thesis proposal

angelica santana | lighting/electrical

princeton neuroscience and psychology complex, princeton, new jersey

Spring Work Requirements
Electrical Advisor: Ted Dannerth
Faculty Advisor: Kevin Houser
January 14, 2011

. Executive Summary .

The Thesis Proposal includes the requirements for next semester. It is a detailed explanation of the problems, solutions, and methods to be taken for both lighting and electrical depths as well as an introduction to the two breadths required. For the lighting and electrical option students, lighting designs for four spaces is required. The four spaces include an exterior, circulation, large-work, and special-purpose space. For the electrical depth, two options must be studied, a branch circuit distribution redesign for the four lighting spaces performed as well as a short circuit analysis.

The four spaces chosen for the lighting were the North Entrance, Lobby, Lecture Hall, and Cafeteria. An extra space, the Large Patio, was also analyzed. The schematic concept designs for these spaces were created to match the occupants and the architecture. They were then presented at Lutron to professional lighting designs and their critiques will be used to improve on the conceptual designs. Next semester, design development and construction documents phases will show the feasibility of the concepts and the methods to achieve this.

The two electrical breadths are a study of Cooper Feeders vs. Aluminum Feeders and Bus Duct vs. Conduit and Wires and they are described in further detail below. The two non-lighting/electrical breadths are an architectural and acoustical study of the Lecture Hall. The changes in lighting will cause changes in architecture which will have an impact on the acoustics of the space.

. Table of Contents .

. Lighting Depth | Background .

The four spaces in the Princeton Neuroscience & Psychology Complex where the lighting will be designed are the North Entrance(exterior space), Lobby(circulation space-three schematic design concepts), Lecture Hall (large work space), and Cafeteria (special purpose space-psychological reinforcement). There is one extra space that will only be conceptually designed; the Large Light Monitor which is a stair/light well. The general lighting includes two different systems. One was done by Fisher Marantz Stone and covers all the public areas and spaces that will be visible from the outside. The other lighting system was design by Arup and it includes most laboratory space, classrooms, and offices.

The most common light source is fluorescent (both compact and linear) with the exception of some halogen downlights in important spaces, metal halide source in the light monitors, and certain LED highlights. Most of the laboratory spaces have linear fluorescent fixtures while most of the public spaces are illuminated with uniformly spaced downlights. The most common fixture in the circulation spaces is the Louis Poulsen Cirkul fixtures in several sizes and mountings. It is also the main fixture type in the Cafeteria.

The public spaces have mostly uniform lighting with some emphasize on the perimeter wooden walls. All luminaires used have lamps with a CRI in the 80s and a CCT of 3000K. This warm color temperature is good to bring out the wooden tones and the 80 CRI is enough for good color rendering. The private spaces have mostly downlights. The exterior is lacking a lighting design with the exception of the fixtures in the canopy and vestibules and the standard Princeton Pole.

. Lighting Depth | Problem .

Lecture Hall | The existing lighting design of the Lecture Hall addresses all the tasks that will be performed in it and provides the flexibility and controls to achieve it. Horizontal illuminance levels for the seating area are above the required and have good uniformity. Additional accent lighting was located for the lectern with good angles for face modeling. Wall-washers on the back wall highlight the chalkboard area. However, vertical illuminance levels for these areas are lower than what the criteria calls for as well as the horizontal levels for the steps. The general downlight scheme provides good uniformity for the reading task and surfaces but it might create veiling reflections, direct glare, and some uncomfortable shadows. Since the illuminance values appear to be lower at the lectern/chalkboard area, the points of interest are not clearly specified. Also, the lighting power densities are above the allowable according to ASHRAE 90.1. Because this is the largest lecture hall, and because the architecture of the entire building is extremely interesting, the lighting will be revised in a way that carries the themes of the complex even more.

Cafeteria | The existing lighting for the Cafeteria exceeds the lighting levels required for leisure type dining space. However the levels are too low for quick service type of dining space and reading. It appears that the space was thus designed for an in between use of the above types mentioned. For the redesign, however, the lighting design will be for a leisure type of dining area thus changing the existing lighting design. The uniformity in the existing design does not promote relaxation. According to Flynn, the lighting should be focused on the walls and non-uniform. The color rendering index should be higher than 80 since color appearance and contrast is so important for food. The Cirkul fixtures used have a diffusing lens which does not produce glare and models object well. However, the points of interest are undefined and there is no sparkle in the space. Also, the lighting power densities are above the allowable according to ASHRAE 90.1.

