Technical Report One

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OCTOBER 5, 2009

Connecticut Science Center
Hartford, CT
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AGI Files are found at P:\jas5149\Tech1AGI
The contents of Technical Report One include an evaluation of the lighting design present in the Connecticut Science Center. This museum functions to promote the excitement and wonder of science as well as the state’s commitment to education and cultural enrichment. The report includes an assessment of the building’s lighting in general. Four distinct spaces are then looked at in more depth.

The spaces include the second floor office area, the multipurpose theater, Science Alley, and the sixth floor outdoor roof garden. Current design layouts can be seen as well as the criteria upon which evaluation should be based. A final evaluation concludes each space.

The Connecticut Science Center lighting mostly serves its purpose for the tasks that will be performed in each space. A victim of value engineering, it is possible to see that some of the lighting design is simple. This causes concern due to the fact that the museum should portray an exciting and dynamic atmosphere.

In general, the same types of lamps with a color temperature of 3000 K are used to create cohesion through the spaces. When available, daylight is used to light the spaces. Photosensor and dimming controls help to coordinate this with the electric lighting.

IESNA recommendations are typically met. In fact, in some cases, illuminance levels are a bit high. ASHRAE recommendations are not met in most spaces. One can assume that since the building is intended to be LEED certified, other spaces not evaluated in the breadth of this report make up for the areas that are over. This provides unique opportunity to not only improve the lighting design aesthetically, but more energy efficiently as well.
General Lighting Critique

The lighting design of the Connecticut Science Center (CSC) is energy conscious and appropriate for a museum setting. Paying close attention to the publicly accessed zones of the facility, the designer worked to distinguish common areas, such as the plaza level, from the exhibit spaces. The bridges, which lead toward exhibit spaces, help to guide patrons with lines of light recessed into the floor. Exhibit space lighting is flexible. In private spaces, such as offices, the design focus is less aesthetic and more functional.

The positioning of luminaires in private spaces, such as the offices, could potentially be adjusted. Proper placement may help reduce glare and improve the occupants’ ability to perform tasks.

Exterior lighting plays a main feature in the illuminance of the building. This is due in part to an LED sign integrated into the façade. The LEDs provide custom effects and animations that help add to the intrigue and wonder that characterizes the CSC.

For most light sources, a consistent color temperature of 3000 K allows for cohesion between spaces. Spaces also pull together through the use of similar decorative fixtures. Although value engineering has eliminated many of these fixtures in favor of less expensive varieties, some remain. The types of fixtures have been simplified to minimize the types of lamps needed for relamping. Overall, the value engineering has eliminated much of the potential for dynamic lighting design.

The controls of the lighting are based upon the room function, and in most cases, seem to be well thought out. In the theater or rooms where A/V is prevalent, dimmers are employed. In the atrium, and many other spaces offering daylighting, photosensors are used. Occupancy sensors are common in restrooms. The controls help alleviate the large load lighting would otherwise have on the CSC’s electrical systems.

The lighting design of the Connecticut Science Center is primarily dedicated to energy efficient lighting systems. At the same time, much attention was paid to the aesthetics as well. Although the intended design is remarkable, room for improvement still exists.
Large Work Space

Second floor open office/Private office

Description:

The second floor open office is located in the western half of the north tower. It encompasses about 1,390 square feet and is 8'-0” from floor to ceiling. Private offices surround the space on two sides, while conference rooms and storage encompass the other two. A staircase is also easily accessible.

Present in the open office space are fifteen cubicles. Each cube is assumed to have one chair and one computer. Five private offices help to separate these working spaces from the atrium. The President’s and Vice President’s offices are also located in this space.

For additional study, one of the private offices will be considered. This 195 square foot space consists of an occupant’s desk as well as two guest chairs. The ceiling height is 8’-0”. The desk has a centrally located computer. Bookshelves and cabinets are also present.

Surface Materials:

OPEN OFFICE

Floor- Covering the entire floor is a broadloom carpet (CP-1).

Base- The wood trim is plain sawn solid maple finished to match the architect’s sample (WD-1).

Walls- The walls separating the open office from private offices or conference spaces consist of regular type painted gypsum wall board (GWB-1).

Ceiling- The open office has a acoustic ceiling tile measuring 2’-0” x 2’-0” (ACT-4).
PRIVATE OFFICE

Floor- Covering the entire floor is a broadloom carpet (CP-1).

Base- The wood trim is plain sawn solid maple finished to match the architect’s sample (WD-1).

Walls- The private office walls are regular type painted gypsum wall board (GWB-1). Select rooms have windows looking into the atrium space.

Ceiling- The private office has acoustic ceiling tiles in addition to gypsum ceiling system with square perforations (ACT-2).

<table>
<thead>
<tr>
<th>Material</th>
<th>Color/Style</th>
<th>Reflectance</th>
</tr>
</thead>
<tbody>
<tr>
<td>CP-1 Broadloom Carpet</td>
<td>Gray</td>
<td>0.23</td>
</tr>
<tr>
<td>WD-1 Plain Sawn Solid Wood</td>
<td>Maple</td>
<td>0.44</td>
</tr>
<tr>
<td>GWB-1 Painted Gypsum Wall Board</td>
<td>White</td>
<td>0.50</td>
</tr>
<tr>
<td>ACT-1 Acoustic Ceiling Tile</td>
<td>White</td>
<td>0.80</td>
</tr>
<tr>
<td>ACT-2 Acoustic Ceiling Tiles and Gypsum Ceiling</td>
<td>White</td>
<td>0.80</td>
</tr>
<tr>
<td>Wooden Door</td>
<td>Maple</td>
<td>0.44</td>
</tr>
<tr>
<td>Desks/ Bookshelves/ Partitions</td>
<td>Matte Gray</td>
<td>0.45</td>
</tr>
</tbody>
</table>

*Not all manufacturer information provided, so assumptions made using similar materials.

**Figure 1**: Surface Material Properties

<table>
<thead>
<tr>
<th>Material</th>
<th>Description</th>
<th>Transmittance</th>
<th>SHGCC</th>
<th>U-factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laminated Glass</td>
<td>General Glazing</td>
<td>0.70</td>
<td>0.38</td>
<td>0.40</td>
</tr>
</tbody>
</table>

**Figure 2**: Glass Properties
**Furnishings:**

In the large work space, twelve cubicles with computer chairs are arranged. Computers are assumed to be placed on the desks. The private office consists of a desk, computer, and desk chair. A bookshelf and two guest chairs are also present.

**Activities/Tasks:**

The open office is a considerable amount of space designed for desk tasks. Paperwork, such as reading and writing, will be completed in this space. Much of the Connecticut Science Center’s administration tasks will be performed here. One can also assume that a great amount of computer work will be necessary for occupants of the space.

A large amount of movement is not anticipated in the open office. However, the corridor surrounding the cubicles will allow for less disturbing pedestrian flow.

The private office will most likely have the same types of desk tasks. Computers will compose a large part of the office work that will occur. Other activities include paperwork and conferencing on the phone or with visitors in the office.
Drawings:

Figure 3: Open/Private Office Floor Plan (NTS)

Note: No available section drawings for these spaces.

Lighting Design Criteria:

IESNA Handbook 2000: Open plan office, Intensive VDT Use/ Private Office

- Appearance of Space and Luminaires: Important
  These spaces are typically not accessed by the public, so an initial impression is not needed. However, employees will spend a great deal of time in the offices. The luminaires should be of good quality, but not necessarily high end, and arranged in an orderly fashion to avoid clutter. Task lighting may help to personalize desks. In private offices, a more decorative type of task lighting will add to the aesthetics of the space. The luminaires installed in the ceiling should be the same in both types of offices to help with the cohesiveness of spaces. The use of computers ensures that lighting should not be too bright that it would cause discomfort.
• **Psychological Impressions**
  The open office should feel spacious. This can be done by lighting the peripheral walls. Work planes should have high light levels in an effort to encourage visual clarity. The lighting, the furniture layout, and the room finishes should work together so that the occupant feels comfortable. The circulation patterns around the workspace should be easily identifiable. This can be achieved with a different style of ceiling luminaire or with wall sconces.

  Like the open offices, private offices should be made with the impression of visual clarity in mind. Higher luminances at the work surfaces and overhead will help achieve this. Some peripheral lighting, like grazing the wall nearest the atrium, is recommended.

• **Color Appearance (Contrast)** - Important
  The private and open offices should have the same color appearance. Continuing with the trend of using warmer color temperatures (3000 K) adds a more pleasant feel to the working environment. A higher CRI, well above 80, will add to the environment as well as improve the appearance of projects and other tasks. Well rendered colors found in the space will add visual interest, creating a more inviting and pleasant place to work.

