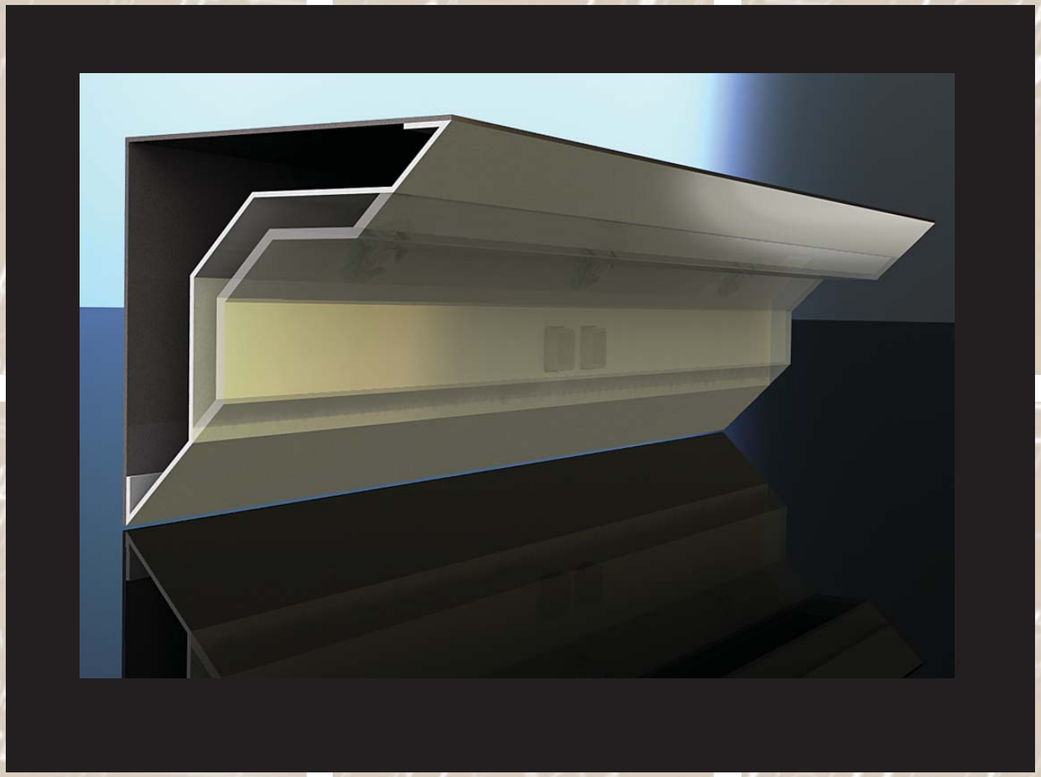
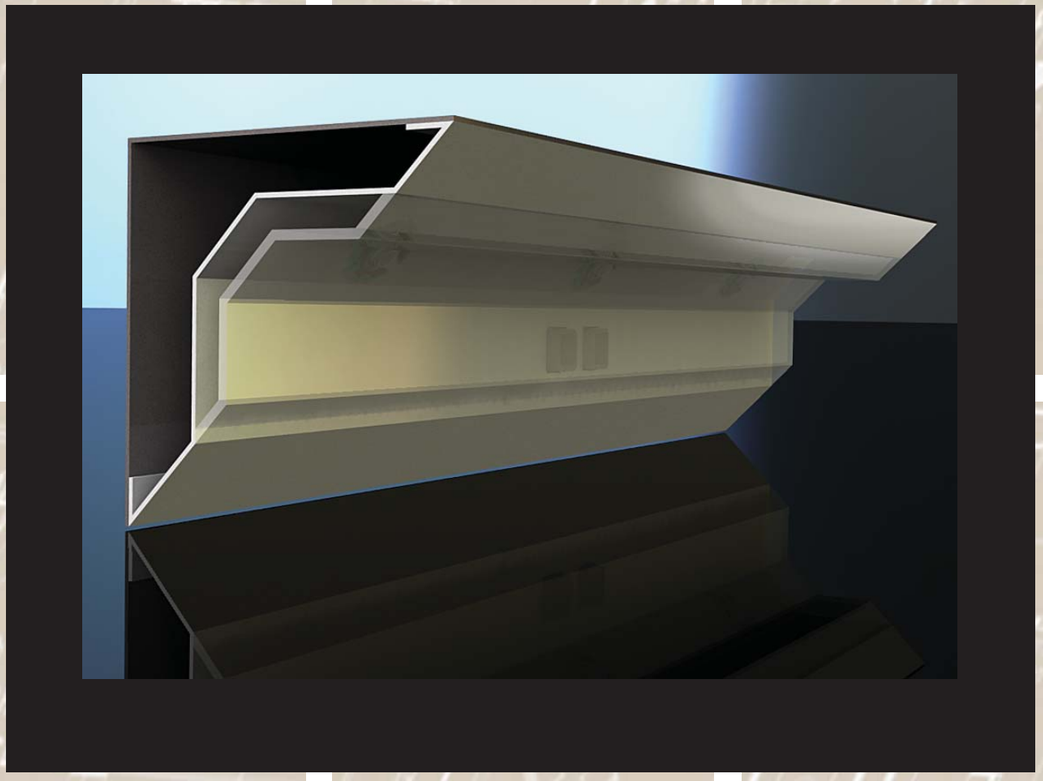
# RCL Lighting Project



DM2316 – Spring Term, 2010

James Gross



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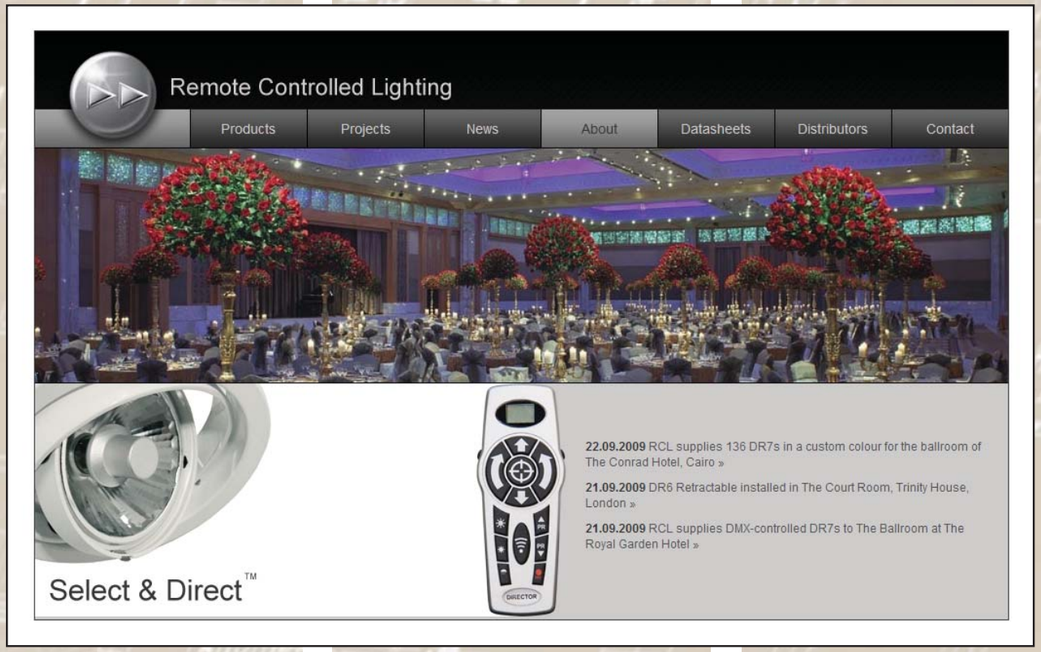



http://www.rclighting.com

From RCL's "About Us":

Remote Controlled Lighting Ltd is the only company in the world to specialise in the design and manufacture of low cost remote controlled spotlights. We supplied our first project in August 2002...

RCL's products are specified when there is a need to adjust the aiming, dimming (or both) of narrow beam spotlights which can only be reached using mechanical hoists, scaffolding or ladders...

**RCL Design Brief (From the DM2316 PowerPoint Presentation):**

You should design and develop an LED architectural light fitting. The design should be innovative either in the lighting effect it produces, its operation, its mounting arrangement, or in the way it fits into its surroundings.

You will have to focus on one of the following sectors of the architectural lighting market:

1. Retail
2. Hospitality and Entertainment
3. Gallery and Museum
4. Office and Commercial

**Important Notes:**

State when submitting the concept which market sector you selected.

The fitting should connect to a low voltage or mains power source and be mounted in keeping with the options currently used in your chosen market sector, unless your system relies on a unique mounting element.

The design proposal must produce a functional light output – LED mood lights that only 'glow' will not be accepted.

The light output level of the supplied source is low but it is acceptable to assume that the design can be scaled up in production (eg using a cluster of LEDs). Beware, although a cluster is more powerful, some effects produced with a single diode source will not work with a cluster.