Lobby | The existing lighting design of the Lobby is very uniform only utilizing Louis Poulsen Cirkul fixtures in two sizes. These luminaires look modern and clean and glow much like the rain screen façade probably glows at night. However, the lighting design could be more interesting, enhance the architecture better, and demonstrate more clearly the theme of connectivity and circulation. The interesting wall is not highlighted with light and the uniformity does not guide visitors in any direction. Since color appearance is very important in a lobby space, the CRI should be higher. The existing lighting design works for the tasks that will be performed in the space but do not make a bold statement in the space. Given the importance of the space, the lighting should leave an impression and be more than just task oriented. It should be art.

North Entry | The existing lighting on the exterior North Entrance only includes one the Princeton Pole. The pathways and nodes have no light to guide circulation. It is lacking many of the features suggested for landscape and building exterior lighting. The Princeton Pole fits well with the entire campus theme and maintains uniformity: therefore, it will not be eliminated. However, other fixtures, that assimilate the architecture of the complex, are required and will complement the Princeton Pole. They should have good CRI, not cause glare, and minimize light pollution while still modeling objects and faces correctly.

Large Patio | The Large Light Monitor is the extra space to design. This space is one of the most interesting spaces in the building because of its interconnected nature of joining the outdoor/indoor, circulation space/light well, and the floors. The space runs three stories high of empty space where the daylight trickles in and creates interesting shadows and angles. Something should be added to this space that would interact with the daylight and promote the theme of connection. Nothing is there now apart from lighting for the steps.

. Lighting Depth | Solution .

Background | Lighting concepts were generated to catapult the schematic design of the Princeton Neuroscience & Psychology Complex in a way that represents its occupants and the architecture. Since the building is occupied by two sciences that deal with the brain, the main inspiration for the concepts was drawn from this. The first concept is *connection*. There are 50-100 billion neurons in the brain linked with up to 10,000 synaptic connections each. Furthermore, the objective of placing both sciences in a complex together was to promote interaction between them while still maintaining their individual identities. That is why the building has two "towers" with a core lobby connecting them and with shared underground floors. The location of the building adjacent to other science buildings was to promote a sense of community between all sciences. Rafael Moneo Valles, the architect, is also known for integrating modern structures with intricate landscapes. The second concept is *mirroring opposites*. The right side of the brain controls the left side of the body and vice-versa. There are two hemispheres in the brain just like in this building. The architecture has two side, the "towers", which are not exactly alike but resemble each other which gives the building an "almost" symmetry. Also, the Neuroscience Institute and the Psychology Department are to interact and mirror each other while still being different. The third concept is *static motion*. Synaptic connections in the brain appear as light moving through different paths. There is no movement, but the appearance of it through light. Appearance and perception is a major part of psychology as well as lighting. The last concept is *building as brain activity*. Like a brain scan, where parts of the brain where there is activity are lit up, the building will represent the users and show the exterior what is happening in the interior. Control of the users and interaction of the lighting with the users will support this concept.

Lecture Hall | To achieve a more interesting space in the Lecture Hall, lines of light will be added to the side wooden walls as well as to the ceiling. This will provide high general levels of illumination for the reading/writing tasks while following of *static motion* and *mirroring opposites* concepts. The diffuse nature of the translucent lens will remove problems of veiling reflections, glare, and shadows. The front wall with the chalkboards will be washed to reach higher levels than the rest of the space and act as a point of attention. When the projector screen is used, controls will allow for dimming and turning off of the front wall-washer. The corridor will also have a linear light element to account for circulation without interfering with the seating area of the space. Step lighting will provide the adequate levels for safety.

Cafeteria | To promote relaxation in the Cafeteria, a non-uniform lighting scheme was created that focused away from the users. Higher level at the food preparation station will attract attention to this area as well as an under-lit cabinets and highlights in the bookshelves. Perimeter lighting includes an existing "nose" detail as well as grazing the top portion of the surrounding wooden panel wall. Suspended luminaires will be hung and controlled by the users promoting the concept of *building as brain activity*. These suspended elements will have lamps with a higher CRI because they will be lighting the food purchased by the occupants.

