7700 ARLINGTON BLVD.
FALLS CHURCH, VA

SENIOR THESIS FINAL PROPOSAL

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CONSTRUCTION MANAGEMENT

2012 CAPSTONE PROJECT

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Executive Summary

Senior Thesis Final Proposal is intended to identify four analyses that will be utilized on 7700 Arlington Blvd. Each analysis either addresses all or some of four investigation areas; Critical Issues Research, Value Engineering Analysis, Constructability Review, and/or Schedule Reduction. The expected outcome and overall theme for the four analyses is defining and creating more efficient means to construction collaboration.

Analysis #1 | Integrated Project Delivery Approach

Material procurement was a challenge for this project and it involved detailed coordination amongst trades in order to reach project start-up. Additional time and money were required to achieve the necessary material, the reason being the type of project delivery method used for 7700 Arlington Blvd. The goal of this analysis is to compare two process maps, one for design-bid-build and one for integrated project delivery, to see where the different coordination and communication levels occur amongst the two delivery methods. The IPD process map will be a way to standardize the process for all parties involved for the lifetime of a project.

Analysis #2 | New Mechanical System in the Northwest Building

The existing mechanical system was to remain in the Northwest Building, but the mechanical system had to be removed due to unforeseen ceiling conditions. A new system was implemented into the project which produced long term benefits, but incurred additional costs for the owner. The goal of this analysis is to study the life-cycle analysis if the same VAV system that was installed in the Southwest Building were to be implemented in the Northwest Building. The expected outcome is the system will cost the owner more money upfront, but could save them time, which is a critical concern on this project. Two breadths will be extracted from this analysis with ***Breadth #1*** being the ***mechanical life-cycle analysis*** and ***Breadth #2*** being a ***structural analysis*** on the additional reinforcement needed for roof top units.

Analysis #3 | Creating a Short Interval Production Schedule

There were many coordination issues that occurred on 7700 Arlington Blvd. due to the complex schedule. There was not enough time allotted for demolition, which directly impacted the structural steel erection schedule. The goal for this analysis is to create a SIP Schedule that can be utilized in the field for the demolition and structural system aspect of the project. An overall reduction in schedule with the utilization of a SIP Schedule is expected. This analysis will be directly inputted into Analysis #4 to create a thorough plan on implementing BIM into the field.

Analysis #4 | BIM Implementation into the Field

Due to the coordination issues that happened with this project, the utilization of BIM in the field could have possibly prevented certain issues. Continuing with the same problem that has happened in Analysis #3, the goal for this analysis is to look at the method of space planning through the use of a Sketch-Up model and the SIP Schedule. The idea of using BIM Implementation into the field is it will benefit everyone on the jobsite and through the use of an Apple IPad; uncertainties will be clarified in order to create a safer work environment.

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Project Background

7700 Arlington Boulevard is comprised of three buildings with a four story atrium in the middle and will be the new home to the Defense Health Headquarters (DHHQ). The three buildings were originally built between the 1950s to the 1980s. The Northwest Building is four stories tall with a height of 47 feet and a gross square footage of 267,436 SF. The Southwest Building is four stories tall with a height of 43 feet 10 inches and a gross square footage of 159,005 SF. The Main Building is two stories tall with a height of 31 feet 10 inches and a gross square footage of 258,209 SF. Overall, the architecture of 7700 Arlington Boulevard looks like a typical office building.

Since this structure was pre-existing, the overall scope of work includes all of the following:

- Demolition of 90% of the current interior partitions
- Demolition of a third story above segment D
- Demolition of a penthouse above segment C
- Replacement of all windows
- A re-skin of the 4th floor
- Construction of new core elements
- Anti-terrorism/force protection (progressive collapse steel and façade hardening)
- Coating the existing brick façade
- Construction of a new canopy at the main entrance
- Renovation of mechanical and electrical systems in segments A and B
- New mechanical and electrical systems in segments C, D, E and F

The project was awarded to James G. Davis Construction Corporation on July 12, 2010 after about six months of evaluating the SFO responses. SFO stands for solicitation from offer which is where an agency, in this case DHHQ, posts all their requirements for a space they would like to occupy. It is a public posting where different property owners will send in a bid in an attempt to meet the owner's requirements and costs. Three months later, Davis Construction mobilized on the construction site.

