FAA Visual Guidance Research & Development Update

Illuminating Engineering Society's Aviation Lighting Committee's

Government Contact's Sub-committee meeting

April 17, 2013

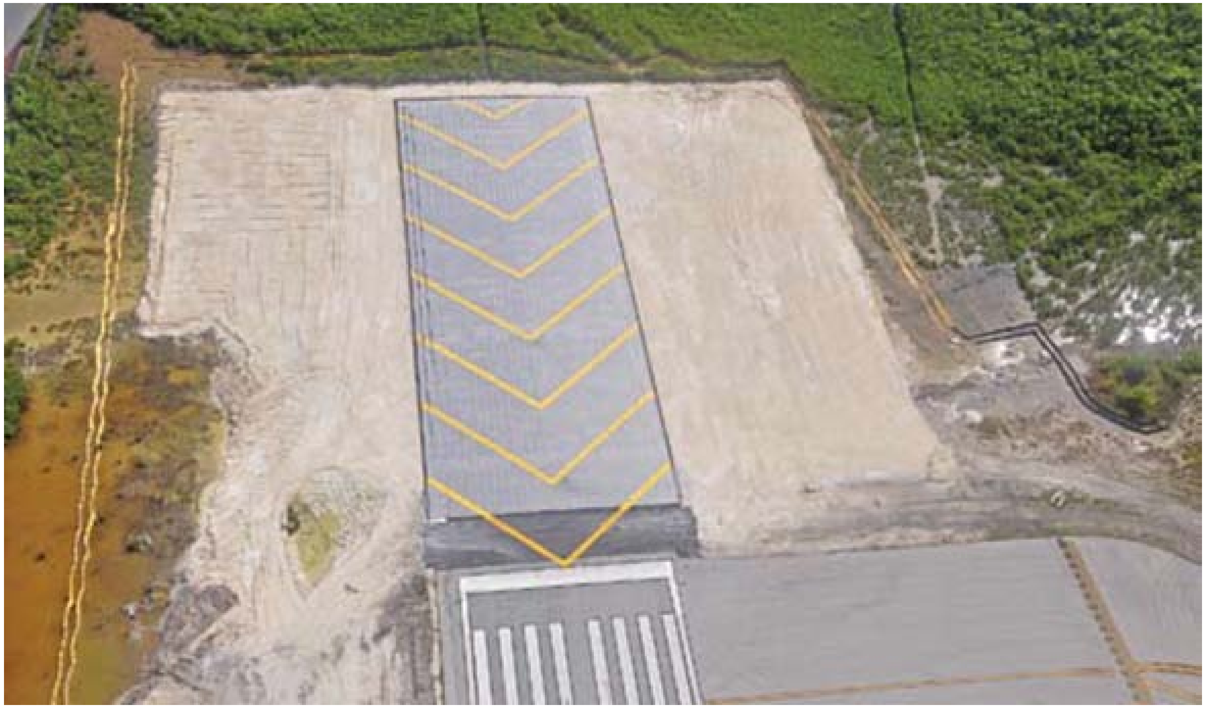
Presented by: Robert Booker

Visual Guidance/Runway Incursion Prevention Projects

- Engineering Materials Arresting System (EMAS) Visual Cues
- Heliport Lighting Research
- Internally Lighted Wind Cone Study
- Method to determine end-of life for LED fixtures
- Electrical Infrastructure Research Team
- Evaluation of Airport Pavement Linear Source Visual Aid

EMAS Visual Cues
Project Description

- Determine if additional EMAS visual cues are required for pilot and ground vehicle drivers awareness to aid in preventing inadvertent vehicle and aircraft entry



EMAS Marking/Signage

- EMAS Installed at 63 runway ends at 42 airports
- Marked with yellow chevrons - No other unique markings
- Some airports have used signs and retro-reflective markers

Evaluations

- Retro-reflective markers
  - Red around sides and back, Yellow in front – spaced 15', 10', 7.5', and 5'

- Signs
  - Stand alone vs. Co-located

Stand alone

Co-located

Testing Results

- Retro-reflective Markers
  - RED sides and back, YELLOW front, 7.5' adequate spacing
  - Markers are visible

