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 | Simplifying the 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 create a process map in order to improve showing an owner, contractor, and architect how to implement an integrated project delivery approach on a project. The map will show the different levels of coordination and communication throughout the entire project lifetime and the map will be a way to streamline the process for all parties involved throughout a project.

Analysis #2 | New Mechanical System in the Northwest Building

The Northwest Building was the only building that did not receive a new mechanical system due to the owner's budget. Therefore, the goal for this analysis is to create a TRACE 700 model for the Northwest Building that gathers data for a comparison between a water source heat pump system and a VAV system. The same VAV system that was used in the Southwest Building will be utilized in the TRACE 700 model. The expected outcome is that one system will perform better than the other as well as cost the owner more money upfront. Two breadths will be extracted from this analysis with ***Breadth #1*** being the ***TRACE 700 analyses*** and ***Breadth #2*** being two raised platform designs for the additional reinforcement roof top units if the VAV system were to be installed in the Northwest Building.

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 issue as in Analysis #3, the goal for this analysis is to look at the influence of flow diagrams and process charts for use in the field. A high-tech work station that incorporates the use of an Apple iPad as well as the use of BIMsight technology will be explored to figure out the applicability for workers in the field.

Table of Contents

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.

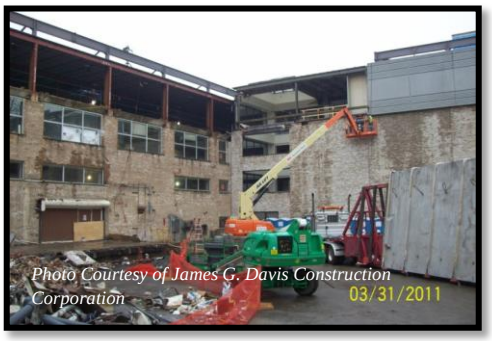

Figure 2 | Demolition of Existing Parapet for Perimeter of Main Building

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: 7700 Arlington Blvd. utilized a CM @ Risk project delivery method with a GMP contract. At the beginning of the project material procurement was a challenge due to the budget and time allotted. The initial planning involved time and money from all ends to ensure the quality of expensive materials. Davis Construction was in charge of organizing the design professionals and specialty contractors during the material procurement process. For example, the steel contractor had to develop an economical design for the progressive collapse steel system for the three building complex. They worked closely with Davis Construction to ensure the materials would be on site prior to the system's installation. After attending the PACE conference in fall 2011, many industry members expressed an interest in figuring a way to simplify the integrated project delivery approach in order to fully utilize the method in future viable projects.

Research Goal: The goal of this analysis is to create a way to show an owner, contractor, and architect how to implement an integrated project delivery approach on a project more efficiently. In order to do this, one process map will be created of an integrated project delivery approach to show the different levels of coordination and communication throughout the entire project lifetime.

Research Steps:

- Contact Davis Construction to receive an IPD contract
- Analyze AIA Contract Documents and AIA IPD Guide
- Perform a detailed analysis on all given information
- Design a process map for fully simplifying the IPD approach
- Analyze and document how to use the process map
- Suggest different strategies to use IPD on 7700 Arlington Blvd.
- 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 by 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 exists 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 for all parties involved.

Research Goal: The overall goal for the analysis is to compare and contrast the idea of implementing two new mechanical systems in the Northwest Building. Since the Southwest Building is fairly similar to the Northwest Building, the same VAV system for the Southwest Building will be placed into the Northwest Building. Also, since a water source heat pump system exists in the Northwest Building, a new system of the same type is going to be looked into. The idea is too show the owner through a basic Trace Model that one system is more beneficial than the other and that even though their budget was not substantial a new mechanical system in an existing building has a variety of benefits.

Research Steps:

- Research and analyze the existing mechanical system in the Northwest Building
- Research and analyze the new mechanical system installed in the Southwest Building
- Build TRACE 700 Model and collect data
- Compare and contrast a VAV system with a water source heat pump system
- Perform cost and schedule analysis
- Design two different raised platforms that will hold a 32000lb roof top unit on the Northwest Building
- 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 TRACE 700 data outputs. 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 one 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.

Research Goal: The goal of this analysis is to create a Short Interval Production Schedule (SIPS) that can be utilized in the field for the demolition and structural system aspect of 7700 Arlington Blvd. 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. Overall, the SIP schedule created should reduce the construction schedule and reduce general condition costs.

Research Steps:

- Obtain information from Davis Construction
- Analyze and document the sequence of work for demolition and structural steel
- Develop a repetitive sequence for demolition and structural steel
- Create the SIP Schedule
- Analyze the SIP Schedule
- Perform schedule analysis
- Perform cost 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: Since there were a large amount of coordination issues on 7700 Arlington Blvd., improving performance through the use of technology in the field could have possibly prevented some of the larger issues that they encountered. The same problem described in Analysis #3 pertains to this analysis, which 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. Through the use of flow diagrams and detailed process charts, the sequencing of work could have been broken down far enough to ensure activities would stay on track.

