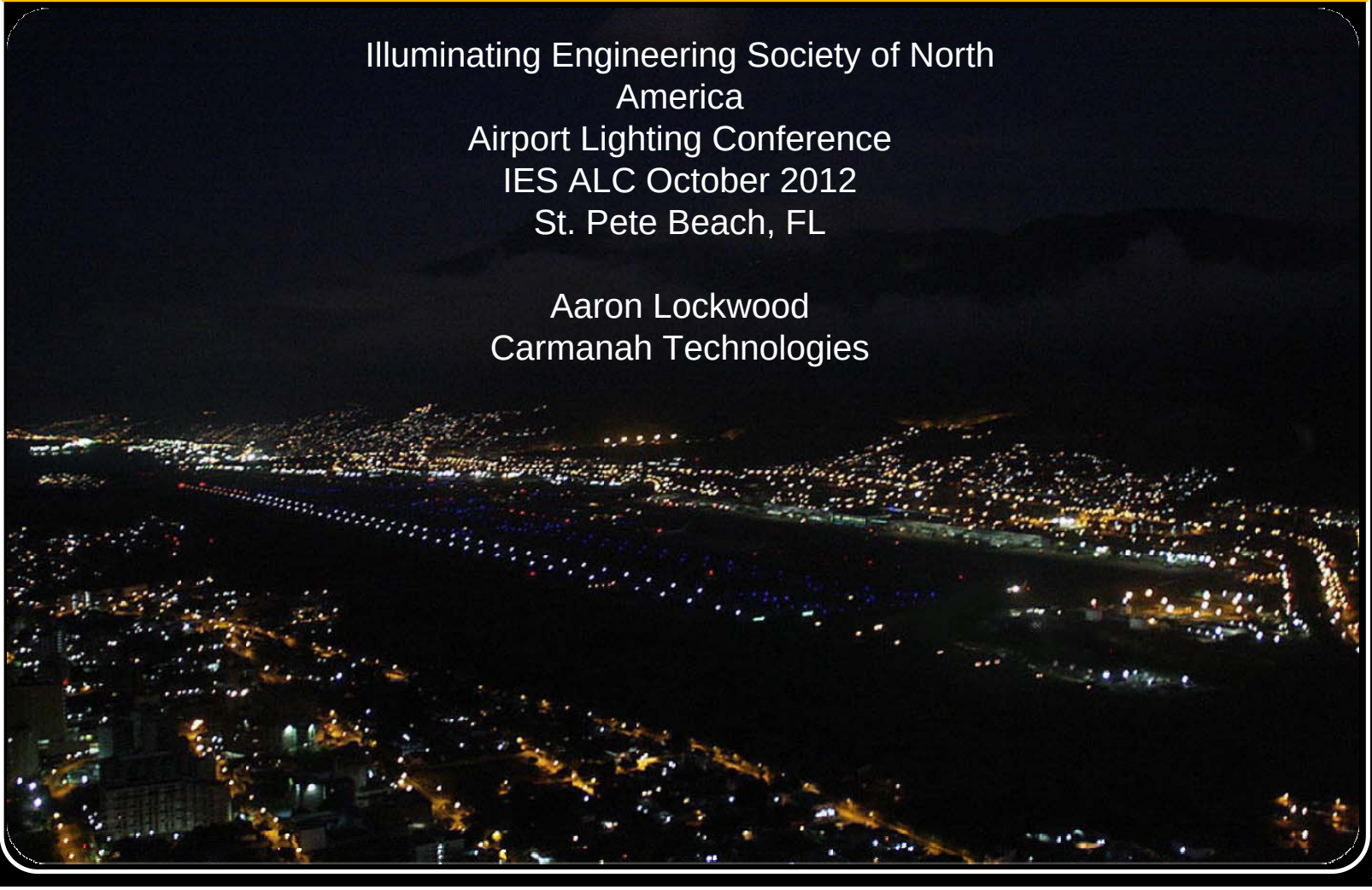
Powering LED PAPIs with Solar



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Airport Lighting Conference
IES ALC October 2012
St. Pete Beach, FL