Testing Results

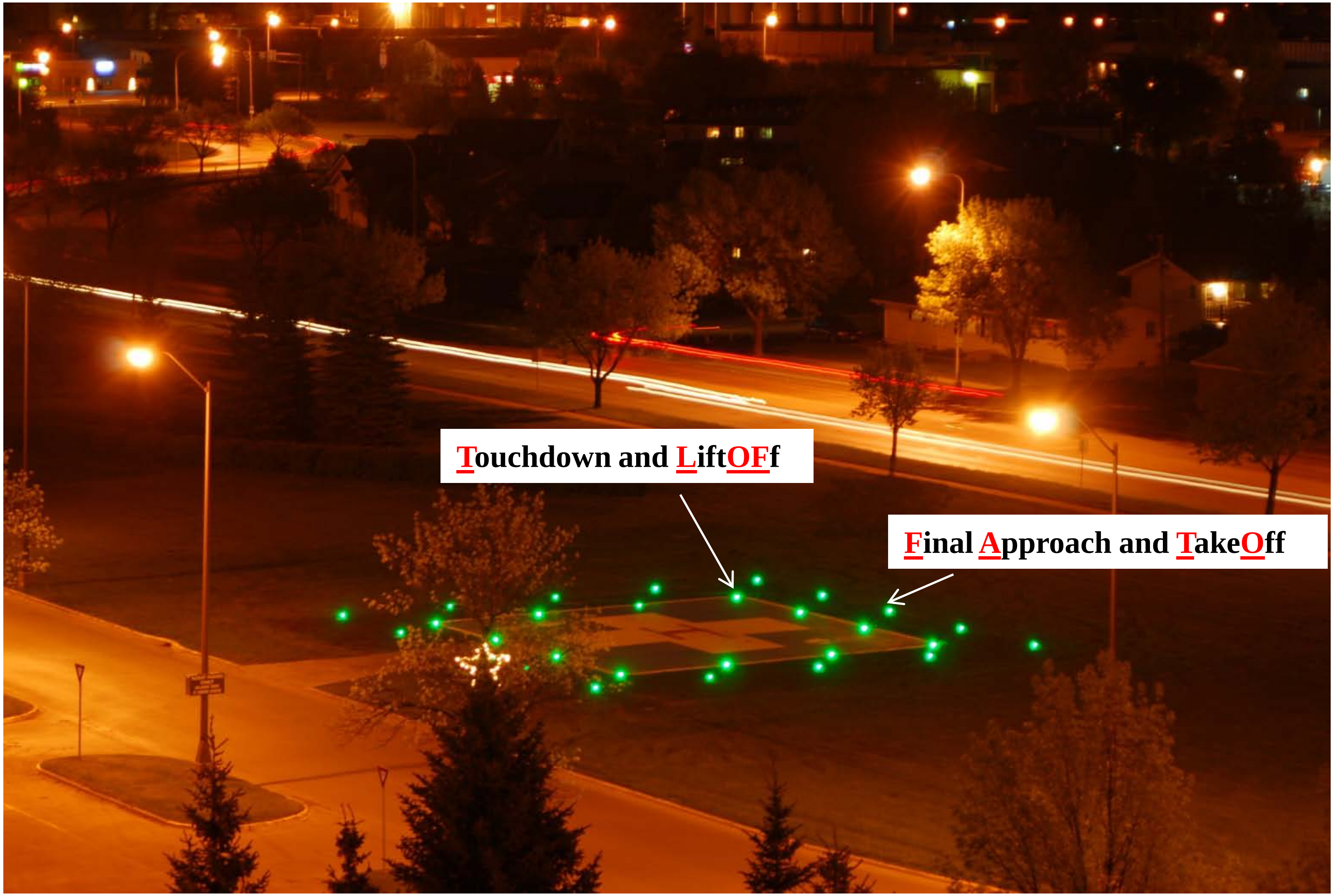
- Signs
  - Stand alone preferred vs. Co-located
  - Located 500’ from the end of runway (both sides)
- Final Report to be published Summer 2013

Heliport Lighting Research

- **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, which one is needed 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?**


Touchdown and LiftOFf
Final Approach and TakeOff

Research Data

- 912 Total Data Points
  - Only configuration that did not meet 2 mile minimum: TLOF Four corners lit, no FATO: 1.39 miles
- Max distance result:
  - Pulsing, both rows fully lit: 2.71 miles however having a visual cue appear to be moving during hovering and landing may negate the benefit.

Internally Lighted Wind Cone Study

Standards for Internally Lighted Wind cone

- Review the current FAA standards for wind cones.

- 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 Literature Review

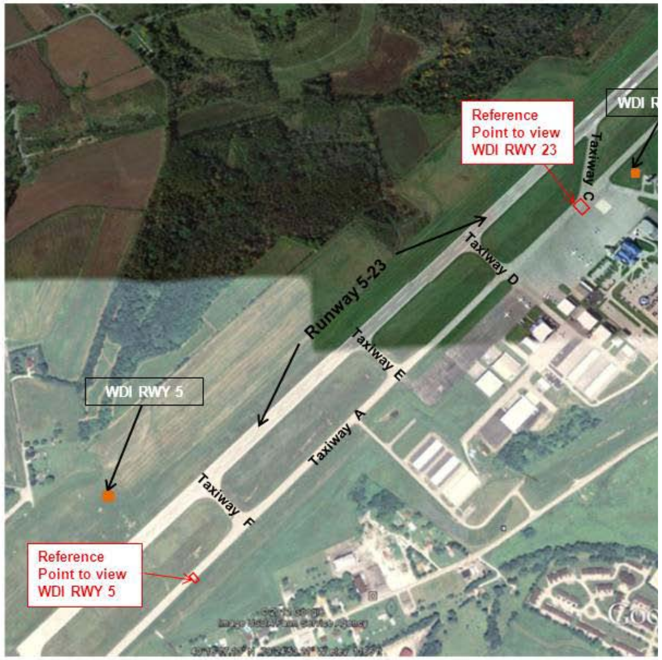
- A literature review was conducted to compare the current FAA standards for wind cones to international standards.

