UNIVERSITY OF PENNSYLVANIA NEURAL AND BEHAVIORAL SCIENCES BUILDING

415 University Ave, Philadelphia, PA 19104

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Advisor | Shawn Good + Leslie Beahm

Updated I Thesis Proposal
01.17.14

EXECUTIVE SUMMARY

The following report is a proposal of work to be completed as part of the Penn State Architectural Engineering Senior Thesis in the spring 2014. The project will consist of a redesign of four focus lighting spaces and consequent electrical systems for the new University of Pennsylvania Neural and Behavioral Sciences Building.

The lighting depth involves a redesign of the following four spaces based on the concept of connection and interaction through biomimicry of a deciduous tree:

- South façade/site
- Lobby/lounge
- Large Classroom
- Lecture hall

In response to the new lighting solution, certain aspects of the electrical system branch circuits will be redesigned to account for the new load. A short circuit analysis will be completed for one of the main electrical distribution paths. This proposal also outlines the introduction of an electrical depth which will concern replacing dry-type transformers with oil-filled transformers; a cost benefit analysis and energy study will be performed.

Drawing from concepts learned in AE565 (Daylighting), the MAE Depth focuses on parametric design and analysis for improved daylighting and energy efficiency: an optimized Kalwall curtain wall system for the East Block perimeter (office block). One typical floor plan will be studied.

Architecturally, the ceiling of the eastern floor plan will be removed to create an extension of spatial sensation among otherwise gloomy graduate student offices. Walls will be removed to introduce an open office floor plan (this will be be considered an accepted schematic design study approved by UPenn). Mechanical studies will address the effects of a raised ceiling, open plan, optimized windows, and Kalwall wall construction allowing for further opportunities to reevaluate the HVAC equipment. Negative components of the proposed change will be addressed and measured against the advantages.

Parametric modeling will introduce the power of improved daylighting technology and responsive architecture; as architectural engineers, this way of thinking and production lends itself well to the curriculum and future sustainability.

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BUILDING **INTRODUCTION**

The Neural and Behavioral Sciences Building is a 77,000 gross square foot higher education lab building with instructional labs, faculty offices, student spaces, and an auditorium. As an expansion of existing laboratory space, the new building will provide for the collaboration, exchange, and integration of knowledge that characterizes the study of the Natural Sciences at the University of Pennsylvania.

The project creates a cohesive street front and inviting place for students and faculty. The modern building is a unifier and connector for other nearby buildings through organic and connective forms. The cantilevered east end is a white metal and glass office block; the west end is a copper clad lab block.

Courtesy of SmithGroupJJR

BUILDING **OVERVIEW**

Name | University of Pennsylvania Neural and Behavioral Sciences Building
Location | 415 University Ave, Philadelphia, PA 19104
Occupant Name | University of Pennsylvania faculty, staff and students
Occupant Type | Business (B), Assembly (A-3), and Storage (S-1)
Size | 77,100 SF total
Number of Stories | Five stories and a basement below grade
Construction Dates | January 2014 – March 2016
Estimated Building Cost | $49,300,000
Project Delivery Method | Guaranteed Maximum Price (GMP)

PROJECT TEAM

Architecture & Engineering | SmithGroupJJR, Inc.

Project Manager: Mark Potter
Architect: Sven Shockey
Structural Engineer: ZY Liu + Liliana Blackson
Mechanical Engineer: Dan Mather + Liz Kaminsky
Electrical Engineer: Joe Trusk + Andrew Verilone
Lighting Designer: Matt Alleman + Leland Curtis
Interior Designer: Lori James
Sustainability: Chris Heine

Owner | University of Pennsylvania
Construction Manager | P. Anges
Landscape Architecture | Christopher Allen
Civil Engineering | Pennoni Associates, Inc.
Audio, Visual, Telecomm, Acoustics | Shen Milsom & Wilke, LLC
Signage | InkSpot DESIGN Inc.

