brought on board earlier in the project during design, which has aided in the overall coordination of the building. Performing a task such as 3D coordination can be daunting, so the model is divided up by floor and the sessions are performed on a single floor until the model is clash free. There have been a few occasions where this was not as successful, mainly because the entire design was not complete and some rework needed to be done on the lower floors after they had undergone the clash sessions.

Virtual Mockups

As previously mentioned, the virtual mockup was used to also help in the meetings with the façade contractors. This showed the discrepancies in the details for both the punch windows in the brick and the precast. The project team plans to try and use other virtual models as necessary to convey information to the owner or to flesh out more details in the installation and sequencing of this project.

4D Scheduling
When the contract documents reached 95% completion, the team decided to use a 4D program called Synchro, seen in figure 8, to better understand how the schedule matched the sequencing of the envelope. The images were taken at different stages of the project, shown on the timeline below. Similar to Navisworks timeliner, it combines the 3D model to the schedule where pieces in the model are attached to the schedule to create a simulation of the building. It was used in the kickoff meeting for the contractors involved in the façade and provided some great feedback to the schedule. It also helped the contractors better understand where the high concentration of workers will be located as well as areas where they will be working on multiple elevations at the same time. This 4D program could be potentially used for the sequencing of the penthouse due to the closeness of the major equipment.

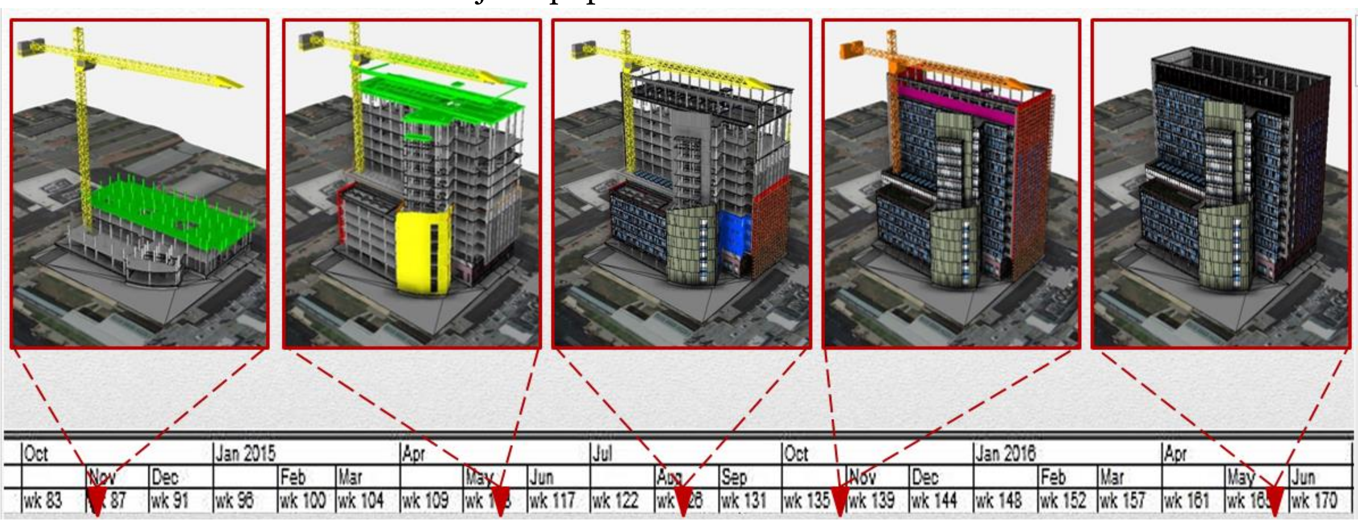

Figure 8 Synchro for HSFIII

Potential BIM Uses
Appendix A shows not only the BIM uses currently utilized on the project, it outlines other potential uses that could be of value to the project.

Site Utilization Planning
The foundation footprint is very tight against the perimeter of the site, making this project challenging to navigate large machinery around the outside of the building. This led to a decision to place the tower crane inside the footprint of the building rather than a mobile crane on the outside. BIM could be a great tool for site utilization because of the limited space for movement and material laydown. This will become challenging when the façade begins because of the need for scaffolding as well as other cranes on site to accommodate the stacked sequencing.

Record Modeling
With this complex of a building, record modeling could potentially be of great advantage to the building after the completion of construction. Record modeling saves time and space by putting all of the information for operation of equipment online. There are programs that exist to more easily navigate this information. Then multiple people have

access to this information rather than one large room of binders of operation and maintenance information. By using BIM for the operation side of the building, data can be more easily transferrable and searchable between projects. This is advantageous to UMB because they maintain several buildings for the university and have opportunities to learn from past building on what products to use or not to use for varying reasons.