Lobby | To add interest, exalt the architecture, and promote circulation, three schematic designs were created for the Lobby space. The first is based on architecture and it highlights architectural masses like the crossing bridge on the second level and the floor. The main focus is on the stone wall where lights are integrated into the stonework at random places and they interact with people passing by. This creates an effect of *static motion* while encouraging interactive circulation. The material opposite to the stone is glass, both translucent and clear, so it will reflect the effects happening on the stone wall creating *mirroring opposites.* The second schematic design is based on Neuroscience. Still highlighting vertical elements and providing enough light for circulation, the main focus is now the ceiling. With curving strips of light that randomly light up in a continuous motion mimicking synaptic *connection*s and encouraging guided circulation. The third schematic design is based on psychology and the Flynn impressions of Openness and Enclosure. Higher light levels and peripheral emphasize attract the occupants while darker space repel them indirectly promoting circulation.

North Entry | The objective of the lighting in the North Entry pathway is to safely guide pedestrians to the building and to the nodes where they can take different routes. To do this, bollards were places along the walkways with their spacing decreasing as they approach the nodes and the building. This spacing difference creates a *static motion* effect. To add to this, certain stones in the exterior will also be lit, again concentrating as they approach the building, and will twinkle interacting with pedestrian while resembling *brain activity*. The façade will remain until so that the lighting from the spaces within is noted from the exterior making the showing the *activity* within.

Large Patio | To interact with the daylight, promote connection, and add aesthetic interest to the space, a light sculpture will fill the Light Monitor hanging from the top glass. It will have crystal balls of light at different levels that will sparkle when the daylight hits them and will glow at night with the use of artificial light. The shape resembles brain *connection*s.

. Lighting Depth | Method | Task and Tools .

Method | Computer software like AGI 32, AutoCAD, and 3Ds Max will be used to create renderings and calculations of all spaces to ensure that the lighting makes sense both quantitatively and qualitatively. The results will be analyzed and exported into documentation for the final presentation.

Tasks and Tools |

1. Fix schematic design with feedback from Lutron | After the Lutron Presentation, the comments provided by the designers will help in making the conceptual design more plausible.

2. Fix models created for Technical Assignment 1 and make other as necessary in AutoCAD | Basic AutoCAD models were already created for the Lecture Hall and the Cafeteria. More detail and any changes tied to the lighting scheme will be added. Based on the plans and sections provided by the architect, new models will be created for the Lobby and North Entry.

3. Select Hardware | Preliminary fixtures were already selected for the Lutron Presentation. These will be furthered analyze before officially selecting them for the final design.

4. Calculate necessary illuminance values and parameters using AGI32 | The AutoCAD models will be imported into AGI32 where detailed calculations of illuminance values and their uniformity will be calculated. To do this, IES files for all fixtures and material properties must be applied.

5. Calculated Lighting Power Densities | ASHRAE 90.1 requires lighting power densities to comply with values according to space and building type. Therefore, calculations with the selected equipment will be performed.

6. Alter designs if necessary | If the calculations for illuminance or power densities conclude in unacceptable results, then the lighting will be altered. These modifications might alter the architecture. If so, the three dimensional models must be changed to match the changes from the lighting.

7. Create Renderings in 3Ds Max | The AutoCAD model will be imported in to 3Ds Max where materials will be either selected or created and IES files uploaded so that real-life renderings are created.

8. Documentation | Final lighting plans will be created in AutoCAD. A fixture schedule will be created and cutsheets gathered to show all the instruments used in the design.

. Lighting Depth | Lutron Comments .

Sandra | Grenald Waldron

- Overall
  - Color are distracting, tone them down
  - Vertical words are ok, nice presentation
  - Two different methods of sketching used = ok but changing in space was confusing
    - Linear vs. kinetic, fast paced, use one technique only for less confusion
  - Be confident, no “maybes” in presenting, be strong!
- Exterior
  - Bollards = do you feel safe with just these? Select something that illuminates faces
  - Modeling faces
  - Liked reasons and explanations for not lighting façade, liked glow
- Lobby
  - Movement piece
  - Liked change of brick vs. wood with lines
- Lecture Hall
  - Speaker being lit with side wall, confusion
- Cafeteria
  - Why private? It is public and lively, rethink
  - Liked lighting back area
- Patio
  - Liked concept with reflections and illuminated at night, enough light at night?