LIGHTING **DEPTH**

SPACES

A new lighting solution will be implemented in four spaces in the Neural and Behavioral Science Building in order to further effectively express the architecture and function of the space.

- South façade/site
- Lobby/lounge
- Large classroom
- Lecture hall

CONCEPT

Building upon the architect's original concept of connections, analytical models, and organic notions, the lighting design seeks to create a cohesive and spherical analytical model that connects architecture, students, and nature. To establish this **connection and interaction**—essentially allowing students to connect to, relate to, and recognize the NBS Building—biomimicry of a deciduous tree drives the lighting solution.

Biomimicry of a deciduous tree inspires the lighting design to conceptually connect the architecture and students of the program. The processes, functions, and aesthetics of a tree guide the lighting design; cohesive and initially unrecognized connections are developed.

The deciduous **tree becomes the muse** through which lighting visually speaks.

SCRIM + SITE

The scrim on the southern wall is a recognizable architectural feature that strongly impacts the architectural concept. Visually, the organic aluminum sunscreen appears to be growing; in reaction to the sun, interesting shadows are created inside the southern corridor during the day.

Trees produce energy and receive nutrients through photosynthesis. As days shorten and the temperature drops, less chlorophyll (essential to photosynthesis) is created giving rise to the festive red, orange, and yellow pigments of leaves. In the same manner, at night, the new lighting solution will allow the scrim to become *a festive expression of the absence of light.*

Colorful + dynamic: the design will use a pastel color palette that slowly changes between colors to impose a dynamic and festive impression. The goal is to create dappled shadows on the ceiling of the corridor: a direct juxtaposition to the day-time character yet responsive to the architecture. Non-uniform lighting and theatrical elements around the site will encourage exploration and visual sensations.

Form: the form of the scrim will be reinforced by adding fixtures but allowing the scrim to be separated from the building and visually placed in silhouette.

Glare: the new solution facilitates a detailed study of glare control; fixture selection and placement, cut-off angles, and visual assessment will be of high importance.

Dark Sky: besides energy concerns, limiting up-light or obtrusive lighting will be considered. Specifying the right fixtures and locations will address the concern.

LOBBY

The main L-shaped lobby and lounge is a welcoming space that is abundantly lit by daylight. The custom perforated ceiling is kinetic in form and promises to provide opportunities for a unique lighting solution.

As a result of uneven pressures in a tree, nutrients are exchanged between the crown and roots of the tree (known as transitional pull). In a similar manner, the lighting responds the form of the perforated ceiling, increasing brightness at areas of high congestion and interest on both the floor and ceiling planes; *organic movement and direction is implied as a result of uneven pressures.*

Movement: non-uniform transitional lighting and subtle pools of light encourage direction through the space. Areas of high importance are relatively brighter facilitating visual clarity and relaxation.

Architecture: the proposed lighting solution aims to complement the high architectural element of the space: a custom perforated ceiling panel system.

Connection: it is the goal of the lighting solution to connect the exterior site and scrim by allowing light to spill out from within the lobby space; highlighting vertical surfaces will define spatial boundaries and establish the lobby as an entrance.

Daylighting: lighting controls and daylight integration will present an energy efficient design; photosensors and time schedules are potential solutions.

CLASSROOM

On the ground floor, a large classroom is arranged to inspire collaboration and teamwork. The interior design is relatively simple and uncluttered.

It is visually noted that a light behaves in an ominous manner when lighting a canopy from above. The sensation of expansion and weightlessness through the interaction of light and asymmetric branches is invoking. *Relating, comfortable uniform functional lighting is achieved through the implementation of an asymmetric placement of fixtures.*

Uniform: light will be uniformly distributed in the space invoking a public sensation. The functional layer of light is achieved through an organic and asymmetric placement of overhead fixtures.

Control: the new design hopes to introduce a highly flexible and controllable space through fixture layout and use of sensors and scene control.

LECTURE HALL

Architecturally, the tiered underground space is organic and includes high architectural elements particularly in the ceiling and walls: custom-made panels that angulate throughout the space.