Cost Estimation

Although not mentioned on the potential BIM uses worksheet, using BIM for cost estimation could potentially help the project. This project has challenges with cash flow which requires a great understanding of the manpower and purchasing of major equipment at any one time. BIM for cost estimation could help them understand this and make necessary adjustments to the manpower or sequencing of work. They could have also used the model to perform more iterations of the cost estimates as the design progressed.

Critical Industry Issues

IPD Panel

The first discussion involved a panel of three industry members from different companies to discuss integrated project delivery. There were several challenging questions that dove into the challenges and opportunities that IPD has to offer. From the standpoint of an owner, the value of the project manager has expanded from only the construction phase to the entire length of the project including all preconstruction services. The current model for projects that have not adapted more modern project delivery techniques still work heavily in silos, where the preconstruction and construction work partly independent of each other and the project manager on the job mostly works in the construction phase. With IPD, the engagement of the project managers across all disciplines allows for more innovation and shared responsibility across the project. This enhances the ability to draw out the best capabilities from the experts for a successful project. One important skill for a project manager in this role is their ability to promote team building and empower the team to perform well. This requires soft skills to better communicate and manage people.

Personnel changes on project are common and generally hinder the project rather than help it. In this model, the distributive leadership style helps with this transition because the responsibility does not just lie with one person. Another shift seen with this method is the establishment of criteria for partners. In the past, cost was the major driver to pick a contractor. This model embraces other criteria in the decision making with the hopes of getting the best value at the specified price. All parties need to buy into this model for it to properly work because the entire team is working from the same budget and establishes similar goals for the project. A challenge involved with IPD is convincing the owner of the worth to shift the cash flow more up front with the hopes of saving money long term on the project. This is a larger risk for the owner and is one of the leading reasons why owners are resistant to implement this method. Many owners want a quantifiable number to measure this type of upfront investment involved with IPD, but there has been little research done to quantify this. With such a wide variety of project types and sizes, this makes the ability to measure the investment more difficult.

Innovative Design

The first breakout session was about innovative design. The discussion took a different direction that originally anticipated. It was focused more on how innovation is born and the drivers behind innovation. Innovation could be divided into two categories: incremental and monumental. Incremental innovation is the re-engineering of smaller items from material to processes. They improve something in a small manner. Monumental innovations completely change the function or construction of buildings. One example of a monumental innovation was the elevator.

Innovation is mean to shift the way we work and should be encouraged on a project. There was a debate as to when the most useful time frame that innovation affects a project. One side argued that innovation is most effective within the first ten percent of the project. Others said there is never a bad time to come up with good ideas. This was an interesting debate because innovation has been successful in both realms. It seemed that the definition of successful innovation was different between the parties.

Budget and regulations are major drivers toward innovation. These limitations require design teams to be more creative with their systems and how they relate to the program of the space. There was also talk about how to facilitate innovation. Some people suggested the type of space while others specified incentives that can lead to ideas. Colocation was also a commonly used word when discussing what type of space is a facilitator of this environment. An example of a financial innovation mentioned is a power purchase agreement. This understands the idea of a construction budget and an operation budget. A company installs a system upfront and charges the owner for power usage as needed. This puts the cost on the operation side rather than the construction side.

This was an interesting topic because HSF is like all other projects with a budget and a strong incentive to stay within that budget. Constructability reviews and value engineering exercises are attempting to promote innovation and bring down the overall cost of the project, but there is potential for more research to be done to help facilitate more innovation on the project. One area that was not discussed in depth was how different parties within the scope of the project affect innovation or contribute to innovation. Different trades on the job are constantly developing new tools to make their work easier and faster. If the project could tap into this potential, then there might be a lot more opportunity for innovation.

Incentivizing Team Performance

The second breakout session discussed many types of incentives that contribute to team performance. The group began with establishing the behavior drivers of team performance. Among those listed included organizational culture, peer pressure, recognition, personal price and potential for repeat work. Motivations to perform well differ between people, which allow for various methods to have different degrees of success on projects.

Although not discussed in depth, some incentives that have been used on past projects include safety lunches, shared savings clauses, and bonuses for exemplary performance. These relate to the motivation that each individual has on a project. Feedback is a crucial element within incentives because they help measure how the project is performing and allow for continuous improvements throughout the project. There have also been unsuccessful attempts at incentivizing a project. Usually when metrics are established on a project such a number of RFIs on a project, there is less drive to report an RFI for the sake of the statistic. This can also potentially apply to PPC and safety numbers tracked on a project. The best way to increase overall team performance is to rally around a mission. Some of the most successful projects were the ones that every individual believed in and was willing to rally with. For example, the rebuilding of the Pentagon had tremendous support and workers were lined up to work on that project to show their support of their country. Coming together with one mission is important, but this is a major challenge on projects when most company visions do no align with the project mission.

