The Pennsylvania State University
5th Year Senior Thesis

Thesis Proposal Revision

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Executive Summary:

The senior thesis final proposal is intended to explain the research and analysis proposed for the spring semester portion of senior thesis. The topics that were chosen have been identified based on cutting costs, energy consumption, accelerating the schedule, value engineering, constructability, jobsite efficiency, and critical industry issues. Additionally, breadth topics were determined relating to the analysis in order to fulfill the requirements as an Architectural engineer.

Analysis #1 – *Alternate Roofing Systems Analysis (Green, Solar):*

The proposed solution to this problem will be to explore two different types of roof systems, a green roof and a PV panel roof. Additionally, research will be conducted for the energy benefits of each roofing system. A financial feasibility study will be performed to indicate whether the proposed roofing system is best for the owner. In addition, an energy analysis will be conducted to determine the benefits and drawbacks of each type of roofing system, these calculations will fulfill an electrical breadth which is explained in Appendix A of this report.

Analysis #2 – *Risk Management – Long Lead Items:*

This is a Risk Management analysis for all the long lead items of the Data Center. This analysis will explore the hypothetical idea of Turner being in control of the buying/fabricating of all the mechanical/electrical long lead items and to determine the benefits and risks using this management method. Cash flow diagrams are appropriate for this analysis to compare the cash flow of the construction manager vs. the subcontractor's responsibilities of the long lead items. The schedule and costs of the Data Center will need to be adjusted for this analysis.

Analysis #3 - *Façade redesign (Implement Tilt-up Construction):*

This analysis explores a redesign of the parapet wall while conducting interviews with the architect about what he wants to accomplish with the current parapet walls. A structural analysis will need to be conducted to determine if any changes in beam/column sizes. The changes in the sizes of the beams and columns may decrease the cost of material for the Data Center. This will apply for a structural breadth. More information on this specific breadth can be viewed in Appendix A of this report. In addition to this redesign, incorporation of tilt-up construction will be assessed to essentially accelerate the Data Center's schedule.

Analysis #4 - *Critical Industry Analysis – Implement Latista (Commissioning):*

The proposed solution for this problem is to research the Latista technology during the construction process. The main focus of this analysis is to look into Latista's commissioning benefits. Latista is also a great tool for organization of materials onsite and procurement. This technology was discussed during the 2010 PACE roundtable. More information can be viewed in technical assignment two.

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Project Background:

NOTE: Due to the sensitivity of this project the name, location, and some cost will not be given.

The Data Center is one story expansion/renovation project consisting of roughly 17,500 square feet of a new addition to roughly an existing 114,500 square feet. This building is the second of three expansions. The project is designed for another a third expansion allowing for an additional 30,000 square feet. The addition will include more computer, electrical and mechanical rooms. As well as more storage and advanced data network distribution. Figure A.1 shows an image on the new addition and the existing buildings that surround it.

