Lighting Research and Development

Federal Aviation Administration

Presented to: ICAO Workshop

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Improved Airfield Electrical Infrastructure

- **Circuits considered:**
  - 450 V, AC Parallel Circuit
  - 2 Amp, DC Series Circuit
  - 2.8 Amp, AC Series Circuit
  - AC Series Circuit w/ Control and Monitoring

- **Currently conducting small scale circuit testing**

Electrical Test Goals

- Characterize Each System's Electrical Performance
- Characteristics will be analyzed for the development of report
- Electrical measurements include power consumption analysis, efficiency of the system, harmonics and electrical emissions
- Fixture level testing includes power analysis at each fixture

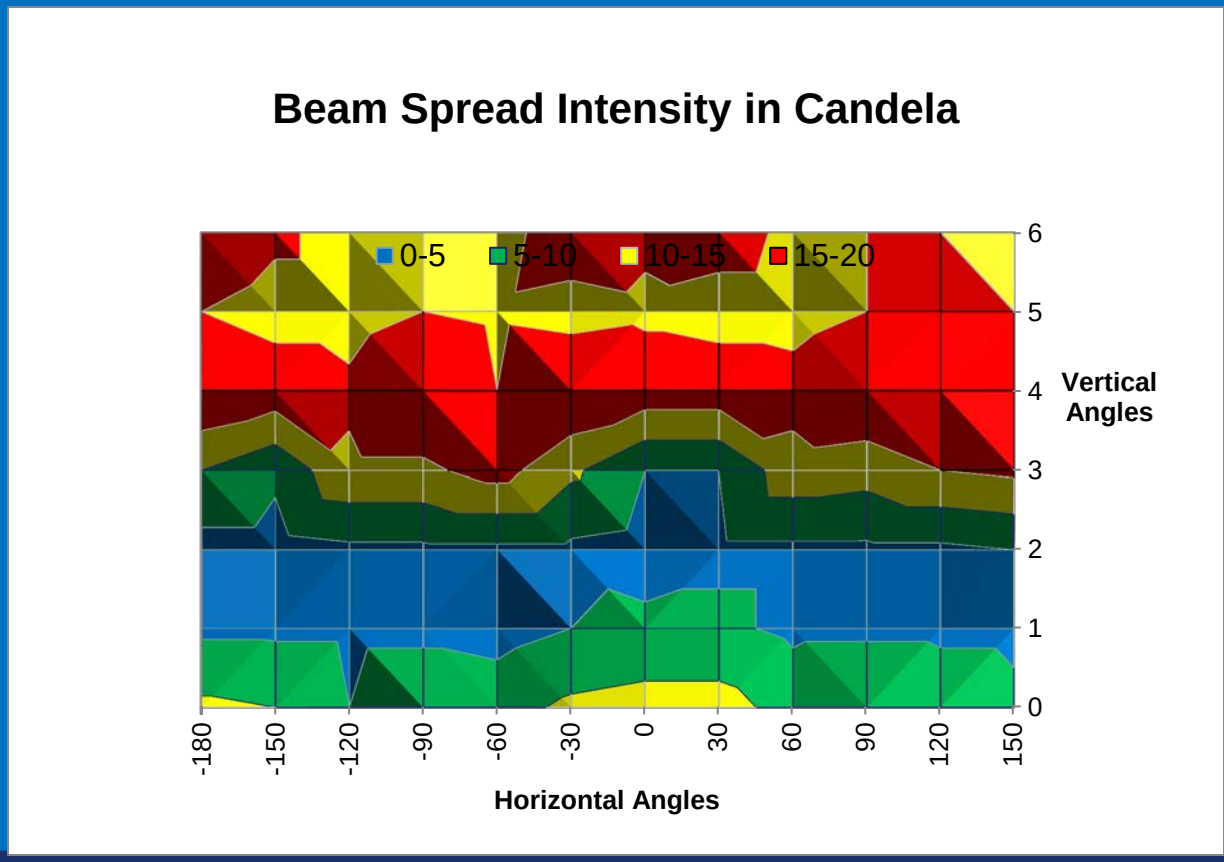
Electrical Test

- 50 Fixture test bed in reference circuit configuration
- Measurements collected at 5 different intensity levels