Nutrients are carried through a tree by way of complex cellular structures particularly larger sieve tubes and smaller companion cells in the sapwood. Vertical movement in the trunk and tree is the essence of the tree's life. *Creative lighting will be used to accentuate the vertically of the space, enforcing the presence of the organic ceiling and* *spatial activity. Lighting speaks to the function of the central learning space and essence of the building.*

To achieve the desired lighting notion, parts of each schematic design will be combined to create an enjoyable space. Notably, peeling back and pushing different modular panels will reveal light, reacting to the form of the ceiling while still providing functional light.

Verticality: vertical movement can be achieved by revealing vertical slithers of light along the modular walls; space beyond the ceiling is encouraged by perimeter lighting and allowing light to graze select ceiling panels.

Functional: lighting aims to be interesting but will not deter from the functionality of the space. A functional layer of light integrated among the ceiling will address this issue.

Control: lighting controls will allow for flexible scene control and appropriate settings for reading, test taking, and AV presentations.

Distraction: visually, lighting a complex ceiling may suggest distractions to the users. Further studying and sketching will be used to obtain a visual impression of the desired motion as to optimize the effect but limit occupant distraction, glare, and unproductivity.

LIGHTING **SCHEMATIC DESIGN PRESENTATION FEEDBACK**

FACULTY PRESENTATION 11.11.13 (implemented before Lutron)

- Be sure to state scrim is part of existing building
- Add illuminance levels and 90.1 to presentation
- Sketch in downlights
- Reduce brightness of uplight on penthouse
- Simplify modular wall in lecture hall schematic III
- Connect lines in sketch for lecture hall schematic II
- Show impact on interior from lighting scrim
- Grazing only works with textured surfaces, referring to lobby ceiling
- Slow down
- Great presentation style
- Good pace

- Kept coming back to overarching concept
- Design criteria was short/prioritized
- Very good conclusion
- Moved too fast in classroom
- Review direction of wall grazing in lecture hall schematic I

EXTERNAL REVIEW 11.12.13 (implemented before Lutron)

- Spend more time speaking on classroom
- Show detail of how scrim behaves
- Brighten pools of light in lobby
- Sketch classroom perspective
- Emphasize festive Flynn impression on façade
- Move wall-washers in lobby closer together
- Turn lecture hall plan or section to match each other
- Consider changing sketch overlay style
- Change brightness of downlights in lobby section to add depth

LUTRON PRESENTATION 12.9.13

SHAWN GOOD

- Calm presenter
- Two and half minutes to set up
- A lot of layers of light for LZ2 zone and lower power density as goal
- Good set-up for each space
- Very low targets in lobby, 40 lux, reconsider
- The buildup plan view showing fixtures was effective
- If lecture hall used by public, consider higher light levels
- Overall, professionals seemed stuck and struggled to gather thoughts for comments

LEE WALDRON

- Why talk about nature and a tree if building is about Neurology?
- Do not light scrim flat but draw out texture
- Will need secondary system of direct light in lecture hall
- Classroom has no lighting of surrounding space and may become a dull, big, and homogenous space
- Intriguing and impressive approach that led design process
- Wonders if some solutions can be functionally solved
- Good creative start to the project

KARI NYSTROM

- Why would you want to highlight the area below and above the scrim?
- Lobby sketch may not be correct, how late behaves on wall
- Consider changing ACT to gypsum
- Will need secondary system of direct light in lecture hall
- Way too much biomimicry
- Poor conceptual renderings, unrealistic
- Good ambition
- Much more work to clearly show intent and prove viability of concepts

TASKS AND TOOLS

SCHEMATIC DESIGN

Schematic lighting design and adjustments will include the use of Photoshop, hand sketches, and Google SketchUp. Reference to the IES Handbook, Standard 90.1, Modeling Lighting Ordinance, and LEED will help guide the solution.