• **Daylighting Integration and Control** - Important/Very Important (Private)
  The open office receives no daylighting because it is located in the center of an exhibit tower. The private office has windows which have a direct view into the atrium. These windows may need blinds as direct sun from the atrium may be able to penetrate.

• **Direct Glare** - Very Important
  Direct glare can reduce the ability of those performing tasks like reading or writing to see clearly. Contrast of computer screens or papers will be reduced. This glare will be uncomfortable for those working in the space. The use of inconspicuous or indirect lighting, as well as shielding will help with this criterion. Actively trying to keep the luminaire placement from an offending zone which would be in the line of sight with eyes is also recommended.

• **Flicker (and Strobe)** - Important
  Flicker can cause headaches and be a nuisance. To avoid this problem, electronic ballasts should be used for the fluorescent lamps.
• **Light Distribution on Surfaces** - Important
  The walls of the open office should be illuminated evenly to provide a more spacious feeling. No other architectural features exist that would specifically need illuminated. In the private offices, the back wall featuring the window to the atrium could be grazed, providing an interesting visual transition in the room.

• **Light Distribution on Task Plane (Uniformity)** - Important
  The task plane for both the open and private office is the desk tops. Uniform light distribution at proper illuminance levels will be important. Another task plane to consider is the space surrounding the cubicles meant as a corridor. This should also receive uniform lighting.

• **Luminances of Room Surfaces** - Very Important
  Open office perimeter walls should be washed with light. Grazing of the walls separating the private offices from the atrium should be done. The materials are typically white gypsum wall board and will need some type of lighting to increase the satisfaction within the working environment.

• **Modeling of Faces or Objects** - Important
  People will continually be working with one another in these spaces. Conversations and interaction will typify this space. Facial recognition is important, as well as being able to see body language. The downlighting in the space will help faces and expressions be seen.

• **Points of Interest**
  The desks are the main points of interest in the office spaces because this is where much of the work will be completed. Sufficient light levels need to be present in order to harbor a stimulating work environment. Office lighting should support the various tasks occurring here.

• **Reflected Glare** - Very Important
  A more productive working environment will be made by making sure light sources are kept away from the offending zone. A mirror image of the light source into the workers eyes can be generated from computer monitors or highly reflective desk tops. It is important that matte surfaces be used in the space and that indirect luminaires be utilized.
Shadows- Important
Shadows should be avoided on desktops because they cause distractions and high luminance ratios. The light should arrive from many directions, such as large area ambient sources, and shadows will be minimized.

Source/Task/Eye Geometry- Very Important/ Important (Private Office)
Keeping luminaire away from the offending zone will help reduce reflections. Indirect lighting, or sources placed off to the sides of the desks will improve the lighting design.

Sparkle/Desirable Reflected Highlights-
Sparkle will add to the satisfaction of a user in the space. Placing decorative wall sconces along the perimeter could improve the aesthetics. This will also help guide with the circulation around the space. In private offices, a high-end decorative task light may add some added sparkle. Washing open office perimeter walls and grazing the back wall of private offices will highlight the space.

Surface Characteristics- Important
As stated before, none of the architectural finishes are particularly visually interesting. Therefore, using techniques such as washing and grazing will help improve the appearance of the space.

System Control and Flexibility-
The open office should have task lighting that is controlled by the user at each desk. The ambient lighting does not need much more than on/off control. The perimeter lighting that is effectively a corridor should have separate on/off control. In private offices, photosensor control should be used to harvest daylight. An occupancy control may also be a good choice.

Special Considerations- Somewhat Important (Open Office)
Lighting should be flexible to accommodate changes in office furniture. The permanence of the furniture layout is subject to change. Indirect lighting will help avoid the problem of glare or low illuminances if furniture is moved.

Acoustical aspects of luminaires need to be considered. The partitions between desks are not permanent walls, so the ceiling becomes more important. Lensed luminaires can reflect noise to adjacent workstations, so
this should be considered. One way to fix this issue is to use louvered luminaires.

- **Maintenance**
  Ceiling heights are not much of a concern in this space. Relamping will be made easier if the same types of lamps used in other spaces of the science center are utilized here. A constant color temperature of 3000 K will also be important for this reason. Choosing fixtures that will not trap dirt allows more time between cleaning and higher illuminance levels.

- **Horizontal Illuminance**- Important
  The IESNA Handbook requires **30 fc** for an open office with intensive VDT use. (The circulation path around the perimeter, which could be considered a corridor, is recommended to be **5 fc**.)
  A private office is recommended to be **50 fc**.

- **Vertical Illuminance**- Very Important/Important (Private Office)
  The IESNA Handbook specifies **5 fc** for both open and private offices.

- **Luminance Ratio**
  The IESNA Handbook suggests an immediate paper task area maximum bright to dark ratio of **3:1**. Away from this, but within the field of view a maximum ratio of **10:1** is recommended. Paper tasks and adjacent VDT screens call for a **3:1** luminance ratio. The ratio between a ceiling plane and VDT screen should not exceed **10:1** to maintain good standards.

- **Power Allowance**
  ASHRAE/IESNA Standard 90.1 (2007) specifies the following allowable power densities:
    - Both open plan and enclosed offices are allotted **1.1 W/sq. ft.**
Lighting Design:

**Figure 4:** Open/Private Office RCP and Lighting Plan (NTS)

**Figure 5:** Open Office North Section -AGI Rendering (Partitions being cut through)
Figure 6: Open Office South Section - AGI Rendering (Partitions being cut through)

Figure 7: Open Office Circulation Path Illuminance Levels (Footcandles)
Figure 8: Open Office Centrally Located Desk Illuminance Levels (Footcandles)

Table:

<table>
<thead>
<tr>
<th>Area</th>
<th>Calc Type</th>
<th>Units</th>
<th>Average</th>
<th>Maximum</th>
<th>Minimum</th>
<th>Max/Min</th>
<th>Meet IESNA Recommended Illuminance?</th>
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<tbody>
<tr>
<td>Perimeter Desk Top</td>
<td>Illuminance</td>
<td>fc</td>
<td>56.21</td>
<td>79.2</td>
<td>27.4</td>
<td>2.89</td>
<td>Over</td>
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<tr>
<td>Center Desk Top</td>
<td>Illuminance</td>
<td>fc</td>
<td>60.11</td>
<td>84.0</td>
<td>28.5</td>
<td>2.94</td>
<td>Over</td>
</tr>
<tr>
<td>Circulation Path</td>
<td>Illuminance</td>
<td>fc</td>
<td>13.61</td>
<td>33.9</td>
<td>5.4</td>
<td>6.28</td>
<td>Under (Open Office) Over (Corridor)</td>
</tr>
</tbody>
</table>

Figure 9: Open Office Perimeter Located Desk Illuminance Levels (Footcandles)

Figure 10: Open Office Calculation Summary
**Figure 11:** Private Office AGI Rendering

**Figure 12:** Private Office Desk Top Illuminance Levels (Footcandles)
<table>
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<tr>
<th>Area</th>
<th>Calc Type</th>
<th>Units</th>
<th>Average</th>
<th>Maximum</th>
<th>Minimum</th>
<th>Max/Min</th>
</tr>
</thead>
<tbody>
<tr>
<td>Desk Top</td>
<td>Illuminance</td>
<td>fc</td>
<td>53.28</td>
<td>77.6</td>
<td>23.7</td>
<td>3.27</td>
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</table>

**Figure 13:** Private Office Calculation Summary

**Figure 14:** Luminaire Schedule

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Manufacturer/ Model</th>
<th>Total Watts</th>
<th>Lamp Type</th>
<th>Voltage</th>
<th>Notes</th>
</tr>
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<tr>
<td>L6</td>
<td>Recessed 6&quot; aperture compact fluorescent downlight</td>
<td>KURT VERSEN P926-SC-WR126W-277V-CC F-PT</td>
<td>29</td>
<td>CF26DT/E/IN/ 830 Osram Sylvania</td>
<td>277</td>
<td>Provide wattage restriction label; with custom color flange finish</td>
</tr>
<tr>
<td>L7</td>
<td>Recessed 6&quot; aperture compact fluorescent downlight/ wallwasher</td>
<td>KURT VERSEN P905-SC-WR126W-277V-CC F-PT</td>
<td>29</td>
<td>CF26DT/E/IN/ 830 Osram Sylvania</td>
<td>277</td>
<td>Provide wattage restriction label; with custom color flange finish</td>
</tr>
<tr>
<td>L7B</td>
<td>Recessed 6&quot; aperture compact fluorescent downlight/ corner wall washer</td>
<td>KURT VERSEN P905-C-SC-WR126W-277V-CC F-PT</td>
<td>29</td>
<td>CF26DT/E/IN/ 830 Osram Sylvania</td>
<td>277</td>
<td>Provide wattage restriction label; with custom color flange finish</td>
</tr>
<tr>
<td>L25</td>
<td>Recessed compact fluorescent parabolic 2' x 2' troffer mounted in 2x2 tile ceiling</td>
<td>LIGHTOLIER DPA-2-(ceiling)-9LS2-2U-277V-SO-TC8</td>
<td>63</td>
<td>(2)FBO 31/830/ XP/ECO Osram Sylvania</td>
<td>277</td>
<td>With air return; Architect to coordinate ceiling system with trim mounting details</td>
</tr>
</tbody>
</table>

**Figure 15:** Light Loss Factors
| Space           | Total Watts | Area or Length (sq. ft.) | Allowable Lighting Power Density (W/sq. ft.) | Total Lighting Power Density (W/sq. ft.) | Meet Standard 90.1?
|----------------|-------------|--------------------------|---------------------------------------------|------------------------------------------|----------------
| Open Office    | 1,583       | 1,390                    | 1.1                                         | 1.13                                     | No             
| Private Office | 252         | 195                      | 1.1                                         | 1.29                                     | No             

At this time, all lighting was considered general. No decorative lighting was considered.