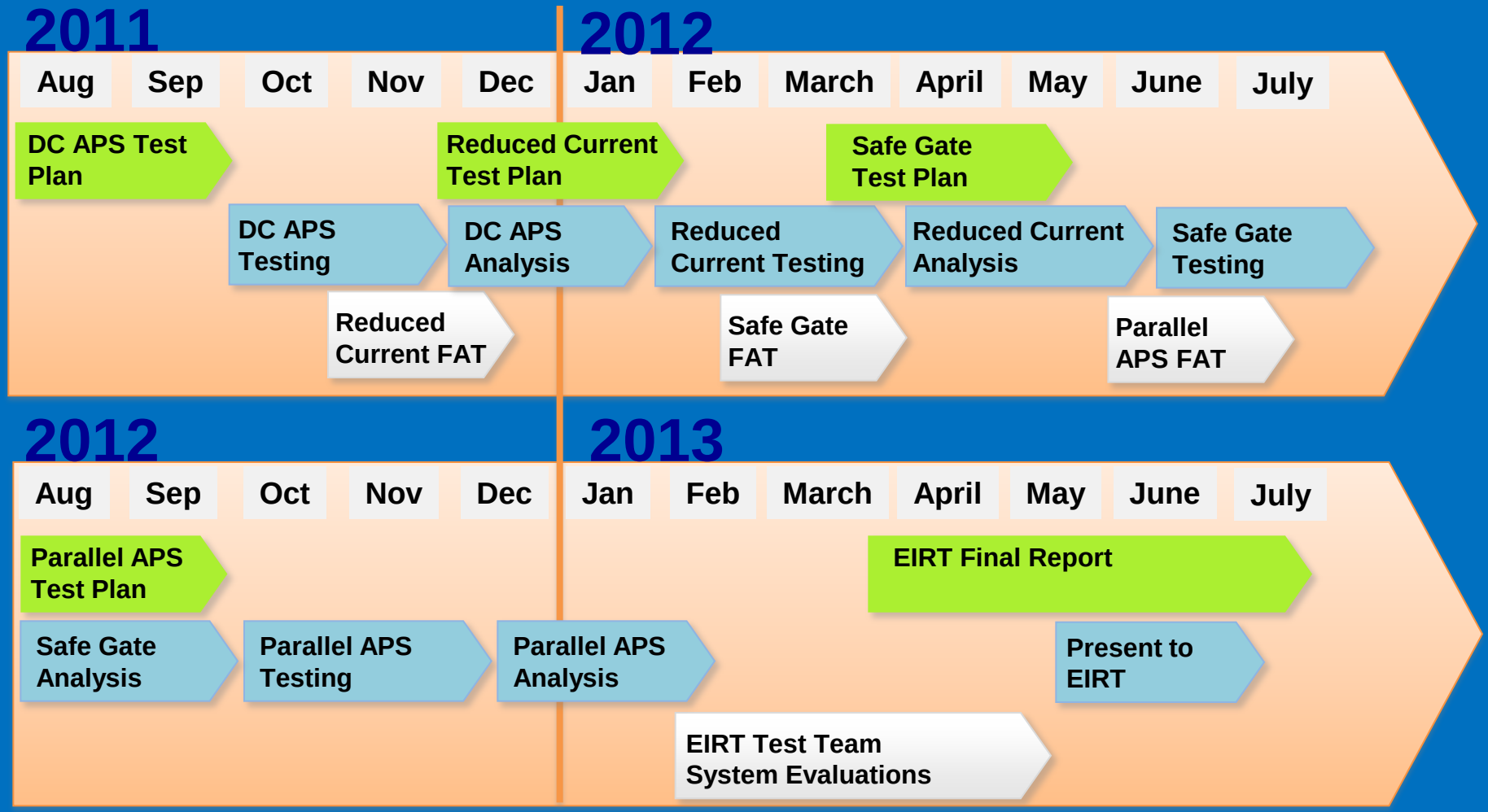
Photometric Test Goals

Measure the following photometric characteristics

- Beam Spread
- Intensity
- Dimming
- Chromaticity



Going Forward



Vertical Flight

- Conducting photometric tests on products being sold as heliport perimeter lights.
  - Intensity
  - Beam spread
  - Chromaticity
- Completed flight test
  - To determine if a suitable candidate exists at ACY and through CGAR in Grand Forks North Dakota.

Findings

Vertical / Horizontal	Intensity
>1° - 15° / 360°	10 Candelas Min
>15° - 90° / 360°	5 Candelas Min

The measured minimum may be no more than three times the specified minimum intensity.