In addition, an understanding of how the fitting(s) will be manufactured is essential. ...it will also count against a good design if your suggestions for manufacture are not realistic.

**Summary RCL assessment criteria:**

- Innovation, eg one or a combination of; lighting effect, operation, mounting details, fit to surroundings.
- Efficiency/effectiveness of lighting effect.
- Aesthetic and detail quality.
- Sound manufacturing considerations.

# RCL Market, and Competition

**Market, and Competition:**

Remote Controlled Lighting ha chosen to focus on a very specific product type: a low co remote-controlled spotlight for commercial applications. T y produce innovative products that serve this market we

I have included two examples other commercial architectural lighting firms that while n ht not produce the specific types of products RCL does, th are involved in the business of providing architectural ghting design services.


http://www.ivalolighting.com

A subsidiary of Lutron Corporation.

From Lutron's "Company Overview":

Joel and Ruth Spira founded Lutron Electronics Company, Inc. in 1961. Lutron's first product was called a "dimmer switch" and represented the world's first solid-state electronic device used to dim lights in a home, replacing bulky rheostats and autotransformers that were inefficient and unattractive.


http://www.tivolilighting.com

From Tivoli's "History":

Mission Statement:
Tivoli strives to create innovative beauty through illumination using quality products at competitive prices and providing superior service to our customers.

Brand Definition:
Tivoli is the industry innovator in LED based linear lighting products, with 40 years experience in low voltage linear accent lighting.

# Some Lighting Inspiration

**Some inspired lighting:**

I have included four examples of lighting that I found particularly compelling. Some examples highlight an interesting form, others add interest to a rather conventional structure.

The Millennium Park pavilion is an example of an already interesting architectural form where the lighting installation highlights the form, and the colour creates additional visual appeal. This lighting is also functional, as it illuminates the surrounding area, creating a inviting space for people to gather.

The Shortlidge Mall example is primarily functional. I found it interesting because of the appealing patterning of the light emitted by the fixtures under the ledge of the seating surface. This adds another bit of visual texture that complements the brickwork well. The light adds a warm glow that in combination with the streetlights, create an inviting environment for people to walk, and to gather.

The Christian Science Centre lighting example illuminates the facade, and the pedestrian area of the building. The reflection in the water creates a kind of a “chandelier” effect, adding ever-changing patterns, giving the person walking along the water a brilliant visual display, as well as in the case of the Shortlidge Mall example, acts in concert with the streetlights to illuminate the public area, inviting people to the space.

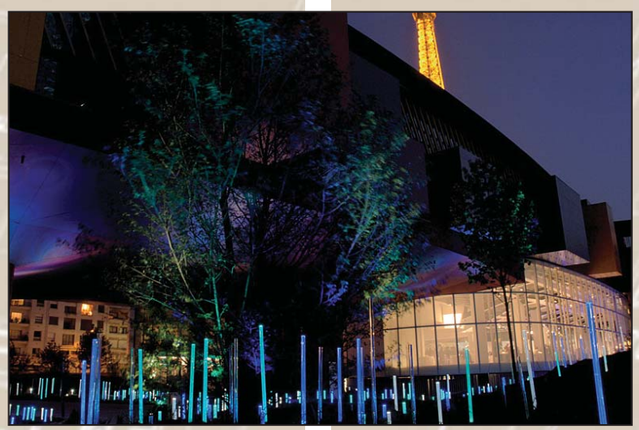
The Musee Du Quai Bronly example is pure eye candy!. Combined with the up lighting on the trees, a blue and green colour fantasy scene is created.

The examples here, for the most part, are some combination of functional, and aesthetic, which should be the goal of a successful architectural lighting installation: fulfil the utility of bringing light to a space, and enhance its visual interest as well.

Pavilion by Amsterdam-based architect Ben van Berkel, in Chicago’s Millennium Park

Shortlidge Mall, Pennstate University


The Christian Science Center in Boston, Massachusetts



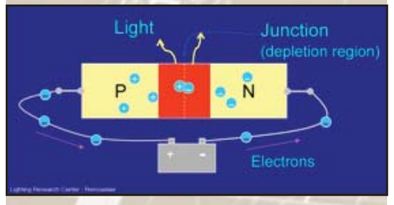
Musee Du Quai Bronly, Paris, France

# Lighting Technologies

**LED Lighting**

Light Emitting Diodes, or LEDs differ from traditional light sources in the way they produce light. In an incandescent lamp, a tungsten filament is heated by electric current until it glows or emits light. In a fluorescent lamp, an electric arc excites mercury atoms, which emit ultraviolet (UV) radiation. After striking the phosphor coating on the inside of glass tubes, the UV radiation is converted and emitted as visible light.

An LED, in contrast, is a semiconductor diode. It consists of a chip of semiconducting material treated to create a structure called a p-n (positive-negative) junction. When connected to a power source, current flows from the p-side or anode to the n-side, or cathode, but not in the reverse direction. Charge-carriers (electrons and electron holes) flow into the junction from electrodes. When an electron meets a hole, it falls into a lower energy level,

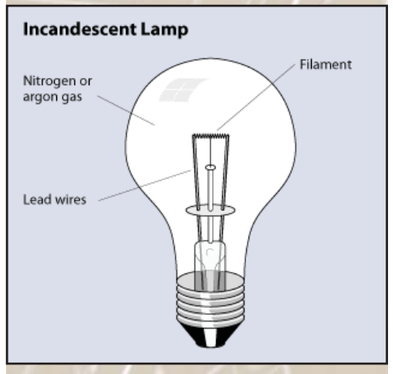



and releases energy in the form of a photon (light).

**What makes LEDs different from other light sources?**

LEDs are semiconductor devices, while incandescent, fluorescent, and high-intensity discharge (HID) lamps are all based on glass enclosures containing a filament or electrodes, with fill gases and coatings of various types.

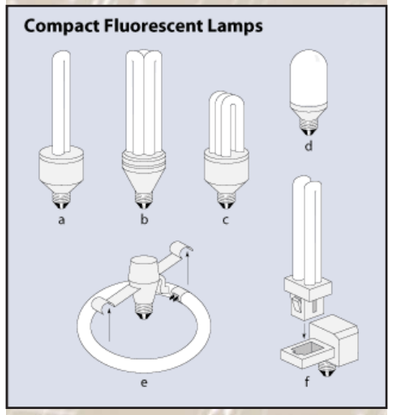
LED lighting starts with a tiny chip (most commonly about 1 mm2) comprising layers of semi-conducting material. LED packages may contain just one chip or multiple chips, mounted on heat-conducting material and usually enclosed in a lens or encapsulant. The resulting device, typically around 7 to 9 mm on a side, can produce 30



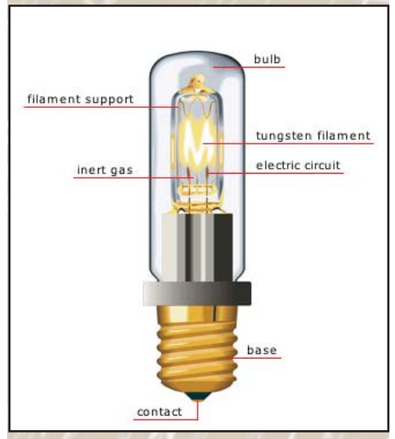

to 150 lumens each, and can be used separately or in arrays. LED devices are mounted on a circuit board and attached to a lighting fixture, architectural structure, or even a “light bulb” package.

**Incandescent Lighting**

Incandescent lighting is the most common type of lighting used in homes. It has traditionally delivered about 85% of household illumination. Incandescent lamps operate without a ballast. They light up instantly, providing a warm light and excellent colour rendition. You can also dim them. However, incandescent lamps have a low efficacy compared to other lighting options (10–17 lumens per watt) and a short average operating life (750–2500 hours). Incandescent




lamps are the least expensive to buy, but because of their relative inefficiency and short life spans, they usually are more expensive to operate. The incandescent lamp is the oldest and most common type of lamp. Light is emitted when electricity flows through—and heats—a tungsten filament.




**Fluorescent Lighting**

Fluorescent lamps use 25%–35% of the energy used by  to provide the same amount of illumination (efficacy of 30–110 lumens per watt). They also last about 10 times longer (7,000–24,000 hours).

The light produced by a fluorescent tube is caused by an electric current conducted through mercury and inert gases. Fluorescent lamps require a ballast to regulate operating current and provide a high start-up voltage. Electronic ballasts outperform standard and improved electromagnetic ballasts by operating at a very high frequency that eliminates flicker and noise. Electronic ballasts also are more energy-efficient. Special ballasts are needed to allow dimming of fluorescent lamps.