**Figure 16: ASHRAE/IESNA Standard 90.1**

**Daylighting:**

As stated previously, the open plan office does not receive any daylighting. The private office has a window that faces into the atrium. This is opposite the southern wall, therefore direct sunlight may cause a problem—especially in Winter months. Shading devices may be necessary. Photosensors and dimming built into the controls may also help conserve energy when supplementary electric lighting is not needed.

**Lighting Controls:**

The ambient lighting of the open plan office should be on simple on/off controls. The perimeter downlights should be on a different zone for separate switching. Private offices will employ photosensor and dimming technology in efforts to harvest daylight.

**Second Floor Open Office/Private Office Lighting Critique:**

The design for lighting the open office seemed to be adequate enough to make the space appear visually clear. The perimeter walls were washed with light and the ambient lighting was provided by troffers.

The circulation space around the perimeter of the office was distinguished from the workspace with the use of downlights and wallwashers instead of troffers. These provided significant illuminance on the floor. The wallwashers did not have scalloping, and were spaced at the correct distances to avoid shadowing and dark spots.
According to IESNA recommendations, this circulation path was given too much light if considering it a corridor. Instead, if it is considered an extension of the open office, it receives too few footcandles. During the night, or on weekends, when people are not working, the light levels will most likely be sufficient for a corridor. This is because the centrally located troffers will not be turned on to contribute to the illuminance of the circulation path.

Moving toward the cubicles, which serves as the actual workspace, desk tops seemed to be uniformly illuminated. Although troffers reduce the risk of reflected glare, a better choice may have been indirect lighting. The placement of the troffers is appropriate for the current partition set up, however it may pose a challenge if partitions are moved in the future. A shadowing effect may occur.

The desk tops, whether located toward the center of the space, or near the perimeter walls seemed to receive too much light. Assuming that this space will be heavily populated with computers, the current illuminance level is much too high. A better choice may be to put this space on dimmable controls or reduce the wattage of the lamps.

In the private office, lighting levels were appropriate. The task plane was evenly and uniformly illuminated. One important thing to mention is that the office space modeled did not include windows into the atrium. However, many private spaces exist that do feature atrium windows. A private office that includes the daylighting technique will more than likely need photosensors and dimming capability. Otherwise, the day light will contribute to illuminance levels far over what is recommended by IESNA.

Both the private and open offices seemed to be appropriate for the tasks performed in them. Improvements can be made in both spaces. Especially aesthetically, as the design seems quite plain. The too high illuminance levels need to be improved. If this can be done while simultaneously reducing wattage use, then meeting ASHRAE 90.1 Standards becomes a realistic goal.
Special Purpose Space

Multipurpose Theater

Description:

The 3D theater, which has entrances on both the plaza level and the second floor, has a capacity of 204 patrons. The footprint is a total of 3,165 square feet. The ceiling reaches a height of 36'-0”.

The plaza level entrances consist of corridors with adjacent vestibules on either side of the seating. These connect the theater with the lobby. An elevator and set of stairs connect the plaza level to the second level balcony. Thirty-four patrons are able to sit at second level seats. This is also where handicap accessible seating is located. The movie screen measures 30’ x 40’.

Surface Materials:

Floor- Covering the floor is a broadloom carpet, as well as concrete sealed with a smooth architectural finish (CP-2/CON-1).

Base- Not specified in the room finish schedule.

Walls- The theater has fabric covered acoustic panels, as well as Eurotex acoustic wall covering (F-1/F-2).

Ceiling- Black 2’-0”x2’-0” and 2’-0”x4’-0” acoustic ceiling tiles cover the ceiling (ACT-3).
Material* | Color/Style | Reflectance
--- | --- | ---
CP-2 Broadloom Carpet | Gray | 0.23
CON-1 Concrete | Smooth Finish | 0.28
F-1 Acoustic Wall Covering | Blue Fabric | 0.29
F-2 Acoustic Wall Covering | Eurotex (Blue) | 0.33
ACT-3 Acoustic Ceiling Tile | Black | 0.10
Movie Screen | White | 0.80
Stage | Gray | 0.23
Seating | Rendered using concrete as material because seats are not yet specified | 0.28

*Not all manufacturer information provided, so assumptions made using similar materials.

Figure 17: Surface Material Properties

Furnishings:

The theater has multiple rows of red padded seats. The screen is located behind a stage area. The stage has a podium off to the left side.

Activities/Tasks:

The 3D theater is a main attraction of the Connecticut Science Center. Typically, two films will alternate showings six times a day. The space will be mainly occupied by movie-goers. Presentations, conferences, and seminars may also be an option. However, the movie showings are the primary activity of the space.
Drawings:

**Figure 18:** First Floor Theater Floor Plan (NTS)

**Figure 19:** Second Floor Theater Floor Plan (NTS)
Figure 20: Theater Section (NTS)

Lighting Design Criteria:

- **IESNA Handbook 2000:** Auditoriums, assembly/Theatre and Motion Picture Houses

- **Appearance of Space and Luminaires** - Somewhat Important
  The theater lighting is meant to give a good impression, however the main use of the space is to show films. When films are being shown, the majority of the luminaires will be turned off. For presentations and other events, the space will want to provide a good impression. This is important because of the science center’s ongoing commitment toward education and cultural enrichment. Decorative sconces that convey the excitement and the wonder of science will be a positive choice. A way of integrating dynamic lighting into a functional design will also add to the space.
Psychological Impressions - ald3e.com
The theater space is intended to be used for further investigation into creating spatial intimacy. Typically the space may feel very open and public. This is especially useful during presentations and assemblies when large groups are gathered together and expected to interact. During film showings, a more private feeling will be desired.

The public feeling can be achieved by giving the room a spacious appearance. The lighting will be more uniform and at higher footcandle levels. The periphery will be illuminated to cause emphasis.

A feeling of privacy can be achieved with just the opposite design features. The lighting design should be more nonuniform, with an emphasis on contrasting lighting levels. The periphery may still be illuminated, but at lower lighting levels than those used to achieve a public feeling.

Color Appearance (Contrast) - Important
In keeping similarities between the spaces of the museum, a CRI above 80 and a CCT of 3000 K is recommended. The room finishes are quite dark to create an atmosphere suitable for film viewing. Therefore, the rendering quality of the light is not as critical. When assemblies are occurring, the warm color temperature will help render skin tones of speakers and guests.

Daylighting Integration and Control - Important
The theater has no windows or daylighting present. This design criterion is not applicable.

Direct Glare - Somewhat Important
In order to view films and presenters properly, no occupants of the space should experience direct glare. Fixtures should be placed in locations that are not in direct lines of view. Shielding accessories will also help. The decorative luminaires found on the side walls should be lensed to alleviate direct glare. The step lights are louvered so that those seated nearby are not bothered.

Flicker (and Strobe) - Somewhat Important
Flicker will be distracting during films and presentations. Therefore, it is quite important that non-magnetic ballasts are used.
• **Light Distribution on Surfaces**
  One of the most important tasks in this space is audience seating. Seats and aisles must have sufficient light levels. The aisles are also stairs, so even distribution along them will add to the safety of patrons.

• **Light Distribution on Task Plane (Uniformity)**
  Task planes for the theater include the aisles, podium top, and any viewed objects such as the movie screen or a presenter. The aisles must be uniformly lit so patrons arrive at their seats safely. Uniformity along the podium top will benefit any presenter. When movies are being shown, any additional lighting on the screen should be avoided. This could ruin the brightness and contrast characteristics of the motion picture.

