FAA Airport Design Competition for Universities
Design Package Submission Form

Participating individuals or teams are required to submit the design package using this form. In additon, one hard copy of the full proposal plus the original of the Sign-off (See Appendix D in Design Submission Guidelines) form must be mailed to the Virginia Space Grant Consortium, 600 Butler Farm Road, Suite 2253, Hampton, VA 236666. All electronic and hard copy submissions must meet the 5 pm (Eastern Daylight Time) deadline on April 20, 2007. It is strongly recommended that a mail service that certifies delivery be used. All submissions will be acknowledged via email.

By proposal submission, Competition participants are agreeing that their proposal may be publicly shared. In addition, participants are giving permission that photographs that may be taken as part of Competition activities can be used for public information purposes and to promote the Program.

If you have questions regarding the Design Package submission process, you can contact the Virginia Space Grant Consortium between 8 a.m. and 4:30 p.m. EST on weekdays at 757/766-5210. Click here for Detailed Submission Guidelines.

Full competition guidelines and all updates are posted on the Competition Website:
http://www.faa.gov/runwaysafety/design_competition.htm.

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Institutions(s):	San Jose State University
Design Challenge Area:	Airport Environment Interactions
Specific Challenge Selected:	Airport Lights
Level(s) of students(s) involved:	Undergraduate
Estimated number of participants:	5 Undergraduate 0 Graduate 1 Faculty Advisors 0 Other, please describe:

Four components of the Design Package in PDF Format.

Executive Summary

Main Body

Required Appendices

Optional Appendix

Approve/Reject: ◉ Approve ○ Disqualify

Reasons for Disqualifcation:

Submit

1. EXCUTIVE SUMMARY

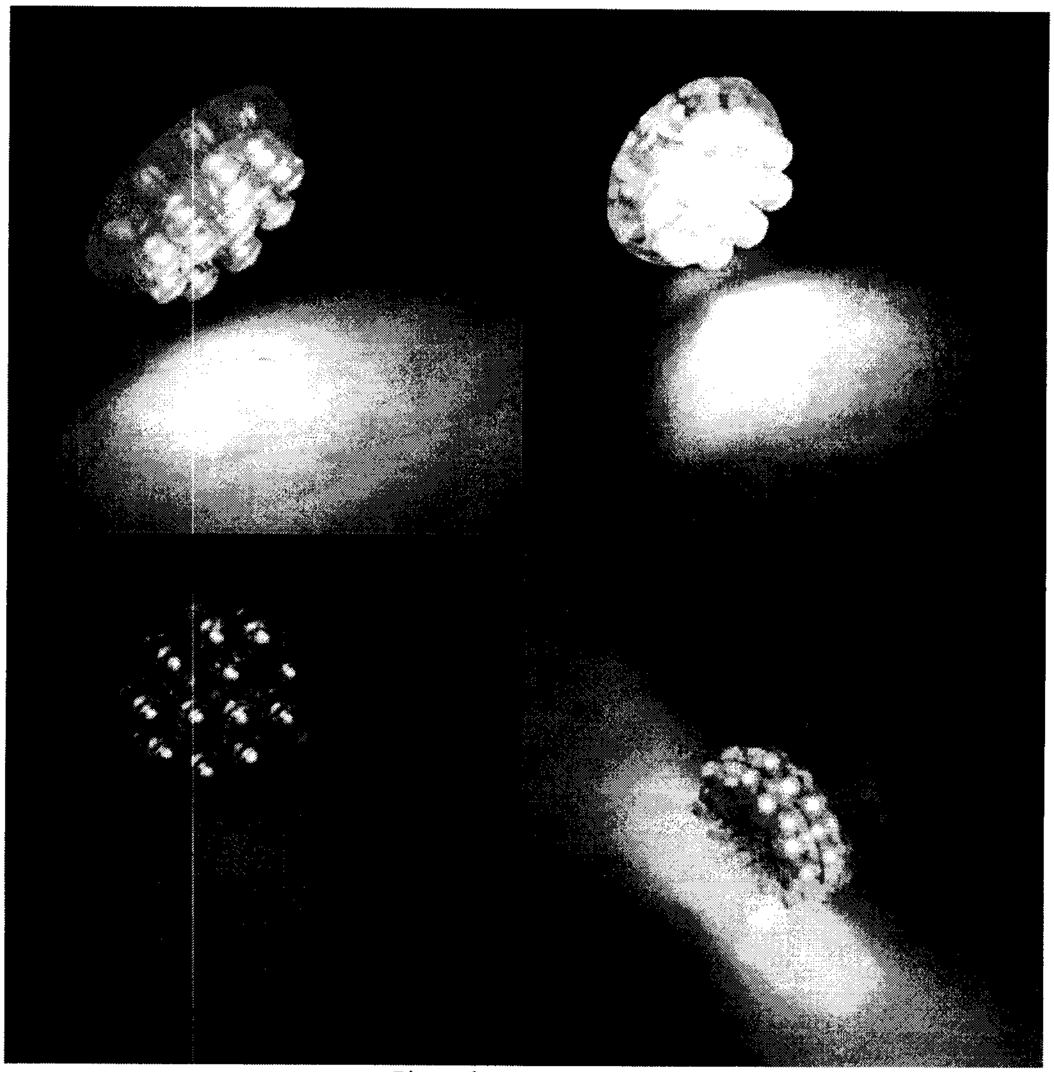
Current conventional lighting systems in many airports cost more than is necessary. Operational costs, maintenance costs, and replacement costs could be lowered by as much as 25% if conventional lighting systems were replaced by LED lighting systems. The implementation of LEDs is a reliable, energy efficient, and cost efficient way of improving and updating airfield lighting. LED lights have a duty life as long as 100,000 hours (compared to 10,000 hours for more conventional light filaments) and can not only reduce replacement costs, but also reduce airport operational delays. The reliability of LED systems will reduce maintenance costs considerably.