Compact fluorescent lamps (CFLs) come in a variety of sizes and shapes including (a) twin-tube integral, (b and c) triple-tube integral, (d) integral model with casing that reduces glare, (e) modular circline and ballast, and (f) modular quad-tube and ballast. CFLs can be installed in regular incandescent fixtures, and they consume less than one-third as much electricity as incandescent lamps do.

**Tungsten Halogen Lamps**

Tungsten halogen lamps—a type of incandescent lighting—achieve better energy efficiency than standard, incandescent A-type light bulbs. Tungsten halogen lamps have a gas filling and an inner coating that reflect heat. Together, the filling and coating recycle heat to keep the filament hot with less electricity.

These lamps provide excellent colour rendition. They also are considerably more expensive to buy than standard incandescent lamps, but are less expensive to operate because of their higher efficacy.

**Philips Lumileds**

**Luxeon® K2 Emitter**

High power LEDs come in 1-3 watt packages. They are driven at much higher current, typically 350, 700, or 1000 mA, and—with current technology—can produce 40-80 lumens per 1-watt package. High power LEDs come in many different shapes and sizes.

*The text and images on this page are from the US Department of Energy Website: http://www.energy.gov/*

# Self-Adjusting Lighting

**Applications of Self-Adjusting Lighting**

There are numerous self-adjusting lighting solutions on the market, some utilizing LEDs. Some utilize motion sensing, some simply use a type of photocell light sensor, some use a combination of both. Here are some examples.

**Sentinel America, Raintight Motion Sensor Switch-White (IS140W), RRSP: $70.11**

This is a sensor only product, they can control any type of electrical appliance, with a load capacity of up to 600 watts. They are UL rain-tight rated, for indoor, or outdoor usage.


**Fulcrum Motion Sensor LED Porch Light, RRSP: $29.99**

Designed specifically for porch lighting, this product uses motion sensing to detect an approaching person, an also adds a photocell detector, so the light will only come on when it is needed, saving battery life.

**Sylvania LED Stair & Hallway Lighting Kit , RRSP: $43.49**

A consumer product that uses LED lights for illumination, motion sensing for detecting the presence of a person, and a photocell so it only operates in the dark, again saving battery life.

**Philips SpotOn LED Motion Sensing Portable Light, RRSP: $19.99**

Compact, easy to install low cost consumer lighting solution for a small area, such as a closet, garage, or storage shed.

# Original Proposal / Sketch

**Original Concept**

My proposal was to create a lighting product that illuminated an area, such as the isle ways of a performance venue, with the feature that the light level would slowly increase as people were using the isle way, and slowly return to a base level when they had passed. There were three basic tasks: 1) House the LED light source in an enclosure that would efficiently create even illumination of the desired area, 2) design a method to detect the presence of people, and control the level of illumination, and 3) perform the function with out any additional intelligence out side of the unit itself.

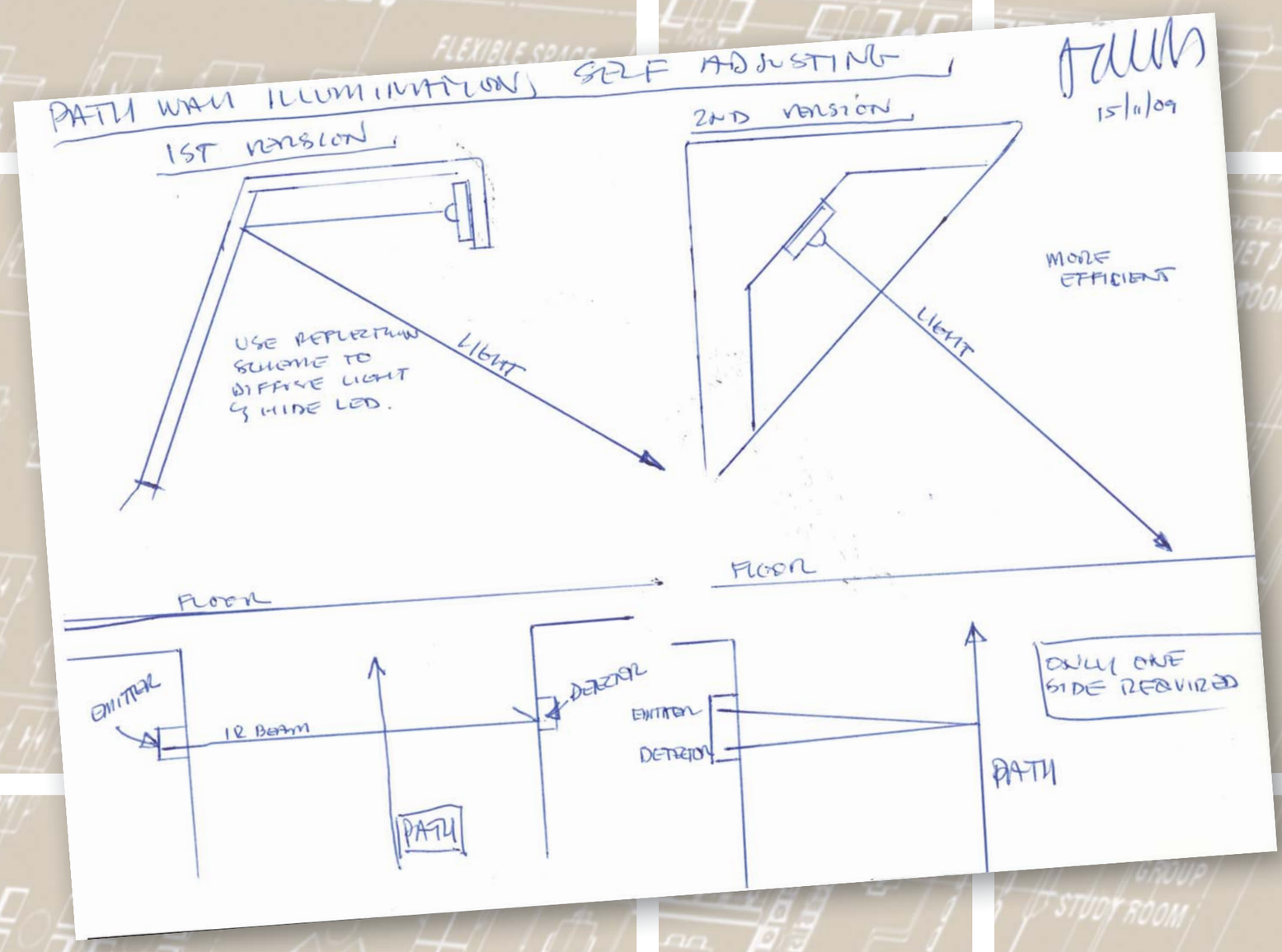
These are the first rough sketches for this concept. The four ideas shown here are:

**Bounce light off of the backside of the housing**
The original intention was to aim the LED source toward the back surface of the housing (painted with a reflective white paint), creating a more diffuse light, without “hot spots” where the actual LED devices were located.

**Use direct from the LED light source**
Experiments showed (images to follow) that too much light intensity was lost with this method. For the sake of efficiency, this was the method chosen.

**Emitter and detector on opposite sides of path**
A separate emitter and detector on opposite sides of the path were how I had originally intended to detect the presence of a person, and trigger the brightening of the light. This method wasn’t chosen for three reasons: 1) there would always be a requirement for access to both sides of a path, 2) extra wiring would be required across the path, 3) an alignment procedure would be required to align the emitter, and detector.

**Emitter and detector on same side of path**
Much simpler approach. The discovery of the Sharp GP2Y0A02YK0F distance sensor made this approach possible.



# Technology, Circuits, etc...

**Theory of operation**

The following is a description of how the circuit detects the motion of interest, and controls the brightness of the LEDs in the product.

**Motion Sensing**

The first task for the circuitry is to detect the motion of interest. There is a single component solution made by Sharp, the GP2Y0A02YK0F Distance Measuring Sensor Unit (U3). This device outputs an analogue voltage determined by the distance an object is from the sensor. The output is a DC voltage from approximately 0.0 to +2.75V.

For the distances of interest, the voltage range of 0.75 to +1.25 will be output by the Sharp sensor. Following the Sharp sensor is a window comparator consisting of U1a and U1b. Resistors R1, R2, and R3 set the window comparator to switch the output low (0v) when the voltage range is between 0.75 and +1.25V. A transistor logic inverted consisting of Q1 and Q2 invert the logic level so there is a high level (+5.0V) when the comparator switches. This generates the signal “People Present”.