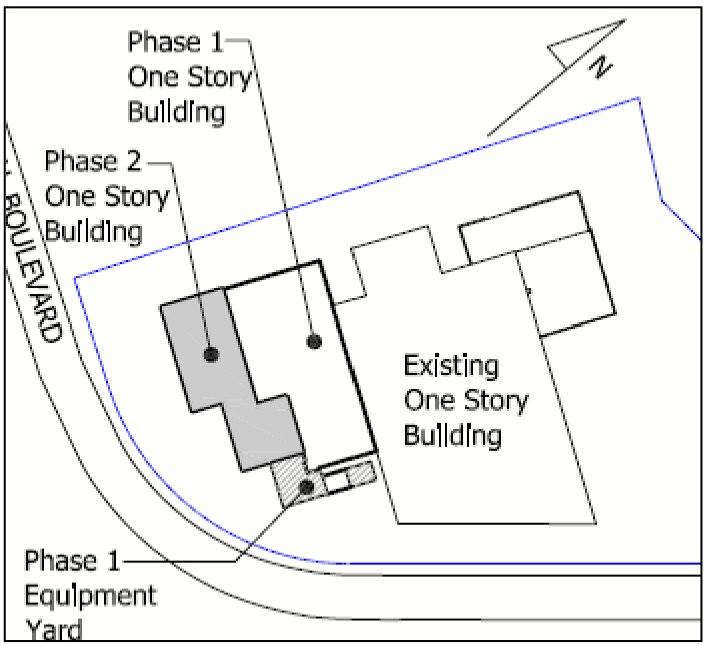


Figure A.1 Building Layout

The Data Center's shell is primarily made up of architectural precast concrete and is designed to withstand wind up to 200 miles per hour. A liquid membrane is used between the precast and flashing for maximum water protection. The precast is erected to bearing surfaces that must bear 2 ½ inches on steel and/or 3 inches on concrete block or masonry brick. Shims or jacks are used to align and level the precast panel.

The mechanical rooms and penthouse is enclosed with EIFS with 3 inch insulation with intake louvers on some areas of the rooms. The rooms are also equipped with acoustical silencer and dampers on a stand to account for any undesirable sound.

For the project's schedule, the design for the Data Center was completed in December of 2008. However the preconstruction did not start until August of 2009 with the completion of the conceptual documents and the soils report. As previously mentioned, this is the second of three expansions. The first and second expansions are done. The second phase was competed on August 30, 2010.

The largest challenge associated with the projects schedule is the complexity of the mechanical and electrical systems. Coordination was the main focal point for this project. The mechanical system includes: Chilled water systems, glygol water systems. The chilled water system is 350 ton and the GPM ranges from 1,100 – 1,300. The dry cooling is a 190 ton system. The glygol water system is located on the roof and pumps out 110,040 CFM. In addition, the electrical system includes a 2N electrical infrastructure with concurrent maintenance.

For more information, please refer to the following website: http://www.engr.psu.edu/ae/thesis/portfolios/2011/djs5162/index.html, click on any of the following links:

- Building Statistics
- Technical Assignments

Analysis #1- *Alternate Roofing System Analysis (Green, Solar):*

Problem Identification:

The Data Center's roof construction primarily constructed with EPDM fully adhered to concrete slab on deck. On top of the EPDM is interlocking insulation board covered with UV protection fabric and is topped off with interlocking concrete pavers. This type of roof was selected for sound isolation purposes. The primary problem is that the owner is not utilizing the opportunity to implement green/solar roofing systems to increase to performance of his/hers building. In addition, the current roof constructed includes various amounts of materials and two different trades to construct this roof type.

Proposed Solution:

The proposed solution to this problem will be to explore two different types of roof systems, a green roof and a PV panel roof. Additionally, research will be conducted for the energy benefits of each roofing system. A financial feasibility study will be performed to indicate whether the proposed roofing system is best for the owner. In addition, an energy analysis will be conducted to determine the benefits and drawbacks of each type of roofing system, these calculations will fulfill an electrical breadth which will be explained later in this report.

Benefits:

- Green Roofing System:
    - Economic Benefits:
        - If constructed correctly, this type of roofing system may last longer than the original design resulting in savings on replacement/maintenance costs.
        - Potential savings on heating and cooling costs.
        - Reduces storm water runoff.
    - Sound Isolation Benefits:
        - Soil and plants can insulate sounds from the mechanical systems located on the roof.
        - Green roofing systems with a substrate layer up to 20 cm can reduce sound by 46-50 decibels.
    - Financial Benefits:
        - Increases the buildings value.
- PV Roofing System:
    - Reduce cost energy for the building.
    - Government benefits (Financial)

Drawbacks:

- More costs up front
- Depending on the type of green roof, a maintenance cost may occur.
- The weight increase may affect the structure of the building.

Research:

The research components of the analysis will include designs of the two types of roofing systems and determine the impacts on the cost and schedule of the project. Also, a life cycle cost analysis will be conducted to determine how much time it would take to pay for the new structure. Additionally, a financial feasibility study will be performed to determine any additional cost savings using a green roof and/or PV roof in an effort to make this analysis more appealing.

