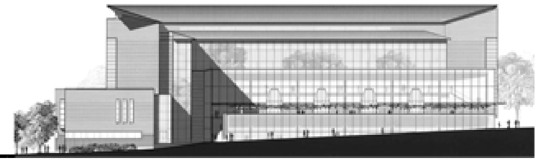
Thesis Proposal

William H. Gates Hall
Seattle, WA

Katherine Jenkins
Lighting/Electrical Option

December 14, 2006

Faculty Advisors:
Dr. Mistrick
Ted Dannerth



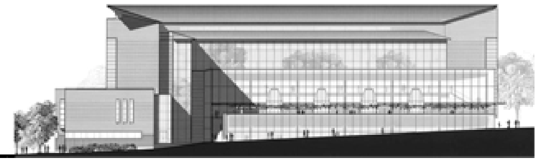
Executive Summary: Thesis Depth Proposal

The thesis proposal outlines and defines the work that will be completed for the various redesigns of systems in William H. Gates Hall during the Spring 2007 semester. Both the depth and breadth will look at the building systems from an integrated standpoint, to best determine systems that will be effective in not just one building system, but beneficial to all systems. The depth analysis work will be completed in the areas of lighting and electrical design.

The depth work for the lighting design portion of the thesis project will look at redesigning the lighting systems for four different spaces within the building. These spaces will include the Marion Gould Gallagher Law Library (reading area), the Senator Warren G. Magnuson & Senator Henry M. Jackson Trial Courtroom, the Jeffery & Susan Brotman Galleria, and the terrace. While aiming to produce an aesthetically pleasing lighting design that complements the architecture of the building, the design will also strive to meet standards set forth by IESNA and ASHRAE 90.1. In addition to this, a daylighting analysis will be conducted for the law library and galleria.

In addition to a lighting redesign, the depth work will also include an electrical analysis portion. In the electrical work, several topics will be explored. These topics will include a coordination and redesign of the electrical system due to lighting changes; a three way analysis of using central transformers, distributed transformers, and energy efficient distributed transformers; and adjusting the electrical distribution system based on mechanical changes made in the mechanical breadth work.

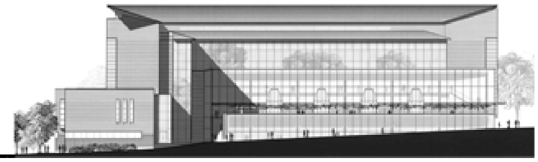
In order to fully understand the implementation of the proposed design changes, additional breadth work will encompass the work done in both of the depth analyses. The breadth analyses will incorporate the effects the electrical and lighting redesigns have on both the mechanical and construction management disciplines.



Building Background

Located in Seattle, Washington, William H. Gates Hall provides a new facility for the University of Washington, School of Law. Spanning six floors, four of which are above grade, the building provides classrooms, mock courtrooms, seminar rooms, conference rooms, administrative offices, a pro-bono law clinic and the “Northwest’s finest law library” to students faculty and visitors. Previously, the law school was located in Condon Hall, a facility located off campus that lacked amenities that would allow the program to grow to its full potential. The new building brings the school back to the main campus, provides students and faculty with 196,000 square feet of state-of-the-art facilities that showcase the tradition and excellence of the law school.

Construction of William H. Gates Hall began in July of 2001 and its doors were opened to the public at a dedication ceremony on September 12, 2003. Strategically located in a prominent area of campus, the building boasts distinguishing architectural features that are clearly visible to all. It is a combination of these features as well as the vast array of resources offered that sets William H. Gates Hall apart from any other building on campus.



Depth Analysis: Lighting Design

Problem:

The lighting design of a building should strive to achieve a balance between providing a building aesthetic that is complementary of the architecture and function of the building and delivering a product that is energy efficient and adheres to criteria set forth by IESNA and ASHRAE 90.1. By achieving a design that is conscious of both of these aspects and considers the integrated aspects of lighting, an optimal lighting design can be achieved.