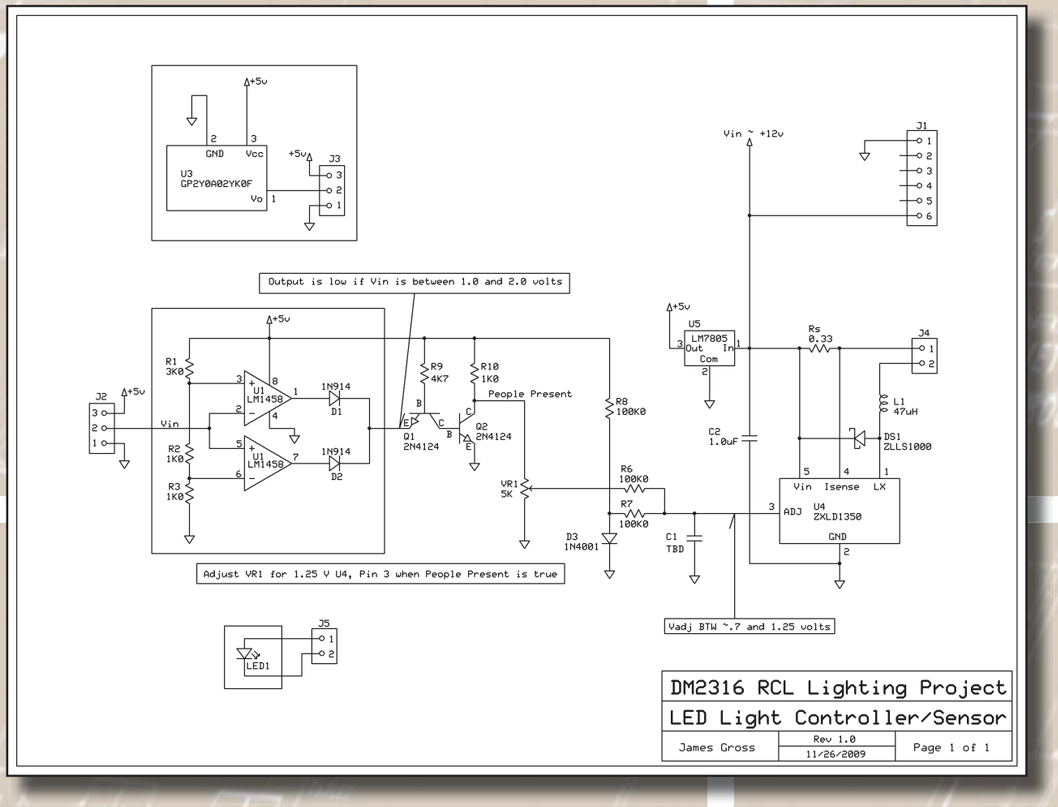
**LED Dimming Function**

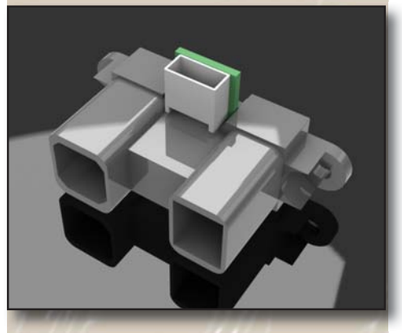
The brightness of the LED is controlled by a ZXLD1350 350mA LED controller IC (U4) and its support components. The brightness of the LED is set by a DC control voltage at the ADJ pin of the ZXLD1350. The forward drop across D3 sets the LED brightness at approximately 75% when no people are present. A voltage divider consisting of R4 and VR1 reduce the high condition voltage output from the comparator from 5.0 to 0.5V. VR5 is added to compensate for variations in components. A fixed value may be inserted here later. This value is summed with Vf of D3 (via R6 and R7), creating a Vadj of 1.25V. This corresponds to 100% LED brightness. The LED’s brightness is adjusted to 100% when there are people present, and will be at 75% when there are no people present.

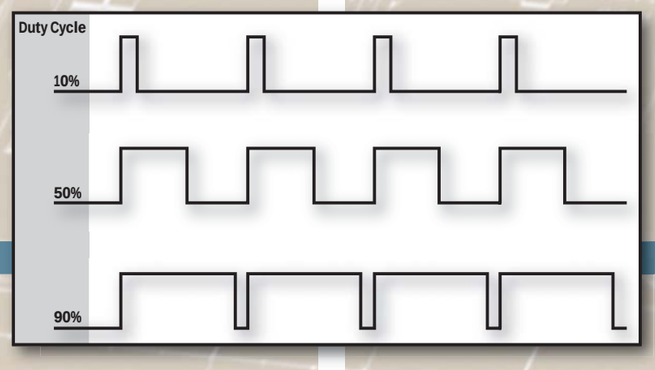
This IC dims the LED by changing the PWM duty cycle of the output voltage. An example of a PWM waveform is shown below.

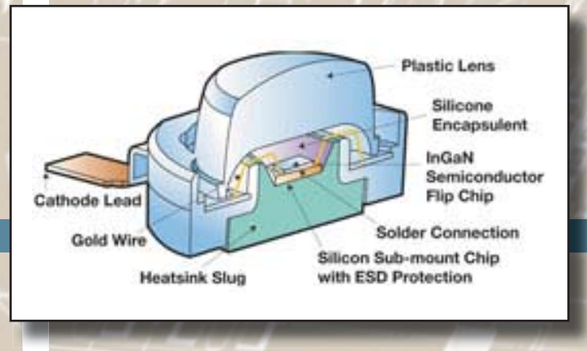
**Power Supply**

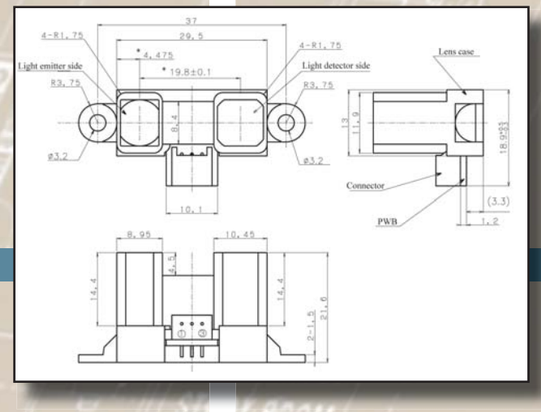
There will be a common 12 to 24VDC power supply that will supply all of the units. This source will supply both the control circuitry, and the LEDs themselves. Appropriate high-efficiency regulation will be utilized as necessary.





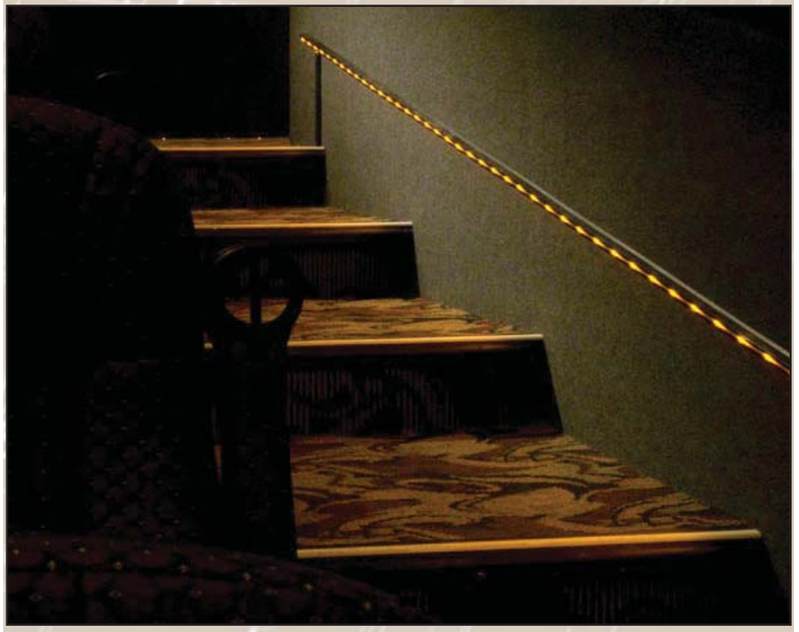



# Application Environment

**The Venue**

Here are some examples of environments that the product might be used. This was just my initial visualization where the product might be used. The applications for this product could be anyplace the needs self-adjusting illumination.



# First Version Concept A3

**Intelligent Lighting**

The first pass ideal was to create a lighting system that would be used in a performance venue, lighting the isle ways where people might need to use while the performance was in progress. The intention was to provide additional lighting when required, then dim it back down. The key was to make the change is such a way that was distracting to the rest of the attendees. The light level needed to change both up, and down at a slow rate, but quick enough to make a difference to the attendee needing the extra illumination.

The first system required a sensor on one side of the isle, and a IR source on the other. The attendee activated the system by breaking the IR beam.

The system was “intelligent” in the respect that it needed no additional controllers to make it operate. It was also expandable.