Since there are three buildings on this jobsite, a lot of coordination had to be done in order to evaluate the correct sequence for the job. The 2-phase construction sequence, shown in Figure 1, was developed because Raytheon will still be occupying the space during construction and DHHQ will be moving into the space as construction approaches completion.

Figure 1 | 2-Phase Construction Sequence

7700 Arlington Blvd. is an existing structure, so there will be certain systems demolished for this project. The main materials that will be demolished include: the removal of the building façade, louvers & windows, elevator structure, interior stairs, existing penthouse structure, cafeteria, antenna room, and the existing parapet for the entire perimeter of the Main building, which is shown in the picture to the right. In addition to these materials being removed, the Main and Southwest Buildings will demolish their mechanical systems, the entire electrical & lighting system, and the plumbing and fire protection systems.

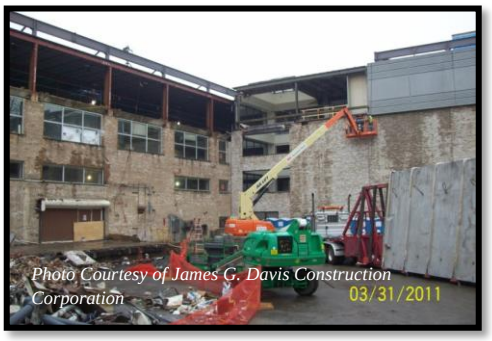

Figure 2 | Demolition of Existing Parapet for Perimeter of Main Building

A large portion of analysis will involve the mechanical systems installed into the buildings. There are three basic air conditioning systems throughout all the buildings, with the Main Building system utilizing an all-air rooftop cooling system, which distributes air to different spaces through low-pressure ductwork and ceiling diffusers. The return air will be sent back to central duct risers, which are through a ceiling plenum.

The Northwest Building system is a closed-loop water source heat pump system. There are interior and perimeter zones for this system, with the interior zone having large heat pump air-handling units in mechanical rooms on each floor. The perimeter zone has individual heat pump units located in each office along the perimeter. A roof top unit is home to the closed-loop hydronic circulation system where it houses pumps, boilers, and cooling towers.

The Southwest Building system is a chilled water/hot water system with central VAV air handling units. Low-pressure ductwork and ceiling diffusers will be used again to distribute the air throughout the building. Increased ventilation is provided for each system type by roof mounted preconditioning outside air units or by integrated heat wheels. A direct digital control system will monitor and control the three HVAC systems.

One of the biggest constructability challenges for 7700 Arlington Blvd. was determining material needed for initial start-up. Usually for a new building, there is time to arrange for different material deliveries to the site. Due to the fact that this is a renovation project, there was minimal time to set the materials on site for project start-up. James G. Davis Construction worked closely with the other subcontractors to formulate a plan from the very beginning as to what was required for the job.

Photo Courtesy of James G. Davis Construction Corporation

Figure 3 | 7700 Arlington Blvd. Navisworks Model

With limited access to the buildings, Davis Construction decided they needed a better solution than hypothesizing the types of material needed for the job. They began taking field measurements to recreate the buildings and site in a BIM model. The BIM model was used to fabricate materials in order to get them on site for start-up. Creating the model was the best idea prior to 7700 Arlington Blvd. starting construction because this job has been fast tracked from the very beginning. One mistake on a large order could be extremely detrimental and could put the project behind.