3D MODELING, LIGHTING CALCULATIONS, RENDERINGS

Exporting from Revit to 3DS Max and Rhino will allow for lighting and daylighting calculations respectively. To complete lighting calculations and develop design solution, 3DS Max will be used. AGI32 may also be used for additional lighting calculations as needed. Detailed renderings of the lighting spaces will be completed in 3DS through radiosity.

DOCUMENTATION

Lighting plans and schedules will be realized using Revit or AutoCAD.

DAYLIGHTING ANAYLSIS/PARAMETRIC DESIGN

Rhino along with plug-ins Diva (Daysim for Rhino) and Grasshopper will allow for in-depth daylighting studies and parametric modeling. Ecotect, EnergyPlus, or Geco may be used to incorporate energy simulations into the parametric architecture and daylighting models.

ELECTRICAL **DEPTH**

OVERVIEW

Currently, power is supplied at medium voltage through UPenn's campus distribution to a 15kV main switchgear located in the penthouse; this switchgear is connected to a double-ended 480V, 3PH, 4W substation where integral 1500 kVA transformers step-down the power from 13.2 kV to 480Y/277V (building utilization voltage). A central 480/277V bus duct provides power for lighting loads through remotely operated circuit breaker panelboards. Dry-type step-down transformers are used throughout the building to supply the appropriate voltages to mechanical and lighting systems. Conductors are copper; MLO and MCB panelboards are used.

A 500kW/625 kVA diesel generator services the fire pump, the central load bank, and switchboard which distributes power for life safety, legally required, and optional stand-by equipment.

The electrical depth will include branch circuit redesigns, short circuit analysis, and a cost benefit analysis and energy efficiency study of using oil-filled transformers instead of dry-type transformers.

BRANCH CIRCUIT DESIGN

To accommodate for a new lighting solution in all four said focus spaces, branch circuits will be redesigned to insure feeders and panelboards are sized correctly.

SHORT CIRCUIT ANAYLSIS

By addressing a single path through the distribution system, a protective device coordination study will provide useful short circuit calculations.

DEPTH | OIL-FILLED TRANSFORMERS VS. DRY-TYPE TRANSFORMERS

The existing electrical design utilizes a large amount of dry-type transformers throughout the building. It would be advantageous to study the cost effects and changes in energy efficiency by replacing the dry-type transformers with oil-filled transformers.

MAE **DEPTH (FOCUS AE565 + AE563)**

DAYLIGHTING AND PARAMETRIC MODELING

A parametric daylight analysis in DIVA will be conducted for a typical eastern floor layout; metal curtain-walls will be replaced with Kalwall (with Aerogel technology) to diffusely transmit daylight into the space. Window size will be evaluated using parametric modeling for efficient studies across much iteration of optimized window area and floor plan layout. Parametric modeling and Kalwall construction will integrate with the proposed architectural and mechanical breadths. In this way, all aspects of the proposed thesis are related, cohesive, and applicable. This depth hereby encompasses topics discussed in AE565 (Daylighting).

ARCHITECTURAL **BREADTH**

EAST BLOCK LIGHT SHELVES, WINDOW ADJUSTMENT, AND OFFICE LAYOUT

Using Grasshopper, Rhino, and Diva, Kalwall construction will allow for window size optimization in the eastern block faculty and post doc offices. To further increase daylighting, interior plan alternations will introduce an exposed ceiling system. The floor plan will become an open office; noise and privacy issues will be considered. With this in mind, it is proposed that introducing Kalwall construction to the eastern office block and increasing the ceiling cavity would allow the interior section of the eastern block to be better diffusely lit by natural daylight; a less enclosed space will be created.

