

LED Airport Lighting Misconceptions



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**LEDs can not be seen as well as Incandescent
lights in low visibility?**

Fact or Fib?

FIB!

**Any source with the same candela* value
can be seen the same in low visibility.**

***1 Candela = The luminous intensity equivalent to a 540×10^{12} Hz
monochromatic radiator with a radiant intensity of 1/683 Watt
per steradian.**



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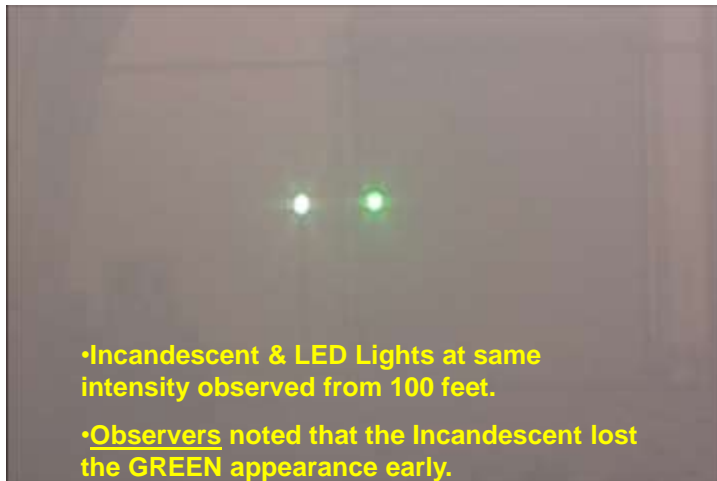
Low Visibility Demonstration of LED Technology



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Low Visibility Demonstration of LED Technology



•Incandescent & LED Lights at same intensity observed from 100 feet.

•Observers noted that the Incandescent lost the GREEN appearance early.



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Brightness/Luminous Intensity Values for Blue, White and Green Aviation Signal Lights Using Light Emitting Diodes

- Signal lights were compared against dark and dimly lighted backgrounds and through simulated fog.
- A new model was developed that could be used to predict signal light brightness perception for FAA blue, white and green signal colors.
- Except for very short-wavelength blue signal lights, the model was able to accurately predict brightness perception data obtained in the present experiment as well as those presented in an independent experiment published 30 years ago. This independent validation lends confidence to the generality of the model for predicting blue, white and green signal light brightness.



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Brightness/Luminous Intensity Values for Blue, White and Green Aviation Signal Lights Using Light Emitting Diodes

- The results confirm that LED signal lights are seen as brighter than incandescent signals at matched luminous intensities when there are no particles in the atmosphere to desaturate the LED.
- Fog reduced the relative brightness difference between the incandescent and the LED signal lights because of light scattering in the fog that desaturated the signal light colors.
- The resulting model developed a brightness/luminous ratio (B/L) for test colors resulting in Blue 1.4, White 1.4 to 1.6 and Green 1.4 when the light source is desaturated such as in lower visibility.



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Raleigh-Durham International Airport Runway Lighting System Study

- There have been complaints by pilots at airports of the runway centerline and touchdown zone lighting having been “too bright”. These particular airports have **LED lights installed for runway touchdown zone and centerline**; however they retain **incandescent for runway edge**.
- While claims had not been received from many airports using LED runway lighting, these claims raised concerns that the **design and operational provisions specified in Engineering Brief 67**, allow for the intensity of LED RCL and LED TDZ lights to operate at a level of brightness that **may create adverse lighting conditions** at intensity steps 1 and 2 of a 5 intensity step system.
- Such issues had been reported at **Raleigh/Durham Airport’s (RDU) runway 23L** where claims have been made stating that the intensity of the LED RCL and LED TDZ lights were “**too bright**” on intensity **step 1 and 2**.
- To address these concerns, members of the FAA’s Visual Guidance Program and supporting personnel traveled to RDU on **November 17, 2010** to conduct an examination of this brightness issue.



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Raleigh-Durham International Airport Runway Lighting System Study

→ EVALUATION APPROACH

- RDU RCL and TDZ lights examined through field and laboratory measurements and flight testing. These efforts consisted of:
 1. Collection of **photometric data** to determine if performance met requirements specified in Engineering Brief No: 67B
 2. Testing **lighting circuits** to verify performance met requirements specified in AC No: 150/5345-10G, Specification for Constant Current Regulators and Regulator Monitors
 3. **Flight tests** of the RCL and TDZ lights to determine whether the lights were visually “too bright” or visually acceptable.