- **Follow-on research to the perimeter lighting study is being conducted with the support of University of North Dakota Aerospace.**

Research Objectives:

Do the pilots need to have both FATO and TLOF lights?

If not, do they prefer FATO or TLOF?

How much can we reduce the number of lights and still satisfy the two-mile operational requirement?

Is there a benefit to toggling the lights in respect to acquisition distance and confidence?

Standards for Internally Lighted Wind cone

- AC 150/5345-27D, FAA Specification for Wind Cone Assemblies, dated 06/02/04, contains a specification for wind cone assemblies used to provide wind information to pilots.

  - The AC covers two types of wind cones, L-806 and L-807. In this AC, the internally-lighted windsock applies only to the L-807.

  - However, manufacturers and airports have also installed internally-lighted L-806 wind cones. FAA is concerned that the internally-lighted L-806 wind cone may pose a safety hazard by presenting confusing information to pilots.

Standards for Internally Lighted Wind cone

1. Review the current FAA standards for wind cones. Considerations should include, but not be limited to:

   Fixture design, light intensities, color, configuration, power, consumption, advances in lighting technology, compatibility with other FAA lighting standards, compatibility with current international standards.

2. Evaluate current commercially available internally-lighted wind cones to ensure they provide adequate wind direction and speed information under low velocity wind conditions.

Wind Cone Evaluation History

- **DOT/FAA/CT-TN/85/4 “Evaluation of an Internally Lighted Wind Cone”, 1985, where pilots were asked to compare the standard externally lighted wind cone to the smaller internally lighted wind cone.**

- **DOT/FAA/CT-TN89/45 “Evaluation of an Updated Design of an Internally Lighted Wind Cone”, 1989, where pilots were asked to compare the standard externally lighted wind cone to the smaller internally lighted wind cone at low wind velocities below 10 knots.**

Wind Cone Literature Review

- A literature review was conducted to compare the current FAA standards for wind cones to international standards.

FAA and ICAO Certified Internally Lighted L-807 12’ Wind Cone

FAA Certified Externally Lighted L-806 8’ Supplemental Wind Cone

Uncertified Internally Lighted L-806 8’ Supplemental Wind Cone

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Wind Cone Literature Review

- ICAO and Transport Canada do not recommend a wind cone with an 8 foot long sock.

Wind Cone Sock Extension			
Wind Speeds	15 knots	10 knots	5 knots
FAA Requirement	full extension	not defined	not defined
Transport Canada Requirement	full extension	no more than 5^{o} below the horizontal	no more than 30^{o} below the horizontal

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Controlled Testing

- A series of test were conducted on several commercially available internally lighted wind cones to determine how the products measure up to both FAA and International standards for wind cone movement and wind cone sock extension.

12 Foot Wind Cone Sock Extension Test						
Wind Speeds	0 knots	3 knots	5 knots	10 knots	15 knots	20 knots
FAA	not defined	not defined	not defined	not defined	full extension	full extension
Transport Canada	not defined	not defined	no more than 30º below the horizontal	no more than 5º below the horizontal	full extension	full extension
Test Photos						