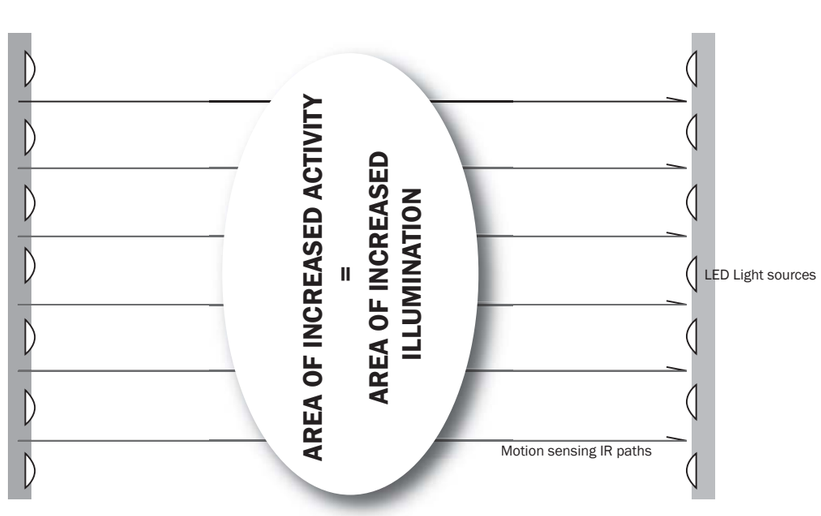
## Intelligent Lighting

### Wayfinding illumination system using IR sensing to provide optimum brightness where needed.

This system is intended for use in a low ambient light environment, such as a theatre or other type of live performance space, where there is a need for patrons to enter, or exit the space whilst the performance is in progress, enhancing their safety of movement.

This system would sense the presence of people and their direction of movement. Using simple processor controlled PWM technology, the brightness levels would be adjusted in such a way to enhance visibility, but the dynamics of the adjustment would never call attention to the change.

This system would be multi-modal, with different behaviours during a performance, and static levels of brightness that could be preset by the user for other situations.



# Revised Version Concept A3

**Intelligent Lighting Revisited**

After a fairly positive feedback session with RCL, two basic changes were implemented to the original design:

1) Make the LED light source fire directly out of the fixture, rather that reflect off of the back of the housing. This provided a comparable light effect, and improved the efficiency of the light usage.

2) Eliminate the need for components on both sides of this isle way. This lessens the installation complexity greatly, and reduces the cost of the overall system.

The discovery of the Sharp sensor was the greatest find of this stage of the project. A bit expensive, but eliminates the complexity of the circuitry. This will also improve reliability, the MTBF always decreases as the number of components and associated connectors and connections is increased. Now, on to makiing it work...

## Intelligent Lighting

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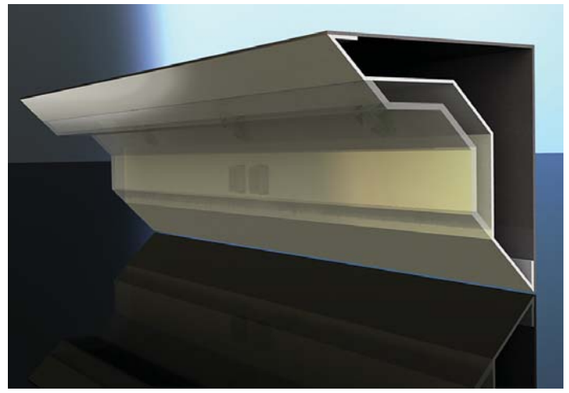
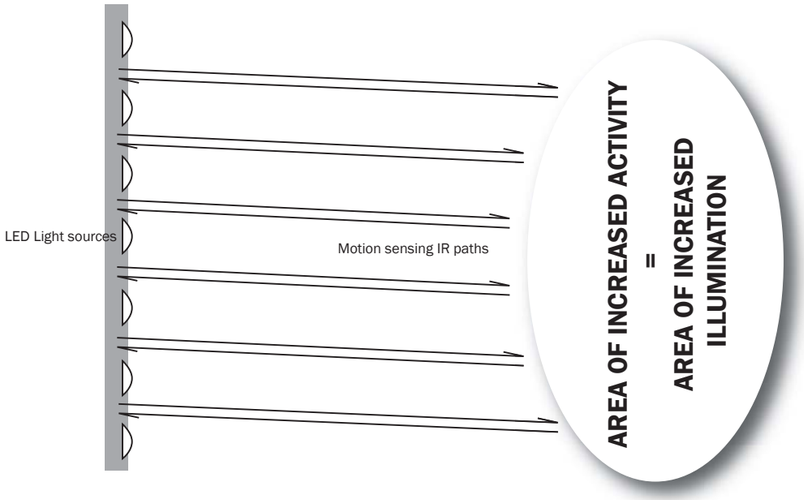
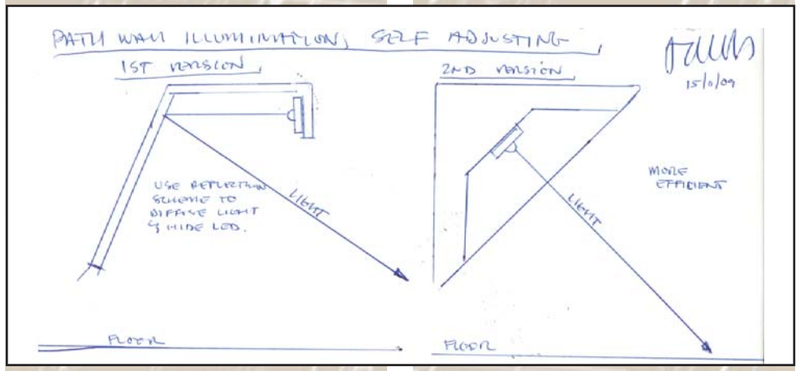




# Lighting Experiments, PPPs

**Intelligent Lighting, Tested**

As shown in the sketch below, two configurations of the LED were considered: 1) The LED reflecting off the back of the housing, and 2) The LED aiming directly out of the housing.