Analysis #1 | Integrated Project Delivery Approach

Problem: Material procurement was a challenge for this project, involving a lot of time and money to ensure the success of materials on site prior to job start-up. The owner invested money up front in order to purchase and ensure the quality of certain materials, such as the progressive collapse steel system. Another problem with the initial design phase of this project was the subcontractors who invested their time and money were not guaranteed a bid to finish the entire project. This poses a business issue because the general contractor requires the subcontractors to submit a bid. If they are not awarded the bid, then there was no benefit for them to help out from the beginning. Granted, more times than not, the subcontractor that has helped in the design phase will be awarded a bid, but it is still not guaranteed. The one subcontractor that invested a lot of their time and money in the design phase was the steel contractor, who helped with the complex progressive collapse steel system.

Research Goal: The goal of this analysis is to create a way to improve showing a general contractor and other individuals how to implement an integrated project delivery approach on a project. In order to do this, two process maps will be created; one of a traditional design-bid-build project delivery approach and one of an integrated project delivery approach to show the difference between coordination and communication levels throughout the entire project lifetime.

Research Steps:

- Contact Davis Construction to receive a design-bid-build contract and an IPD contract
- Analyze AIA Contract Documents on both project delivery methods
- Communicate with the Steel Subcontractor and document what they believe would have been helpful when coordinating the progressive collapse steel system
- Perform a detailed analysis on both contracts
- Design a process map for each stage of a project for both contracts
- Compare outcomes of similarities and differences
- Suggest different strategies to use IPD on 7700 Arlington Blvd.
- Develop a word document explaining how to use the process maps
- Explain any conclusions and recommendations that were made from the analysis

Resources and Tools to be used:

- Industry professionals including Davis Construction
- AE 570 Project Development and Delivery Planning
- AE 572 Production Management in Construction
- Microsoft Visio
- Applicable resources (books, websites, papers, etc.)

Expected Outcome: The expected outcome for this analysis is to show where the different coordination and communication levels are on a project for both delivery methods. The idea is to prove using an integrated project delivery approach, higher levels of commitment must be made and everyone must rely on one another throughout the life of a project. Also, since implementing IPD successfully on projects is not an easy task, the process map will be a way to standardize the process.

Analysis #2 | New Mechanical System in the Northwest Building

Reference Appendix A for Breadth Topics

Problem: Since this building is a renovation, some of the systems are to remain due to the owner's budget. The Northwest Building is to keep the control system and mechanical system that already exist with minor improvements. Due to the unforeseen ceiling conditions, a mistake was made by the general contractor with the control system, resulting in time and money lost. Even though there was a mistake made on the jobsite, the owner will benefit from the loss of the control system because a new control system will be implemented and tied in with the other two buildings. This was a sizeable constructability challenge and a learning lesson because it is not always better to skimp in areas that could potentially result in big changes.

Research Goal: The Southwest Building is similar to the Northwest building, so the goal is to do a comparison if the same system that was installed in the Southwest Building would be installed in the Northwest Building. The idea is too show the owner that even though their budget was not substantial that installing a new mechanical system from the very beginning would have been beneficial in the Northwest Building. This is due to the fact that the building is dated and no original ceiling plans existed to show what was going to be found in the ceiling during demolition.

Research Steps:

- Research and analyze the existing mechanical system in the Northwest Building
- Research and analyze the mechanical system to be installed in the Southwest Building
- Perform a life-cycle analysis on both systems to prove one is better than the other
- Determine feasibility of implementing the Southwest mechanical system into the Northwest Building
- Calculate reinforcement needed for any extra roof-top units
- Summarize results and draw conclusions on the outcomes developed

Resources and Tools to be used:

- Davis Construction
- Fellow AE Classmates (Mechanical and Structural)
- Architectural Engineering Department Faculty
- AE 476 Building Construction Engineering II
- AE 404 Building Structural Systems in Steel and Concrete
- Applicable resources (books, websites, papers, etc.)