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

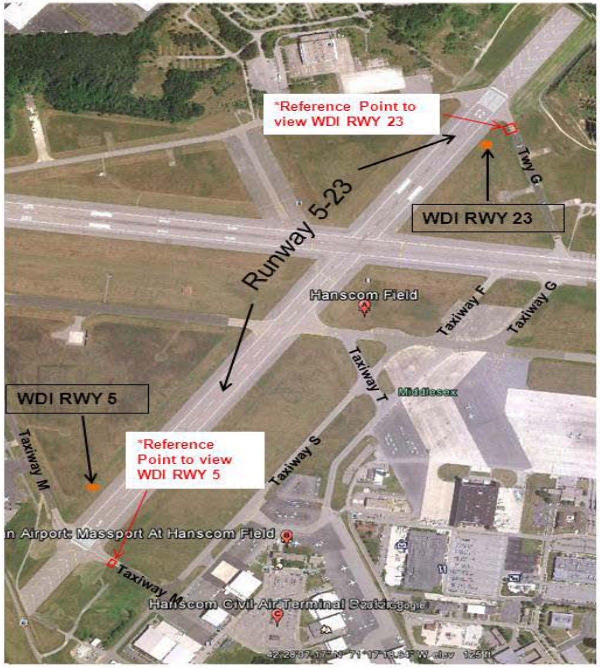
FAA Certified Externally Lighted L-806 8’ Supplemental Wind Cone

Uncertified Internally Lighted L-806 8’ Supplemental Wind Cone

Field Evaluations



Arnold Palmer Regional Airport (LBE)



L.G. Hanscom Field Airport (BED)

Results

- **117 questionnaires were completed**
- **57% indicated that the 8 foot internally lighted wind cone provided an accurate indication of the current wind conditions**

Method to determine end-of life for LED fixtures

- One of the challenges of using Light Emitting Diode (LED) technology is the time at which the light sources need replacement.
- A typical incandescent fixture (lamp containing a filament) lasts approximately 2,000 hours.
- LED fixture (LEDs and electronics) are claiming 50,000 hours or more.
- The two items that have a direct influence on end-of-life are maintaining required:
  - Light output
  - Chromaticity (Color)

Method to determine end-of life for LED fixtures

Light Output

- Unlike, traditional light sources, the light output of LEDs may degrade over time and depreciate below the minimum light level needed for the application.
- Incandescent sources degrade however they burn out before much loss of light occurs.
- Since the LED light source may not completely cease to produce light the maintenance crew may not know when to change the light sources.

Method to determine end-of life for LED fixtures

- The lighting industry has established a light output depreciation limit of 30% passed which the light is no longer producing the required light output and is considered failed.
- An objective of this part of the research is to investigate the change in electrical parameters of an LED as a function of time and as it degrades.
- By detecting these changes a method can be developed that can be used for signaling end-of-life.

Method to determine end-of life for LED fixtures

Chromaticity

- A secondary part of this research is the color shift that occurs over time.
- Incandescent sources at maximum intensity have minimal color shifting during their useful life, however there is a large shift when they are dimmed. White runway lights appear Yellow when at lower intensity steps.
- LED sources have minimal color shifting when they are dimmed however due in part to their longer life they have a color shift over time.
- While the LED color shift is not as dramatic to the human eye as with an incandescent source, it in part, factors into end-of-life.

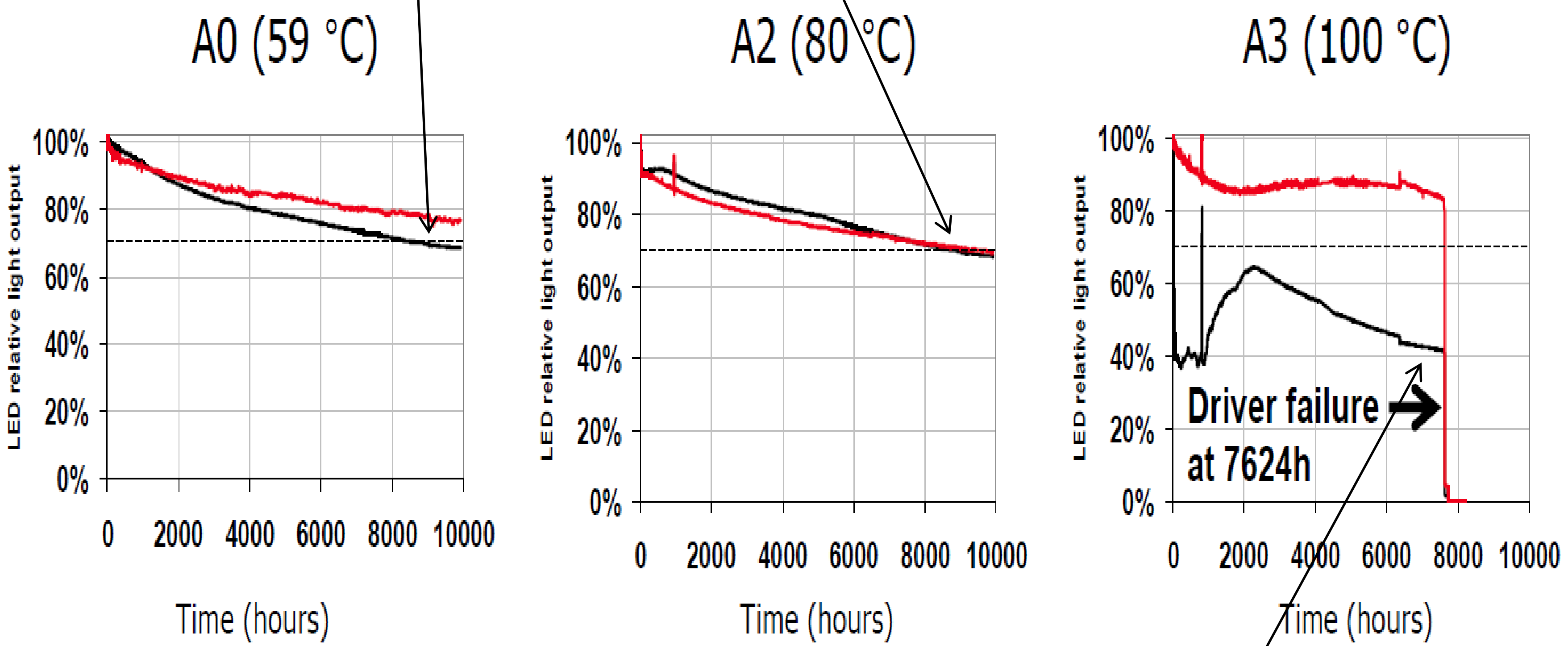
Method to determine end-of life for LED fixtures

A series of laboratory experiments are being conducted using certified LED airport lighting fixtures.