Other advantages include the ability of LED lighting to be highly directional. This will enable approach lighting to be directed to the exact spot where pilots will need it. Ground lighting can be placed where it is not blinding the pilots, but rather aimed across the taxiways, enabling pilots to see the specific area that they need to see. The approach lights would be capable of being aimed out toward the arrival area. LED lighting is safer than traditional lighting due to redundancy. LED lighting has less toxic material that will eventually end up in landfills at End of Useful Life. LEDs have a specific wavelength (color) without the use of filters, and electricity savings from a decrease in air conditioning costs due to the decrease in heat released by LEDs.

In order to keep costs as low as possible, implementation must occur in a manner that will keep the basic airside and landside infrastructures intact. This will involve the replacement of the conventional light bulbs or ballasts with an appropriate LED system (in accordance with FAA / ICAO requirements and guidelines), without modifying the power distribution system or any physical bases or mounts. To make the LED device "insertable" into the existing electrical infrastructure, all adaptor circuits must be contained within the device. This increases the expense of an LED system above that of a conventional system. This cost can be partially mitigated by replacing conventional lights with LED lights in accordance to the normal maintenance schedule. This bypasses the need for a large expenditure to implement the changeover.

In addition, the cost to operate LED devices overcomes the initial cost to put up the new LED system. Despite a higher initial cost, LEDs offers more financial benefits over time when compared to the cost of purchasing and operating incandescent lights (given the same hours, one test concluded a ten-fold electric bill decrease -- $6,000 to $600 – over the course of a year).

FEASIBILITY OF REPLACING CONVENTIONAL AIRPORT LIGHTING WITH LIGHT EMITTING DIODES



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Revision: J

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1. PROBLEM STATEMENT

Airport lighting is expensive, and a major source of energy consumption. It is also a vital part of airport operations. Current lighting systems in many airports are outdated, costing more than is necessary, and using energy that could be conserved. Implementation of an efficient and reliable lighting system is needed.

2. BACKGROUND

Light Emitting Diodes (LEDs) are a reliable, energy efficient, and cost efficient way of improving and updating airfield lighting. These lights can be used on the airfield as well as at the terminal to cut electricity costs and save energy while increasing safety. This form of lighting has been implemented at a number of airports already, including Prescott Municipal Airport in Arizona, where the FAA has conducted LED observations.

3. EXCUTIVE SUMMARY

Current conventional lighting systems in many airports cost more than is necessary. Operational costs, maintenance costs, and replacement costs could be lowered by as much as 25% if conventional lighting systems were replaced by LED lighting systems. The implementation of LEDs is a reliable, energy efficient, and cost efficient way of improving and updating airfield lighting. LED lights have a duty life as long as 100,000 hours (compared to 10,000 hours for more conventional light filaments) and can not only reduce replacement costs, but also reduce airport operational delays. The reliability of LED systems will reduce maintenance costs considerably.

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4. SUMMARY OF LITERATURE REVIEW

In this paper our team will address availability, cost, implementation, and advantages and disadvantages when converting an airport from traditional lighting methods to LEDs. With the current environmental and energy conservation issues at hand, a more current approach to airport lighting is necessary and available (Siemens).

The cost of lighting an airport's terminal and field is high. According to information collected and published (PG&E), the cost to operate LEDs in one year is ten times less than a 30W incandescent bulb. Observations of an implemented LED system at a trial airport in Prescott, AZ, have concluded that there is a payback for installing new LED fixtures in about five to ten years. (Whitley, FAA)

Some of the most intensive planning when switching to LED lighting is in the implementation of the new system. In many cases, the adaptor and all associated electrical circuitry is already part of the LED fixture, and simply needs to be inserted and attached to the existing base. One such example is the taxiway edge light offered by Dialight, which fits into a standard 6.6-ampere base (Dialight, *L861 LED taxiway edge lights*). Other implementation concerns include power differences and temperature sensitivity of LEDs.

LED bulbs offer many advantages including redundancy, energy savings, and life of the bulb. LED lights last 6-10 times longer than traditional bulbs. (The Electricity Conservation Program) LEDs can last 75,000 hours or longer and consume far less power than standard incandescent bulbs. (DenBaars)

Though LEDs seem to be a perfect solution to today's energy problems, there are some disadvantages. Temperature sensitivity may limit the climates where LEDs can be economically utilized because a rise in temperature effects LED's longevity. (LEDTronics, Inc) Other issues may arise because LED lights focuses in one direction. Light that the diode releases from the LED bounces off the sides of the bulb and through the rounded end of the LED. (Harris)

5. TEAM SOLVING PROBLEM APPROACH

Our team utilized quality management principles of process evaluation and improvement. We examined an airport infrastructure process, measured parameters, interpreted data, formed information, and scrutinized the information for process improvements (Evans and Linsey).

The process we examined involved airport lighting systems. The parameters we measured consisted of material cost, maintenance cost, operational cost (electrical usage), and replacement cost (or life time of a given light source). This data was converted into dollars. We then compared the dollar cost of using LED lighting sources to conventional lighting sources and discovered a large cost savings could be realized.