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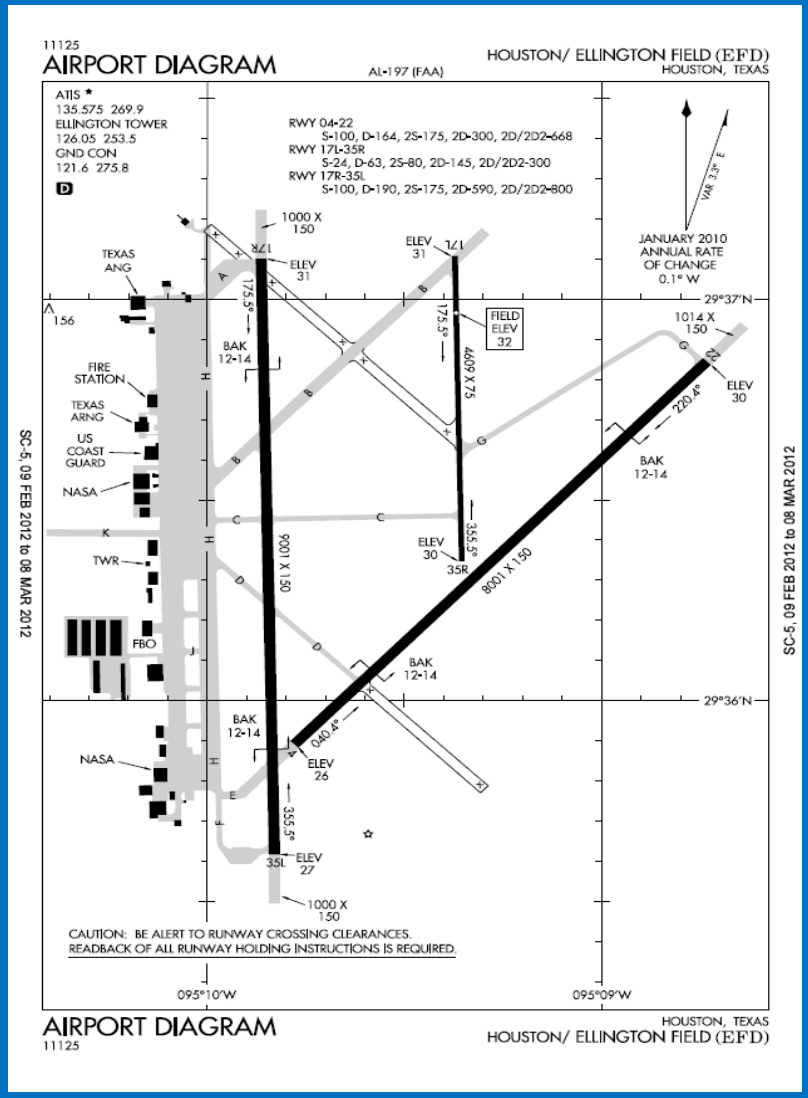
Flight Evaluations

- Agreement reached with Ellington International Airport and their local flight schools Aerosim Flight Academy and Flying Tigers.
- Installed at Ellington International Airport are both 12 foot internally lighted wind cones as well as 8 foot internally lighted wind cones.
- Instructors and trainees will complete questionnaires to evaluate if the 8 foot internally lighted wind cone and the 12 foot internally light wind cone both give an adequate indication of the reported wind speed and wind direction conditions.



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Schedule

Literature Review	Completed 08/2011
Movement Test	Completed 10/12/2011
Extension Test	Completed 10/14/2011
Flight Test Site Visit	Completed 2/29/2012
Flight Testing	3/12/2012 - 5/1/2012
Final Report	06/04/2012

Evaluation of Light Emitting Diode (LED) Airport Pavement Linear Source Visual Aid