• **Luminances of Room Surfaces** Somewhat Important
  The surfaces of the theater are mostly for acoustics rather than aesthetics. The periphery should be lit according to the psychological impressions that are chosen to be made. No other reasons exist for these walls to be showcased. The dark colors of the ceilings, walls, and floor ensure that they will need to be lit with higher amounts of light.

• **Modeling of Faces or Objects** Important
  This criterion differs depending on the usage of the multipurpose theater. During presentations, the faces of patrons are important to see. Guests will intermingle with one another and must be able to recognize expressions. The speaker’s face must also be seen. Quartz halogen downlights will help achieve facial modeling.

  During films, adequate visibility of the aisles and seats is the priority. This can be achieved by direct lighting overhead initially, followed by step lighting for emergency egress.

• **Points of Interest**
  The movie screen is a main point of interest in the space. Additional lighting on the screen should be avoided. Controlled lighting is therefore necessary for the front of the theater. Direct lighting evenly spaced is one potential way to light the space. This ensures that the screen will be dark when the front luminaires are off. House lighting can be placed on a dimmer.

  An accent light above the podium would be ideal for easy viewing of the speaker. A task light on the podium would be an advantage as well.
• **Reflected Glare**-
  Reflected glare would especially cause an issue if present in the eyes of someone viewing a film. It should be avoided on the podium top as well. Dialog between audience members is more likely to occur in a glare free environment. Direct lighting has a tendency to cause reflected glare, so it should be positioned off to the side of the podium slightly. Glare control and shielding on fixtures will also be helpful.

• **Shadows**-
  Shadows on any of the task planes are not recommended. In the aisles, a shadow may cause a safety issue. The workplane on the top of the podium will typically be for reading, and shadows would be detrimental.

• **Source/Task/Eye Geometry**-
  Lighting fixtures should not be placed in a location near task planes that will cause a reflection into the user's eye. Shielding on stair lights will ensure that those viewing films will not be disturbed.

• **Sparkle/Desirable Reflected Highlights**
  The multipurpose theater has sparkle appropriate for the space thanks to large decorative dimmable incandescent wall sconces. They have an opal lens to reduce glare and are easily turned off during screenings.

• **Surface Characteristics**-
  The surfaces of the multipurpose theater are more functional than aesthetic. The theater is not meant to be a showpiece so very little of the surface characteristics are pertinent to showcase. The concrete stairs must be highlighted simply for safety issues.

• **System Control and Flexibility**- Very Important
  In this space, control and flexibility are key. Different settings must exist depending on the event occurring. For movies, general lighting during seating and intermission must be available. This includes all downlights providing ambient illumination as well as stair and decorative wall sconce lighting. Downlights must be dimmed prior to the start of the film. Wall sconces can be turned off. The stair lighting must stay on as a means of emergency egress.

  For presentations, comfortable ambient illumination is necessary. If the screen is being used for projection, some sort of dimming should be available. Decorative wall sconces can add visually interesting aspects to a speaker’s
presentation, but should have the ability to be switched on or off depending on preference.

- **Maintenance**
  High ceilings will cause relamping to be a difficult task. Lamps with long lives will help. Using the same lamps found in other spaces at 3000 K will also help with upkeep.

- **Horizontal Illuminance**- Important
  The IESNA Handbook requires **10 fc** for an auditorium assembly space. During general seating and intermission of a motion picture theater, **5 fc** are recommended. During the picture, illuminances between **0.1 and 0.2 fc** are considered safe. No deviations are anticipated.

- **Vertical Illuminance**- Important
  The IESNA Handbook does not specify a particular vertical illuminance, but recommends less than **5 fc** on a projection screen. The amount of light on a movie screen should be as low as possible.

- **Luminance Ratio**
  The IESNA Handbook suggests that the ratio between a paper task and adjacent VDT screen to be no more than **3:1**. Aisle luminaires should be spaced to give an illuminance of **10:1** in the aisle.

- **Power Allowance**
  ASHRAE/IESNA Standard 90.1 (2007) specifies the following allowable power densities:
  - Seating area for a motion picture theater may have **1.2 W/sq. ft**.
  - Conference/Meeting/Multipurpose spaces may have **1.3 W/sq. ft**.
Lighting Design:

Figure 21: Third Floor Theater RCP and Lighting Plan (NTS)

(10) L36 wall sconces at each side wall; see theater elevations for locations
Figure 22: Theater Section One (NTS)
Figure 23: Theater Section Two (NTS)
Figure 24: Section cut of Multipurpose Theater - AGI Rendering
Figure 25: Stage at General Lighting Illuminance Levels (Footcandles)

<table>
<thead>
<tr>
<th>Area</th>
<th>Calc Type</th>
<th>Units</th>
<th>Average</th>
<th>Maximum</th>
<th>Minimum</th>
<th>Max/Min</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage</td>
<td>Illuminance</td>
<td>fc</td>
<td>8.33</td>
<td>12</td>
<td>1</td>
<td>12.00</td>
</tr>
</tbody>
</table>

Figure 26: Stage Calculation Summary
Figure 27: Center Row of Bottom Tier Seating at General Lighting Illuminance Levels (Footcandles)

<table>
<thead>
<tr>
<th>Area</th>
<th>Calc Type</th>
<th>Units</th>
<th>Average</th>
<th>Maximum</th>
<th>Minimum</th>
<th>Max/Min</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bottom Tier Seats</td>
<td>Illuminance</td>
<td>fc</td>
<td>9.75</td>
<td>10</td>
<td>9.0</td>
<td>1.11</td>
</tr>
</tbody>
</table>

Figure 28: Bottom Tier Seating Calculation Summary
Figure 29: Center Row of Top Tier Seating at General Lighting Illuminance Levels (Footcandles)

<table>
<thead>
<tr>
<th>Area</th>
<th>Calc Type</th>
<th>Units</th>
<th>Average</th>
<th>Maximum</th>
<th>Minimum</th>
<th>Max/Min</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bottom Tier Seats</td>
<td>Illuminance</td>
<td>fc</td>
<td>35.04</td>
<td>37</td>
<td>21</td>
<td>1.76</td>
</tr>
</tbody>
</table>

Figure 30: Top Tier Seating Calculation Summary
<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Manufacturer/Model</th>
<th>Total Watts*</th>
<th>Lamp Type</th>
<th>Voltage</th>
<th>Notes</th>
<th>Ballast/Transformer</th>
</tr>
</thead>
<tbody>
<tr>
<td>L11</td>
<td>Recessed 6&quot; aperture dimmable halogen BT-15 downlight</td>
<td>KURT VERSEN C 7321-WRL100W-C.C.F.-120V-PT</td>
<td>150</td>
<td>BC100BT15/HAL/W Philips</td>
<td>120</td>
<td>Fixture must have socket in A19 position; with clear cone; provide wattage restriction label</td>
<td></td>
</tr>
<tr>
<td>L12</td>
<td>Recessed 7&quot; aperture dimmable halogen PAR38 downlight</td>
<td>KURT VERSEN C 7303-WRL100W-C.C.F.-120V</td>
<td>250</td>
<td>100PAR38/CAP/IR/FL40 Osram Sylvania</td>
<td>120</td>
<td>With clear cone; provide wattage restriction label; with custom color flange finish</td>
<td></td>
</tr>
<tr>
<td>L36</td>
<td>Large decorative dimmable incandescent wall sconce, 17.7&quot; diam</td>
<td>POULSEN LIGHTING AJ E-17.7&quot;-1/100-120V-WHT-WHITE OPAL-WALL-PT</td>
<td>100</td>
<td>BC100BT15/HAL/W Philips</td>
<td>120</td>
<td>Architect to coordinate mounting to wall fabric panels, blocking may be required</td>
<td></td>
</tr>
<tr>
<td>L37</td>
<td>Recessed line voltage incandescent louvered step light</td>
<td>COLE T158-J-CCF-WRL25W-120V</td>
<td>10</td>
<td>25T10/IF Osram Sylvania</td>
<td>120</td>
<td>With louvered faceplate; contractor shall confirm j-box position on fixture based on architectural details; 25W wattage restriction label; with custom color finish</td>
<td></td>
</tr>
<tr>
<td>L38</td>
<td>Recessed line voltage halogen PAR38 7&quot; aperture wall washers</td>
<td>KURT VERSEN E7529-C-CCF-WRL100W-120V-PT</td>
<td>250</td>
<td>100PAR38/CAP/IR/FL40 Osram Sylvania</td>
<td>120</td>
<td>With clear cone, provide wattage restriction label; with custom color finish</td>
<td></td>
</tr>
<tr>
<td>L39</td>
<td>Recessed line voltage single-circuit track with halogen PAR38 accent lights</td>
<td>LIGHTING SERVICES INC. 81300-Series track - 120V-C.C.F-PT 238-00-Louver C-C992-C998-WL-C.C.F-120V-PT</td>
<td>250</td>
<td>250PAR38SP/CAP/SPL/SP10 Osram Sylvania</td>
<td>120</td>
<td>Provide power feeds, connectors and mounting hardware by specified manufacturer as required; provide circuit interrupts as required, see Electrical drawings; Provide cellular metal louver, linear spread lens and beam softening lens; fixture to be wrench lockable</td>
<td></td>
</tr>
</tbody>
</table>

*Total watts were a provided allotment by the lighting designer.