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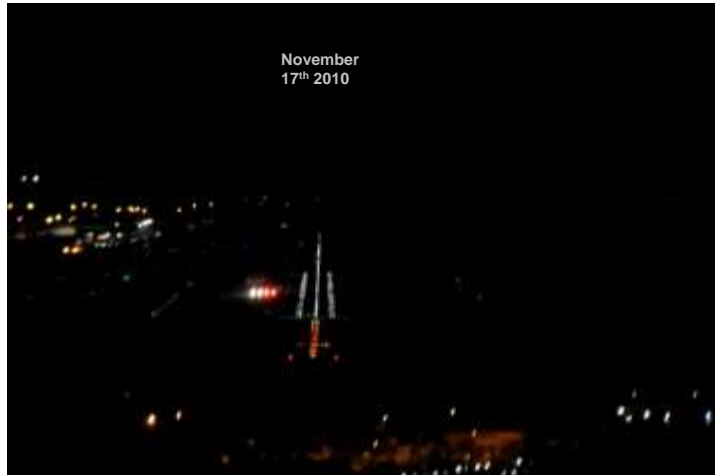
Raleigh-Durham International Airport Runway Lighting System Study

- After **initial flight**, the test team agreed that in **VMC conditions**, while not a safety concern, the intensity for **steps 1 and 2** could be lower so **additional flights were conducted**
- The **lights** at the subject runway at RDU, at the time of the evaluation, on **step 1** were **52.5 candela**
- Based in part, on the **Brightness to Luminous Ratio in VMC**, defined in research conducted, dividing **52.5 cd** on step 1 by a **B/L of 1.5** equals **35 cd** which also equates to **.7%** of full brightness for the **CCR**.
- **Adjustments** were made to the percentage of maximum brightness at RDU and in EB67B for steps **1** to **.7%** and step **2** to **2.0%** were recommended.
- Since these adjustments, **no other issues at RDU** have been reported.



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Raleigh-Durham International Airport Runway Lighting System Study



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Raleigh-Durham International Airport Runway Lighting System Study



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Aviation Weekly Article

“Approach Lights Problems Lead To Broader Examination Of LED Rollout”

- “The lights are **overpowering**, blotting out visibility.”
- “The fundamental problem is that these lights have been fielded with **no testing done**,”
- “... FAA has not conducted testing to determine the **potential effect of the lights on pilots at night and in different weather conditions, including rain, fog, smoke, haze and “break out effects”** when a pilot descends below low cloud bases on an instrument approach.



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- “The explanations are that LED lights and standard incandescent lights are the same if the basis for comparison is limited to a measure of candela.”
 - This statement makes it appear that Candela is the only criteria. Candela is the unit of measure used when talking about light through atmosphere only. Experts in the lighting field agree that the intensity of light measured in **Candela quantifies the amount of light** (no matter what source) the human eyes sees at an established angle, **in a given atmospheric condition.**
- “Since they are the same in this measure, there is no apparent reason to perform the rigors of weather, spatial disorientation, safety assessments, instrument trials, medical studies and the like as was required for incandescent lighting trails several decades ago. “
 - I have never heard of anyone from the FAA stating that no testing is needed.
 - The **knowledge** on the ability of the **human eye to see light through any type of atmosphere** has **improved tremendously since** the original PAR38 lamp was used in the MALS R adopted in the late **1960's.**
 - While it is true there **were more tests performed** when aviation lighting was **first adopted**, the **results** of those tests **still hold true** (no change in physics)
 - There has been much more research on the way **a light effects the human eye** since then, which means that **some of the original testing is not required.**
 - Medical studies have been performed on the affects of LEDs on the human eye (CAMI) and human factors evaluations such as the affect of flicker have been performed (RPI).



- “If this is possible under ideal atmospheric conditions my very strong concern is what will the affects be under less than ideal conditions, to include, at a minimum, the following in both day and night conditions:
 - Rain evaluated at light, moderate and heavy levels.
 - Fog and mist evaluated at varying degrees of visibility values.
 - Snow evaluated at light, moderate and heavy levels.
 - Low ceiling conditions.
 - Low visibility conditions for any type of obscuration.
 - Research has been completed (Tech Note available) concerning LEDs and visibility. Results show there is a **brightness perception factor in VMC** where a **white LED** will appear **1.4 to 1.6 brighter** than an incandescent because a **LED is a saturated light source**. However **as visibility diminishes** with more particles in the air (snow, rain etc.) **LEDs become desaturated** and become equivalent to incandescent.
 - Break-out and visual acquisition of the runway during any type of visibility and obscuration condition.
 - It is **common today** on approaches **in IMC** low visibility and **lights are on a higher step**, when an aircraft **“breaks out” to VMC**, pilots **request for approach lights to be turned down**. This would be the **same for an LED** Approach Lighting system.



