Final Proposal

[Arena Stage]

Washington, DC

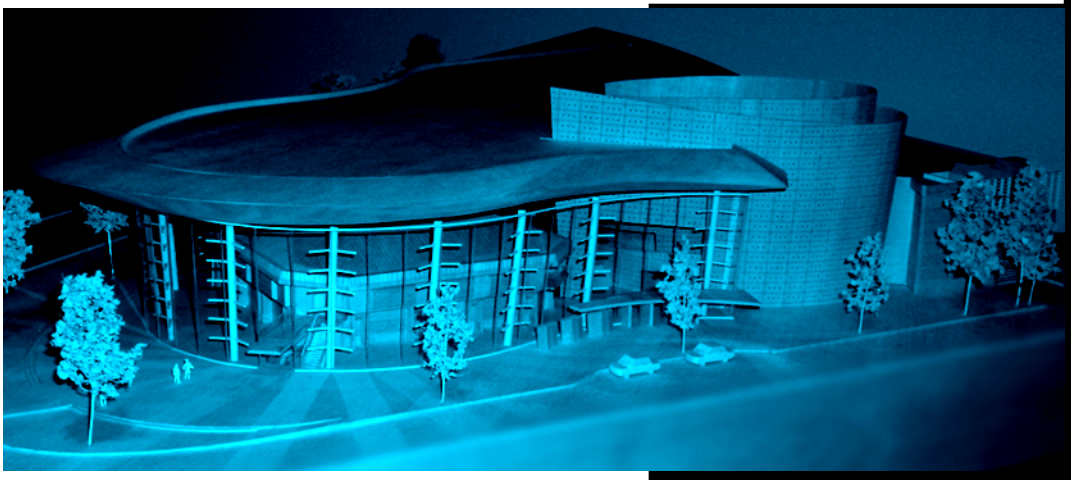

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Table of Contents

Executive Summary

This Final Proposal serves as an outline for the research and analyses that I plan to conduct in the spring semester. The analysis areas include:

Analysis I: Eliminate Slope of Curtain Wall

Currently the curtain wall glazing is on an inverted 4 degree slope and runs along a serpentine comprised of multiple radii. There are several sections of glass that are trapezoidal instead of rectangular because of the gradual increase in unit size due to the slope of the wall. Very few are the exact same size and shape, which has caused the glazing to be very expensive. In this analysis, the slope of the glazing will be eliminated and then redesigned to have more uniform unit sizes. This is expected to not only lower the cost of the system, but also decrease the time to install the system.

Analysis II: Application of Photovoltaic Panels

Theater complexes usually consume large amounts of energy due to their large open spaces and high ceilings which can result in excessive heating and cooling. Since *Energy and the Economy* is a critical industry issue that was discussed at the PACE Roundtable, this analysis will enhance Arena Stage with the application of solar tracking panels to employ the use of solar/renewable energy. Although a high upfront cost is expected for the material and installation of this system, is likely that it will increase the life-cycle cost of the building.

Analysis III: Application of Fabric Duct

Due to the complex renovation of the existing Fichandler and Kreeger theatres, there are many locations throughout the building that do not allow for easy installation of mechanical equipment due to limited space. The application of fabric duct in such locations would not only be easier to maneuver into these tight spaces, but would provide a similar low air velocity so as to not disrupt the acoustical performance of the mechanical system. Not only will the aesthetic quality of fabric duct enhance the space, but it is expected to be easier to install, therefore reducing schedule installation time.

At the end of this document, a weight matrix is provided to illustrate the distribution of time and effort among the proposed analyses as well as a summary of the proposed breadth topics. Also incorporated is a calendar which is a week by week summary of the spring 2009 semester with completion dates for each of the analyses discussed above.

A. Background

Arena Stage is a performing arts theater complex that is located on the corner of Sixth Street and Main Avenue in Southwest Washington, DC. Main Avenue SW is a busy street that runs the length of the Washington Channel and terminates at the Tidal Basin with the intersection of 17th Street and Independence Ave. The site has an awkward triangular shape and is adjacent to several residential high-rises to the north and east.