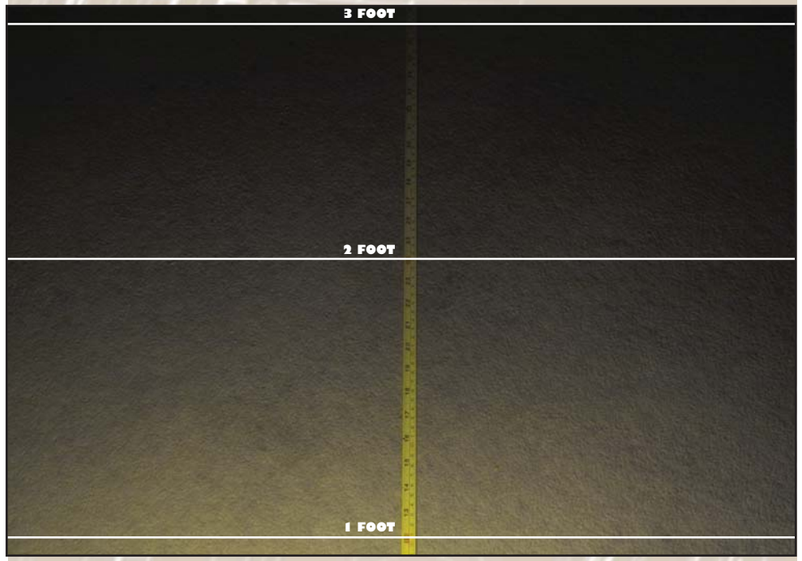


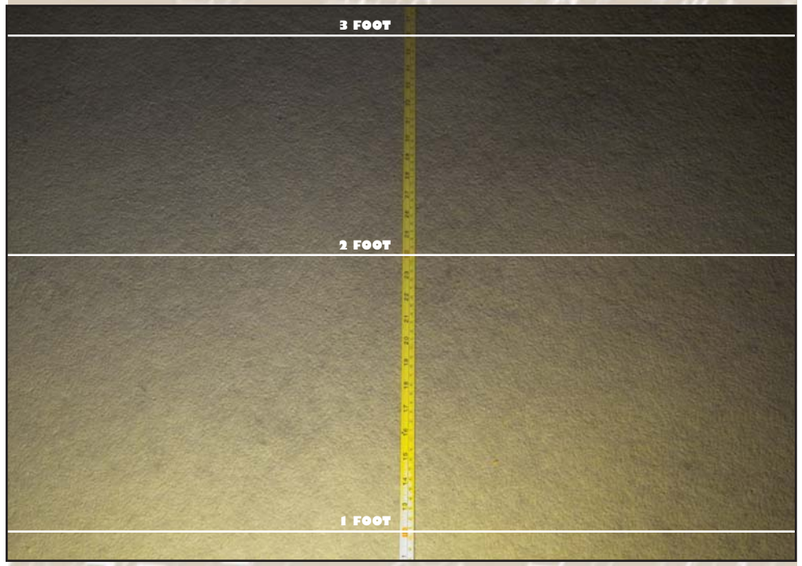

**PPPs**

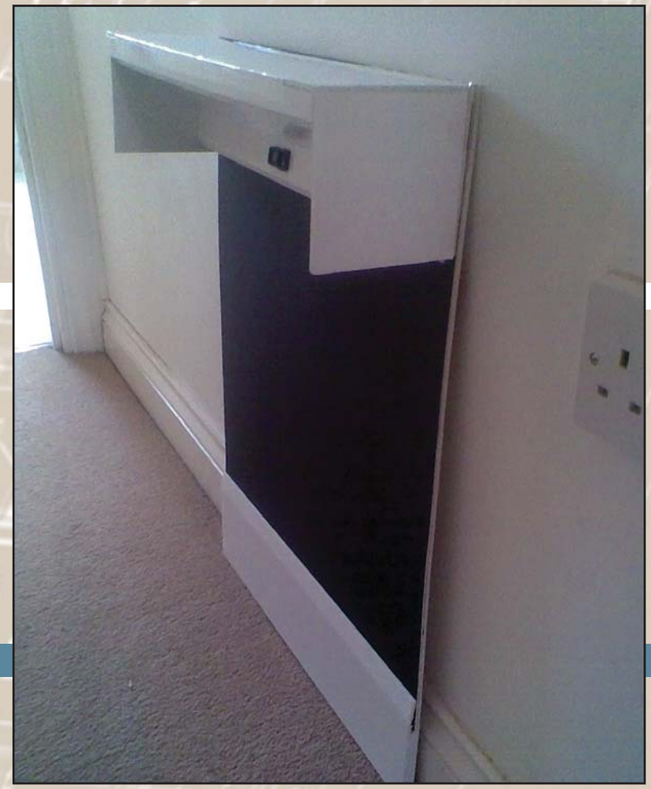
A mock-up was constructed out of white foam core board, and card stock. The “channel” shape was created to test the illumination pattern with
the LED reflecting off the rear of the housing, as well as aimed directly out. The PPP was located in the lounge of a flat, the lights were turned out, and a long exposure photo was taken. A tape measure was laid out on the carpet for a distance reference. It can be seen in the centre of the image. You can see from the images, there is a much brighter illumination of the carpet area with the LED aimed out (bottom image). Images on the top right of this page show the form of the PPP.

**Mock-up of the Final Shape**

There is an example of the final shape, with a section of wall and skirting board is shown on the bottom right. This is only a short section for demonstration. The final product would be the entire length of the isle



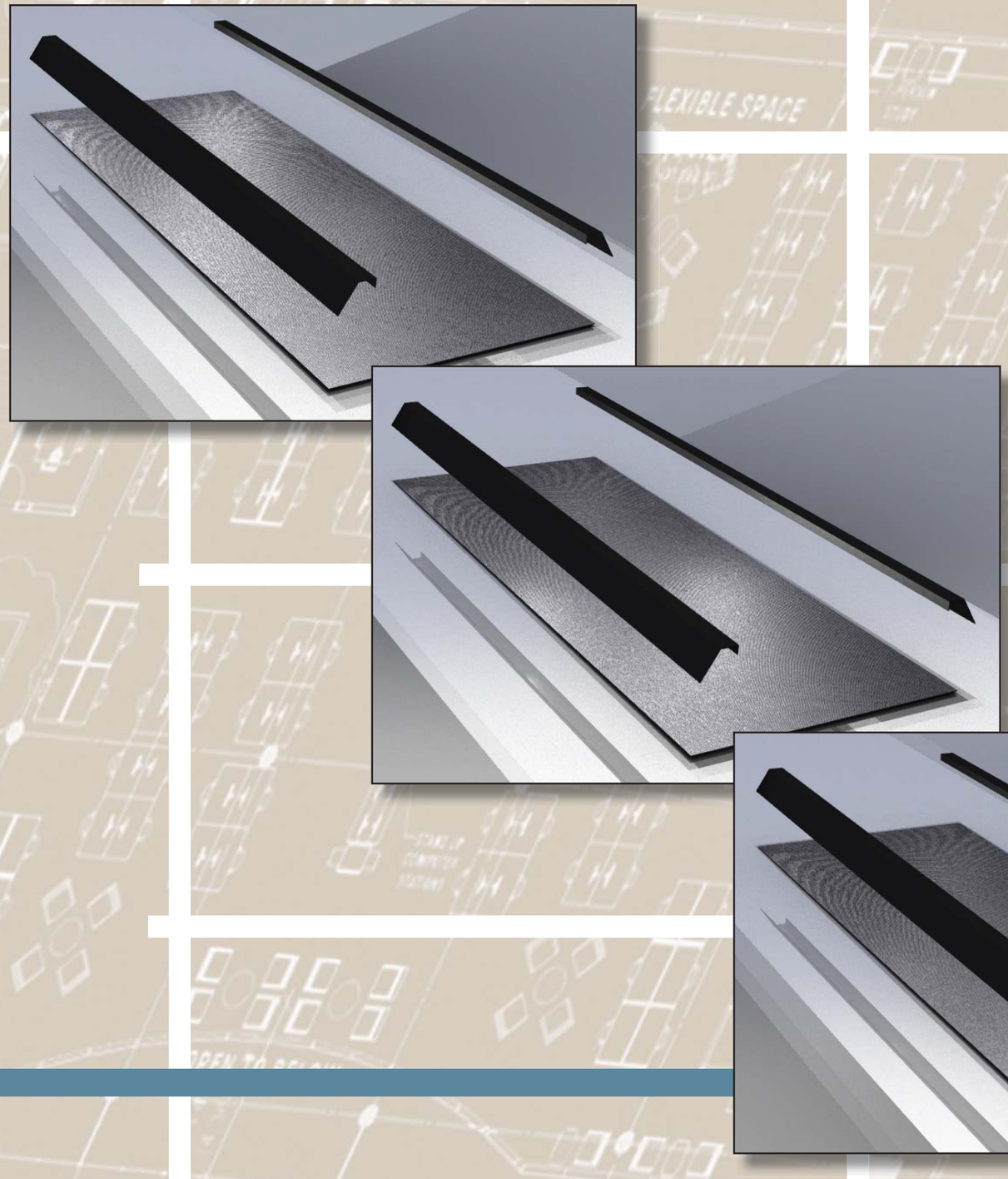
# Original Concept, Renderings

**Intelligent Lighting, Visualized**

As far as a physical product idea, the intention was to make the fixture virtually invisible. The illumination provided is all that is to be seen.

As is shown in the rendered views to the right, the basic structure is a modified channel shape, keeping it low cost. The external enclosure material could be cut to the length required for the installation, and the lighting units installed afterward. This would provide a great deal of flexibility, as the profile of this channel shape could be customized for any number of applications, and the lighting units could remain a common assembly, again reducing redundant types of components, and lowering final product cost.

The three images here also show how the area of increased brightness moves along the aisle, following the presence people in the aisle.