**Figure 31:** Luminaire Schedule
**Lamp lumen depreciation** was taken from suggested standards for tungsten halogen lamps provided by Cline Bettridge Bernstein Lighting Design.

*Figure 32: Light Loss Factors*

<table>
<thead>
<tr>
<th>Type</th>
<th>Ballast Factor</th>
<th>Lamp Lumen Depreciation Factor</th>
<th>Luminaire Dirt Depreciation* (Maintenance Category)</th>
<th>Room Surface Dirt Depreciation (RCR, Distribution Type)</th>
<th>Total Light Loss Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>L11</td>
<td>0.90* (IV)</td>
<td>0.89</td>
<td>(7, Direct)</td>
<td>0.97</td>
<td>0.78</td>
</tr>
<tr>
<td>L12</td>
<td>0.90* (IV)</td>
<td>0.89</td>
<td>(7, Direct)</td>
<td>0.97</td>
<td>0.78</td>
</tr>
<tr>
<td>L36</td>
<td>NOT USED FOR GENERAL LIGHTING LEVEL CALC S</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L37</td>
<td>NOT USED FOR GENERAL LIGHTING LEVEL CALC S</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L38</td>
<td>0.90* (IV)</td>
<td>0.89</td>
<td>(7, Direct)</td>
<td>0.97</td>
<td>0.78</td>
</tr>
<tr>
<td>L39</td>
<td>0.90* (V)</td>
<td>0.88</td>
<td>(7, Semi-Direct)</td>
<td>0.93</td>
<td>0.74</td>
</tr>
</tbody>
</table>

Unless specified above, all other Light Loss Factors assumed to be 1.0

*Lamp lumen depreciation was taken from suggested standards for tungsten halogen lamps provided by Cline Bettridge Bernstein Lighting Design.*

---

### Table: Light Loss Factors

<table>
<thead>
<tr>
<th>Space</th>
<th>Total Watts</th>
<th>Area or Length (sq. ft.)</th>
<th>Allowable Lighting Power Density (W/sq. ft.)</th>
<th>Total Lighting Power Density (W/sq. ft.)</th>
<th>Meet Standard 90.1?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motion Picture Theater</td>
<td>9,040</td>
<td>3,165</td>
<td>1.2</td>
<td>2.86</td>
<td>No</td>
</tr>
<tr>
<td>Multipurpose</td>
<td>9,040</td>
<td>3,165</td>
<td>1.3</td>
<td>2.86</td>
<td>No</td>
</tr>
</tbody>
</table>

*Space was checked as both a motion picture theater and a multipurpose space. The multipurpose space will be the preferred classification.*

*Figure 33: ASHRAE/IESNA Standard 90.1*
Daylighting:

The multipurpose theater is not exposed to any daylighting conditions.

Lighting Controls:

Energy-efficient halogen incandescent sources will be used to avoid the use of transformers and ballasts and allow easy dimmability. A preset dimming system will control the settings of the lamps.

Lighting Evaluation and Critique:

The multipurpose use of the theater space creates a difficult lighting design situation. The halogen sources provide easy dimmability, but at a higher energy cost than fluorescents. In fact, the ASHRAE 90.1 standards in this space are far from being met.

When looking at the actual illuminance levels, it is possible to see that the bottom tier seating receives just about the target level of illuminance. One can assume that since the work plane was set to be the floor, those seated will also receive the correct amount of light. Travelling upward to the top tier, however, proves the light levels too high. One reason for this could be the usage of 100 watt PAR sources at a much closer distance to the seating area. Using lower wattage lamps could remedy the high lighting levels—especially because the second tier is much closer to the ceiling. This becomes very important as seats are installed and the task plane raises to seat level. Illuminance levels will most likely increase.

The AGI renderings were performed using general lighting conditions. This means that decorative fixtures and step lights were not included in calculations. One can assume that when decorative wall sconces are turned on, the illuminance levels toward the front of the theater will be higher. In Figure 34, found below, the opal shielding of the fixture is noticeably reducing the amount of light leaving the luminaire. These decorative fixtures are providing some ambient light, but it is more of an aesthetic effect.

The step lights, if placed at the spacing recommended by the manufacturer, are expected to perform to IESNA standards for egress and aisle lighting. They are a necessary part of any motion picture theater. One would expect them to
not be used often for general lighting, but used frequently during movie showings.

Aesthetically, the design of the multipurpose theater leaves a little more to be desired. It is evident from this design that the lighting is secondary to the main purpose of viewing films. The decorative fixtures help to portray the dynamic theme of the science center without becoming overwhelming. They just seem a bit simple if the space were to be used for an assembly or presentation.

Looking at AGI renderings, the track lighting fixtures found along either side wall seem to be creating slight scallops. This can be easily fixed with reaiming of the fixtures. Reaiming of these fixtures may also improve illuminance levels on some of the seating.

Overall, the lighting of the multipurpose theater is proper for the purpose it is serving. The space is simple, and the lighting reflects that. However, the Connecticut Science Center is a vibrant, stimulating facility. The theater is one of its showpieces and the lighting should help reinforce that fact.

Figure 34: Decorative Wall Sconce Lighting
Circulation Space

“Science Alley” (Lobby/atrium space)

Description:

The Science Alley sits under the sweeping “magic carpet” roof, which is the main feature of the building. It is enclosed with monolithic glass and is 143’-0” at its highest point. The north and south exhibit towers are located on either side of the 7,425 square foot space.

All visitors must enter through the Science Alley at plaza level. The main doors are located at the east end. Adjacent to it are the gift shop, the theater, and the café. Ticketing is also in this level.

Escalators and stairs are located at the west end. They connect visitors to the exhibit spaces found in the tower floors above. The space is mainly without furniture, although a few benches are located near the entry.

Surface Materials:

Floor- Covering the entire floor is a broadloom carpet (CP-1).

Base- The wood trim is plain sawn solid maple finished to match the architect’s sample. The steel is stainless with a #4 finish (MTL-5/WD-1).

Walls- The glazing of the atrium space occupies a large majority of the walls. This is made of a truss supported curtainwall system. Painted gypsum wall board is found where the stairs connect to the towers and anywhere glazing is not present (W-1/GWB-1).

Ceiling- The ceiling is painted gypsum wall board (GWB-1).
## Furnishings:

The atrium is a mostly open space used for circulation, so the majority is without furnishings. A few benches are opposite the ticket counter. Ticket, info, and security desks are furnished with chairs and computers.

## Activities/Tasks:

Because the Science Alley is foremost used as a circulation space, way finding is one of its most important aspects. Visitors need to be able to find their destination. They also must be drawn to the exhibit spaces located above.

Most visitors will pass through the ticketing area, where normal desk activities will occur. Drawing people into the gift shop and cafeteria to make purchases will also be important.
Drawings:

**Figure 37:** First Floor Science Alley Plan (NTS)

**Figure 38:** Science Alley North Elevation (NTS)
Lighting Design Criteria:
IESNA Handbook 2000: Museums, Lobbies

- **Appearance of Space and Luminaires**- Very Important
  When entering the Connecticut Science Center, the first thing one sees is the Science Alley. Situated underneath the curving roof, which the architect considers to be the statement piece of the building, the atrium must make an impact. Visitors come to this facility to experience the wonder and intrigue of science. The lighting design should help spark these feelings. Daylight will be a major contributor to the lighting of the space, but the fixtures should work to supplement it. The soaring height of this space should be emphasized and the various tasks should be sufficiently lit.

- **Psychological Impressions**
  A feeling of spaciousness will be beneficial in this space. This can be achieved by keeping uniform light levels throughout the space. Additionally, the high peripheral walls can be illuminated to reinforce the aspect of height. The uniform light levels will also help ensure that people can find their way to the ticket counters and then to various exhibits.

- **Color Appearance (Contrast)**- Somewhat Important
  A CRI above 80 will ensure that signage will be comprehensible. Daylight will be the primary source during operational hours thanks to the glazing surrounding the space. The warm interior colors featured in the Science Center will have a better appearance at 3000 K, but daylight will offer a contrasting cooler source.

- **Daylighting Integration and Control**- Very Important
  Science Alley is characterized by its dynamic daylighting throughout. The design will need to integrate sunlight control—especially for the largely glazed southern wall. To help use less energy, the lighting is linked to a photo sensor. This is especially useful during overcast days when luminaires will be needed to enhance the space. In addition, a dimming system time clock can be used at night.