In 1999, Arena Stage decided to build a new facility and, instead of relocating to a new site, the Board of Trustees chose to remain in their waterfront location. By staying in the original location, the theater became a part of the city's Anacostia Waterfront Initiative (AWI). The goal of the initiative is to make the Southwest DC Waterfront a more alluring section of the city and join the ranks as a leading attraction. It is currently the city's number one economic development priority. The new Arena Stage is a crucial part of the city's revitalization, just like the New Nationals Ballpark which was one of the first major movements.

The rebirth of Arena Stage, called The Next Stage Campaign, involves a massive renovation of the original Fichandler and Kreeger theatres complete with modern amenities, updated décor, enhanced acoustics, and brand new building equipment. Also, an additional space called the Cradle is being added to promote the writing and production of new American plays. New office and rehearsal space is being built in the Back of House region atop a new one-story parking garage located below grade.

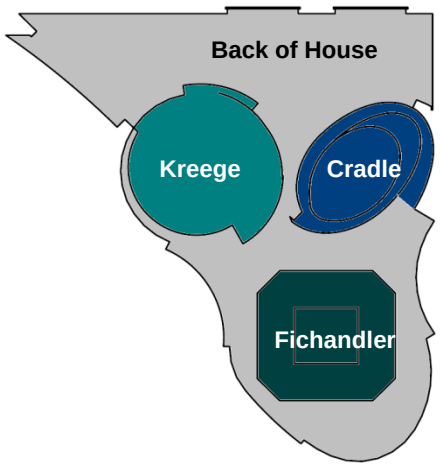

Figure 1: Schematic floor plan of Arena Stage

Clark Construction Group, LLC was awarded the construction contract in May of 2007 for the 200,000 square foot project costing approximately $125 million. Construction began in January of 2008 and is scheduled to complete in June 2010.

B. Analysis I: Eliminate Slope of Curtain Wall
Depth

Problem Statement:
One of the most problematic features of the project is the 45' tall curtain wall. The glazing is on an inverted 4 degree slope and the wall is a serpentine comprised of multiple radii. It is sectioned off into 12'×6'-4" insulated glass frames, which weigh approximately 850 pounds per unit. Several sections of glass are trapezoidal because of the gradual increase in unit size due to the slope of the wall. The use of multiple radii also results in size variance amongst the glazing units. Very few are the exact same size and shape. The glass is hung from the ceiling by stainless steel cables, which are supported by wide flange beams located in the ceiling above the lobby. Finally, the load is passed off to the parallam timber columns, supported by cast ductile-iron caps and bases.

As one of the main design features of Arena Stage, the curtain wall is a very extravagant and expensive component. The custom cut glazing units greatly increase the cost of glass portion of the curtain wall. According to the detailed estimate performed in Technical Assignment 2, the curtain wall costs approximately $3,925,000, or $143.15 per square foot of glazing.

Figure 2: Curtain wall similar to Arena Stage (image provided by StructureCraft Inc.)

Proposed Solution:
Eliminate the 4 degree slope of the curtain wall so that the façade is vertically plumb along the serpentine path.

Solution Method:
In order to perform this analysis, achieving a full understanding of the current system is necessary. I will need to obtain a full set of shop drawings of the glazing component of the wall to determine the exact number of custom units. Then it will be reengineered to the non-sloping alternative which maintaining the structural integrity of the system. Once the new number and size of the units is calculated, a new glazing estimate will be performed and compared to that of the original design. A model of the current and

proposed designs will also be produced to compare the appearance of both glazing systems.

This adjustment would not only alter the design and manufacturing of the curtain wall, but will affect its installation as well. Being educated in how the system is installed will allow for a better study of its effect on the schedule. Using historical performance logs of both of the structural and glazing contractors and working with them to determine a realistic time deduction for this potentially simpler system will then be completed.