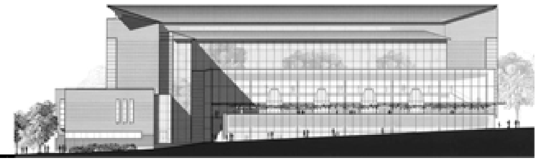
Solution:

As the UW Law School moves into its new home, it is important for the lighting design to reflect the tradition and excellence of the program, while highlighting the modern architecture of the building. In addition to this, an underlying awareness for creating an energy efficient design is necessary. Four specific spaces have been chosen for a redesign of the lighting system. These include the Marion Gould Gallagher Law Library (reading area), the Senator Warren G. Magnuson & Senator Henry M. Jackson Trial Courtroom, the Jeffery & Susan Brotman Galleria, and the terrace.

In redesigning the trial courtroom, the ultimate goal is to provide a realistic courtroom setting. Knowing that this space will be used to help prepare students for their legal careers, it is essential to provide a space that is reflective of “real life” settings. Through the incorporation of ambient and task lighting, a visual hierarchy should be created to draw emphasis on the most important areas of the space. It is also imperative to provide adequate light levels throughout the space and a system that is flexible to accommodate for the variety of tasks that are likely to occur.

Located at the center of the building, the two-story law library space acts as the “heart” of the building. In redesigning this space, it is essential that the lighting systems are appropriate for this task intensive space and help to resonate that this is the “Northwest’s finest law library.” An interesting, yet not distracting, lighting design should be used in complementing the space’s architecture. In addition to this, a daylight study of the four large overhead skylights will be performed in order to maximize the incorporation of daylight while avoiding undesirable direct glare. As a part of this analysis, and in conjunction with the breadth mechanical analysis, the most appropriate type of glazing for these skylights will be determined.

The galleria space acts as the main artery of the building, moving people from one end of the building to the other. This double height space, while fairly modest from an architectural standpoint, acts as a “viewing window” for the law school, with substantial exposure to the surrounding campus. The lighting design of the space should not only



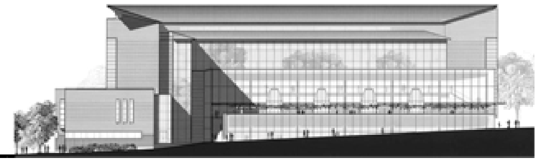
aim to help guide people through the space, but also provide a welcoming and interesting space to viewers from afar. Also, the adjacent terrace should also be taken into consideration, in order provide a design that is complementary to this visually adjacent space. In addition to this, extensive consideration should be given to how the large influx of daylight into this space via the double-height glass curtain wall will be integrated into the lighting design. A daylighting analysis of this space will be conducted, in conjunction with the mechanical breadth analysis, to determine the optimal daylighting system, including glazing and controls. This in turn, will be taken into consideration when determining electric light needs.

Sitting directly atop of the law library, the terrace provides an outdoor gathering space for students and visitors. Due to the space being sandwiched between both the law library and the adjacent galleria, consideration of how the lighting design of each of these three spaces directly affects one another is imperative. With the presence of several prominent architectural features in the space, including the skylights and perimeter trellis, the lighting design should aim to highlight such aspects while providing adequate light levels for safety.

While each of these four spaces are individually distinguishable from one another, an overall effort will be made to provide lighting systems that reflect the excellence of the law school and takes into consideration the importance of energy efficiency design. For further detailed information regarding lighting concerns and approaches for theses spaces, refer to the Lighting Existing Conditions and Design Criteria Report and the Lighting Schematic Design Proposal.

Task and Tools:

In redesigning the lighting systems for these four spaces, computer modeling will be utilized to ensure that design requirements and parameters, as well as desired aesthetics, are met. Design criteria for the four spaces will be developed according to the design requirements and criteria outlined in the IESNA Handbook. Keeping this criteria in mind, lamps, ballasts and luminaires will be selected and used in AGI 32 lighting software to determine achieved illuminance values and obtain photorealistic renderings of the space. Upon completion of renderings and obtaining calculation values, the lighting design compliance with ASHRAE 90.1 will be verified and appropriate lighting control systems will be determined. In order to clearly communicate the design intentions, lighting plans, schedules, control diagrams and renderings will be produced.