6. TECHNICAL ISSUES

It would be simpler and cheaper if an airport could just go to the local hardware store and purchase light bulbs, but this is not the case. There are specifications on the type of lighting airports can use. The FAA enforces these requirements. When proposing to exchange traditional airport lighting with LED's,, these requirements must be met. ICAO also has requirements, which can be found in Annex 14 Volume 1.

6.1. Intensity

6.1.2. white obstruction lights

According to the FAA Advisory Circular Number: 150/5345-43F, "white obstruction lights must automatically change intensity steps when the ambient light changes as follows:

a. From day intensity to twilight intensity when the illumination decreases below 60 foot-candles (645.8 lux) but before it reaches 35 foot-candles (376.7 lux).

b. From twilight intensity to night intensity when the illumination decreases below 5 foot-candles (53.8 lux) but before it reaches 2 foot-candles (21.5 lux).

c. From night intensity to twilight intensity when the illumination increases above 2 foot-candles (21.5 lux) but before it reaches 5 foot-candles (53.8 lux).

d. From twilight intensity to day intensity when the illumination increases above 35 foot-candles (376.7 lux) but before it reaches 60 foot-candles (645.8 lux)."

6.1.2. red obstruction lights

If automatic control is utilized, the light unit must turn on when the ambient light decreases to not less than 35 foot-candles (367.7 lux) and turn off when the ambient light increases to not more than 60 foot-candles (645.8 lux) (Advisory Circular Number: 150/5345-43F).

Figure 1a: L-856 Lights, Obstruction, High Intensity, White, 40 FPM Intensity Requirements.

Step	Beam Spread		Peak Intensity (2) (candela)
	Horizontal (1) (degrees)	Vertical (degrees)	
Day	90 or 120	3 - 7	270,000 ±25%
Twilight	90 or 120	3 - 7	20,000 ±25%
Night	90 or 120	3 - 7	2,000 ±25%

(Advisory Circular Number: 150/5345-43F)

Figure 1b: L-865 Lights, Obstruction, Medium Intensity, White, 40 FPM Intensity Requirements.

Step	Beam Spread		Peak Intensity (2) (candela)
	Horizontal (1) (degrees)	Vertical (degrees)	
Day/Twilight	360	3 minimum	20,000 ±25%
Night	360	3 minimum	2,000 ±25%

(Advisory Circular Number: 150/5345-43F)

6.2. Power

6.2.1 airport runway centerline bulbs -airport lighting

Airport lighting centerline bulbs are tungsten quartz halogen and are certified. The bulbs are 6.6 Ampere and wattages are 30, 45, 65, 100, 200, and 500. These bulbs are used in airfield runway in-pavement fixtures. The lamps go into runway and taxiway centerline, touchdown zone, and stop and hold fixtures. These bulbs meet the requirements listed by the FAA for L-861, L-862, L-880, L-881, and L-858 specifications (IQAirport.com , http://www.iqairport.com/parts/).

6.2.2. airport threshold lighting bulbs - airport lighting

Airport Threshold Lighting Bulbs - Airport Lighting - This lamp is a 20-ampere/500 watt and 500-hour lamp. It is used in high intensity threshold inset fixtures. The lamp conforms to Spec E-2491 (IQAirport.com, http://www.iqairport.com/parts/).

6.2.3. elevated approach lighting - airport lighting par lamps

Airport lighting par lamps are tungsten quartz halogen or xenon strobe flash lamps. Lamp current for the halogen types is either 6.6 Ampere or 20.0 Ampere (IQAirport.com, http://www.iqairport.com/parts/).

6.2.4. runway end identification lights (REIL) strobes & flash tubes - airport lighting

The flash lamps and flashtubes or strobes are used in airport runway lighting, approach lights, touchdown zone lighting, runway centerline lights, runway end identifier lights, and obstruction lighting. The lamps are used in sequential or single flash systems such as ALSF and ALSF-II lights, MALSR lights, and REIL light fixtures. They are available in Par 56 and ceramic 3 or 5 pin bases. They are high voltage bulbs that operate in the 1200 volts to 2000 volts range (IQAirport.com, http://www.iqairport.com/parts/).

6.2.5. taxiway edge lights - T Bulbs - airport lighting

These bulbs are incandescent "T" shape bulbs, they come in T10 size and T14 Size and wattages range from 30, 45, 200, 204, and 210 at 6.6 Ampere current (IQAirport.com, http://www.iqairport.com/parts/).

6.3. Color

Airports use tungsten quartz halogen lights, meaning white lights. They use lenses and domes to cover the lights in order to change the color. If plastic covers are used, they must be resistant to checking, crazing, or color changes caused by ultraviolet radiation or ozone gas exposure. (Advisory Circular Number: 150/5345-43F) When using LEDs, the LED's themselves are colored, and a clear dome is used to protect the LED's. The colors that airports use are: red, amber, green, blue, and white. Sometimes the lenses are split into two different colors, and LED's will also do this. With new technology, a white LED is available.

6.4. Availability

LED's that meet the specification given by the FAA are available at this time. These LED's are able to meet the environmental requirements which, according to Advisory Circular Number: 150/5345-43F, means that the equipment must be able to work continuously in conditions of:

a. Temperature. -40 degrees F (-40 degrees C) to 130 degrees F (55 degrees C).
b. Humidity. 95 percent relative humidity.
c. Wind. Wind speeds up to 150 miles per hour (mph)
d. Wind-blown Rain. Exposure to wind-blown rain from any direction.
e. Salt Fog. Exposure to salt-laden atmosphere.
f. Sunshine. Exposure to solar radiation.

There are companies that are currently selling LED lighting systems to airports. One company that is taking an initiative in developing LED technology for airport lighting is Siemens. They have developed products that airports can currently purchase. As technology increases, so will the availability of LED technology.