Resources:

- StructureCraft Inc.
- Icon Exterior Building Solutions
- Glazing Mock-up design/Test procedure narrative
- Structural wind load testing and tolerance narrative

Expected Outcome:

The trapezoidal glazing units would be eliminated and more uniform units could be manufactured in their place, therefore reducing the overall cost of the glazing. It is also expected that this will significantly reduce difficulty of construction, resulting in an accelerated schedule. Also, this would have little architectural impact since the curtain wall is partially concealed by the overhang of the roof.

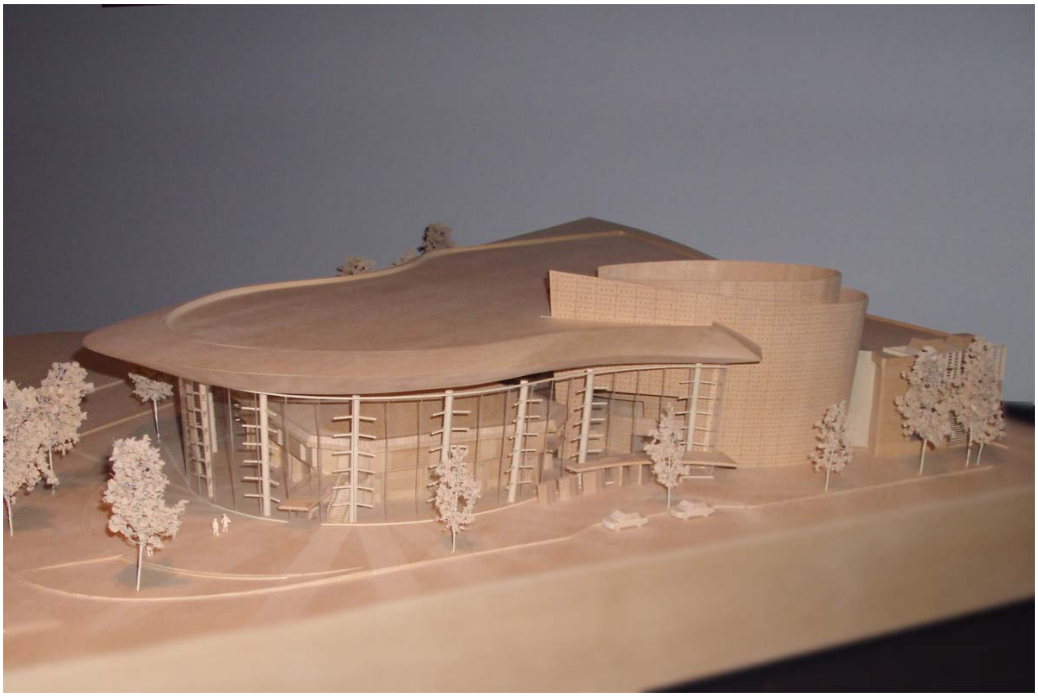

Figure 3: Current (2008) Model showing the roof overhang

C. Analysis II: Application of Photovoltaic Panels

[Energy and the Economy]
Sustainability Breadth

Problem Statement:
Since Arena Stage is not striving to achieve LEED certification, little was done in regard to the environment or energy consideration. Theatre complexes usually consume large amounts of energy due to their large open spaces and high ceilings which can result in excessive heating and cooling. Since *Energy and the Economy* is a critical industry issue that was discussed at the PACE Roundtable, it would be wise to enhance Arena Stage with the application of sustainable systems. This will reveal areas where Arena Stage may have been able to be a little more energy conscious and increase the life-cycle cost of the building.

Proposed Solution:
The use of solar tracking panels to implement the use of solar/renewable energy.

Solution Method:
Research the availability of sunlight on the site in order to propose a location where PV panels could be installed in order to optimize solar gain without drastically affecting the aesthetics of the building. Examining the sun path in Washington, DC and the effects of the shade from surrounding buildings will also be necessary. Finding a material provider and experienced PV installer from the area will be pivotal for this addition. Once these preliminary studies are done, the size and number of solar panels can be determined. A calculation can be performed to see what types of energy savings can be expected, if any, and compare them to projected energy consumption of the building (if available). The cost and time associated with adding the system will be produced as well.