1. Determine if a linear light source can provide significant advantages versus a point source as a visual aid.

2. If it is determined that a linear source has advantages, determine what applications would benefit from this source.

3. Evaluate LED Linear light source applications through field tests.

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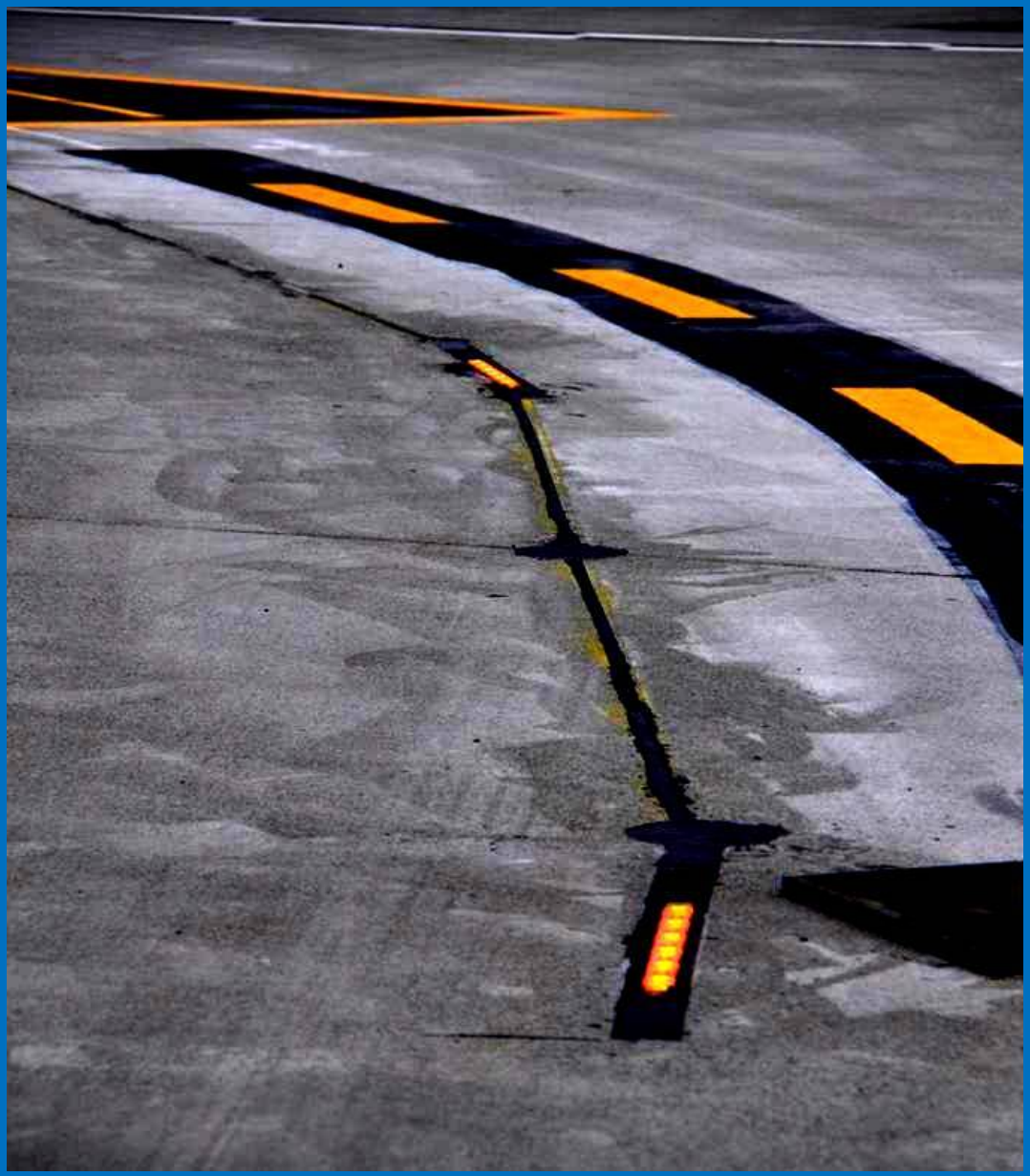

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Evaluation of Light Emitting Diode (LED) Airport Pavement Linear Source Visual Aid

- **PHASE ONE**

- **Perform a search of LED linear source products available that could be considered for outdoor application on airports.**

  If products are found that are installed in an outdoor setting or airport location, conduct site visits and interview custodians of these installations to capture their opinions of the effectiveness, reliability, as well as, installation and operational costs of that application.

Evaluation of Light Emitting Diode (LED) Airport Pavement Linear Source Visual Aid

- **PHASE TWO**

Identify applications that can benefit from a linear light source compared to an array of point sources for optimum conspicuity for movement and non-movement areas. These applications can be:

Taxiway guidance (In-pavement taxiway edge lines), Illuminated in-pavement signs or symbols, Illumination at Taxiway/runway intersections for increased conspicuity, Lead-in line to gates, Visual guidance at de-icing or other facilities.

Evaluation of Light Emitting Diode (LED) Airport Pavement Linear Source Visual Aid

- **PHASE TWO**

- **Conduct analysis based on technology capabilities and human vision and identify up to two most promising applications to further study in a laboratory experiment. The analysis will include appropriate colors, optimum length of sources, light level modulation and spacing.**

Conduct a laboratory study for the application(s) selected above to determine if a linear source has advantages in providing visual signal to the user compared to an array of point sources. Identify the key parameters for optimizing this application.

Evaluation of Light Emitting Diode (LED) Airport Pavement Linear Source Visual Aid

- **PHASE THREE**

Conduct a field evaluation for the most promising application for the linear light source found in Phase Two, which demonstrate the potential to provide a substantially improved visual cue. The field evaluation will be used to validate the linear source laboratory findings and determine the installation's robustness in airfield conditions.

Develop a photometric equivalence between standard FAA point source lighting and a linear LED lighting source. The methodology for measuring the intensity will also be developed.