Fixtures Tested:

- **3 Runway centerline lights one direction white, one direction red:**
  - **A0 at 59° C (138.2° F), A2 at 80° C (176° F), A3 at 100° C (212° F)**
- **3 Touchdown Zone lights white:**
  - **B1 at 55° C (131° F), B2 at 80° C, B3 at 100° C**
- **The study was ended after 10,404 hours of testing have elapsed.**

White runway centerline LEDs of samples A0 and A2 and the red side of sample A2, (before failure at 9,926 hours) have passed the 30% depreciation mark, which is considered the benchmark to define end of life.



A3 failed at 7,624 hours

Plots of light output maintenance

B1 the only Touchdown Zone remaining has depreciated 7%

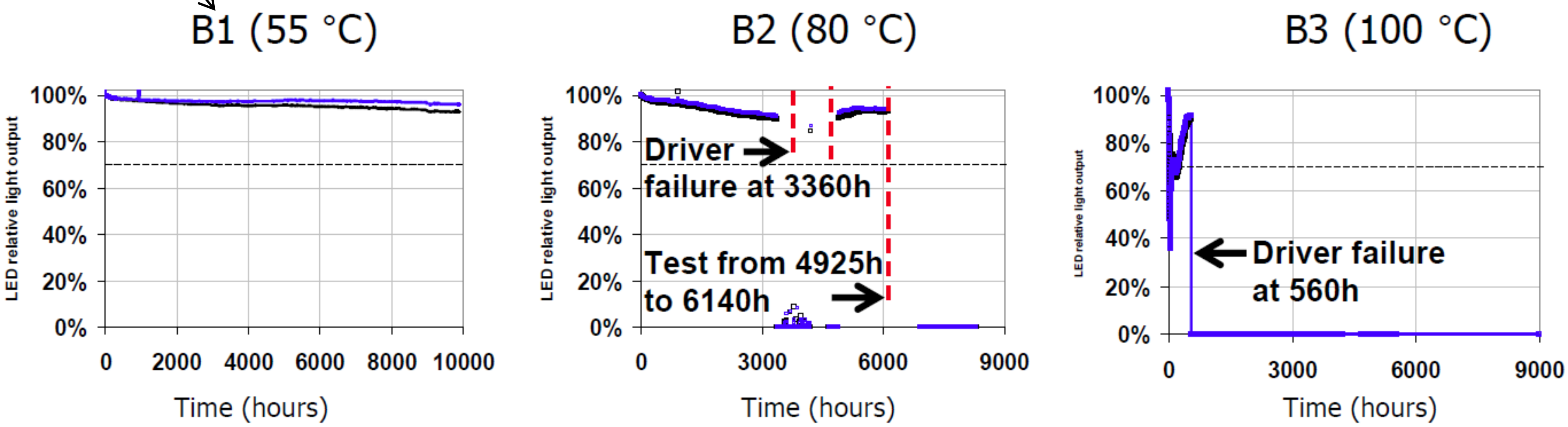


Figure 3 Plots of light output maintenance

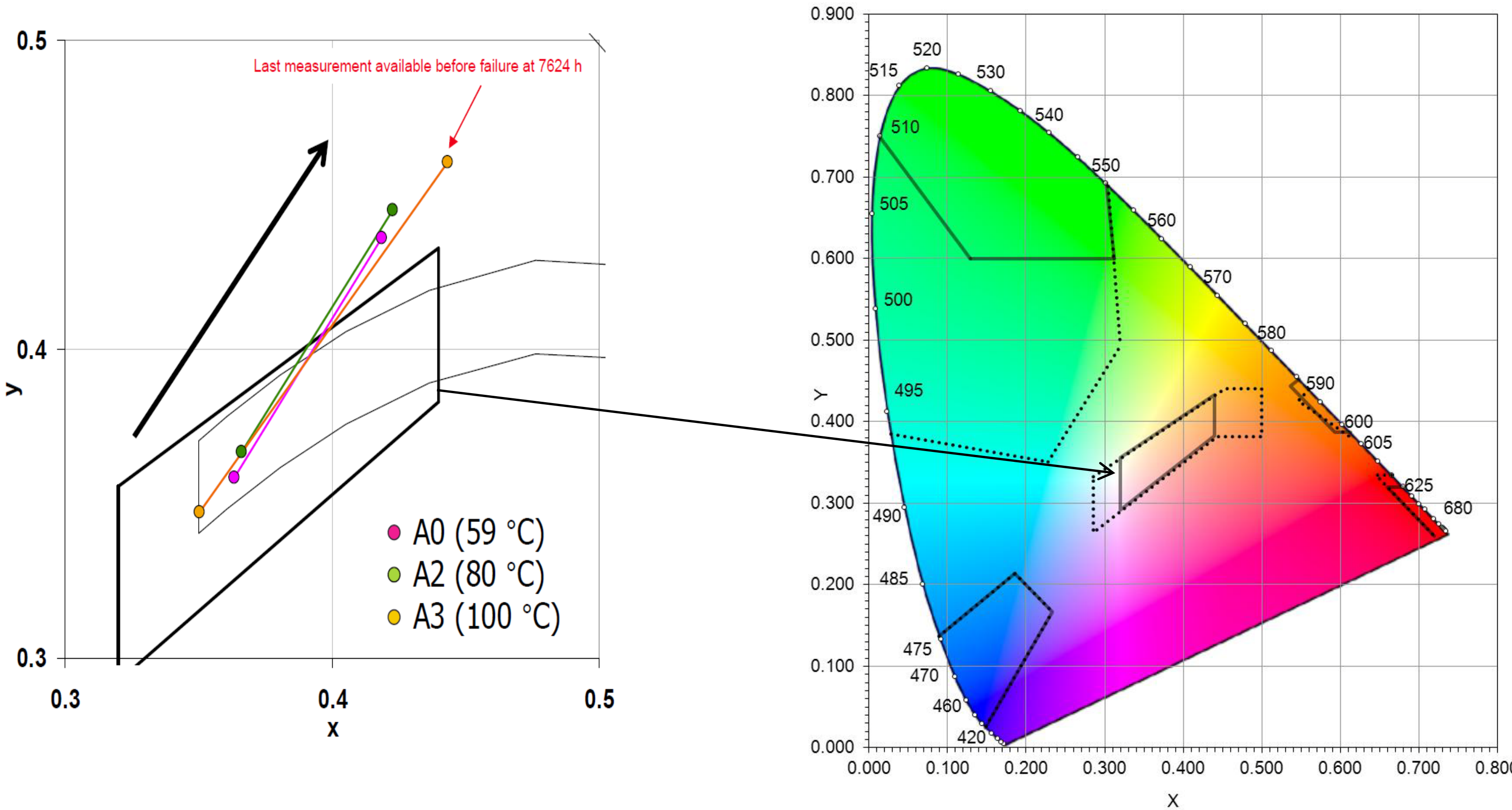


Figure. ICAO Aeronautical Colors for IncandescentGround Light (dotted line) with FAA Non-Incandescent Aviation Colors (solid line) overlay