One area within motivation that could have been elaborated on was the discussion about how to trickle down the incentives to the individual. One company would publicly praise standout performance weekly as a way to motivate employees. This is a smart way to reinforce positive behaviors and encourage others to perform to the same standards. There could have been more discussion on aligning personal goals with the goals of the project. Since the majority of the drivers of performance are in the laborers, there is a lot of opportunity to work on incentives for the individual rather than just at a company or a construction management level.

This particular topic is of great interest. It was mentioned that out of this topic one area of research could be to monitor owner engagement and how it affects success. With an owner that likes to be involved in every small decision, there is potential to research this topic on HSF. The motivations of people are interesting areas to study how it affects communication and success on a project. With a lab and research facility that requires a lot of communication between trades, this could be an interesting thing to study.

Feedback from Industry Roundtable

Through discussion with Bill Moyer from Davis Construction, there were a few ideas that came up to potentially analyze for thesis. HSF has a tight site with limited mobility and access, so it was recommended to do an in depth site logistics survey of the project. The material hoist is located outside the building and the masonry that is held off to keep that hoist in place is on the critical path. To eliminate this schedule driver, the material hoist could be potentially moved inside of the building. Also, a second tower crane could be investigated as an option on the project to work with the tight sequencing of the façade. Finally, a last planner session could provide some benefit on the project to help with the scheduling, site logistics and cash flow challenges.

Concerning the dewatering issues on the project, Bill suggested investigating other excavation methods for the project. Options like a slurry wall or steel piling completely blocks the water from seeping through the walls, but they also can cause heaving of the soil at the bottom of the hole. Also, a slurry wall does not have a smooth finish and may need to be finished in the rooms in the basement.

Bill also suggested investigating modularization of some capacity for this project. Many of the corridors are similar in the wet lab areas and span multiple floors. The repetition has potential to take advantage of a modular rack for the MEP equipment. The analysis could also focus on how repeatable an element within the building should be to take advantage of modularization.

Appendix A

BIM USE ANALYSIS
Version 2.0

BIM Use*	Value to Project	Responsible Party	Value to Resp Party	Capability Rating			Additional Resources / Competencies Required to Implement	Notes	Proceed with Use
	High / Med / Low		High / Med / Low	Scale 1-3 (1 = Low)					YES / NO / MAYBE
				Resources	Competency	Experience			
Maintenance Scheduling	LOW	Facility Manager	HIGH	1	1	1	Need software and training		**NO**
		Contractor	LOW	2	2	2	Need software and training		
Building Systems Analysis	LOW	Facility Manager	HIGH	2	2	3			**NO**
		Consulting Engr	MED	3	3	3			
Record Modeling	MED	Contractor	LOW	2	2	3	Need software identified		**YES**
		Facility Manager	HIGH	2	2	1			
		Arch/Engr	LOW	2	2	3			
Cost Estimation	LOW	Contractor	HIGH	2	2	1		Software not developed enough	**YES**
		Architect	MED	1	1	1			
4D Modeling	MED	Contractor	MED	3	3	3			**YES**
		Subcontractors	HIGH	1	1	3		Subs provide knowledge, not technical skill to perform this task	
Site Utilization Planning	HIGH	Contractor	HIGH	3	3	3		Tight site makes this high importance to all parties involved	**YES**
Layout Control & Planning	LOW	Subcontractor	MED	3	2	2			**NO**
3D Coordination (Construction)	HIGH	Contractor	HIGH	3	3	3			**YES**
		Engineers	HIGH	3	2	2	Need compatibility between multiple software types		
Engineering Analysis	MED	Engineer	HIGH	3	3	3	Learning curve of software		**MAYBE**
		Architect	MED	1	2	2			
Site Analysis	LOW	Owner	MED	2	2	2		Site determined by owner at beginning of project	**NO**
Design Reviews	MED	Arch/Engr	HIGH	3	3	3			**YES**
		Contractor	HIGH	2	2	2			
3D Coordination (Design)	LOW	Architect	LOW	2	2	2	Knowledge of software		**NO**
		Engineer	MED	2	2	2	Knowledge of software		
Existing Conditions Modeling	LOW	Architect	LOW	2	2	1			**NO**
Design Authoring	HIGH	Architect	HIGH	3	3	3			**YES**
		Engineer	HIGH	3	3	3			
Programming	MED	Architect	HIGH	3	2	3			**MAYBE**

BIM Execution Process

Health Sciences Facility III