- **Direct Glare**- Somewhat Important
  Direct glare from daylight can be avoided with the use of fritted glazing. Positioning fixtures so that they are not in the occupants line of sight also helps to remedy this issue. As patrons look for signage, it is important that their views not be impeded.
• **Flicker (and Strobe)**- Somewhat Important
  Flicker may be an annoying distraction to some, so electronic ballasts are recommended. The plentiful amount of daylight, as well as the fact that the space is primarily for circulation, provides leeway in case flicker may occur.

• **Light Distribution on Surfaces**- Somewhat Important
  The most important surfaces to patrons are the signs that direct them throughout the museum. Even illumination covering these will be ideal. To help emphasize the expansive height of the atrium, washing the walls with light will be aesthetically pleasing. Grazing may also provide a more interesting design on the gypsum walls. Trusses supporting the curtainwall, which are an interesting architectural feature, should be highlighted uniformly. The bridges spanning the space may also need to be highlighted for the same reason.

• **Light Distribution on Task Plane (Uniformity)**- Somewhat Important
  The task plane of the circulation space will mainly be the floor. Other task areas include the desktops of ticketing, information, and security. The prevalent daylight will always dictate a rather uniform distribution, so the supplementary lighting may not need that strong of an emphasis for this criteria. Task lighting at desk areas will help. Also, positioning of the overhead luminaires to the sides will reduce the potential for reflected glare.

• **Luminances of Room Surfaces**- Somewhat Important
  The height of the walls should be accentuated through either grazing or washing. Grazing will allow the plain gypsum to have a more dynamic appearance which is fitting for a children’s museum. Interesting architectural features like the trusses supporting the curtain wall and the pedestrian bridges should have higher light levels. Glazing is difficult to light.

• **Modeling of Faces or Objects**- Important
  The museum experience begins when you step foot into the atrium, thus the objects present need to be seen clearly. This space is also anticipated to be very populated and facial recognition will be important. When the daylight is not sufficient, downlights with some accent lighting will really help with this criterion.

• **Points of Interest**- Very Important
Quite a few points of interest exist in the Science Alley. The most important to visitors would be the ticketing counter so that they may gain entrance into the Connecticut Science Center. Overhead lighting paired with decorative wall sconces or maybe pendants would help attract people to the desk. The ticketing needs to be instantly recognizable.

The escalators and stairs leading to exhibit spaces are another point of interest. Once people gain entrance to the science center, they need to be guided to exhibit halls. The stairs are a major feature in the atrium, and with appropriate ambient lighting and perhaps handrail lights, their importance will be ensured.

Bridges that cross through the atrium go hand in hand with the stairs. They also work to lead people to spaces. They should be evenly illuminated in order to help visitors find their way.

Architecturally, the lofty walls and curving roof provide for interesting features. As mentioned previously, grazing along the walls will add a dynamic emphasis to the height. The curving roof can be illuminated using uplights positioned on the side walls to ensure that it is noticed by anyone within the space.

The glazing is another important feature, but will prove difficult to light. Instead, by lighting the trusses supporting this glazing, interesting shadows can be achieved.

- **Reflected Glare** - The presence of curtainwall façade holds a high potential for reflected glare. Positioning of luminaires should be considered so that this is avoided. They should not be aimed directly at the glazing.

- **Shadows** - Shadows on any of the task planes are not recommended. However, the daylighting will provide dynamic shadowing throughout the course of the day. This will add to the wonder and excitement of the science center setting.

- **Source/Task/Eye Geometry** - Somewhat Important
  
  As in the reflected glare design issues, lighting fixtures should not be aimed against glazing. Luminaires should be positioned to the sides of task planes to reduce issues. Also, signage and exhibit features should be lit in a way that
will not cause glare as a result of the geometry. Luminaire shielding can be a key solution to this issue.

- **Sparkle/Desirable Reflected Highlights**
  Highlighting the points of interest listed previously will help visitors have an enjoyable experience at the museum. Sparkle is encouraged in the space, especially because it can help make the space more interesting. Decorative pendants or wall sconces near ticketing will add sparkle. Sconces near the elevators will additionally add some interest. LED handrail lighting in the stairs can add some highlights to their otherwise ambient lighting scheme.

- **Surface Characteristics**- Important
  The surfaces of this space are not very unusual. The floor is carpeting, the walls are either curtainwall or painted gypsum board. The ceiling is also gypsum wall board. The characteristics are not easily accented or enhanced. Techniques like wall grazing will add a more interesting aesthetic to the space.

- **System Control and Flexibility**- Somewhat Important
  In this space, photosensors and dimming systems will play a very important role. The daylight that will filter in through the glazing will vary depending on the time of day, year, and weather. The electric lighting will need to be adjusted according to this natural light. Supplemental lighting will always be needed at night. However, when the facility is not in use, task lighting may be turned off. The glow of the HID fixtures illuminating the roof will provide sufficient ambient light.

- **Maintenance**
  At its highest point, the ceiling reaches 143'-0". This does not hold promise for easy relamping. Fixtures with long lamp lives will assist in increasing the time between relamping. Catwalks within the roof structure provide access to some hard to reach luminaires. Lifts will most likely be needed to provide help. Using similar lamps to those found in other spaces and sticking with a color temperature of 3000 K will also make maintenance easier.

- **Horizontal Illuminance**- Important
  The IESNA Handbook requires **10 fc**. No deviations are anticipated.

- **Vertical Illuminance**- Important
  The IESNA Handbook requires **3 fc**. No deviations are anticipated.
• **Luminance Ratio**
  The IESNA Handbook suggests that the ratio between a paper task and adjacent VDT screen to be no more than 3:1. An information desk set in a larger public space is suggested to have a ratio of 3:1 to 5:1.

• **Power Allowance**
  ASHRAE/IESNA Standard 90.1 (2007) specifies the following allowable power densities:
  
  - Atrium may have **0.6 W/sq. ft.** for the first three floors.
  - Each additional atrium floor may have **0.2 W/sq. ft.**
  - Total atrium (six floors) should be **2.4 W/sq. ft.**
  - Corridors (bridges) may have **0.5 W/sq. ft.**

**Lighting Design:**

![Figure 39: Atrium Level One RCP (NTS)](image)

Note: No lighting is present on Atrium Level Two RCP.
Figure 40: Atrium Level Three RCP (NTS)

Figure 41: Atrium Level Four RCP (NTS)
Figure 42: Atrium Level Five RC P (NTS)

Figure 43: Atrium Level Six RC P (NTS)
Figure 44: Enlarged Lighting Elevation of Science Alley North Wall (NTS)
Figure 45: Lighting Elevation of South Wall
Figure 46: Bridge 1 Lighting Plan

Figure 47: Bridge 2 Lighting Plan
Figure 48: Bridge 4 Lighting Plan
Figure 49: Science Alley Cross Section Rendering (Cline Bettridge Bernstein)

Figure 50: Science Alley North Rendering (Cline Bettridge Bernstein)
Figure 51: Science Alley South Rendering (Cline Bettridge Bernstein)
Figure 52: Science Alley Interior Rendering (Cline Bettridge Bernstein)