Figure 4 Color shift

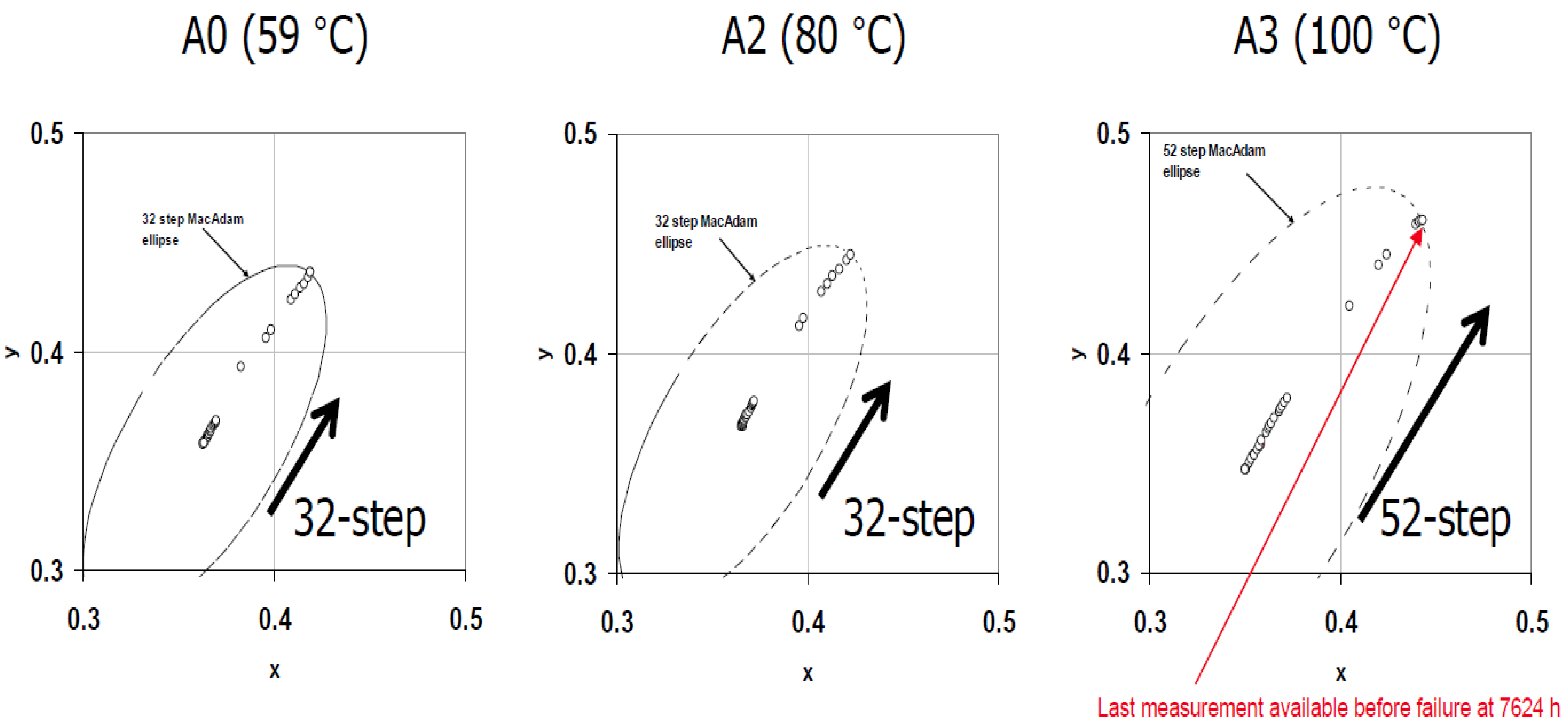


Figure 2 Color shift

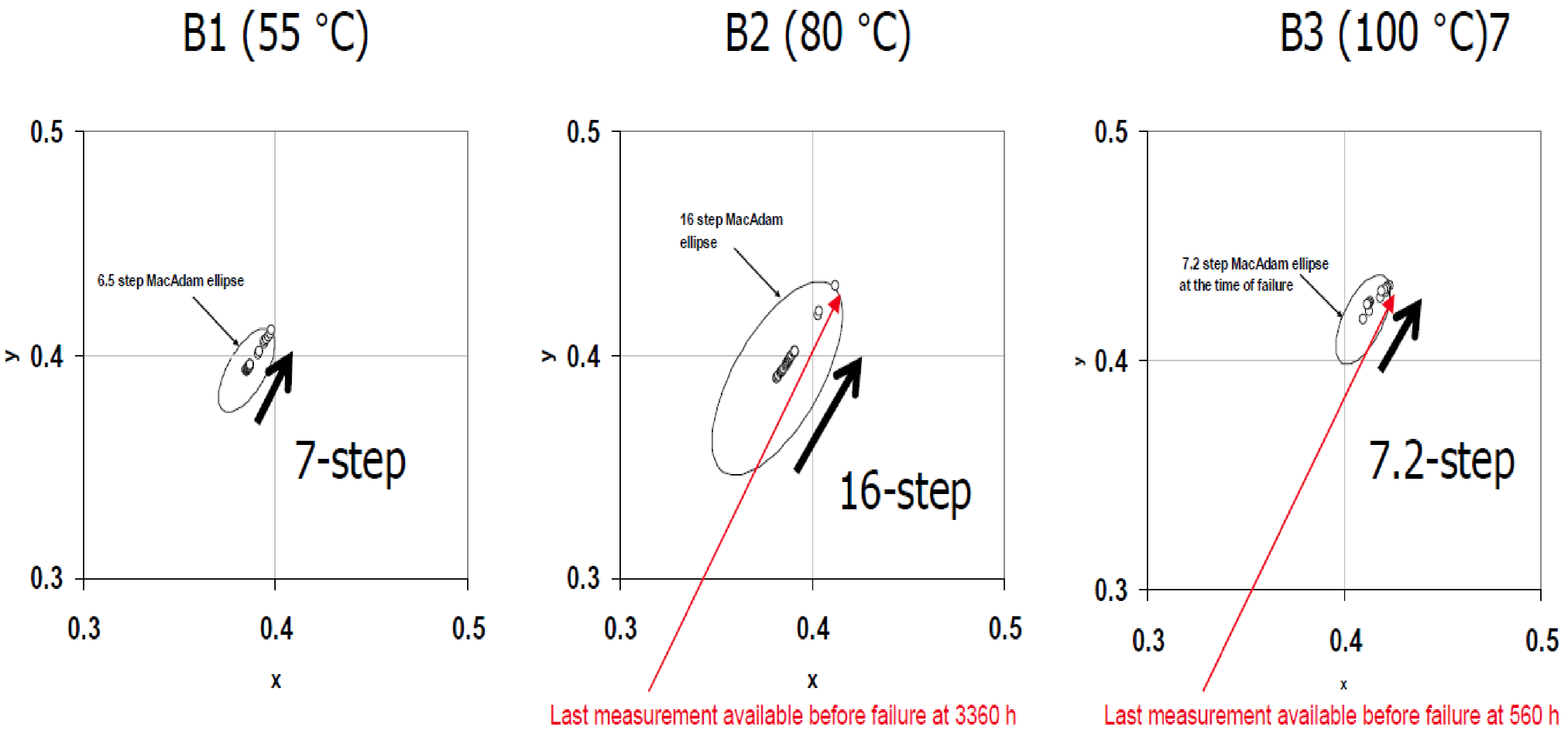


Figure 4 Color shift

Method to determine end-of life for LED fixtures

- Most of the fixtures tested failed before their "claimed" lifetime. The LEDs did not fail, however the drivers failed.
- The only fixture that did not fail was a touchdown zone light B1, it has a light output depreciation of 7%.
- B1 has a small color shift with a 7-step MacAdam ellipse. However, even with the small color shift, the chromaticity of sample B1 is now just outside the white color boundaries.

Next Step

- Additional fixtures will be tested
- Field testing at a number of airports will be conducted summer 2013
- Depending of results of field tests Final Report will be published by December 2013.

Electrical Infrastructure Research Team (EIRT)

- A team of FAA and Industry experts formed to design an Airport Lighting Infrastructure to take full advantage of new lighting technologies.

- Goals
  - A system that promotes interoperability.
  - Reduced life cycle cost without dependence upon a single source.
  - A standards-based, robust architecture airfield lighting system.