Methodology:

- Develop conceptual designs of both roofing systems.
- Consult with professionals on the proposed designs.
- Evaluate the constructability issues associated with this proposed solution.
- Develop a feasibility study on both roofing systems.
- Calculate the cost and schedule impacts to the proposed solution.
- Calculate any energy savings (electrical breadth) cost that may appeal to the owner.
- Summarize findings.

Resources and Tools to be used:

- Industry Professionals
- AE Faculty – Acoustical
- Turner Construction
- Sigma 7 – Architect
- Microsoft Excel
- Project owner

Expected Outcome:

The expected outcomes from this analysis will conclude that a PV panel roofing system will be more beneficial to the owner because of the type of building it is. The effects on duration and cost will be affected in a negative way, but the life cost cycle will make up for the longer duration and cost to the owner. To successfully complete this analysis, client research cannot be taken likely.

~~**Analysis #2** – *Implement 3D coordination:*~~

Please see the update following this section.

~~*Problem Identification:*~~

~~The use of BIM and 3D coordination was not pursued for the Data Center. This is a problematic feature because the Data Center could have benefited by implementing BIM and 3D coordination. The schedule shows a portion of the coordination meetings for the whole project between Sigma 7 and Turner. This portion of the detailed schedule can be viewed in Appendix C of this report.~~

~~3D coordination could have been implemented shaving time and money for this project. The use of this coordination technique could have lowered the amount of time spent in coordination meetings.~~

~~*Proposed Solution:*~~

~~The proposed solution to this problem would be implementing 3D coordination in the design and preconstruction phases to this project. The goal of this analysis is to decrease the amount of RFI's and change orders, also accelerate the coordination portion of the schedule, which can be found in Appendix C of this report. The use of 3D models and clash detection can give insight to subcontractors on what will be needed onsite, which in term could decrease site congestion. Also, a good 3D model could essentially benefit the prefabrication/procurement process.~~

~~*Benefits:*~~

- ~~Possibly cut the scheduled coordination meetings.~~
- ~~Benefit the preconstruction/procurement of the project.~~
- ~~Minimize the RFI's and change orders early on.~~
- ~~Essentially minimize site congestion.~~
- ~~Extensive system coordination.~~
- ~~An increased interaction between trades.~~

~~*Drawbacks:*~~

- ~~More cost upfront.~~
- ~~Lack of experience with 3D coordination with subcontractors.~~

~~*Research:*~~

~~This analysis will need several items to research. The cost will need to be research for the BIM/3D coordination team and any RFI and change orders that could have been resolved using 3D coordination. The feasibility of the 3D coordination will need to be research to determine if all trades have or lacked experience to complete actual 3D coordination clash detection. The schedule will need to be researched to determine if this analysis will decrease the duration of the coordination meetings.~~

~~Methodology:~~

- ~~Determine the effect of the cost for a 3D coordination team.~~
- ~~Determine the effect of the schedule for coordination meetings.~~
- ~~Develop a 3D model for areas where RFI's/change orders occurred.~~
- ~~Perform clash detections.~~
- ~~Summarize results.~~

~~Resources and Tools to be used:~~

- ~~Industry Professionals~~
- ~~3D coordination Professionals~~
- ~~Professors and Colleagues~~
- ~~Revit and Navisworks~~
- ~~Turner Construction – Project Manager~~
- ~~Sigma 7 – Architect and Engineers~~
- ~~Subcontractors~~

~~Expected Outcome:~~

~~The expected outcomes from this analysis would include having positive effects on the cost, schedule, prefabrication, and procurement for the Data Center. To successfully complete this analysis, research for how many RFI's/Change orders will be assessed and a 3D model/clash detection would be performed for this analysis.~~

Analysis #2 – Risk Management – Long Lead Items:

Problem Identification:

The Data Center's procurement/fabrication process for major long lead items could have been implemented with risk management. Turner could possibly increase their profit by buying out the major, complex long lead items and taking care of the fabrication/procurement process themselves, other than the alternative (subcontractors).