Figure 53: Science Alley Northeast Rendering (Cline Bettridge Bernstein)
<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Manufacturer/Model</th>
<th>Total Watts</th>
<th>Lamp Type</th>
<th>Voltage</th>
<th>Notes</th>
<th>Ballast/Transformer</th>
</tr>
</thead>
<tbody>
<tr>
<td>L4</td>
<td>Recessed pinhole aperture MR16 halogen downlight</td>
<td>LUCIFER LIGHTING DHT/ZF housing-120V DL1522 trim-CCF- E- “Solite” lens</td>
<td>41</td>
<td>37MR16/IRNFL25/C Osram Sylvania</td>
<td>120</td>
<td>With overlap trim plate; provide “Solite” soft focus lens; with integral electronic transformer, provide compatible dimmers</td>
<td></td>
</tr>
<tr>
<td>L21</td>
<td>Recessed in-floor linear fluorescent lensed uplight</td>
<td>MARK LIGHTING B13505-277V-TC8</td>
<td>63</td>
<td>(2) FP28/830/ECO Osram Sylvania</td>
<td>277</td>
<td>Provide stainless steel face plate with walk-over grade lens; provide internal baffle for glare control</td>
<td>Integral electronic rapid start slim line ballast</td>
</tr>
<tr>
<td>L30</td>
<td>Recessed rectangular 2-lamp metal halide accent light</td>
<td>KURT VERSEN T6239-SC-F30-2-FL-LL- LP-MP-Electronic Ballast-277V-C CF-PT</td>
<td>88</td>
<td>(2) MC P39PAR30LN/U/830/FL Osram Sylvania</td>
<td>277</td>
<td>Provide hexcell louver, linear spread lens, large prism lens, and micro prism lens; fixture to have accessory holder to hold two accessories</td>
<td>Electronic ballast</td>
</tr>
<tr>
<td>L31</td>
<td>Recessed rectangular 2-lamp metal halide accent light</td>
<td>KURT VERSEN T6239-SC-F30-2-FL-LL- LP-MP-Electronic Ballast-277V-C CF-PT</td>
<td>156</td>
<td>(2) MC P70PAR38/U/FL/830/ECO Osram Sylvania</td>
<td>277</td>
<td>Provide hexcell louver, linear spread lens, large prism lens, and micro prism lens; fixture to have accessory holder to hold two accessories</td>
<td>Electronic ballast</td>
</tr>
<tr>
<td>L32</td>
<td>Continuous handrail light integrated into typical escalators</td>
<td>BY ESCALATOR MANUFACTURER</td>
<td>Allow 9W/LF</td>
<td>T8/T5 linear fluorescent, 3000K tri-phosphor, or equivalent in cold cathode or neon</td>
<td>277</td>
<td>Use manufacturer's standard detail</td>
<td></td>
</tr>
<tr>
<td>L35</td>
<td>Decorative compact fluorescent wall sconce</td>
<td>TRANSLITE SONOMA PR4-OW-BS-277V-FE25</td>
<td>28</td>
<td>FO25/830/XP/ECO Osram Sylvania</td>
<td>277</td>
<td>Architect to verify brushed stainless steel finish; sconce must be ADA compliant</td>
<td></td>
</tr>
<tr>
<td>L41A</td>
<td>Pipe mounted metal halide ceiling uplight</td>
<td>LIGHTING SERVICES INC. TPM38-100-MOD-3G- Louver C-Bamdoor TP-C990-C995-C998-WL-Electronic Ballast - CCF-277V-PT</td>
<td>167</td>
<td>MC P150/PAR38/U/830/VWFL Osram Sylvania</td>
<td>277</td>
<td>Modify for lockable pipe-clamp mount and power cord for hardwired connection to remote, adjacent junction box; fixture is field adjustable and with lockable aiming; provide barn doors, cellular louver, linear spread lens, prismatic spread lens, and beam softening lens</td>
<td>Fixture to have integral electronic ballast</td>
</tr>
<tr>
<td>L41B</td>
<td>Pipe mounted metal halide ceiling uplight</td>
<td>LIGHTING SERVICES INC. TPM38-100-MOD-3G- Louver C-Bamdoor TP-C990-C995-C998-WL-Electronic Ballast - CCF-277V-PT</td>
<td>167</td>
<td>MC P150/PAR38/U/830/FL Osram Sylvania</td>
<td>277</td>
<td>Modify for lockable pipe-clamp mount and power cord for hardwired connection to remote, fixture is field adjustable and with lockable aiming; provide barn doors, cellular louver, linear spread lens, prismatic spread lens, and beam softening lens</td>
<td>Fixture to have integral electronic ballast</td>
</tr>
</tbody>
</table>
Bridge lighting consists of and the in-floor linear fluorescents that line them and wall sconces. Metal halide accent lights found on RCPs above bridge are aimed toward the atrium and counted as atrium lighting.

Figure 55: ASHRAE/IESNA Standard 90.1
**Daylighting**
- The curtainwall that surrounds the space will provide a great deal of daylighting throughout the Science Alley. The opportunity for dynamic lighting schemes will present themselves as the sun’s position varies throughout the day and time of the year. Controls, such as photosensors, will help to incorporate the supplementary lighting necessary in the space. The glazing installed should be able to lessen the glare present on the south side. No frit is planned to be incorporated into the glass. The windows of the interior offices inside the atrium may need additional blinds to deal with the direct sunlight.

**Lighting Controls**
- The controls in this space are of the upmost importance. To use the daylight in an advantageous way, the luminaires should be placed on photosensors that sense the weather conditions and adapt lighting levels accordingly. The lighting designer intended for these lamps to be dimmed when necessary. Full lumen output will be utilized when there is not sufficient daylight. Unfortunately, value engineering may have eliminated the photosensors in favor of simpler on/off control.

**Science Alley Lighting Critique**
- The lighting of the Science Alley is designed around the daylight that is anticipated to be present in the space. When additional light is needed, luminaires provide support to achieve proper illuminance levels. This electric lighting works to highlight important architectural features in the space. Pedestrian bridges, ticket counters, and stairs are uniformly lit for appropriate tasks. The technique on the soaring walls is a combination of a rhythmic contrast and grazing. This creates an interesting element of contrast and movement.

Looking at the renderings of the space, it is possible to see that there are quite a few hotspots on the walls. Although the rhythmic design is appreciated, it also creates a distracting environment. A subtle change in intensity, such as grazing may be more suitable. The extreme height of the walls may not be ideal for grazing, so another solution for the hot spots may need to be found. One possible improvement could be extending the arm length of the metal halide fixtures. Even attempting a change in their aiming angle could help. During this process, direct glare would still need to be considered.
The floor seems to be illuminated evenly with sufficient lighting levels. However, the stair lighting is not evident from the renderings provided. One would hope that they would also be lit in an effort to pull people up through the atrium space. Bridges are quite bright, due to the in-floor fixtures. This will help circulate visitors between exhibit towers. This may also cause glare and to alleviate this, proper lensing must be ensured.

The ticketing counter is currently lit with recessed downlights. Not only does this have the potential to create veiling reflections and glare on VDT screens, but it also does nothing for the space aesthetically. The ticketing counter is one of the first areas a patron should notice. This space would be better served with decorative sconces or pendants.

One thing that will be very important to this sustainable facility will be the incorporation of the lighting controls. It would be unnecessary and wasteful to have all fixtures turned on during sunny days. Value engineering has removed the photosensors and dimmers in favor of simple on and off switching. Although photosensors and dimmers are ideal, creating zoning using on and off switching can still be valuable. This is especially useful in cutting energy costs. One way to do this is to zone together luminaires located in areas with typically high daylight levels.

Another feature of the glazing that may cause problems is the southern facing wall. This largely glazed surface may need some sort of sunlight control, especially in winter conditions. The north facing glazing is positioned best for daylighting.
Outdoor Space

Sixth floor roof garden

Description:

The sixth floor roof garden is connected to the exhibit space via a pedestrian bridge. This bridge crosses over the atrium space. Upon entering the 8,385 square foot roof garden, a pedestrian pathway becomes apparent. Lining the path are grasses, shrubs, and trees. The atrium windows are visible to the south.

Surface Materials:

Floor- The floor of the roof garden is actually a green roof assembly. It is a membrane roofing system covered with a porous fill. Landscaping then covers the majority. The pedestrian pathway is assumed to be tiles of lightweight porous concrete.

Base- Not applicable.

Walls- The walls that are visible at the back of the roof garden are actually created by the adjacent atrium. They consist of a truss supported curtainwall system.

Ceiling- Not applicable.

<table>
<thead>
<tr>
<th>Material*</th>
<th>Color/Style</th>
<th>Reflectance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greenroof Assembly</td>
<td>Grass, Landscaping</td>
<td>0.24</td>
</tr>
<tr>
<td>Lightweight Porous Concrete</td>
<td>Concrete/Gray</td>
<td>0.38</td>
</tr>
</tbody>
</table>

*Not all manufacturer information provided, so assumptions made using similar materials.

Figure 56: Surface Material Properties
Material Description | Transmittance | SHGCC | U-factor
--- | --- | --- | ---
W-1 Monolithic Structural Glazing | 0.87 | 0.75 | 1.27

**Figure 57: Glass Properties**

**Furnishings:** N/A (See Figure 59 below for planting plan.)

**Activities/Tasks:**

The main tasks of the roof garden are those that apply to an exhibit space. Because the roof garden is used to teach visitors about sustainability, it becomes an important focus of the Science Center. Appreciating and understanding the sustainable technology is an important activity. Visitors will also be walking down a specified pathway, so wayfinding becomes another concern.

**Drawings:**

**Figure 58: Sixth Floor Roof Garden Plan (NTS)**
Figure 59: Sixth Floor Roof Garden Planting Plan (NTS)

Figure 60: Section featuring Sixth Floor Roof Garden (NTS)
**Lighting Design Criteria:**

IESNA Handbook 2000: Gardens, decks

- **Appearance of Space and Luminaires** - Very Important
  The Connecticut Science Center has a strong focus on sustainability. The roof garden is an active place to learn about sustainable technology. It is in essence a “living laboratory”—educating patrons about green possibilities while simultaneously experiencing them. Thus, the space should be quite recognizable. The luminaires should not take away from the landscaping of the roof garden. In fact, they should be integrated into the landscape and building so that they seem to be fluid with the whole experience. Views into the atrium are possible from this location, so the glow of the light from within should be present. Movement from the interior bridge toward the exterior pathway is important, and the transition should not differ greatly as far as illuminance is concerned.