Shawn Good | Brinjac Engineers

- Overall
  - Color scheme: too intense of yellow oin slides with transitioning
  - Plans in CAD were intense because of white background vs. slide color
  - Liked sketches better because more concept showing through
  - Said “um” a lot and stood out, got better at end
- Exterior
  - “You are what you light”, liked hierarchy to pull people, kinetic movement, use this
  - Bollard issue
- Lobby
  - Missed concept with building as brain activity
  - static motion: openness vs. closure = good concept but way to do it disagree with
  - Be careful with where people will be drawn to with lighting certain surfaces
  - Set hierarchy correctly, bright vs. dark areas
- Cafeteria
  - Liked overall concept but felt it was more relaxation (corrected)
- Large Patio
  - Good concept with sparkling element, go further with design

Don't slip at end because it's a good space

Charles Stone | Fisher Marantz Stone

Overall

Good presentation
Took a lot of risks : good, use comments to advantage
Color scheme too much
Benefit with footer on bottom in smaller font
Liked different techniques (different sketches, AGI, etc.) but took risks: good
Set high bar with "brain" concept:
Remind guest with images from beginning as inspiration mentioned
Problem: too many approaches to renderings, use to advantage why you chose different

Lobby

Liked "line" sketching with wall types (brick vs. wood)

Exterior

Princeton Pole still there or bollards only?
Prove safety and security issues

. Electrical Depth .

Background | The Neuroscience & Psychology complex has an intricate electrical system design due to its large area and complicated laboratory spaces. The electricity supplied by the utility company to Princeton University's main distribution system enters the building through the northwest corner where there are two service entrances. These supply power to two double-ended substations with difference voltage systems. From here, power is distributed to the entire building through switchboards and distribution panels. There are approximately 65 pieces of switchgear equipment, 30 lighting panelboards, 65 receptacle panelboards, 25 transformers, 60 different luminaires, and 200 mechanical equipment (including plumbing and cafeteria equipment). Most of the lighting loads are part of the 480Y/277V system and the mechanical equipment is in the 208Y/120V system.

The emergency electricity is supplied by a generator on the exterior of the building that feeds three transfer switches and the fire pump. Special equipment includes Uninterrupted Power Supply and Transient Voltage Surge Suppressor systems. A very complex grounding system runs through the entire complex as well as a security and fire alarm system.

Four Spaces |The four spaces in the Princeton Neuroscience & Psychology Complex where the lighting will be designed are the North Entrance, Lobby, Lecture Hall, and Cafeteria. Since the lighting will change, the electrical loads of the spaces will also be altered and therefore a redesign of the branch circuit distribution is necessary.

The North Entrance has some pathways that lead to the lobby. There is only one Princeton standard gas lamp in the walkway areas in addition to the canopy LED downlights and fluorescent vestibule downlights. The lighting in the Lobby, Lecture Hall, and Cafeteria is composed of fluorescent downlights. The lamp sources for the proposed lighting schemes have not been decided. When the lighting schematic design is officially chosen, then the sources will be selected.

Short Circuit Analysis | A short-circuit analysis will be performed through a single path along the distribution system. The study will begin at the Service Entry Tap Box #1 and go through Main Switchgear C, A2-Busway, and will end in Distribution Panel AA. The feeders that connect the equipment are not all numbered in the original plans. The single line drawing created for Technical Assignment 2 has numbers for the feeder of the service entrance (Tag 1) and for the Main Switchgear C (Tag 2). The original plans have the A2 Busway feeder tagged as 4-P380D and no tag for the feeder to Distribution Panel AA.

Depth Topic 1 | Cooper Bus Ducts vs. Aluminum Bus Ducts | There are five existing copper bus ducts in the building. They will be replaced with aluminum bus ducts and a comparison will be made regarding the cost and maintenance to decide which option is better. The tasks to complete the analysis are the following: Make a list of all bus ducts in the building that includes the size and length of each, find prices for both materials, research maintenance issues regarding both materials, and compare.

Depth Topic 2 | Motor Control Center | A motor control center will be designed to try to improve the system. Tasks associated with the design include: Creating an AutoCAD isometric to make sure the control center fits in the mechanical room, calculating the design loads for branch conductors and feeders, and providing manufacturers catalogue.

. Breadth 1 | Architectural .