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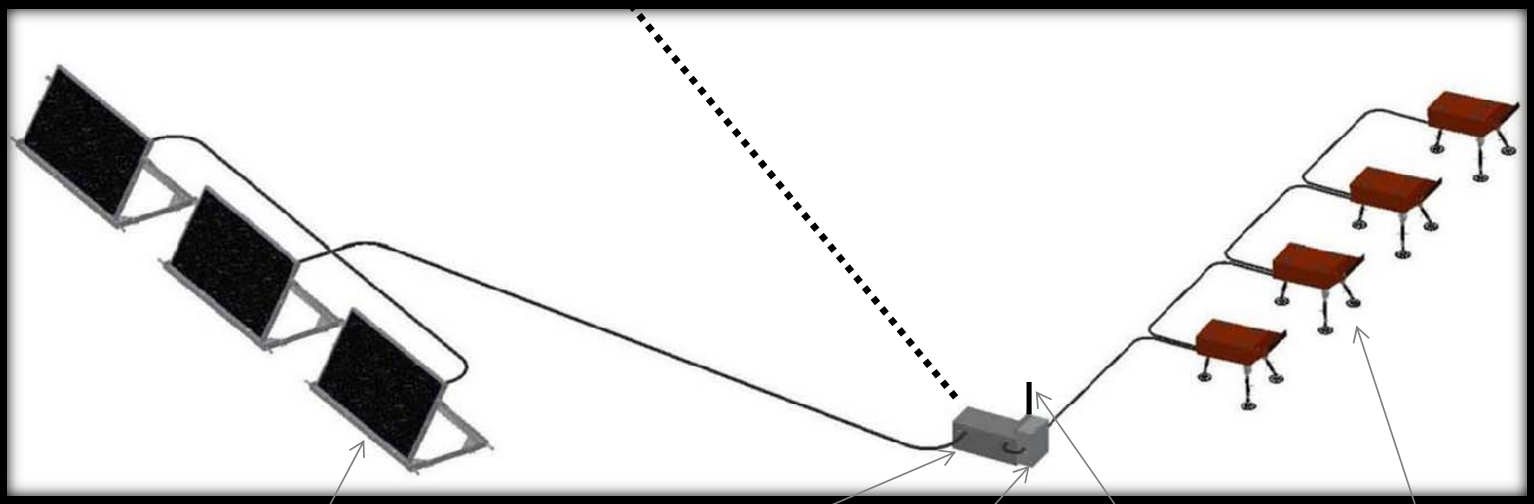
Carmanah Technologies

What is a solar PAPI?



Can solar be robust?

There are 3 keys to making a solar PAPI reliable and still cost efficient:

#1 Efficient design

#2 Location, location, location!