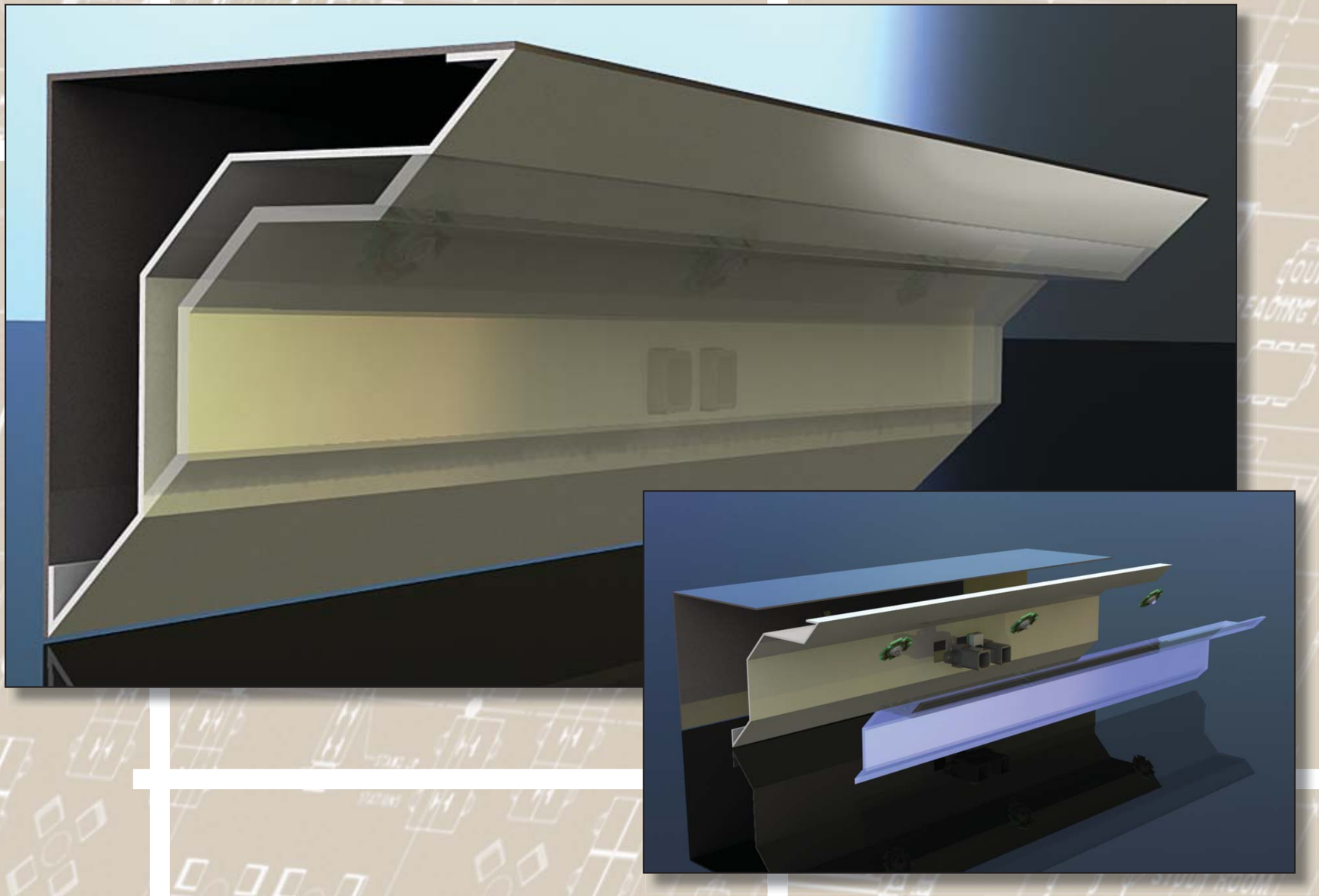


# Revised Concept, Renderings

**Intelligent Lighting, Finalized**

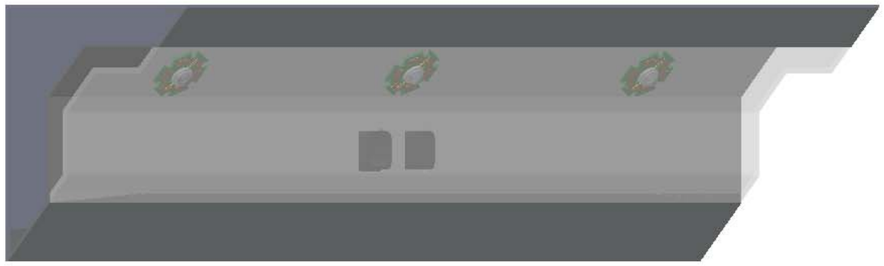
Here is the final concept for the product. The discovery of the Sharp sensor allowed a single-sided configuration, making all of the electronics self-contained. Each of the lighting modules act independently, sharing only a power source.

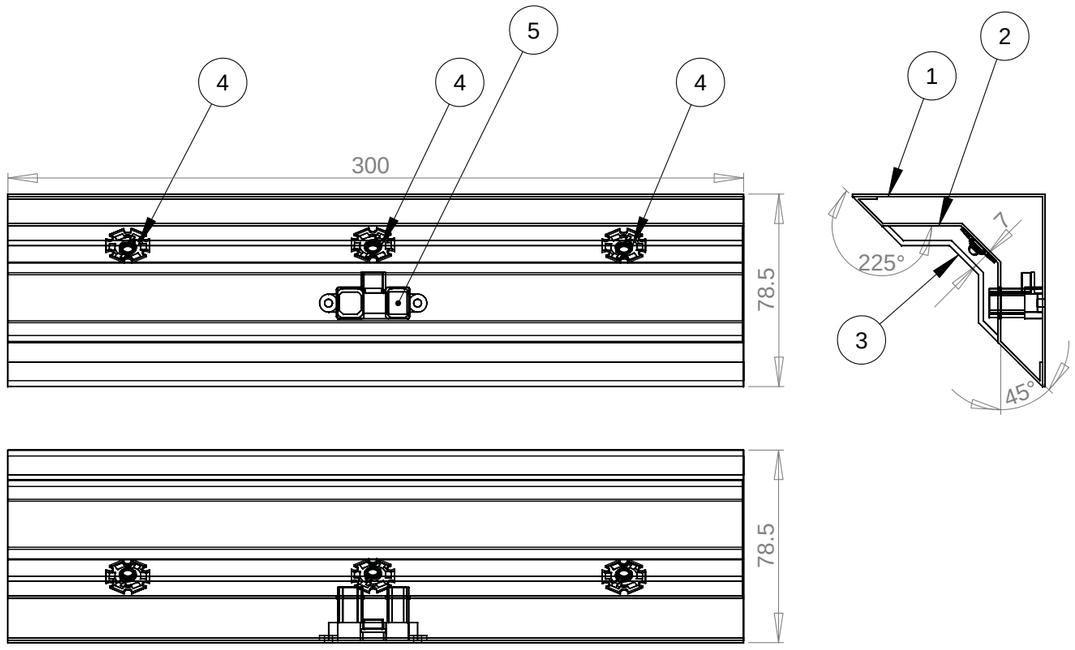
What is shown here is only a section of the final installation. This triangle-shaped channel could be produced six meters long, or 20 meters long. As mentioned earlier, the shape could also be customized to fit a particular application. Adapting this product to many aesthetic styles would be possible.



# Product GA Drawing

| ITEM NO. | PART NUMBER | DESCRIPTION | QTY. |
|---|---|---|---|
| 1 | RCL-1001-A1 | Housing | 1 |
| 2 | RCL-1002-A1 | Housing Insert | 1 |
| 3 | RCL-1003-A1 | Lens Assembly, Clear | 1 |
| 4 | RCL-1004-A1 | LUXEON Star LED Lamp | 3 |
| 5 | RCL-1005-A1 | Sharp GP2Y0A02YK0F | 1 |









| | | | | | | | |
|---|---|---|---|---|---|---|---|
| UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS SURFACE FINISH: TOLERANCES: LINEAR: ANGULAR: | | FINISH: Semi-Gloss Painted Cold-Rolled Steel | | DEBUR AND BREAK SHARP EDGES | | DO NOT SCALE DRAWING | REVISION A 1.0 |
| | NAME | SIGNATURE | DATE | | | TITLE: Self-Adjusting LED Commercial Lighting Fixture | |
| DRAWN | JSG | James Gross | 27/4/10 | | | | |
| CHK'D | JSG | James Gross | 27/4/10 | | | | |
| APPV'D | JSG | James Gross | 27/4/10 | | | | |
| MFG | | | | | | | |
| Q.A | | | | MATERIAL: Various | | DWG NO. RCL-100-A1 | A3 |
| | | | | WEIGHT: | | SCALE:1:2 | SHEET 1 OF 1 |