Electrical Infrastructure Research Team

- Circuits be tested:
  - 2 amp Bipolar Pulsing DC System – Completed 2011
  - Reduced Current System – Completed March 2012
  - Smart Fixture Low Current System – Completed June 2012
  - Parallel Smart Fixture System – Completed September 2012

Electrical Infrastructure Research Team

STATUS:

- **All testing completed**
- **Test results being compiled by test team.**
- **Results will be delivered to full EIRTS 4/15/13**

Next Step:

- **Based on decision of full team, Full scale field testing on selected system(s)**

Evaluation of 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.
- PHASE TWO
  - Conduct a laboratory study to determine if a linear source has advantages in providing visual signal to the user compared to an array of point sources.
  - The analysis will include appropriate colors, optimum length of sources, light level modulation and spacing. Identify the key parameters for optimizing this application.

Evaluation of Airport Pavement Linear Source Visual Aid

- **PHASE THREE**

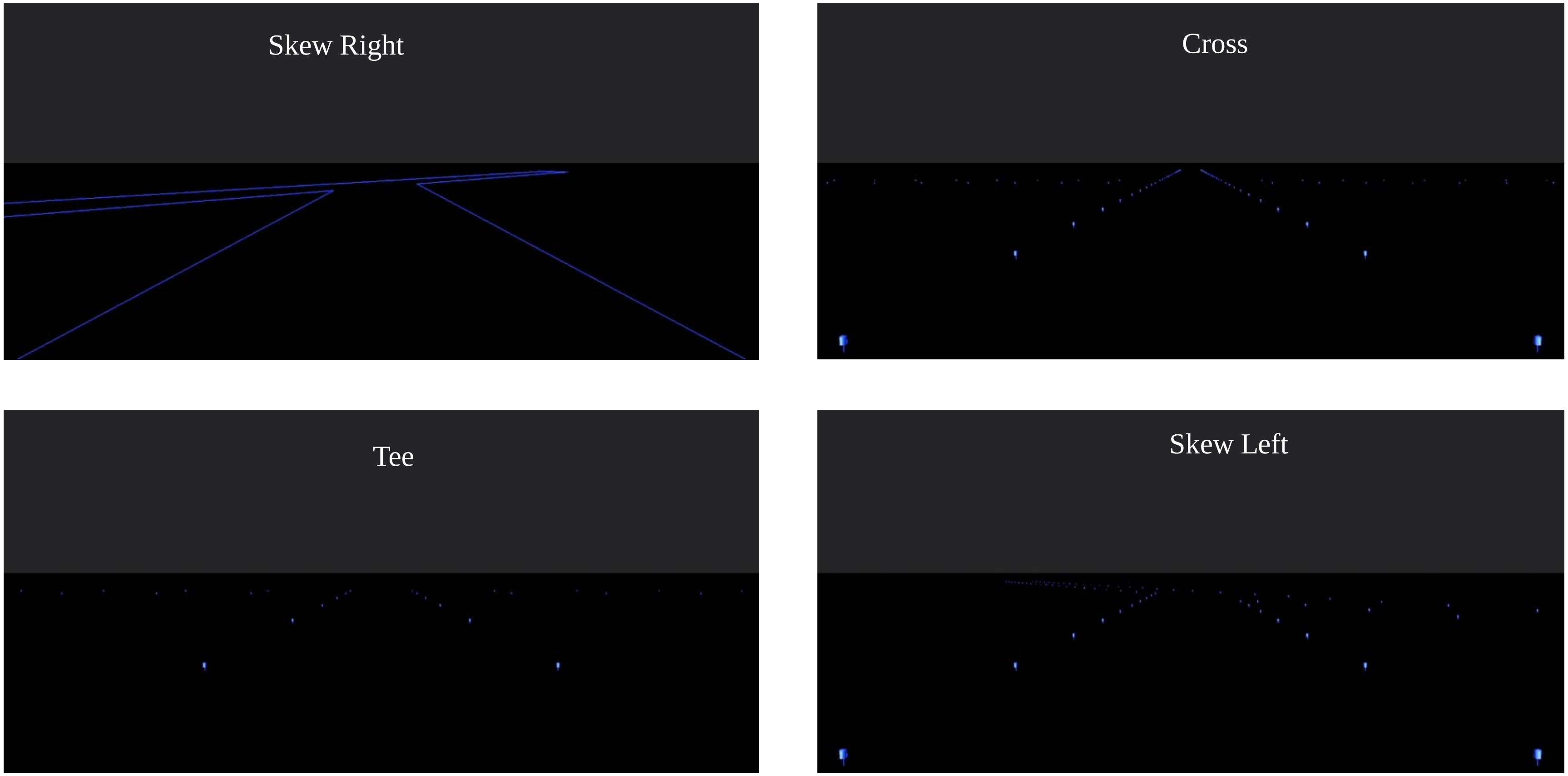
  - **Conduct a field evaluation for the most promising application for the linear light source found in Phase Two, which demonstrate the potential to provide a substantially improved visual cue. The field evaluation will be used to validate the linear source laboratory findings and determine the installation's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