Proposed Solution:

The solution for this situation is to investigate a Risk Management analysis for all the long lead items of the Data Center. This analysis will explore the hypothetical idea of Turner being in control of the buying/fabricating of all the mechanical/electrical long lead items and to determine the benefits and risks using this management method. Cash flow diagrams are appropriate for this analysis to compare the cash flow of the construction manager vs. the subcontractor's responsibilities of the long lead items. The schedule and costs of the Data Center will need to be adjusted for this analysis.

Benefits:

- Accelerate the Data Center's fabrication/procurement process.
- Increase in return for the construction manager.

Drawbacks:

- The construction manager takes on a greater risk using this management technique.

Research:

The research for this analysis will involve collaboration with Turner to get a list and a rough price on the mechanical/electrical long lead items. This analysis will need consultations with industry professionals that may have used this management technique. Costs analysis will be assessed to determine the effect on the cash flow of the project for both the construction manager and the subcontractors.

Methodology:

- Interview Turner contact and receive information on all the mechanical/electrical long lead items.
- Consult with the mechanical and electrical subcontractors.
- Develop a schedule integrating this management technique.
- Develop cash flow diagrams for both management situations (Construction management, Subcontractor.)
- Develop a risk analysis assessment.
- Summarize results.

Resources and Tools:

- Industry Leaders
- PACE seminar contacts
- AE faculty – Construction
- Colleagues
- Equipment Manufactures
- Turner Construction
- Subcontractors

Expected Outcome:

The expectation of this analysis is to have a positive effect on the fabrication/procurement process. In addition, this analysis will increase the return for the Turner construction. To conclude this analysis, recommendation/conclusions will be analyzed to determine the feasibility of this management technique.

Analysis #3- *Façade redesign (Implement Tilt-up Construction):*

Problem Identification:

The architectural precast poses a problem due to the twenty foot parapet wall that extends past the roof, in turn, there is over use of materials and labor for this parapet wall.

Proposed Solution:

The proposed solution to redesign the parapet wall with conducting interviews with the architect about what he wanted to accomplish with the parapet walls. A structural analysis will need to be conducted to determine if any changes in beam/column sizes. The changes in the sizes of the beams and columns may decrease the cost of material for the Data Center. This will apply for a structural breadth. More information on this specific breadth can be viewed in Appendix A of this report. In addition to this redesign, incorporation of tilt-up construction will be assessed to essentially accelerate the Data Center's schedule.

Benefits:

- Decrease the labor and material costs.
- Accelerate the schedule.
- Decrease truck deliveries.

Drawbacks:

- Increase site congestion.
- Depending on design, possibly make the Data Center unappealing.
- Risy for the CM if the tilt-up method is not executed correctly.

Research:

An interview with the architect will need to the conducted with regards to the high parapet walls. Cost research will need to be conducted for the materials and labor savings. A construction analysis will need to be conducted to determine the effect of the schedule for integrating tilt-up construction.

Methodology:

- Interview Architect/Industry professionals.
- Develop a new façade design.
- Consult with industry professionals about façade design.
- Determine the effect on the schedule using tilt-up construction method.
- Run a structural analysis, determining the effect of the column/beam sizes.
- Determine the effect on the material and labor cost.
- Summarize results.

Resources and Tools to be used:

- AE faculty – Structural/Architectural

- Sigma 7 – Architect
- Revit
- Client
- Colleagues

Expected Outcome:

The expected outcomes from this analysis would include having positive effects on the cost of materials and labor, as well as, accelerate the schedule for the Data Center. The redesign will minimize the size of the Data Center's exterior columns and possibly exterior beams. In turn, minimizing the cost of structural steel. Shortening up the precast panels will result in a decrease cost for the façade. Additionally, integrating tilt-up construction method will accelerate the schedule.

Analysis #4- *Critical Industry Analysis – Implement Latista:*

Problem Identification:

As mentioned in previous technical reports, the mechanical and electrical systems in the Data Center are highly complex. The owner(s) is a leader in current technology (cannot specify) and should take advantage of the current technology in the construction industry. The commissioning process for the data center is substantial given the size of the expansion.