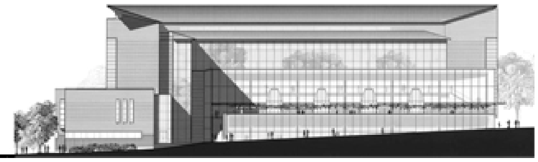


Design Outline

I. Fixture Selection and Design Development
   a. Luminaires will be selected based on desired appearance, efficiency and photometric distribution
   b. Corresponding energy efficient lamp types will be selected
   c. Compatible ballast for each luminaire will be selected
   d. Lighting layout and spacing will be developed based on established design criteria

II. Electric Lighting Analysis
   a. AGI models for each of the four spaces will be created and analyzed
   b. Illuminance values for spaces determined
   c. Rendered images of each spaces created

III. Daylighting Analysis
   a. Analyze current daylight conditions in library and galleria
   b. Use AGI32 to determined best glazing material to maximize daylight and minimize mechanical loads
   c. Analyze and integrate appropriate daylight controls into spaces to determine energy savings through decreased electric lighting needs



Depth Analysis: Electrical Design

Problem:

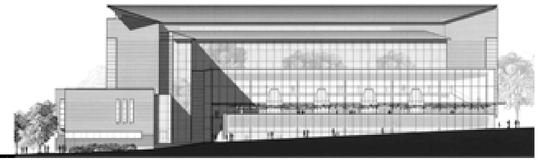
While the electrical distribution system of William H. Gates Hall does not have any overwhelming design issues or concerns, an analysis of a modified system should be considered to seek addition energy and cost savings. While this building was not designed specifically under the direction of LEED criteria, the building as a whole should include systems that run as efficiently as possible. By incorporating both energy efficient lighting and the proper electrical distribution system, building systems meeting this criterion can be achieved.

Solution:

There are several areas of analysis within the electrical spectrum that will take place as part of the electrical depth. The first area pertains to the electrical coordination required in conjunction with the lighting redesign. For each of the four spaces to be redesigned in the lighting depth, the branch circuit distribution will be analyzed and redesigned to accommodate for the changes made. This includes redesigning the circuits and corresponding panelboards for the circuits that have been changed. All branch circuits, as well as equipment and controls are to be considered and (re)designed to the appropriate panels.

The second topic that will be explored is overall design and layout of the transformers in the building. Currently a central transformer configuration is utilized, with the majority of the step-down transformers located in the main electrical room on Level L2. This dictates the use of larger wire sizes up through the building to serve each floor's respective panels. In my analysis a different design approach will be used, distributed transformers. I will redesign the electrical distribution system to allow for localized transformers on each floor to serve the respective panelboards and loads. This will allow for smaller wire sizes to be used throughout the building. In addition to this, a secondary analysis will be conducted for the distributed transformers, looking at using energy efficient transformers, such as those from Powersmith. This will help to address an alternative to the common concern about the inefficiency of smaller transformers needed for distributed transformers. Once equipment has been selected and sized for both situations, a comparison of all three configurations/systems will be conducted (existing central transformers, distributed transformers, distributed transformers utilizing energy efficient transformers). This comparison will look at both cost and energy efficiency of these systems.

Additionally, an electrical analysis will be completed in conjunction with the proposed mechanical breadth analysis. This analysis calls for a switch from fan-powered terminal



boxes to variable air volume boxes throughout the building. This component of the electrical depth will look at how this mechanical redesign will affect the electrical distribution system. All parts of the distribution system, including panelboards, feeders and distribution panels affected by this change will be adjusted and redesigned.

Lastly, a protective device coordination study with be conducted in which a single-path through the distribution system will be analyzed to ensure proper coordination of protective devices. This analysis will also include short circuit current calculations

For additional information on the current electrical distribution system, refer to Electrical Systems Existing Conditions and Load Summary Report.