7. COST ISSUES

Converting an airport lighting system from standard incandescent bulbs to LED sources will involve cost issues. Costs range from purchase and replacement, to disposable and ongoing maintenance of the system. A cost analysis will be processed in order to quantify and manage the issues involved in switching to LED lights. This section will reflect cost analysis chart(s), disposal cost, and maintenance cost.

7.1. Cost Analysis

Cost analysis involves the airport's cost breakdowns, focused on lighting costs, verifying the data, and evaluating it with the cost to change to LED sources, including the initial cost to implement the new system, and its benefits over time.

The cost to operate energy-consuming devices (LED sources) overcomes the initial cost to implement the new LED system. Despite a higher initial cost, LEDs offer more financial benefits over time, when compared to the cost of purchasing and operating incandescent lights.

Figure 2 is an example of evaluating incandescent lights versus LEDs. Based on this assumption, the cost to operate LEDs in one year is ten times less than a 30W incandescent bulb.

Figure 2: Incandescent vs. LED (Light-Emitting Diode) Lights

Incandescent Light Bulbs

Taxiway Edge Lights "T" Bulbs (6.6Amps)

Wattage	[1]Hours of Operation	kWh	[2]kWh Unit Cost	Annual Cost	# of Fixtures	Total Annual Cost
30	4380	131.4	0.15	$19.71	300	$5,913.00
45	4380	197.1	0.15	$29.57	300	$8,869.50

Web Source: (Victor's part)

LED (Light-Emitting Diode) Lights

Taxiway Edge Lights "T" Bulbs (6.6Amps)

Wattage	[1]Hours of Operation	kWh	[2]kWh Unit Cost	Annual Cost	# of Fixtures	Total Annual Cost
3	4380	13.14	0.15	$1.97	300	$591.30

Web Source: http://www.flightlight.com/airportlighting/1.1/1.1.2.html

[1]*Based on 12 hrs of operation in 365 days.*

[2]PG&E CA Electricity Rate

Year	Cost
2003	$0.12
2004	$0.13
2005	$0.14
2006	$0.14
2007	$0.15

**Assumption: 5% increase every year.*

Web Source: http://www.energy.ca.gov/electricity/current_electricity_rates.html

7.2. Maintenance Cost

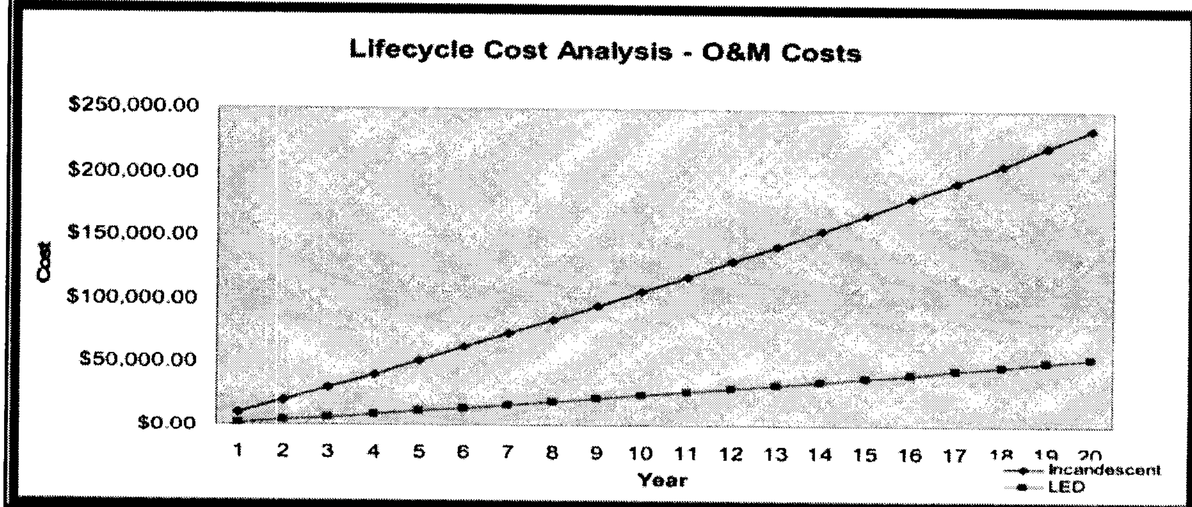
Maintenance cost is the cost to maintain the LED system in comparison to the current system. This involves manpower labor (salary), the cost of materials needed, and other miscellaneous cost.

Figure 3a illustrates 20-year life cycle benefits for both incandescent and LED lights. It shows that the initial purchase price of LED is higher than that of incandescent lights. However, the annual maintenance and energy costs for LEDs over time is lower when compared to incandescent lights.

Figure 3a: Life Cycle Cost Benefits – Sample Case Study

	Incandescent	LED
Installation Costs	$370,000.00	$430,000.00
Annual Maintenance Costs	$2,372.50	$1,782.50
Annual Energy Costs	$7,327.93	$426.72
TOTAL O&M	$9,700.43	$2,209.22
Annual Adjustment	2%	