Proposed Solution:

The proposed solution for this problem is to research the Latista technology during the construction process. The main focus of this analysis is to look into Latista's commissioning benefits. Latista is also a great tool for organization of materials onsite and procurement. This technology was discussed during the 2010 PACE roundtable. More information can be viewed in technical assignment two.

Benefits:

- Benefits of the Tablet PC onsite:
  - Decrease site congestion.
  - Increase efficiency.
  - Benefit the preconstruction/procurement of the project.
  - Material organization onsite.
  - Save costs on drawing documentation.
  - Track down material deliveries for all trades.
- Table PC commissioning benefits:
  - Accelerates the commissioning process.
  - PDF and paper forms can be recreated in LATISTA easily and are are easier to manage, organize, and communicate than hardcopies.*
  - Record issues and performance for later reference (including facilities management) and risk management*
  - Improved collaboration between owner representatives and contractors in process and reporting*

Drawbacks:

- Increase in cost upfront
- May be a lack of knowledge from all the trades.
- Current technology may still be working out the defects/"bugs".

Research:

A research study on the knowledge/experience of this tool would need to be conducted to figure out if preliminary classes would need to be held for the project team to learn this tool. Additionally, the upfront costs for the equipment will need to be determined. Collaboration/Interviews with a variety of industry leaders will be conducted to develop a substantial case study of the technology.

Methodology:

- Research Latista - Benefits, Cost, Complexity of technology, etc…
- Determine the upfront cost from manufacture.
- Interview Turner and subcontractors on experience with Latista, develop survey on the knowledge/experience with tablet PC's for commissioning.
- Conduct a case study from other industry leaders that have used Latista for commissioning.
- Summarize whether Latista is a good tool to use for the Data Center and other construction projects.

Resources and Tools to be used:

- Industry Leaders
- PACE seminar contacts
- AE faculty – Construction
- Colleagues
- Equipment Manufactures
- Turner Construction
- Subcontractors

Expected Outcome:

The expected outcome from this analysis is to show from the case studies/interviews that Latista is an adequate tool to use for commissioning on highly complex mechanical and electrical systems on a variety of projects.

Analysis Weight Matrix:

Shown below in Table 1 is the weight matrix. This table represents how each analysis for all four focal points of investigation. The percentages illustrate the time and effort for each analysis.

Analysis Description:	Research	Value Engr.	Const. Rev.	Sched. Red.	Total
Alternate Roofing Systems	5%	15%	10%	5%	35%
Risk Management	10%	5%	-	10%	25%
Façade Redesign	5%	5%	5%	10%	25%
Critical Industry Analysis	15%	-	-	-	15%
Total:	**30%**	**25%**	**20%**	**25%**	**100%**

Table 1 Weight Matrix

Timetable:

For the purpose to stay on schedule and meet thesis milestones, a preliminary spring semester timetable has been developed to represent the work progression for each technical analysis. For more information, refer to Appendix B of this report.

Conclusion:

The proposed technical analysis will provide a detailed review of improving the construction cost, schedule acceleration, future energy consumption savings, and increase the efficiency onsite. It is irrelevant that some of the analysis will cost more upfront, but researching each analysis will benefit the project and essentially buyback the original proposed solution. This proposal is a working submission and is expects feedback from thesis advisors for revisions.

Appendix A – Breadth Studies:

Breadth Topics:

The following topics involve a more detailed analysis from the disciplines within the Architectural engineering major. Each topic mentioned in this section relates to an analysis mentioned in the previous analysis, which are identified accordingly.