#3 Minimize usage

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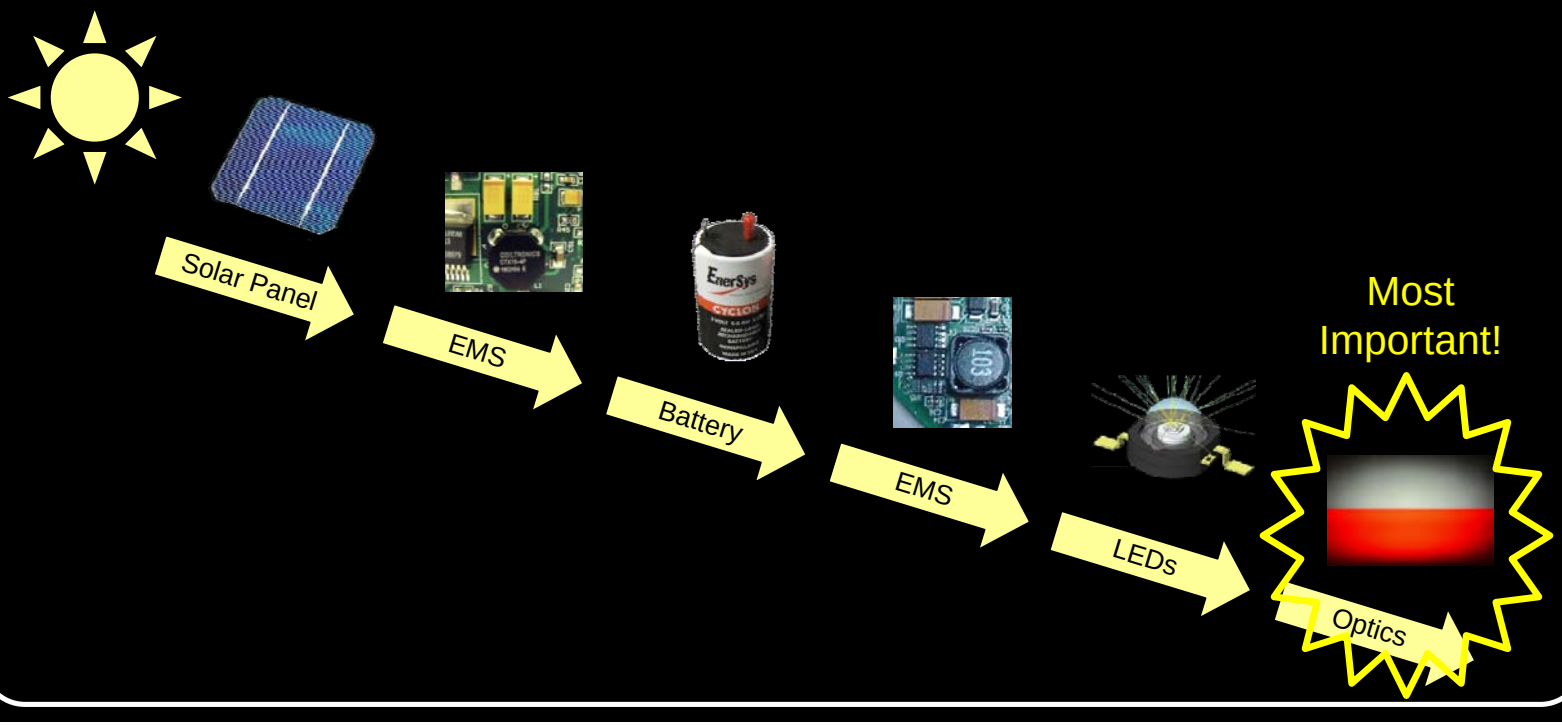
#1 Efficient Design

Solar products are a series of components, each with their own efficiencies



LED vs. Halogen

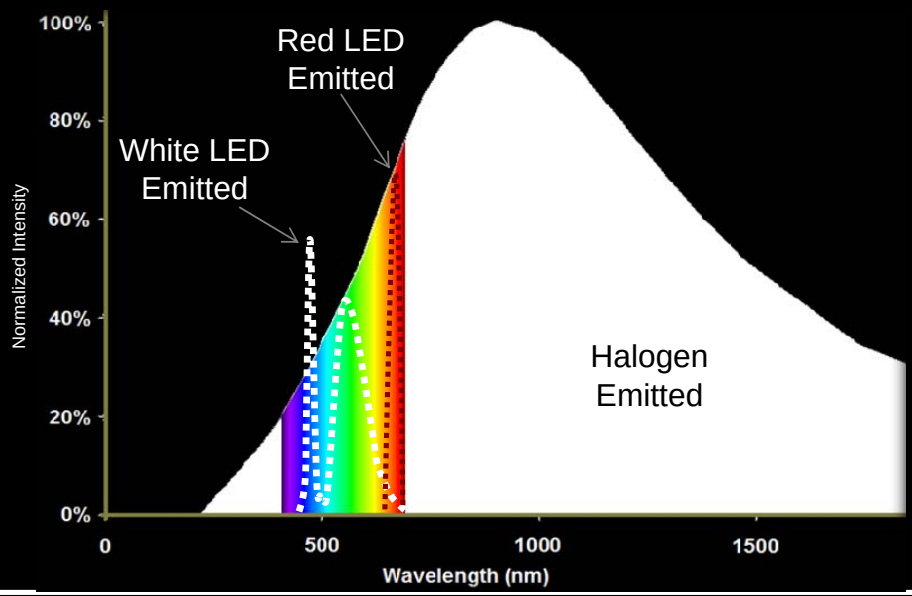
Much prior work on LED vs. halogen and incandescent fixtures:

- “White Runway LEDs on Airfields” – Runyon, IESALC 2011
- “Brightness/Luminous Intensity…LEDs” – Bullough et al., 2006
- “Optimizing the Performance…LEDs” – Skinner et al., IESALC 2011
- “Elevated Runway Guard Lights” – Williams, 2009
- “LED Trial at Manchester Airport” – Dunn et al., 2011
- IESALC 2012

LED vs. Halogen PAPI

How are the colors generated?

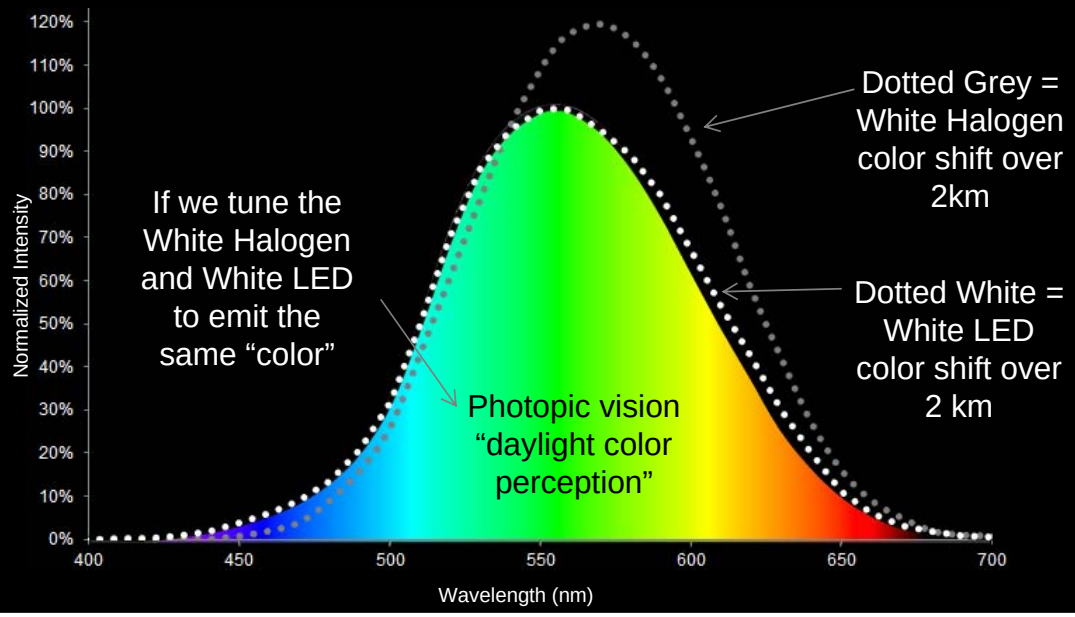
- Halogens emit many wavelengths
- Red LEDs are a very saturated color
- White LEDs emit a range of wavelengths