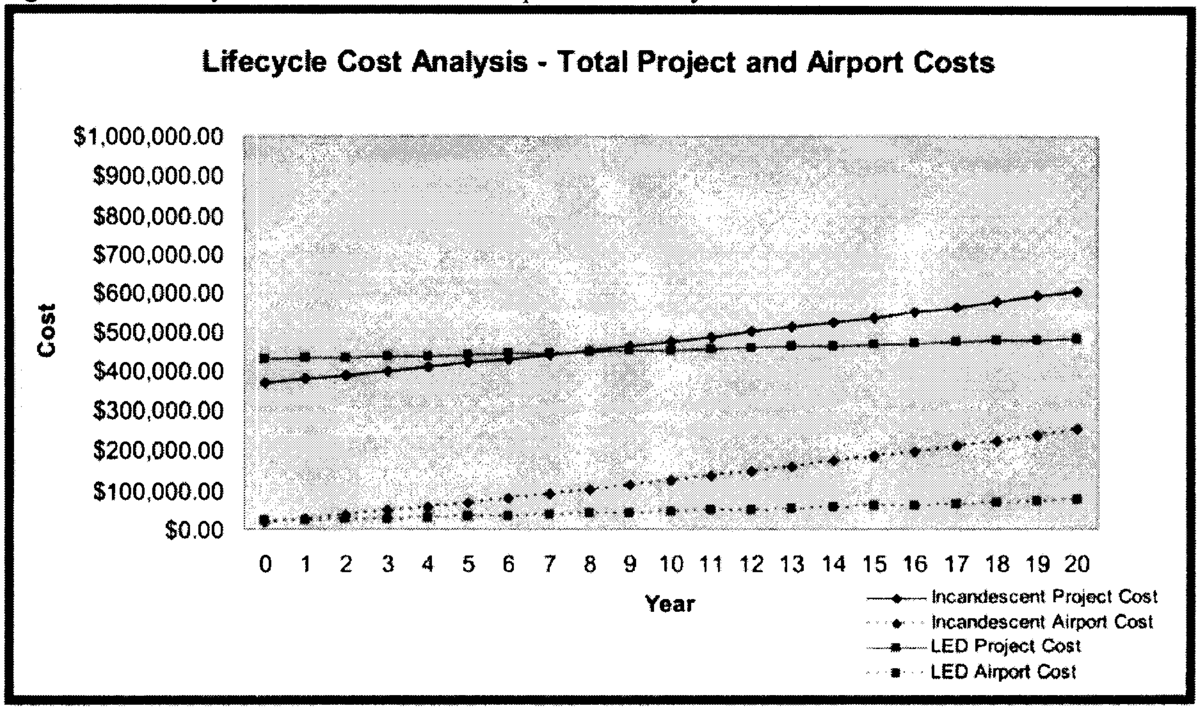
This example is based on a New Installation with 300 LED Fixtures @ .15 each kWh



Source: Federal Aviation Administration, "Prototype LED Taxiway Lighting System Evaluation Summary."

Figure 3b illustrates a 20-year total project and airport costs. The chart shows that the project costs for both sources breaks even on the 7th and 8th year. This also shows a payback for installing new LED fixtures in about 5 to 10 years.

Figure 3b: Life Cycle Cost Benefits – Sample Case Study



Source: Federal Aviation Administration, "Prototype LED Taxiway Lighting System Evaluation Summary."

8. IMPLEMENTATION ISSUES

Changing airport incandescent and fluorescent lighting sources to LED sources involves some challenges. In order to keep costs as low as possible, implementation must occur in a manner that will keep the basic airside and landside infrastructure intact. The technical issues and the cost issues of installation are examined in this section.

8.1. Technical Issues of Installation

8.1.1. adaptors

In order to preserve the electrical and physical infrastructure of the airport lighting systems, we propose that adaptors be utilized. An adaptor is a device that replaces the conventional socket for incandescent bulbs and fluorescent tubes. In many cases, the adaptor and all associated electrical circuitry is already part of the LED fixture, and simply needs to be inserted and attached to the existing base. One such example is the taxiway edge light offered by Dialight, which fits into a standard 6.6-ampere base (Dialight, *L861 LED taxiway edge lights*). In other situations, the adaptor would be a one-time installation. Three advantages using adaptors include: (1) the lighting structures themselves do not need replacement, (2) the current electrical wiring does not need alterations and (3), the installation of the adaptors occurs as needed (for example, when a light bulb burns out, or otherwise needs replacing). From that point forward, LEDs would then be inserted into the adaptor in a manner similar to replacing light bulbs – as in the course of general maintenance.

8.1.2. power

The electrical power needed for LEDs is much less than that needed for conventional light sources. Therefore, the power carrying capacity of current electrical cables is more than sufficient to provide for the needs of LEDs. According to Siemens (a manufacturer of airport LED lighting systems) the lower power consumption by the LED systems typically draws greater current reducing the life of an LED system (Siemens, *Products and Solutions*). To overcome that, the adaptor (self-contained or otherwise) includes circuitry to adjust the current load to the correct amount. This increases the expense of the LED lighting system. Using adaptors to preserve existing infrastructure does involve some expense, but this is offset by the cost savings of the LED efficiencies alluded to earlier.

8.1.3. temperature issues

Incandescent bulbs generate a fair amount of waste heat, and in cold weather operations, this heat typically melts any ice build-up. On the other hand, LEDs are more energy efficient and generate considerably less heat. For external LEDs, this has led to problems of icing in cold weather operations. One countermeasure developed by Siemens prevents this problem with the use of anti-icing fluids (Siemens, *Products and Solutions*).

8.2. Costs Issues of Installation

Physical infrastructures such as power distribution and base mounts are to remain intact. This focuses implementation costs into the actual LED lighting systems. Airside and landside implementation cost issues center on material and labor-installation costs.