Task and Tools:

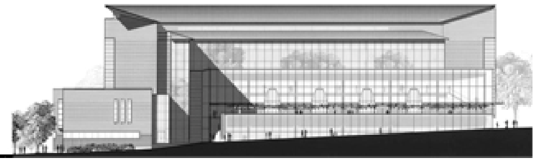
The 2005 National Electric Code will be used extensively throughout this depth work to determine resizing of electrical equipment due to building load changes.

Design Outline

I. Coordination of Lighting Changes
   a. Prepare panelboard schedules that are affected by lighting redesign
   b. Indicated branch circuits that change as a result of the redesign
   c. Prepare new panelboard schedules indicating new loads
   d. Resize/layout affected panelboards
   e. Layout branch circuits and controls for each designed space

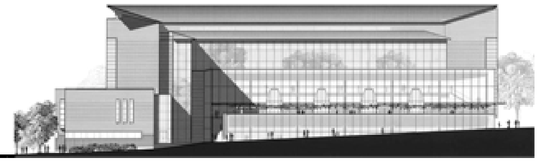
II. Central Transformers vs. Distributed Transformers
   a. Evaluate existing transformer configuration and determine loads served by each transformer
   b. Select and redesign transformers, using smaller, distributed transformers
   c. Select and redesign transformers, incorporating energy efficient transformers into new distributed transformer design
   d. Adjust changes to electrical distribution system caused as a result of changed transformers
   e. Conduct three way comparison and cost savings analysis of original system, distributed transformer configuration, and distributed transformer configuration utilizing energy efficient transformers

III. Analyze mechanical changes
   a. Determined mechanical load changes due to switching from fan-powered to VAV boxes
   b. Prepare panelboard schedules that are effected by mechanical redesign
   c. Indicate circuits which have changed
   d. Prepare new panelboard schedule indicating changes
   e. Resize/layout affected panelboards



   f. Adjust electrical distribution panels and feeders that are affected by the changes
   g. Analyze energy savings achieved as a result of the change

IV. Protective device coordination study
   a. Determine single path through distribution system that has been redesigned
   b. Verify all protection devices have been sized appropriately
   c. Determine if components through this path have been coordinated properly
   d. Perform short circuit calculations for this feeder path
   e. Adjust any feeder/protection device sizes if necessary

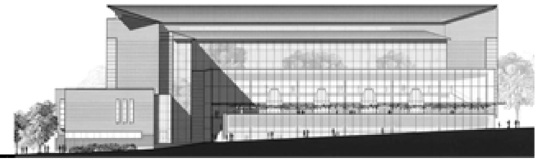


Executive Summary: Thesis Breadth Proposal

In order to fully understand the integrated characteristics of the different systems in William H. Gates Hall, it is necessary to look beyond the initial lighting and electrical changes proposed for the depth analysis to see how they affect the building as a whole. The Breadth Proposal incorporates changes made in one discipline and takes it to the next level by considering how it affects systems throughout the remainder of the building. The proposed breadth analysis includes topics in the spectrum of the mechanical and construction management disciplines, and considerations which can be directly linked to the proposed lighting and electrical changes.

The mechanical breadth will offer a chance to evaluate the daylighting system in the building and the consequential effect it will have on the heating and cooling loads. A study to determine the appropriate type of glazing will be conducted, followed by a redesign of the mechanical equipment to adjust for changes in the required heating and cooling loads, and wrapped up with an energy analysis of the changes. In addition to this, energy consumption will also try to be minimized through a study of replacing the fan-powered terminal boxes throughout the building with variable air volume boxes.

The construction management breadth will consider the cost effectiveness of the daylighting solutions considered in the lighting and electrical depth, as well as the mechanical breadth. By comparing first initial cost with energy saving and looking at the corresponding payback period, the effectiveness of the daylighting system can be determined. Additionally, a cost analysis looking at the cost implications and payback period of switching to VAV boxes throughout the building will be conducted. This will allow for a conclusion on the overall effectiveness of this proposed system.