LED vs. Halogen PAPI

Colors are affected by atmosphere

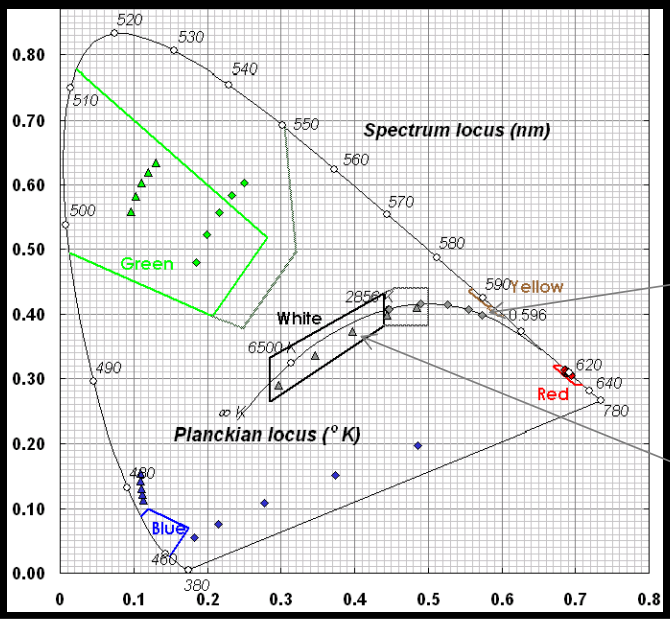
- "Spectral Absorption Over Distances" – Kergadallan, IALALITE 2008
- IALA Guideline 1073 "Conspicuity of AtoN lights at Night"
- Rayleigh and Mie scattering (Angstrom's Law)



LED vs. Halogen PAPI

What does this look like?

- White halogens become less blue / “cold” and more orange / “warm”
- White LEDs appear slightly “yellow”
- Red-filtered halogens become slightly “deeper red”
- Red LEDs stay constant “red”



Grey Diamonds = White Halogen

Grey Triangles = White LED

LED vs. Halogen PAPI

What signal is the aviator receiving?

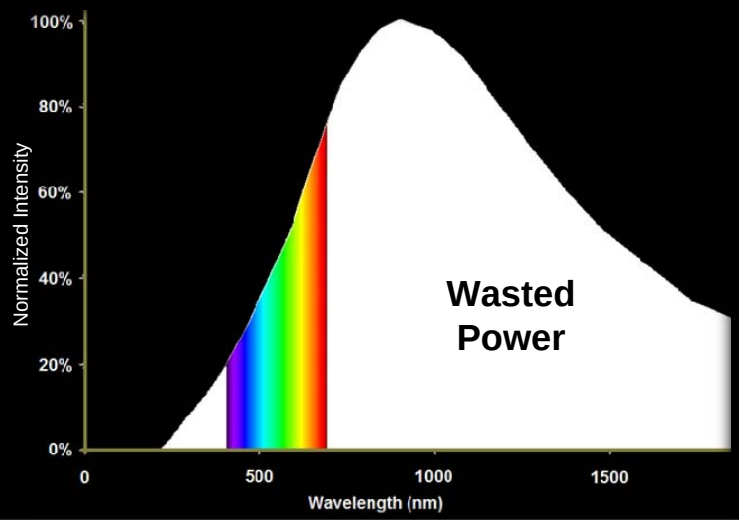
LED vs. Halogen PAPI

Power Consumption

- 400 - 450W per halogen LHA
- 30 - 60W per LED LHA

} +670% savings

- LEDs' low power consumption is the only path to a solar-powered PAPI



LED vs. Halogen PAPI

Condensation

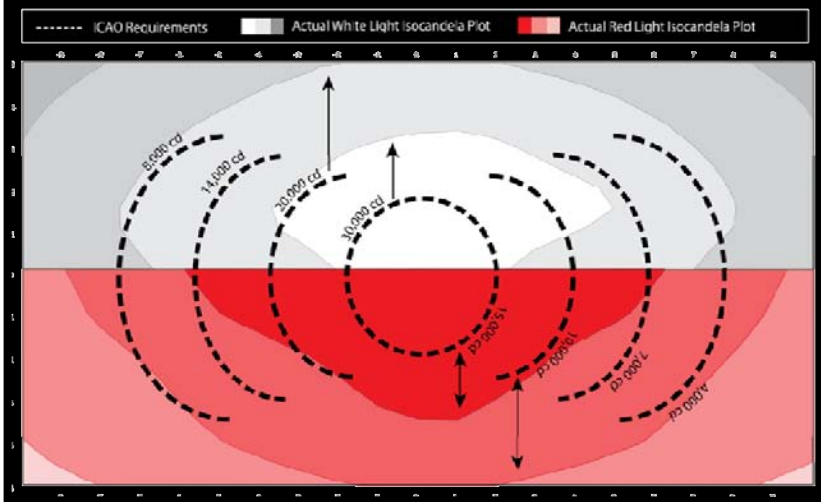
- Halogens create enough heat to counter condensation on the optics
- LEDs do create heat; in certain conditions, extra heaters may be required