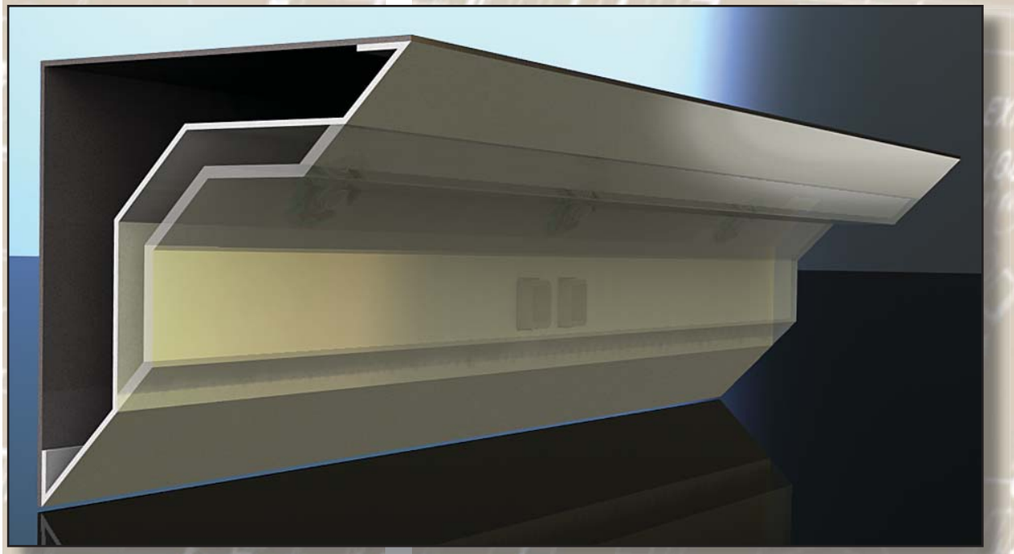
# Final Renderings

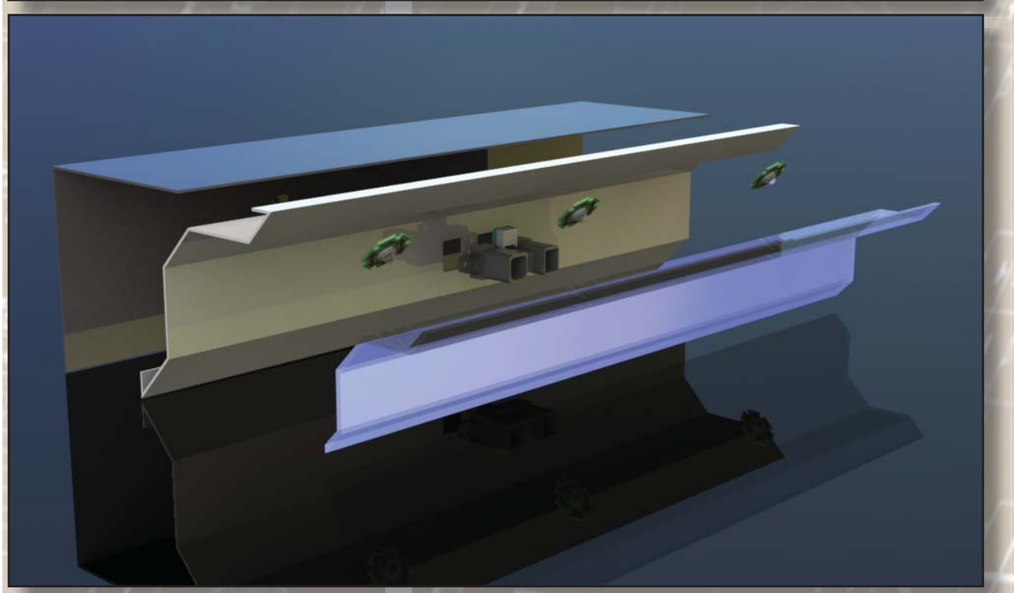
**Intelligent Lighting, PathLighter PL**

Here is the final concept for the product, shown by itself, and mounted in a possible user environment. The discovery of the Sharp sensor allows a wider range of possible applications for the core product. Commercial applications, as well as consumer applications are possible, expanding the possibilities for customer base.

**Further Development**

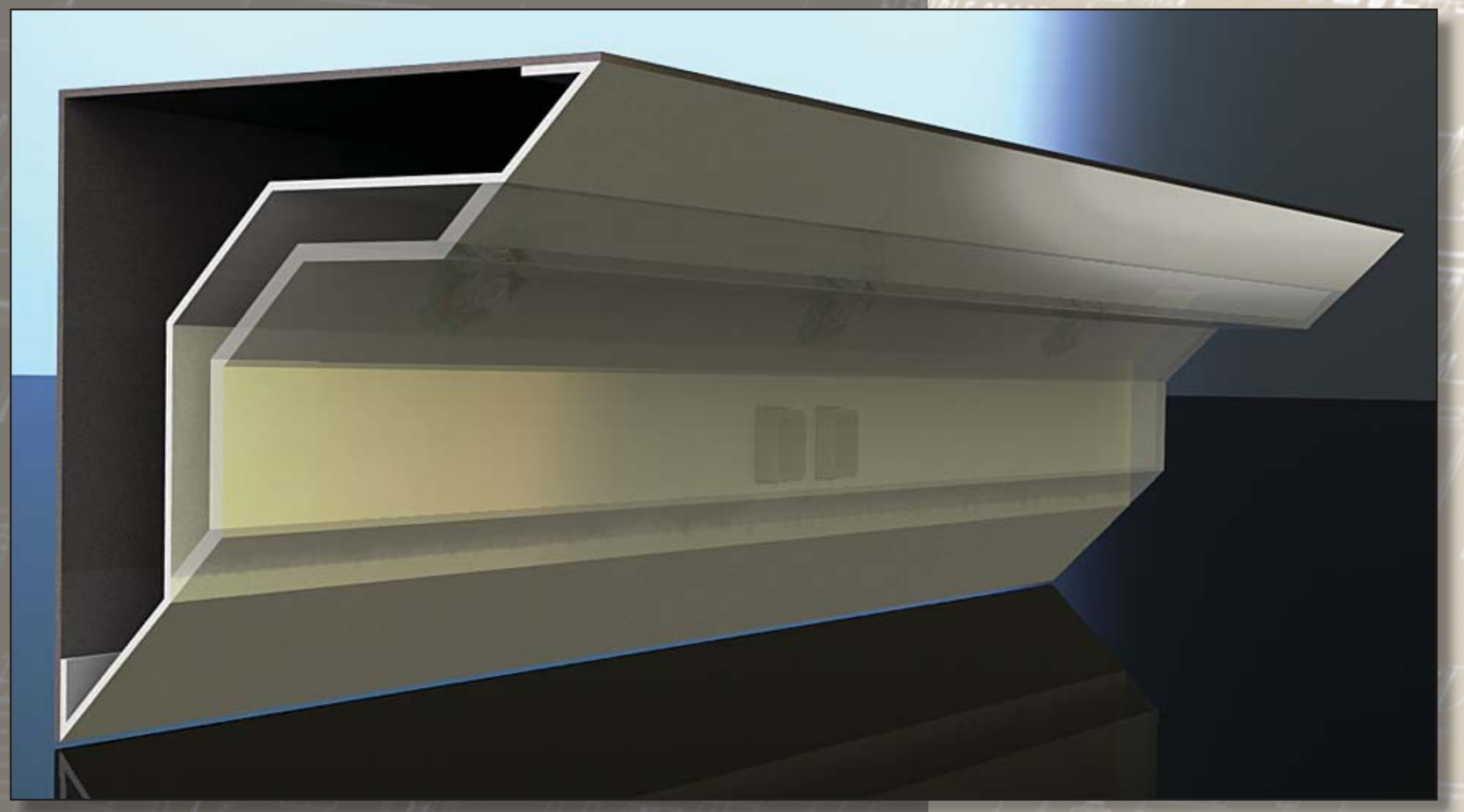
- A cost reduced consumer version.
- Design additional styles of the main housing.
- The addition of RGB LEDs. so colours can be adjusted as desired.
- Addition of computer control ports.





# Self Contained Intelligent Lighting

# PathLighter PL



- Energy Efficient LED source
- Self Adjusting Illumination
- Efficient Switching DC Supply
- Scalable System Solution
- No External Controller
- Low-Cost Components
- Customizable Housings
- Low Maintainance

James Gross – DM2316 Design Process 2 – Fall Term 2010

## Lighting that Moves With You

# References, Materials Cited


http://www.tivolilighting.com/applications/Amstar%20Alabaster/AmStarTivoli1.jpg

(P.8)

http://www.tivolilighting.com/applications/Cineplex%20Galaxy/Cineplex%20%20Galaxy%20Aurora%20Canada%2006%20001%20web.jpg

(P.8)

http://www.tivolilighting.com/applications/Cineplex%20Galaxy/Cineplex%20%20Galaxy%20Aurora%20Canada%2006%20006%20web.jpg

(P.8)

http://www.tivolilighting.com/applications/Kabuki%20Theatre/Kabuki06.jpg

(P.8)

http://www.tivolilighting.com/applications/Kabuki%20Theatre/Kabuki05.jpg

(P.8)

http://www.tivolilighting.com/applications/Kabuki%20Theatre/kabuki07.jpg

(P.8)

http://www.tivolilighting.com/applications/Livermore%20Stadium%2010/DSC_1091.jpg

(P.8)

http://www.tivolilighting.com/applications/Kabuki%20Theatre/Kabuki01.jpg

(P.8)

http://www.tivolilighting.com/applications/PSU%20Shortlidge%20mall/PSU%20Shortlidge_MG_0964-01.jpg

(P.3)

http://www.tivolilighting.com/applications/Seattle%20Bridge/Seattle%20bridge%201.jpg

(P.8)

http://blog.lampartners.com/photo-of-the-month/photo-of-the-month-july-2009.html

(P.3)

http://www.mondoarc.com/projects/Architectural/215872/musee_du_quai_bronly_paris_france.html

(P.3)

http://www.amazon.com/Philips-SpotOn-Motion-Sensing-Portable/dp/B000X92EG6?ie=UTF8&s=hi&qid=1217441836&sr=1-1

(P.5)

http://www.amazon.com/Fulcrum-Motion-Sensor-Porch-Light/dp/B001JJBZCS/ref=pd_sbs_ol_14

(P.5)

http://www.techmall.com/Sylvania-LED-Stair-Hallway-Lighting-Kit-p/58015.htm

(P.5)

http://www.techmall.com/Raintight-Motion-Sensor-Switch-White-IS140W-p/42863.htm

(P.5)

*http://www.energy.gov/*

(P.4)