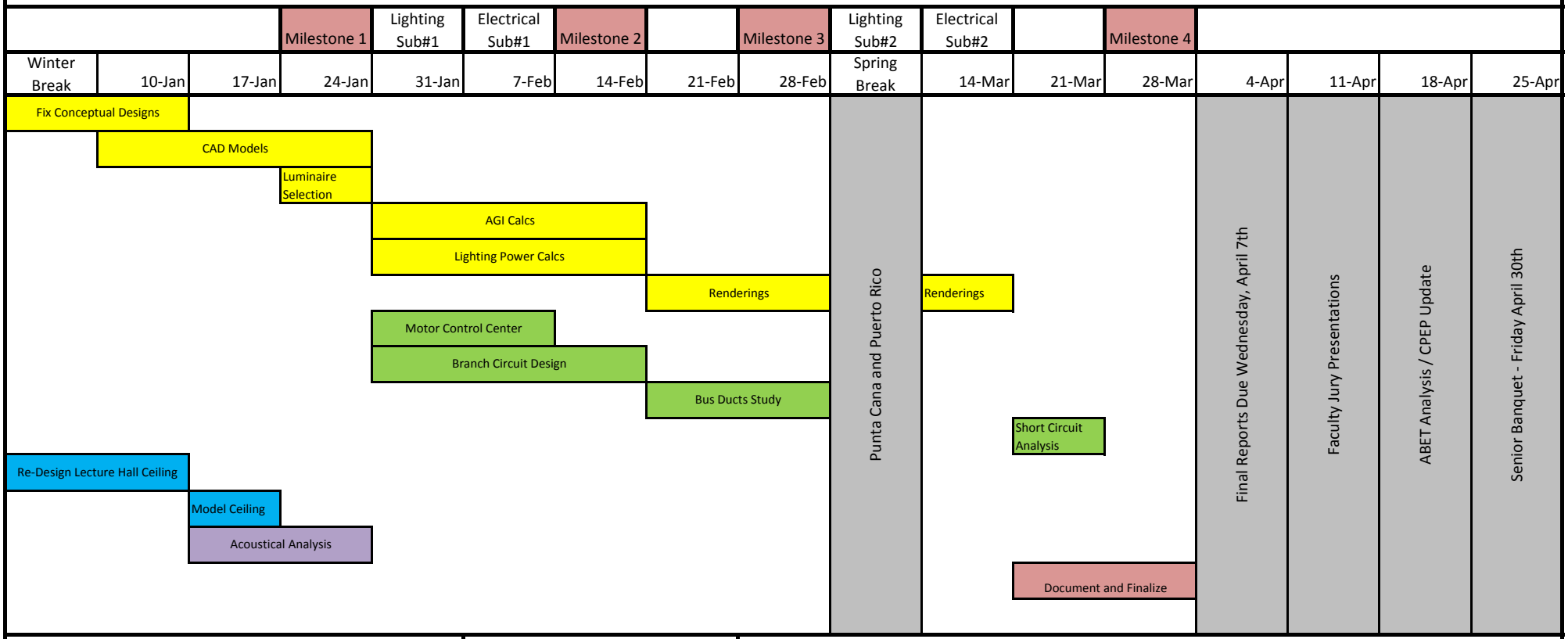
Overview | The lighting in the lecture hall will be changing from circular spot elements to linear ones. The ceiling in this space has a curved element. The idea is to re-design the ceiling to create different levels and linear elements that match the linearity of the wooden panels that surround the entire seating area. The changes in elevation in the ceiling re-design will allow for the lighting to be fully integrated while still concealing mechanical and structural elements. This would unite architecture and light into one and will add visual interest to the space as well as functionality.

. Breadth 2 | Acoustical .

Overview |The architectural alteration in the ceiling accompanied with the new lighting design will create changes in the acoustical properties of the space. Therefore, an acoustical study will be conducted that includes a reverberation time calculation. The new ceiling materials will be chosen to improve the acoustics of the space, and other materials will be altered as necessary to reach the desired reverberation time for a lecture hall space.

Spring 2011 Proposed Thesis Schedule

Angelica Santana | L/E Option | Consultant: Dr. Houser | Princeton Neuroscience & Psychology Building | Princeton, NJ



Milestones

1: Conceptual Lighting Design and Breadths
2: Go-No Go Check
3: Final Lighting Design and Electrical Depth
4: Renderings and Documentation

Key

- Lighting Depth
- Electrical Depth
- Architectural Breadth
- Acoustical Breadth
- All

Submissions

Lighting #1: One lighting space complete
Lighting #2: Second lighting space complete
Electrical #1: One depth topic complete, requirments for one lighting space
Electrical #2: Second depth topic complete, requirments for another lighting space