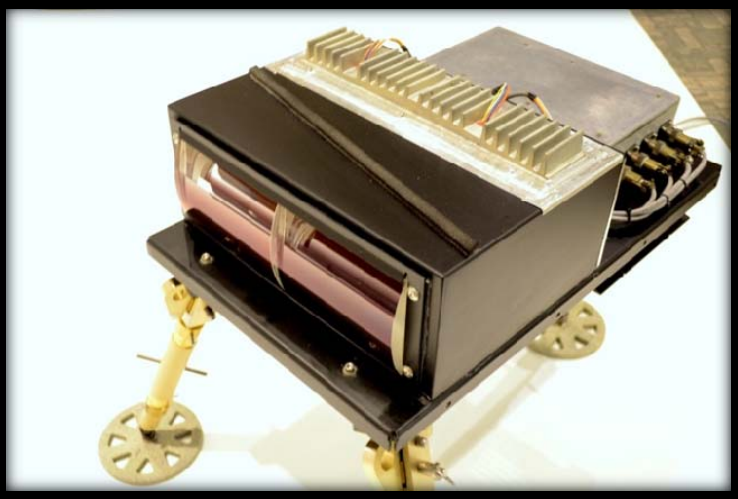
LED vs. Halogen PAPI - Downsides

- LHA cost
- Few production/certified models
- Condensation must be mitigated

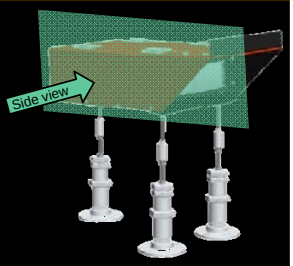
LED vs. LED PAPI