Expected Outcome: It is believed that implementing a new system in the Northwest Building will save time, but cost more money, after studying the detailed life-cycle analysis. Since time is the most important construction criteria to the owner on 7700 Arlington Blvd., it can be assumed installing a new system instead of updating the old is a more viable option. Any additional reinforcement that would be needed will be added into the cost comparison.

Analysis #3 | Creating a Short Interval Production Schedule

Problem: There are many areas throughout the project from the initial design phase to construction that have been challenging for the design team. The problem is coordination is a large part of the day to day tasks and 7700 Arlington Blvd. has a complex schedule. There seems to be many areas of the job having repetitive work, but have schedule lags for one reason or another. The time allotted for the demolition was not enough and impacted the structural erection aspect of 7700 Arlington Blvd. The project team had to create a new plan as to how they were going to keep the schedule on time, as well as get the demolition and structural systems installed. The plan that was created ended up being extremely successful, but costly because most crews worked double shifts in order to complete the work. The issue here, which was discussed earlier, is safety on the jobsite.

Research Goal: The goal of this analysis is to create a SIP schedule that can be utilized in the field for the demolition and structural system aspect of 7700 Arlington Blvd. Space planning will be used in order to reduce the schedule the project team had to deal with. Another goal is to create a plan that better suits this type of project and a plan, eliminating the possibility of running a double shift and creating an unsafe work environment by having multiple trades in one area.

Research Steps:

- Obtain most recent schedule from Davis Construction
- Analyze and document the sequence of work for demolition and structural steel
- Determine preliminary elements that are needed for the schedule such as segmenting different areas of the buildings
- Develop a repetitive sequence for demolition and structural steel
- Create the SIP Schedule
- Analyze the impact of all other items on the critical path that follow these two activities
- Perform schedule analysis
- Implement SIP Schedule into Analysis #4

Resources and Tools to be used:

- Architectural Engineering Department Faculty (Construction Management & Structural)
- AE 570 Project Development and Delivery Planning
- AE 473 Building Construction Management and Control
- Applicable resources (books, websites, papers, etc.)
- Microsoft Excel & Microsoft Project will be utilized to develop the schedule

Expected Outcome: Through the development of a short interval production schedule, it is expected there will be an overall reduction in the project schedule. Also, by implementing a new lean process into the project, different BIM uses will be designed for use in the field, which will be discussed in the fourth analysis. Another expected outcome of the SIPS will be the development of an overall safer environment on the site. This is extremely important because what actually happened during the project created a vast amount of unnecessary safety issues that they dealt with on a day to day basis.

Analysis #4 | BIM Implementation into the Field

Problem: BIM Implementation into the field is a new part of construction being explored amongst many companies and projects throughout the country. Since there were a large amount of coordination issues on 7700 Arlington Blvd., utilizing BIM in the field could have possibly prevented some of the larger issues that they encountered. The same problem was described in Analysis #3, which was there was not enough time allotted for the demolition to complete what was necessary in order for the structural steel crew to begin their installation. The schedule was the owner's top priority on this project, but meeting the schedule was pricy with the amount of work that had to be re-sequenced.

Research Goal: Developing a Sketch-Up model, that can be tied into the SIP schedule in order to reduce the schedule and make the sequence of the demolition crew and structural crew easier, is one goal for this analysis. Also, by utilizing the Sketch-Up model to use the space planning method to show where material, workers, and equipment will be placed is another goal that can help with the proper sequencing and safety of the project. The idea of using BIM in the field will benefit everyone on the jobsite because the use of an Apple IPad will help answer any uncertainties with the sequence of construction.

Research Steps:

- Complete Analysis #3
- Create floorplans in Sketch-Up (use areas developed from the SIP schedule)
- Develop different areas using the space planning method
- Attach the SIP Schedule to the Sketch-Up model
- Create animation to use on Apple IPad
- Upload animation to Apple IPad and fix any issues
- Summarize results and analyze the effectiveness of this method

Resources and Tools to be used:

- AE 597F: Virtual Facility Prototyping
- Sketch-Up
- SIP Schedule from Analysis #3
- Borrowing a friend's Apple IPad
- Davis Construction: Finding out what they think would be beneficial with implementing BIM into the field
- Applicable resources (books, websites, papers, etc.)