Research Goal: Developing flow diagrams and detailed process charts, which 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. The overall goal is to create a physical station that can be placed on job sites and will house a tablet to give workers access to the necessary information, such as the SIP schedule, flow diagrams, and process charts. These stations and a software program, BIMsight, will be implemented to better help the contractor coordinate with the other trades on a daily basis.

Research Steps:

- Complete Analysis #3
- Create big picture flow diagrams (use areas developed from the SIP schedule)
- Create detailed flow diagrams
- Create process charts
- Develop physical station in SketchUp
- Research programs and what will be loaded onto the tablets
- Research potential issues with station
- Create images to use in technology
- Discuss how technology can be used in the field through the use of BIMsight
- Summarize results and analyze the effectiveness of this method

Resources and Tools to be used:

- Sketch-Up
- SIP Schedule from Analysis #3
- 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	5%	10%		15%	**30%**
BIM into the Field	5%	10%		5%	**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 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 sequencing plan, 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: TRACE 700 Analyses

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 TRACE 700 model will be designed in order to show the various differences between a VAV system and a water source heat pump system. The TRACE 700 model will show the different energy outputs, system performance data, and other critical items for the owner to compare both systems. Once the data is collected, cost, schedule, and system life analyses will be performed. The findings in this breadth will be thoroughly incorporated into the second analysis.

Structural Breadth: Two Raised Platform Designs

In addition to a mechanical breadth, two raised platforms will be designed to ensure the roof top unit will be able to sit on the Northwest Building. 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 on the existing Northwest Building; therefore additional structural support may need to be installed. Strength and deflection checks of the designed members will be performed to ensure appropriate steel members will be used for the roof top unit to sit on. A cost analysis will be performed for the two different designs in order to figure out which platform is less expensive and takes less time to install.

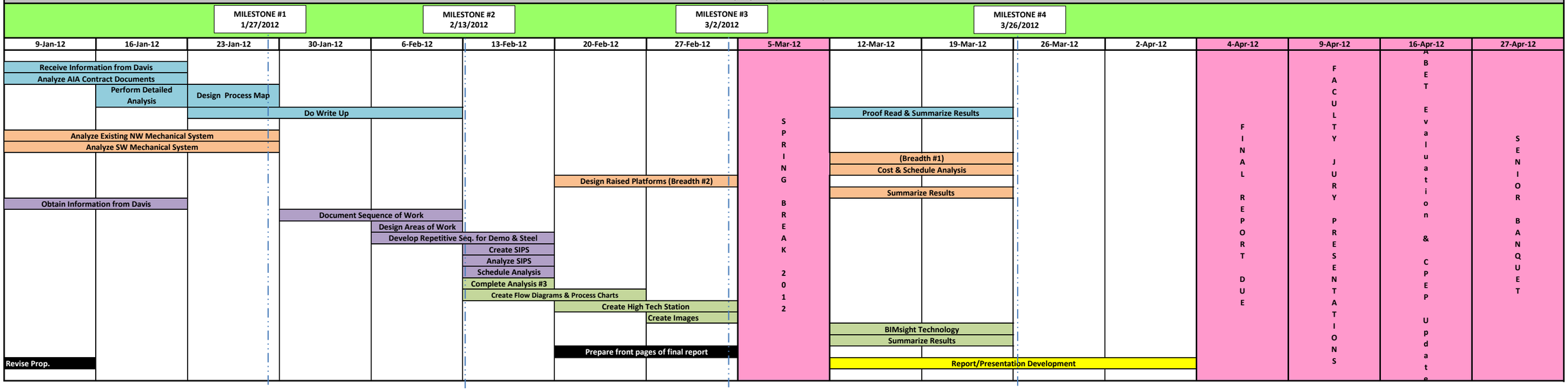
MAE Requirements

Two of the four analyses will incorporate work taught in the MAE curriculum. AE 570: Project Development and Delivery Planning and AE 598D: Legal Aspects of the Engineering and the Construction Process will be used to create an IPD process map. Creating a SIP Schedule for 7700 Arlington Blvd. is one beneficial method taught in AE 570: Production Management in Construction that will be utilized.

Appendix B

Spring Semester Preliminary Timetable

PROPOSED THESIS SEMESTER SCHEDULE
JANUARY 2012 - APRIL 2012



MILESTONE ACTIVITY LIST	
1	70% Completetion on Analysis #1
2	50 % Complete w/ Analysis #3, Analysis #1 Complete
3	Finish Breadth #1, 60% complete w/ Analysis #4, Complete Analysis #3
4	Complete Analysis #2 & #4, Finish Breadth #2

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