- **Psychological Impressions**
  Visual clarity is important in this space. A bright, uniform lighting mode with some peripheral emphasis is favorable. The glow on the outside edge from the atrium may be favorable for this. However, because this is a garden, a feeling of relaxation should also be present. The lighting uniformity should be lessened, and the peripheral glow will add to the calming feeling.

- **Color Appearance (Contrast)** - Important
  A CRI of 80 or above should be sufficient for this space. Daylight will be the primary source during operational hours. One can assume that any signage will appear appropriate under these conditions. Cooler color temperatures are acceptable due to the outdoor location (3500-4500 K). However, to keep the lamping consistent, a 3000 K lamp will suffice.

- **Direct Glare** - Very Important
  Direct glare can be avoided by positioning fixtures at heights and positions that will not interfere with lines of view. Shielding can be used.

- **Light Distribution on Surfaces** - Very Important
  The pathways are the most important surfaces to illuminate. They should be an even light that promotes wayfinding from the entrance through the exit of the roof garden. Signage that may be present in the space should be evenly lit so that reading is not difficult. The landscape should have asymmetrical lighting to promote depth and intrigue. The uniform glow from the atrium will
provide a point of visual interest and draw patrons back into the space. The lighting on the landscape nearest this glazing should work to regain the dynamic, asymmetric look of the other areas of plants.

- **Light Pollution/Trespass**- Important
  Shielding or cutoff fixtures will help to keep light pollution to a minimum. The positioning of the luminaires should ensure that only the intended areas of the roof garden are illuminated. Pathway lighting should be kept as close to the path as possible.

- **Modeling of Faces or Objects**- Very Important
  Any objects that will be present here are part of the museum experience, and should be viewed at a sufficient light level. The pathways will have various guests passing one another, so face recognition is important. Regardless, the exhibit experience is the priority, and fixtures should be aimed to optimize signage, etc.

- **Peripheral Detection**- Somewhat Important
  Because people will be passing one another, it is important that they be aware of each other. However, the small path allows for peripheral detection to be to a somewhat lower degree. At night, peripheral lighting will add to the safety feeling of a darker space.

- **Points of Interest**- Important
  Due to the fact that the location is not just a garden, but a continuation of an exhibit, a discrepancy may exist. The points of interest should be very important. They should be immediately apparent, especially because they are part of the learning experience of the museum. Points of interest could include signage, or even certain aspects of landscaping. The pathway should also be evenly lit as it guides visitors through the garden. Entrances and exits should also be considered points of interest and illuminated accordingly.

- **Reflected Glare**- Somewhat Important
  The presence of curtainwall façade holds a high potential for reflected glare. Positioning of luminaires should be considered so that this is avoided. They should not be aimed directly at the glazing.

- **Shadows**- Somewhat Important
  As long as shadows do not impede reading signage, finding paths, finding entrances, and finding exits, they can help with the dynamic lighting of the
landscaping. In the planting, areas of darkness coupled with layers of lightness help intensify intrigue and depth.

- **Source/Task/Eye Geometry**- Somewhat Important
  As in the reflected glare design issues, lighting fixtures should not be aimed against glazing. Also, signage and exhibit features should be lit in a way that will not cause glare as a result of the geometry. Luminaire shielding can be a key solution to this issue.

- **Sparkle/Desirable Reflected Highlights**- Somewhat Important
  Sparkle will come from inside the atrium as a result of the bridge lighting. The trusses found inside may also serve as an important aesthetic feature viewed from outside if lit correctly. Highlighting the magic carpet roof of the atrium space will accent its interesting shape.

- **Surface Characteristics**- Important
  The surface of the pathway is assumed to be a lightweight porous concrete. It will serve as an easily lit surface. The landscaping, which is dynamic and varying, will be harder to illuminate. The darker colors of native plantings will need higher illuminance levels to create certain effects.

- **Maintenance**
  Because this is an outdoor space, the fixtures should be rated for all weather conditions occurring in Hartford. The lamps should be one used commonly throughout the Connecticut Science Center to ensure easier relamping. Shielding to protect from dirt and damp location rating are preferable.

- **Controls**
  The controls should be an astronomical time clock or a daylight sensor. No local switching should be present due to the outdoor location.

- **Horizontal Illuminance**- Important
  The IESNA Handbook requires **5 fc**. No deviations are anticipated.

- **Vertical Illuminance**- Important
  The IESNA Handbook requires **3 fc**. No deviations are anticipated.

- **Luminance Ratio**
  The IESNA Handbook suggests that the ratio between a site and neighboring site be no more than **20:1**.
Trees or important features can be illuminated at 3:1 to 5:1, or for special effect, 10:1 at the most.

- **Power Allowance**
  ASHRAE/IESNA Standard 90.1 (2007) specifies the following allowable power densities:
  - Building walkways may have **1 W/linear foot**.
  - Doors that are not the main entrance may have **20 W/linear foot of door width**.
  - Building plazas, or outdoor special feature areas may have **0.2 W/sq. ft**.

**Lighting Design:**

*Figure 61: Roof Garden Lighting Plan (NTS)*
Figure 62: Roof Garden Rendering: Plan View (Cline Bettridge Bernstein)

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Manufacturer/ Model</th>
<th>Total Watts</th>
<th>Lamp Type</th>
<th>Voltage</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>L63</td>
<td>Surface mounted exterior incandescent bollard</td>
<td>Spaulding M02-P70-Q-(finish)-PT</td>
<td>70</td>
<td>MHC 70/V/3K/ALTO</td>
<td>120/277</td>
<td>Mounted on exterior wood walkway, Architect to coordinate mounting; Architect to select finish from manufacturer's standard options</td>
</tr>
</tbody>
</table>

Figure 63: Luminaire Schedule
### Space Requirements

<table>
<thead>
<tr>
<th>Space</th>
<th>Total Watts</th>
<th>Area or Length</th>
<th>Allowable Lighting Power Density</th>
<th>Total Lighting Power Density</th>
<th>Meet Standard 90.1?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roof Garden (Outdoor special feature area)</td>
<td>2,380</td>
<td>8,385 sq. ft.</td>
<td>0.2 W/sq. ft.</td>
<td>0.28 W/sq. ft.</td>
<td>No</td>
</tr>
<tr>
<td>Doors</td>
<td>280</td>
<td>15.25 linear ft</td>
<td>20 W/linear ft. of door width</td>
<td>18.36 W/linear ft. of door width</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Because landscape lighting is not yet specified, all current luminaires were considered part of the entire roof garden (outdoor special feature area). The walkways were omitted.

**Figure 64: ASHRAE/IESNA Standard 90.1**

- **Daylighting** -
  Because this space is an outdoor roof garden, daylighting will play an integral part in its everyday appearance.

- **Lighting Controls** -
  The lighting for the roof garden will be connected to an astronomical time clock.

- **Sixth Floor Roof Garden Lighting Critique:**

  The roof garden’s lighting design should provide the feel of an exhibit space extended outdoors. Curiosity and desire, sparked by inventive lighting, should lead visitors down the walkway. A children’s museum allows for dynamic, exciting design. The current lighting design neglects this feeling quite a bit.

  Despite being a casualty of value engineering, the simple lighting design is appropriate for the tasks being performed in the space. The walkway is lit with great contrast from the unlit landscaping. This draws visitors along the path and gives them the opportunity to see as much of the garden as possible.

  To keep maintenance simplistic, the same lamps used within other spaces in the Science Center are used in the garden bollards. They have a warm color temperature—3000 K. This similarity helps keep the facility’s lighting cohesive. One can assume this space will be used seasonally, and for the majority of
the time, during the day. Using an astronomical time clock is a sufficient control option.

From the AGI32 rendering, it is possible to see that landscaped areas may be much too dark. The green roof should showcase the ability to create gardens on building structures. However, this absence of light downplays that quality. The placement of luminaires along the walkway allows for rhythmic bright spots. Nevertheless, a more uniform illumination would be desirable. Back corners of the walkways aren’t lit sufficiently, and the lack of perimeter light makes the space feel more confined. At night, this may also make patrons feel less safe.

One can assume the glow from within the atrium would contribute to the lighting levels of the roof garden. Therefore, the path may not need to be so brightly illuminated. The use of high wattage metal halide sources is not only less efficient, but impedes the design’s ability to meet ASHRAE Standard 90.1. One way to remedy this would be to find a better source, or even change the luminaires all together. In-grade pavers may provide a better solution.