Expected Outcome: By creating a way to easily address certain coordination and space issues on a job through the utilization of an Apple IPad in the field, it is believed a safer work environment will be created. Also, by attaching the SIP Schedule to the model, the same schedule reduction found in Analysis #3 will help show the feasibility of the actual work being performed. This is a great way to make something complicated into something user friendly for the owner, general contractor, and all trades involved to understand.

Weight Matrix

Table 1 shows the weight matrix distribution for the core thesis investigation areas of each analysis. The percentages represent the effort that will be put forth in each investigation area for each analysis topic. There is a even distribution amongst all the topics that will be analyzed.

Table 1 | Weight Matrix for Core Thesis Investigation Areas

Description	Research	Value Engineering	Constructability Review	Schedule Reduction	Total
IPD	20%				**20%**
New Mechanical System		10%	20%		**30%**
SIPS	10%	10%		10%	**30%**
BIM into the Field		10%		10%	**20%**
Total	**30%**	**30%**	**20%**	**20%**	**100%**

Spring Semester Preliminary Timetable

Reference Appendix B for the Spring Semester Preliminary Timetable

Appendix B outlines when each analysis will be performed and is broken down into major task requirements. Also, every milestone and major event is listed on the timetable. The schedule was created to show the progression of work and to make sure goals are being met throughout the semester.

Conclusion

The spring semester has four analyses involving an in-depth look at four core investigation areas; critical issues research, value engineering, constructability review, and schedule reduction. The expected outcome and overall theme for the four analyses is defining and creating more efficient means to construction collaboration. A process map will help define the most important measures for a Design-Bid-Build & an IPD method for the owner, general contractor, and subcontractors involved. Also, by implementing a new mechanical system into the Northwest Building from day one will prove even though the system may cost more, the overall life of the system and building will be more beneficial than keeping the existing system. By re-sequencing the demolition and structural steel into a SIP Schedule and attaching it to a 3D Sketch-Up model, it will be an easy way to show workers in the field what needs to be completed. Also, using an Apple IPad in the field, workers will be able to see what the space should look like in each area in order to maintain a safe work environment. This proposal is a working document and revisions will be made based on the feedback received from the thesis advisors.

References

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Appendix A

Breadth Topics and MAE Requirements

Breadth Topics

The two breadth topics that will be explored are both apart of Analysis #2. The requirement for the course is to perform an in-depth analysis on two options separate from construction management. The two that have been chosen are a mechanical breadth and structural breadth.

Mechanical Breadth: Life-Cycle Analysis on Two Mechanical Systems

As stated in the project background, the Southwest Building is a chilled water/hot water system with central VAV air handling units. Increased ventilation is provided for each system type by roof mounted preconditioning outside air units or by integrated heat wheels. The existing Northwest Building is a closed-loop water source heat pump system. There are interior and perimeter zones for this system with the interior zone having large heat pump air-handling units in mechanical rooms on each floor. The perimeter zone has individual heat pump units located in each office along the perimeter. A roof top unit consists of the closed-loop hydronic circulation system, where it houses pumps, boilers, and cooling towers.

The same VAV system will be implemented into the Northwest Building and a life-cycle analysis will be performed in order to show the various differences between the two systems. The life-cycle analysis will show the different energy outputs, maintenance life, cost analysis, and other critical items for the owner to compare both systems. Once the life-cycle analysis is developed, the different cost analyses will be compared to the original budget. The cost and schedule impact of the findings in this breadth will be thoroughly incorporated into the second analysis.