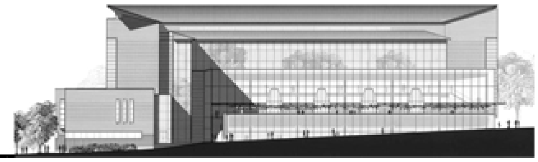


Breadth Analysis: Mechanical

One of the most architecturally prevalent features of William H. Gates Hall is the incorporation of daylighting into the space, both through the four large trapezoidal skylights and the glass curtain wall spanning almost half of the building's exterior. While this large area of glazing allows for a large influx of desirable daylight, the solar heat gain associated with such materials may inherently cause mechanical equipment and loads to be sized larger to account for this. As part of the daylighting analysis performed in the lighting depth analysis, a study on glazing types will be performed to find the optimal system, allowing daylight while avoiding undesirable glare. As part of the mechanical depth analysis, glazing types will be further explored in order to find an optimal system that also decreases mechanical loads associated with solar heat gain. Daylighting studies using programs such as AGI32 will be used to study daylight penetration into the space in order to find the best glazing for the building.

Once an optimal glazing is selected, a more extensive analysis of mechanical loads can be performed. This analysis will look at the impact that changing the glazing used will have on the mechanical system. Mechanical equipment will then be resized to account for these load changes due to solar heat gain and the overall energy savings can be compared between the two glazing systems.

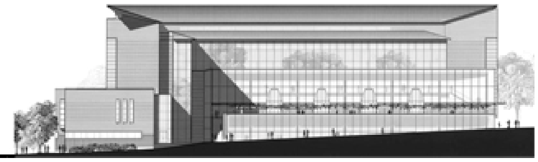
In addition to this, another area of great potential energy savings within the building will be explored. Currently the air distribution system in the building utilizes over 170 fan-powered terminal boxed which as a whole consume approximately 175 KW of energy. By changing these to variable-air-volumes (VAV) boxes, the high energy loads required to run the fans can be eliminated. An analysis will be conducted of the potential energy savings that could be accomplished by switching to VAV boxes, and the subsequent electrical loads will be analyzed as well.



Breadth Analysis: Construction Management

With the integration of proper daylighting techniques, not only can mechanical loads throughout a building be decreased, but potential for a cost effective system exist as well. While implementing a proper daylighting system may require increased first cost due to more expensive glazing, daylight sensors and controls, and dimmable ballast, there is often a payback on the energy side of the equation due to decreased mechanical loads and decreased electrical loads (from being able to dim or completely shut off electric lighting during adequate daylight conditions). An analysis of the potential energy savings from the proposed daylighting system will be completed by comparing initial first cost and the payback period of potential energy savings of the system as a whole.

Furthermore, a cost analysis of the proposed mechanical changes will be completed to verify the new system’s efficiency. By replacing the fan-powered terminal boxes with variable air volume boxes throughout the entire building, it is expected that significant energy savings will result. The cost of a new system and the expected energy savings will be compared to the existing system and its respective cost. This will help to determine if the system cuts cost in addition to helping to reduce mechanical loads throughout the building.



Time Table

Week	Task
1/1/07 – 1/13/07	Finalize AGI Models
1/14/07 - 1/20/07	Daylighting Study Electric Lighting - Fixture Selection
1/21/07 - 1/27/07	Electric Lighting - Calculations and Determine Controls Electrical - Lighting Coordination
1/28/07 - 2/3/07	Electric Lighting - Calculations and Determine Controls Electrical - Lighting Coordination
2/4/07 - 2/10/07	Mechanical Analysis of Daylighting Cost Analysis of Daylighting System
2/11/07 - 2/17/07	Electrical - Transformer Redesign and Analysis
2/18/07 - 2/24/07	Mechanical Analysis - Fan-Powered vs. VAV Boxes
2/25/07 - 3/3/07	Electrical – Mechanical Coordination CM - Mechanical Cost Analysis
3/4/07 - 3/10/07	Finalize Renderings
3/11/07 - 3/17/07	Spring Break
3/18/07 - 3/24/07	Time for Unforeseen Problems
3/25/07 - 3/31/07	Finalize Repot
4/1/07 - 4/7/07	Finalize Presentation
4/8/07 - 4/14/07	Practice/Prepare for Presentation
4/15/07 - 4/21/07	Thesis Presentations