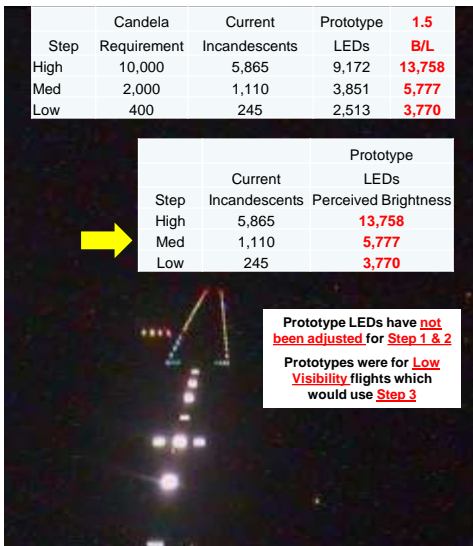
Experimental MALSR Runway 4 ACY

Step	Candela Requirement	Current		Prototype LEDs	Prototype 1.5 B/L 13,758 5,777 3,770
		Incandescents	LEDs		
High	10,000	5,865	9,172		
Med	2,000	1,110	3,851		
Low	400	245	2,513		



Step	Current Incandescents	Prototype LEDs	
		Perceived Brightness	
High	5,865	13,758	
Med	1,110	5,777	
Low	245	3,770	

Prototype LEDs have not been adjusted for Step 1 & 2
 Prototypes were for Low Visibility flights which would use Step 3



Station	Lamp
200	60W Incandescent
400	Prototype LED
600	Prototype LED
800	150W Incandescent
1000 Left	Prototype LED
1000 Center	Prototype LED
1000 Right	Prototype LED
1200	Prototype LED
1400	150W Incandescent



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Pictures Are Worth 1000 Words!



With The Right Camera!



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Our Research on LED use at airports Started 2004

- LED and Incandescent Aviation Signal Brightness.
- LED versus Incandescent Conspicuity in all weather conditions.
- Accuracy of LED Aviation Signal Light Color Identification by Pilots With and Without Color-Deficient Vision versus Incandescent.
- Understanding flicker in airfield lighting applications.
- Photometric testing of Incandescent lights versus LEDs.
- LED System Life - How is the Operational Failure of LED Fixtures Identified?



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Summary

- The FAA has been conducting research on LEDs since 2004 (article claimed no testing had been done)
- There is a known that LEDs appear brighter than Incandescents only when the LED remain a saturated source.
- A Brightness/Luminous Ratio has been developed and validated by flight testing at RDU in 2010 for adjusting LEDs in VMC to eliminate the “too bright” issue.
- Since the adjustment to-date no known brightness issues reported at RDU
- The “break out” issue is the same whether using Incandescent or LEDs. Pilots today ask ATC to turn down the lights if they are flying in low visibility then descend below a cloud base into clear weather (article implies this is unique to LEDs)



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LED Symposium (Oct 7 – 8, 2014)

- **FAA and Industry symposium on LED airport lighting**
 - Ensure safe integration and transition from incandescent to LED lighting
- **Primary objectives:**
 - Identify needed areas of research and testing
 - Achieve collaboration from stakeholders
 - Establish plan of action and timelines
- **Established 3 Working Groups**
 - Science, Operational Test, and MALSR
 - Design/conduct operational testing of LED airport lighting



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LED Flight Test – Near Term

- **FAA/Industry partnership to work LED issues**
- **Complete flight test plan**
 - Test criteria (duration, environment, aircraft type) being defined
 - Flight and ground test assets
 - Success criteria
 - Single Engine Propeller testing
 - Test “stroboscopic” effect of LED lights
 - Embry Riddle Aeronautical University/Ohio University
- **Testing at existing LED installations**
 - Runway edge, centerline, touchdown zone, and taxi lighting
 - FAA Flight Inspection
- **Initial testing at Atlantic City prototype LED MALSR**
 - Brightness perception testing on approach lighting system



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Questions or Comments?

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