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

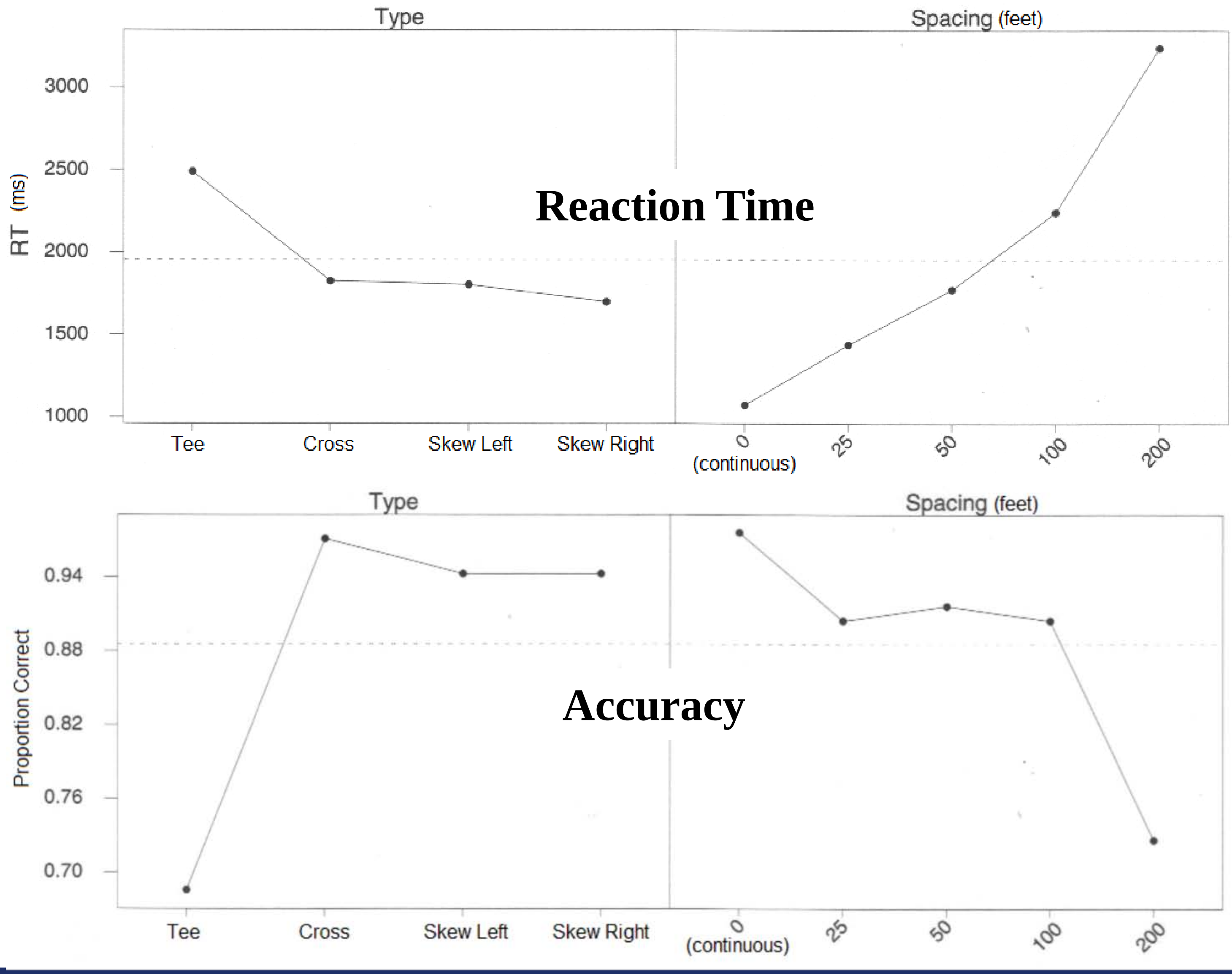
Experimental Method: Initial Study

- Initial conditions: Simulation of pilot view while approaching a taxiway intersection
- Spacing of point elements: 25, 50, 100, 200 ft
- Continuous linear elements also included
- Conditions presented in randomized order
- Initial experimental conditions consist of stimuli presented against a visually-simple, clear background
- Subjects requested to identify the configuration as quickly and accurately as possible
- Software records identification time and reported response for subsequent data analysis

Example Experimental Stimuli



Preliminary Experimental Results



Discussion of Preliminary Results

- For the conditions investigated (visually "simple" backgrounds with no clutter, and four representative taxiway intersection configurations):

  - Spacing and apparent continuity of edge information may influence the speed and accuracy of identifying intersection types

  - Accuracy of identification appears to be largely constant between spacing's of 25 and 100 ft.

  - Identification of tee intersections was more difficult (especially with longest spacing)

  - Length of source less then 8 feet provides no visual advantage at 50 foot or greater spacing.

Evaluation of Airport Pavement Linear Source Visual Aid

Activity	Completion
Test Plan	02/28/12
Phase 1	**09/30/12**
Analysis/Decision Point	**10/31/12**
Phase 2	**02/15/13**
Analysis/Decision Point	**02/27/13**
Extended Phase 2	06/30/13
Phase 3	08/31/13
Final Report to Sponsor	09/30/13

Discussion of Next Steps

- Identification of configurations under moving conditions
  - Develop a simulation module for displaying delineation configurations differing in spacing and length, and viewed dynamically at the range of speeds previously identified
  - Modify experimental apparatus to allow measurement of visual acquisition times under dynamic viewing conditions corresponding to the appropriate range of speeds
  - Formulate protocols for scale model and subsequent field study evaluations to identify the photometric characteristics of delineation elements that support visual acquisition under an appropriate range of ambient and taxiway-speed conditions

Questions or Comments?

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