Structural Breadth: Additional Reinforcement for RTUs

In addition to a life-cycle analysis breadth, calculations will be computed to ensure proper loads for any additional roof top units. This is assuming that there will need to be a change in either the placement of the units on the roof or the size of them. The Southwest Building has two roof top units for the VAV system, which will be taken into account for the Northwest Building. Five smaller roof top units are installed from the existing Northwest Building; therefore additional structural support may need to be installed. Strength and deflection checks of members will be performed to analyze if additional structural support is required. A cost analysis will be performed for any necessary additional reinforcement and will be incorporated with the cost of the VAV system to be installed. Also, the time to install the equipment will be calculated and inputted into the baseline schedule for comparison purposes. The expected outcome of adding reinforcement would be that it will cost more and take more time to install, but overall will be beneficial with the new mechanical system being added to the building.

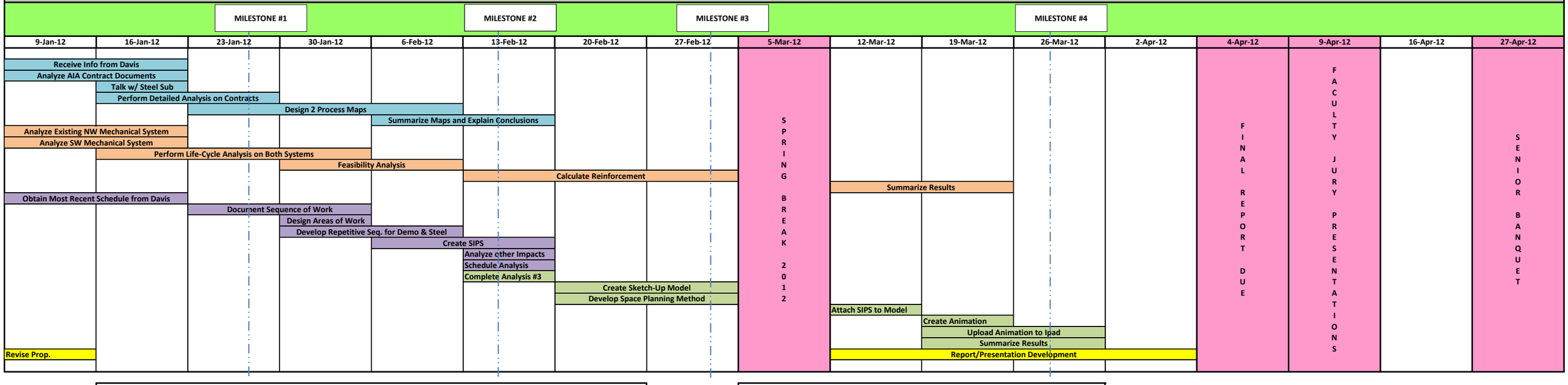
MAE Requirements

Three of the four analyses will incorporate work taught in the MAE curriculum. AE 570: Project Development and Delivery Planning and AE: 572 Production Management in Construction will be used to create a Design-Bid-Build and an IPD process map. Creating a SIP Schedule for 7700 Arlington Blvd. is one beneficial method taught in AE 570 that will be utilized. Space Planning, another method taught in AE 570 will be developed in the BIM Implementation into the Field Analysis, in order to create a new sequencing plan. In addition to the BIM Implementation, a few methods that were taught in AE 597F: Virtual Facility Prototyping will be used in 4D planning, which will incorporate the newly developed SIP Schedule and 3D Sketch-Up Drawings of each floor plan.

Appendix B

Spring Semester Preliminary Timetable

PROPOSED THESIS SEMESTER SCHEDULE
JANUARY 2012 - APRIL 2012



MILESTONE ACTIVITY LIST	
1	Collect all necessary data, Begin process maps, Complete half of the life-cycle analysis
2	Complete Analysis #1
3	Finish up to Reinforcement for Analysis #2
4	Complete Analysis #2 & #4

ANALYSIS DESCRIPTION	
#1	Integrated Project Delivery Approach
#2	New Mechanical System in the Northwest Building
#3	Creating a Short Interval Production Schedule
#4	BIM Implementation into the Field