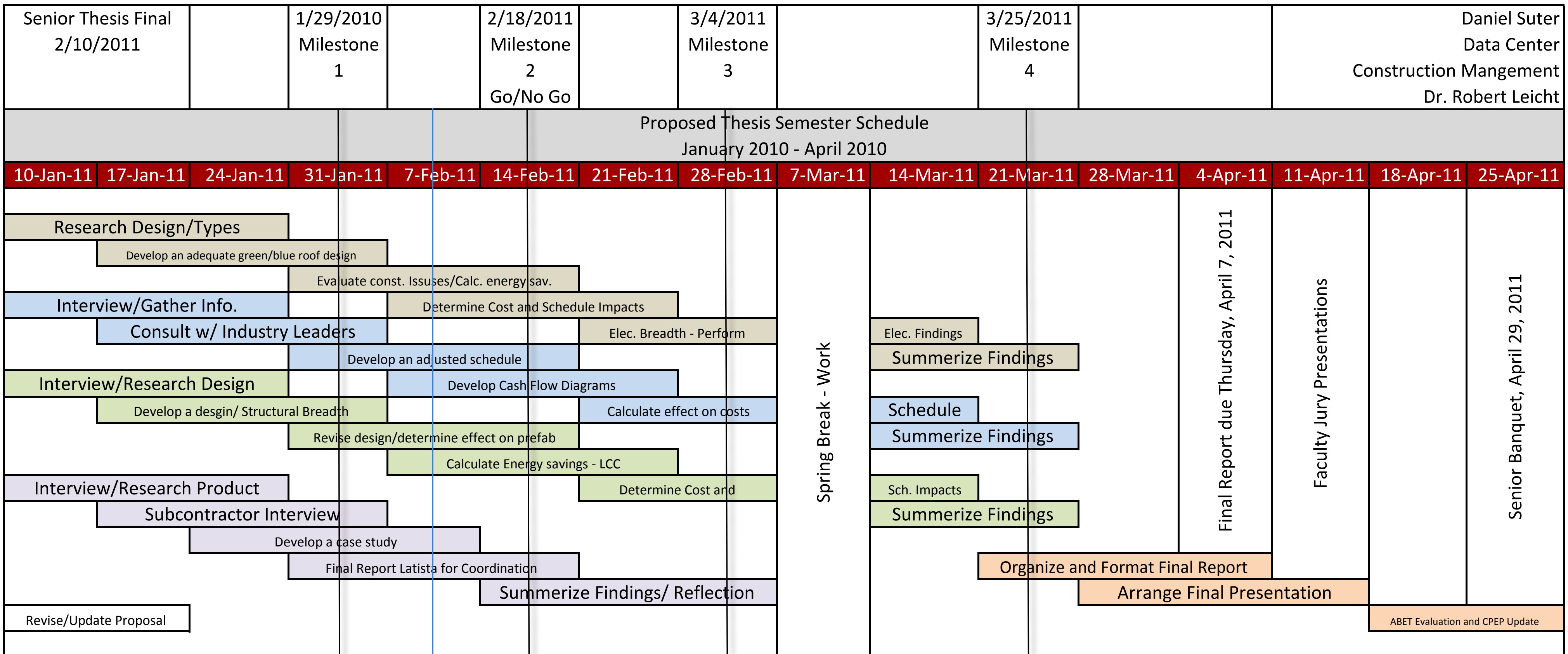
Structural Analysis (Analysis #3):

In an attempt to redesign the current architectural precast panels. This analysis will include redesigning the 20 foot parapet walls, while collaborating with the architect. Different size beams and columns may arise through the structural calculations that will be performed.

Electrical/Lighting Analysis (Analysis #1):

Looking into the integrating solar roofing, the PV panels will reduce the energy consumption of the Data Center. This breadth will explore the amount of energy that the PV panels will bring and determine how the energy is distributed into the building electrical systems. Furthermore, a Life Cost Cycle analysis will be determined.

Appendix B – Spring Semester Schedule:



Milestones	
1	Gather the necessary information for analysis.
2	Preliminary designs for green/solar roof and façade
3	Analysis 4 complete.
4	Start the final report and have all the analysis substantially complete

Analysis 1 - Alternate Roof Analysis - **Electrical Breadth**
Analysis 2 - Risk Management - Long Lead Items
Analysis 3 - Façade Redesign (Tilt-up Construction) - **Structural Breadth**
Analysis 4 - Critical Industry Issue - Latista for Coordination