8.2.1. airside

For airside operations, material costs include only the LED lighting system. Runway centerline lights, threshold lighting, elevated approach lighting, and runway end identification lights are all available with LED based lighting system. The price of these systems varies according to quantity, type, and manufacturer. Typically, the cost for these types of lighting systems ranges from 10% to 20% more than conventional bulbs. According to Siemans, these costs are more than recovered by as much as 25% in a ten-year period when compared to conventional lighting systems (Siemans, *Industrial Solutions and Services*). Labor cost rate, according to licensed electrician David Ozoa would be $50 per hour (Ozoa, *Interview*). Total installation time would take place over several months or years, as conventional lighting systems would be replaced according to their appropriate maintenance schedule.

8.2.2. landside

For landside operations typical material costs include LEDs. Prices for LEDs that are needed to replace standard 100w light bulbs are about $15.00 (The Light Company, *E-12 Tapered Candelabra*). For strip LEDs that can be used in place of fluorescent lighting, prices start in the $50.00 range, per lamp (LEDtronics, *LED strips replace fluorescent lamps*). As before, conventional lighting systems are replaced according to the appropriate maintenance schedule, at the same cost. These LED lights install into either existing sockets (like an incandescent light bulb), or utilize the same wiring (like the ballast in fluorescent bulbs).

9. ADVANTAGES

"Institutional, Industrial and Commercial Lighting: LED products can have a significant impact on energy use in airport, ports and roadway lighting, where conventional fluorescent- and incandescent-lit signage is heavily used."
Flex Your Power (Fypower.org)

There are many advantages of LED lighting, ranging from reduced power consumption on both the ground side and airside of airport operations, low heat output, reduced carbon dioxide and lower toxic material in the end of life of the bulbs. Perhaps the greatest benefit of LED lighting comes from their long life and reduced power consumption. They are quite well suited for the runway environment because of their increased safety and ability to be directional.

The primary advantage of LED lighting is reduced power consumption. It is estimated that the widespread use of LED lighting can reduce energy demand from lighting by 50%. "The new lighting technology would also dramatically cut electricity demand. According to a study commissioned by the U.S. Department of Energy, widespread adoption of next-generation white LEDs for lighting could, by 2025, slash electricity consumption by 10 percent worldwide, cutting $100 billion per year from electric bills and saving $50 billion in averted power-plant construction costs. Lighting is a major contributor to the use of electricity. Collectively we could save half the energy we use on lighting," says George Craford, chief technology officer at Lumileds. "Make lighting more efficient and the question of building new power plants starts to go away."

Another study suggests that in home and workplace, the effects of switching to LED lighting could save upwards of 100 million. "A 2005 U.S. Dept. of Energy study indicated that simply switching home and office light bulbs to LED lighting could "cut electricity costs by $100 billion over the next 20 years." You don't have to wait to try LED lighting at home--a number of companies currently sell LED-based bulbs. Enlux, in Chandler, AZ, makes the one that I find most interesting. Their LED floodlight recently won top honors from Popular Science in the magazine's "best of what is new" home technology category." –Alan Pierce of Tech Directions it is quite clear that the decrease in energy consumption is the primary advantage. This is an advantage twofold, it saves money and it is aiding in solving environmental issues.

The advantages affecting the airside specifically are the abilities of LED lighting to be highly directional. This will enable approach lighting to be directed to the exact spot where pilots will need the lighting. Ground lighting can be placed where it is not blinding the pilots, but rather aimed across the taxiways, enabling pilots to see the specific area that they need to see. The approach lights would be capable of being aimed out toward the arrival area.

LED lighting is safer than traditional lighting due to redundancy. Where a standard light only has one bulb, LED lighting has many small bulbs comprising one lamp. This means that when a bulb burns out, there are still many more providing light under the same cover plate. Another safety feature of the LED lighting is the lack of heat produced.

An example of exterior lighting provided for maneuvering vehicles, and the dramatic energy savings associated can be found in a study done by the Department of Transportation. "According to the California Department of Transportation, replacement of conventional traffic-light bulbs with LEDs--red, yellow, and most recently, green--has trimmed at least $10 million from the state's annual electric bill. Nationwide, according to Strategies Unlimited, a market research firm in Mountain View, CA, LED traffic lights are becoming commonplace: as of 2002, 39 percent of red lights and 29 percent of green lights used LEDs"

There is a dramatic advantage over traditional lighting in cost savings due to the increased life cycle of LED lighting. The Electricity Conservation Program estimates that LED lights last 6-10 times longer than traditional bulbs. "The electricity conservation program aimed to push past consumer reluctance to purchase more expensive CFL bulbs by showing that the cost of each bulb would be eclipsed by savings on electric bills and longer CFL bulb life. A CFL bulb lasts 6 to 10 times longer than its incandescent equivalent, which means replacing bulbs only once every 8 to 10 years. So far--15 years after I received the CFL bulbs--I've replaced just one." – Alan Pierce

Santa Barbara professor Stephen DenBaars states "LEDs can last 75,000 hours or longer and consume far less power than standard incandescent bulbs. Only about 5 percent of the energy that goes into conventional bulbs actually turns into light; the rest gets dissipated as heat. If 25 percent of the light bulbs in the United States were converted to LEDs putting out 150 lumens (a measure of light output) per watt--higher than the most current models--the country as a whole could save $115 billion in utility costs cumulatively by 2025". There is an advantage here in that there is a material cost savings, due to less replacement bulbs. There is another cost savings as well with the decrease in maintenance costs associated with replacing the bulbs.

There are more benefits of LED lighting including reduced toxic material that will eventually end up in landfills at End of Useful Life, specific wavelength (color) without use of filters, and electricity savings from a decrease in air conditioning costs due to the decrease in heat released from lighting. Another potential benefit is the positive consumer relation image set by being ahead in environmental issues such as energy conservation.