Resources:
- EDSGN 498A: *Solar Electrical System Design and Construction* (spring 2009 course)
- Penn State Professors knowledgeable in sustainable design
- PACE Industry Professionals
- Online research

Expected Outcome:
Although a relatively high upfront cost is expected, by collecting solar radiation from the sun and converting that energy to electricity, the operating costs of the theater complex can be reduced, therefore reducing the life-cycle cost of the building.

D. Analysis III: Application of Fabric Duct
Mechanical Breadth

Problem Statement:
Due to the complex renovation of the existing Fichandler and Kreeger theatres, there are many locations throughout the building that do not allow for easy installation of mechanical equipment. Among others, these areas include a large ring duct around the top of the Fichandler exterior wall and several dressing room spaces.

Proposed Solution:
The application of fabric duct in such locations would not only be easier to maneuver into these tight spaces, but would provide a similar low air velocity so as to not disrupt the acoustical performance of the mechanical system. The aesthetic quality of fabric duct would also be more appropriate in these spaces where the duct was originally exposed.

Solution Method:
In order to perform this analysis, a full review of the mechanical system and the sizes of the duct (required cfm) need to be recorded. Also, extensive research will be obtained on fabric duct. Once completed, the original design can be altered to the proposed fabric duct, tying into the standard sheet metal duct system. As with the PV panels, a material provider and experienced installer of fabric duct from the area will be found. Finally, a cost and schedule analysis will be produced to compare the original and proposed systems. Finally, consultation with a mechanical contractor will occur to assess the pros and cons of each application.

Resources:
- Southland Industries
- HVAC Basis of Design
- Penn State Professors knowledgeable in mechanical design and alternatives
- Online research

Expected Outcome:
After discussion with a representative from Southland, fabric duct is expected to be a more appropriate application for these spaces. When dealing with sheet metal ductwork, all pieced are rigid and fabric duct has the ability to maneuver more easily. Due to the flexibility of fabric duct, installation in hard to reach places is expected to be faster, therefore reducing schedule time for installation. While this application may be more expensive than the traditional ductwork, its aesthetic appeal may prove to be a better solution. This analysis will be an example of how fabric duct could be applied in several areas of Arena Stage, especially those public spaces that are being constructed to appear state of the art and high end.

E. Conclusion

Arena Stage is a complex project that has undergone several changes since the inception of its design almost eight years ago. Through value engineering measures, it has been stripped of all frivolous features in order to meet its very tight budget which is limited by the donations made to the Next Stage Campaign.

Although there are several problematic features on the project, the three analyses listed above were chosen due to my interest in the topics and knowing that I will enjoy performing the research. Also, the educational value of the research and analysis that I will be completing will be beneficial to my future career in industry. Analysis I involves the curtain wall system which, since I obtained this project, has been my favorite design component of Arena Stage. The adjustment of system is expected to cost less money and increase the project schedule. Although minor structural implications are expected, it is a reasonable adjustment that has the opportunity to drastically simplify the entire system and decrease the overall cost.

Analysis II deals with the critical industry issue *Energy and the Economy* that was discussed at the PACE Roundtable. It is important to understand that there are ways to decrease, or counter, the amount of energy a building consumes. Although photovoltaic panel systems cost a lot of money up front, they not only add value to the building, but they have the ability to decrease the life-cycle cost of the building, which often gets overlooked. By educating the owner in this area of importance, they could become willing to spend the extra money in the beginning in order to save money in the long run.

The application of fabric duct in Analysis III provides an alternate solution to the existing sheet metal ductwork, which is exposed in multiple locations. A difficult challenge is installing the ductwork in areas that are being renovated because space is limited. The flexibility of the fabric duct will not only provide a solution to these odd-shaped spaces, but will be easier to install as a continuous run. Providing not only ease of maneuvering, but aesthetic appeal, fabric duct is expected to decrease the installation schedule while enhancing the high-end look of the building.