Evaluation of Light Emitting Diode (LED) Airport Pavement Linear Source Visual Aid

Activity	Completion
Test Plan	02/28/12
Phase 1	06/30/12
Analysis/Decision Point	07/31/12
Phase 2	11/30/12
Analysis/Decision Point	12/31/12
Phase 3	03/31/13
Final Report to Sponsor	05/31/13

Color Boundaries for Non-Incandescent light sources

Canada	Germany	USA
Adopt existing CIE S004-2001 for all colors. Already established international standard. No need to produce additional figure in Annex 14.	<u>GREEN:</u> White y = 0.600 Yellow x = 0.360 – 0.080y Blue y = 0.760 – 0.725x White boundary: If we consider that the color point of new cool white high power LEDs are placed around the upper green boundary of the white area, the new green area must be moved up to the green which is achieved by a boundary of y > 0.6. Yellow boundary: Existing ICAO boundary. Blue boundary: To provide clear physiological separation of green to blue a min. distance should be 30 nm. Which creates a new borderline start at 510nm and continues parallel to the existing boundary between the bluish and yellowish green.	<u>GREEN:</u> Modified Germany proposal for Green. White boundary: y = 0.600 Yellow boundary: y = 3.47 - 9.200x Blue boundary: y = 0.768 - 1.306x <u>YELLOW:</u> Adopt CIE S 0004/E-2001 yellow region is proposed. <u>RED:</u> Adopt restricted red region recommended by CIE S 004/E-2001 (2001), which excludes the long-wavelength chromaticity region. <u>BLUE:</u> Stay with current ICAO Annex 14 blue region.

Color Boundaries for Non-Incandescent light sources

FAA Proposal:

RED same as CIE Class A1 restricted region.

Yellow same as CIE.

Blue same as ICAO.

Green Modified proposal from Germany.

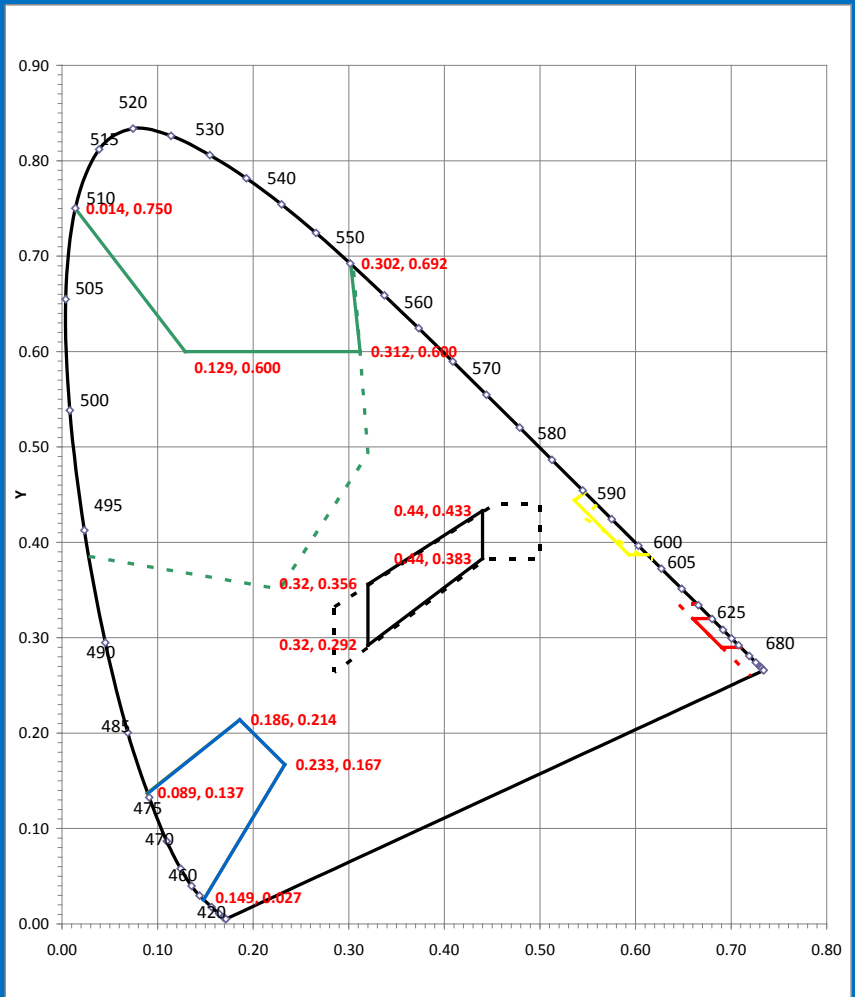

Figure. ICAO Aeronautical Colors for IncandescentGround Light (dotted line) with FAA Non-Incandescent Aviation Colors (solid line) overlay

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Questions?