There are many benefits of LED lighting. These benefits range from the huge cost savings in long term energy conservation, safety in redundancy, long lasting bulbs which save maintenance and replacement costs. Additional benefits include less toxic end of life disposal, decreased air-conditioning costs and positive consumer image.

10. DISADVANTAGES

Light Emitting Diodes have many great advantages when applied to the airport. But there are some limitations that can become a big factor when choosing an LED over incandescent or fluorescent lights. Angle alignment, cost, narrow temperature zone, power supply setup, and limited brightness are some disadvantages of LEDs.

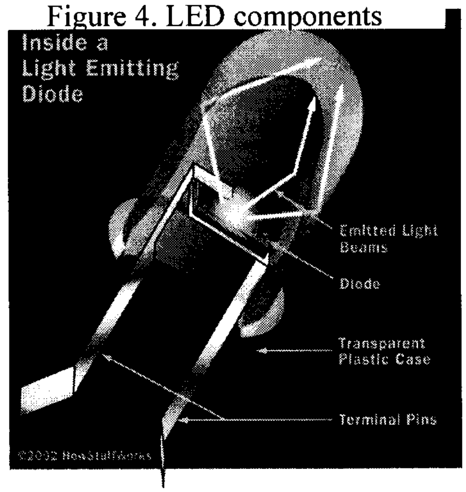
10.1. Angle alignment

LED light focuses in one direction when it is illuminated. Its plastic casing is designed to make the light in the LED direct to the top part of the LED.

As you can see from figure 4, when the LED is illuminated, the light that is produced in the LED is concentrated to the round top of the LED container. According to Tom Harris from HowStuffWorks.com, the light that the diode releases from the LED bounces off the sides of the bulb and through the rounded end of the LED.

With the light from the LED focusing only in one direction, the positioning of the LED will play a big factor in the airport because different angles will give varying brightness's. Therefore, angle alignment of the LED is a big disadvantage because it does not emit the same brightness at different angles.

Figure 4. LED components



Source: Howstuffworks.com

10.2. Cost

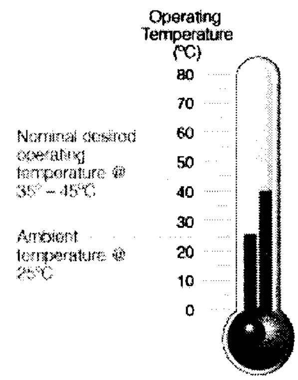
The initial cost of changing the airport's light into LED will be a disadvantage compared to using incandescent or fluorescent light bulbs. LED Light World states, "The currently available LEDs in the market are 3 ~ 10 times more expensive than equivalent incandescent light bulbs." With the prices of LED costing three to ten times more than incandescent light bulbs, LEDs are less desirable than incandescent light bulbs or fluorescent lights.

One reason why LEDs cost more than incandescent and fluorescent light bulbs is because it uses a semiconductor chip to create light. Incandescent light uses filaments, and fluorescent light uses gas, which is a lot cheaper to manufacture than a semiconductor chip. As of now, semiconductors are getting cheaper but still cost more than incandescent or fluorescent. Therefore, cost is a big disadvantage when it comes to using LEDs.

10.3. Narrow Temperature Zone Affects Performance

Temperature can greatly affect LEDs; therefore knowing the temperature range of the airport will play a big factor in implementing LEDs. LEDTronics, Inc states that the rise in temperature effects LED's longevity. Heat can effect the current in LEDs and each time the temperature changes, the LED current is affected based on the temperature of the zone. LEDTronics, Inc states, "in order to maintain the projected longevity (100,000 hours) of the Based LED, the Based LED and its components should be redesigned to operate within the nominal desired operating temperature range of 35°C - 45°C." One way to fix this problem is to increase or decrease the current that goes through the LED to make sure that the temperature in the LED will be the desired temperature of 35°C – 45°C. Making sure that the temperature of the LED is in the desired range is a big disadvantage.

Figure 5. LED Operating Temperatures



Source: LEDTronics, Inc

10.4. Power Supply Setup

By installing LEDs in the airport, the power supply setup has to be altered to fit the LEDs. By altering the power supply setup, additional cost will be applied. Since incandescent and fluorescent light bulbs use 110volts, the power supply for LEDs will need to be changed because LEDs use a lower voltage. As of today, there are some transformers or adapters that can be used to put an LED light bulb to a regular 110volts power supply. With this transformer/adapter, additional cost will be implemented.

10.5. Limited brightness

One problem that occurs by using LED is its limited brightness. LED has a lower brightness compared to incandescent and fluorescent lights. According to LED light World, currently LEDs have limited brightness, but this is increasing as better technologies are developed to make them brighter. As of today, incandescent and fluorescent light bulbs have more brightness than LEDs. Hence, using LED light bulbs to light up a certain zone is not as efficient as using incandescent and fluorescent light bulbs.

APPENDICES

Appendix A: Contact Information

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Michelle Sheffield

Appendix B: Description of University

San Jose State University
Department of Aviation and Technology
1120 Coleman Avenue
San Jose, CA 95110

According to the university's website at www.sjsu.edu:

"San José State provides a comprehensive university education, granting bachelor's and master's degrees in 134 areas of study. Quality teaching and small classes are a priority at SJSU, where tenured professors teach introductory as well as advanced courses. One of the 200 top research universities in the nation, SJSU offers rigorous course work and research opportunities to more than 30,000 undergraduate and graduate students in seven colleges."