F. Weight Matrix

The weight matrix shown in Table 1 illustrates the distribution of time and effort among the proposed analyses.

Table 1: Weight Matrix

Description	Research	Value Engineering	Constructability Review	Schedule Reduction	**Total**
Curtain Wall	-	10%	15%	10%	35%
PV Panels	20%	15%	-	-	35%
Fabric Duct	10%	10%	5%	5%	30%
Total	30%	35%	20%	15%	**100%**

G. Appendix I: Breadth Excerpts

Architectural/Structural Depth: Eliminate Slope of Curtain Wall

Currently the curtain wall glazing is on an inverted 4 degree slope and runs along a serpentine comprised of multiple radii. There are several sections of glass that are trapezoidal instead of rectangular because of the gradual increase in unit size due to the slope of the wall. Very few are the exact same size and shape, which has caused the glazing to be very expensive. In this analysis, the slope of the glazing will be eliminated and then redesigned to have more uniform glazing unit sizes. A structural analysis will be performed to make sure that the structural integrity of the system is maintained. This is expected to not only lower the cost of the system, but also decrease the time to install the system.

Sustainability Breadth: Application of Photovoltaic Panels
[Energy and the Economy]

Since Arena Stage is not striving to achieve LEED certification, design considerations were not focused around energy saving measures. Theatre complexes usually consume large amounts of energy due to their large open spaces and high ceilings which can result in excessive heating/cooling. Since *Energy and the Economy* is a critical industry issue that was discussed at the PACE Roundtable, the use of solar tracking panels to implement the use of solar/renewable energy is a way to counter Arena Stage's energy consumption. Researching the availability of sunlight, examining the sun path in Washington, DC and the effects of the shade from surrounding buildings will all be necessary. After finding a material provider and installer from the area, the size and number of solar panels will be determined. Energy savings will be calculated to see how it compares to the expected consumption of the building. Although a relatively high upfront cost is expected, by collecting solar radiation from the sun and converting that energy to electricity, the operating costs of the theater complex can be reduced.

Mechanical Breadth: Application of Fabric Duct

Due to the complex renovation of the existing Fichandler and Kreeger theatres, there are many locations throughout the building that do not allow for easy installation of mechanical equipment. Among others, these areas include a large ring duct around the top of the Fichandler exterior wall and several dressing room spaces. The application of fabric duct in such locations would not only be easier to maneuver into these tight spaces, but would provide a similar low air velocity so as to not disrupt the acoustical performance of the mechanical system. The aesthetic quality of fabric duct will also be more appropriate in the dressing rooms where the duct was originally exposed. In order to perform this analysis, a full review of the mechanical system and the sizes of the duct (required cfm) need to be recorded. Extensive research needs to be performed on fabric duct and how it ties into standard sheet metal duct. A cost and schedule analysis will also be produced to compare the original and proposed systems.

H. Appendix II: Spring 2009 Timetable

The following bar chart shows a summary of the spring 2009 semester and target dates for the completion of each of the analyses discussed above.

Topic	Task
Achitectural/Structural Depth Redesign of Curtain Wall System	Speak with subcontractors about redesign
	Obtain shop drawings
	Obtain installation instructions/historical performance logs
	Establish new layout and glazing unit sizes
	Analyze load change/perform calculations
	Design final system
	Make 3D model
	Perform cost/schedule analysis
	Document
Sustainability Breadth [Energy and the Economy] Application of PV Panels	Perform research on DC sun path/site obstructions
	Make 3D model showing sun exposure
	Choose final install location
	Obtain expected electricity consumption of building
	Size PV Panels
	Find material provider/installer near DC
	Perform cost/schedule analysis
	Calculate energy savings over time
	Document
Mechanical Breadth Application of Fabric Duct	Consult with Southland Industries
	Perform research on fabric duct options
	Determine IAQ requirements and calculate velocity and ACH
	Design fabric duct system
	Find material provider/installer near DC
	Perform cost/schedule analysis
	Document