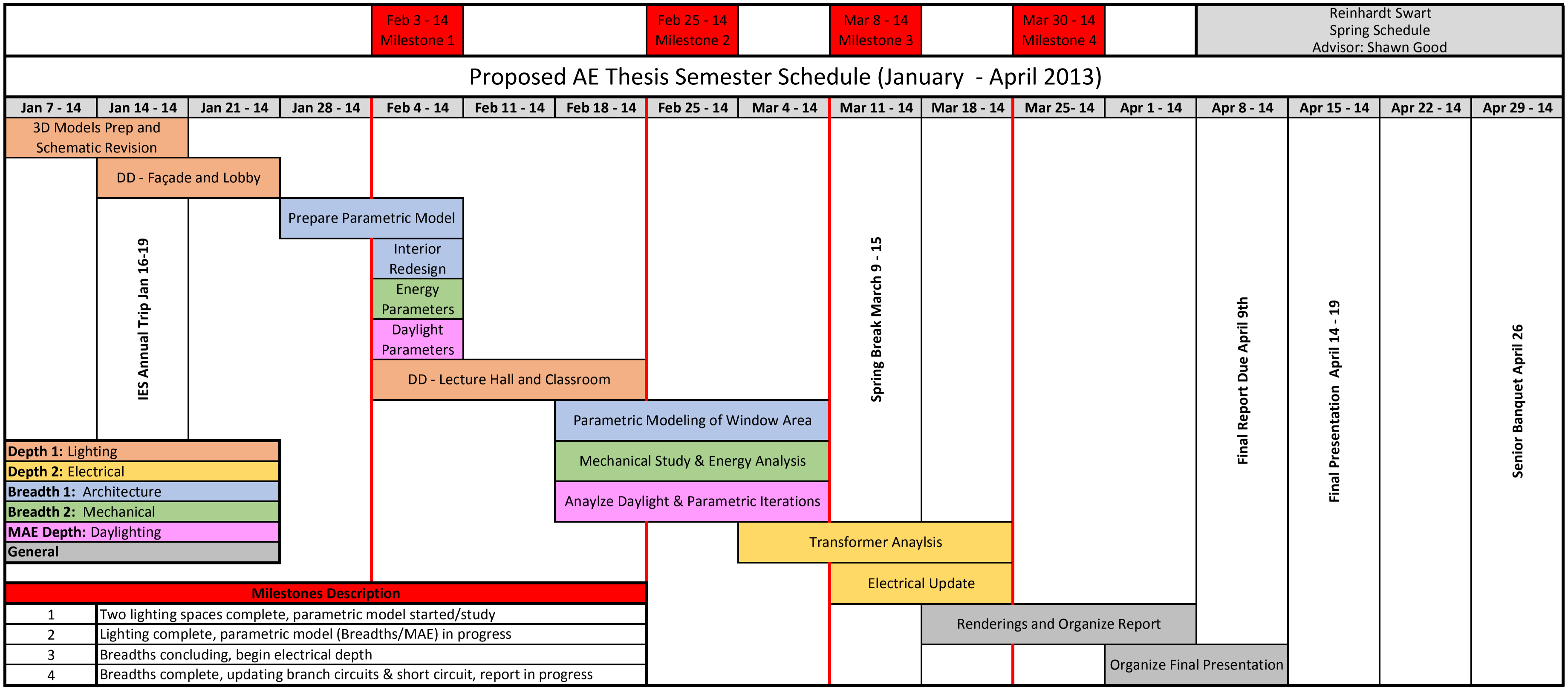
MECHANICAL **BREADTH**

IMPACT FROM LIGHT SHELVES, WINDOWS, AND INTERIOR DESIGN

The main objective of this breadth is to determine whether added daylighting will impose an additional energy load and if the energy savings from daylight will offset this potential load. Ideally, daylighting will be improved and mechanical load decreased. Architectural changes as a result of optimized daylight and minimized mechanical load is an intriguing challenge. Additional plug-ins into Grasshopper include EnergyPlus, Ecotect, or Geco. However, these programs are also applicable as stand-alone software. Effects on the existing mechanical system will be studied and documented.

PROPOSED SPRING SCHEDULE

Please see the next page for the proposed Senior Thesis spring schedule.



Milestones Description

1	Two lighting spaces complete, parametric model started/study
2	Lighting complete, parametric model (Breadths/MAE) in progress
3	Breadths concluding, begin electrical depth
4	Breadths complete, updating branch circuits & short circuit, report in progress