Appendix C: Description of Non-University Partners

San Jose State University students are currently working together with staff of the San Jose International Airport (SJC), where the SJSU Aviation Department is located.

Appendix E: Evaluation of Educational Experience

AVIA 190: Aviation Seminar, San Jose State University

Student assessment of the research process and teamwork for the FAA Airport Design Competition

Part 1. Research Process Evaluation

In the space below (use extra sheets if necessary) please reflect on the challenges and successes you faced during the research process for the FAA Airport Design Project as part of AVIA 190. Make reference to each of the categories below, but focus on those issues that are most relevant to you.

Planning: Reflect on the process of focusing your research. What challenges did you encounter in developing a question, hypothesis, or thesis?

Being on a team of aviation students, my biggest challenge was narrowing down and choosing the multitude of ideas that resulted from our brainstorm session. We had several ideas and discussed them at length. Even after choosing our theme, we initially thought back and compared previous ideas. Fortunately, this mindset did not last long.

Gathering: Describe any problems or successes you had as you searched. Did any particular search strategies work well or disappoint you? Which databases and search engines worked well? What were the major barriers to your search for balanced and credible resources?

We did encounter some difficulties contacting airport officials, but we were prepared for this. We typically conducted web research, textbook review, industry specifications, and government regulation. We were also in a fortunate position of leveraging of some of our classmates who are already professionally involved in the industry.

Organizing: How did you ensure that your information comprehensively addressed the question, hypothesis, or thesis? How and why did you modify your original question, hypothesis, or thesis? What strategies did you use to reorganize the information? Did these strategies lead you to connections, patterns, etc.?

Our original thesis remained static with only a slight change whereby we decided to emphasize implementation as opposed to the actual benefits of the technology under consideration. However, we were constantly re-organizing our sub-topics as new or contradictory information appeared. Most of the organization was driven by our research data.

Documenting: Did any issues arise as you documented your sources?

Not really an issue.

Part 3: Goals Evaluation of the Project

Please provide an answer to the following questions any briefly address any general comments you may have.

Did the FAA Airport Design Competition provide a meaningful learning experience for you? Why or Why not?

Yes, on two levels:

1) The technical specifications of airport lighting were examined in depth.
2) Better appreciation for the difficulties in deploying a new technology.

Was the learning experience appropriate to the course level and its objectives? Why or Why not?

Yes, re-engineering is a concept that is emphasized. These types of improvements, especially in relation to the current economic climate of the aviation industry as a whole, are precisely what our project entailed. The methodology and logic analysis were other factors that was present in our lectures and reflected in our paper.

Was the learning experienced balanced between academic and industry goals? Why or Why not?

Yes, we were constantly searching for current vendors and industry experts. We then reflected on how to use their information with models that were taught in class.

Was participation by industry in the project appropriate, meaningful, and useful? Why or Why not?

We gained meaningful insight mostly through our traditional research methods and through interviews with classmates who had relevant industry experience.

Did this project help you with skills and knowledge you need to be successful for entry in the workforce or to pursue further study? Why or Why not?

Yes, as the idea occurred to of our teammates: "why not make our proposal into reality by starting our own business."

This idea increasingly became popular as we realized the financial possibilities.

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Appendix G: List of current airports that are using some form of LEDs

- Baghdad International Airport, Iraq
- Bagram AB, US Army, Afghanistan
- Balad Air Base, Iraq
- Balad Medivac Unit, Iraq
- Beale AFB, CA
- Beaufort Marine Corps Air Base, SC
- Bryan Airfield, US Army, AK
- Calgary International Airport, AB
- Chicago O'Hare International Airport, IL
- Dubrovnik International Airport, Croatia
- Eglin AFB, FL
- Ellington Air Field, Air National Guard
- Ellsworth AFB, SD
- Elmendorf AFB, AK
- Ganci AFB, Kyrgyzstan
- Halifax International Airport, NS
- Hickam AFB, HI
- Homestead Air Reserve Base, FL
- Honolulu International Airport, HI
- John F. Kennedy Airport, NY
- Kandahar AFB, Afghanistan
- Keesler AFB, MS
- Kingsley Air Field, OR
- Kirkuk AFB, Iraq
- Langley AFB, VA
- Logan International Airport, MA
- London International Airport, ON
- Los Angeles International Airport, CA
- MacDill AFB, FL
- McGhee Tyson Airport, TN
- McGuire AFB, NJ
- McEntire Airfield, Air National Guard, SC
- Memphis International Airport, TN
- Milan International Airport, Italy
- Minot AFB, ND
- Moody AFB, GA
- Nassau International Airport, Bahamas
- Nellis AFB, NV
- Oakland International Airport, CA
- Old Bridge Airport, NJ
- Ottawa International Airport, ON
- Phoenix International Airport, AZ
- Prescott Municipal Airport, Prescott, AZ
- Prince George Airport, BC
- Ramstein US Air Force Base, Germany
- Richmond Air Field, Air National Guard
- Royal Air Force, High Wycombe, UK
- Scott AFB, IL
- Seymour-Johnson AFB, NC
- Shilo Canadian Forces Base, MA
- Smith Reynolds Airport, NC
- Spokane International Airport, WA
- St. Paul International Airport, MN
- Sustainer AB, US Army, Iraq
- SW Florida International Airport, FL
- Tallil USAF Base, Iraq
- Toronto International Airport, ON
- Travis AFB, CA
- Truckee Tahoe Airport, CA
- Vancouver International Airport, BC
- Victoria International Airport, BC
- Warner Robins AFB, GA
- Wash. Dulles International Airport, DC
- Whiteman AFB, MO
- Yellowknife International Airport, NWT