Several different possible LED designs

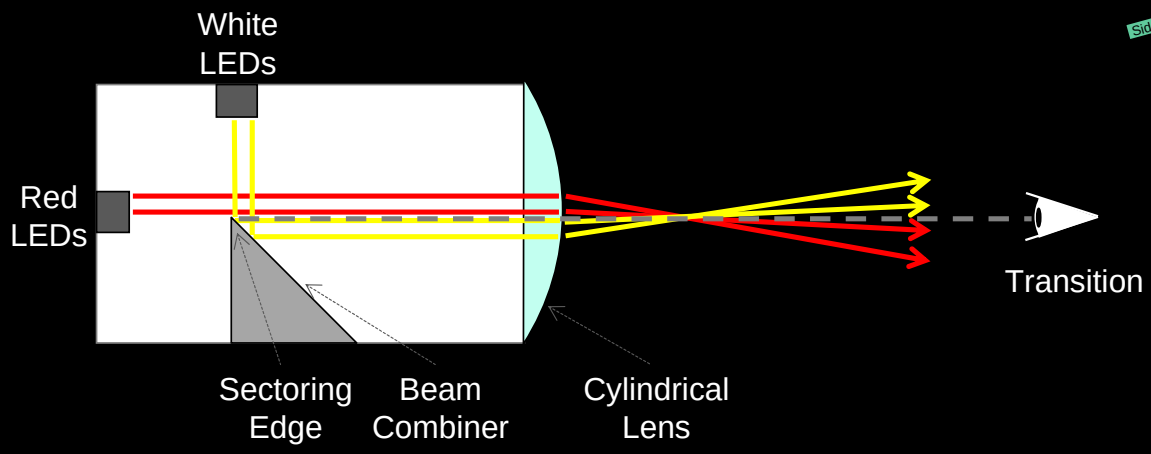




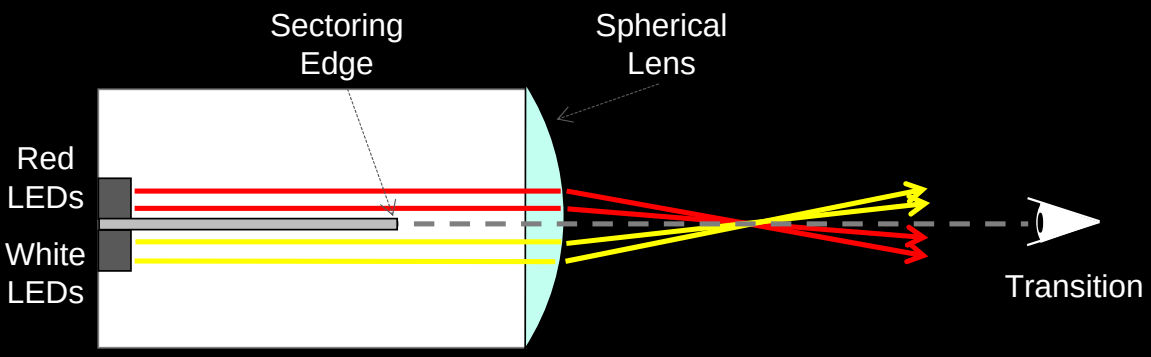
Optical Design - Transition



Linear Design



Array Design

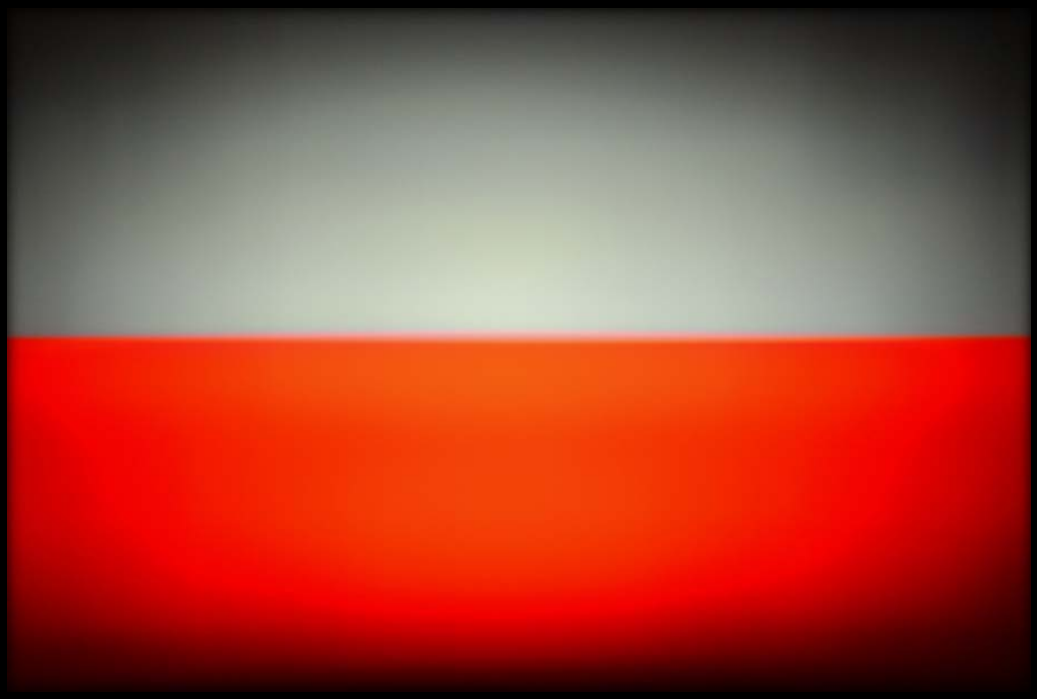


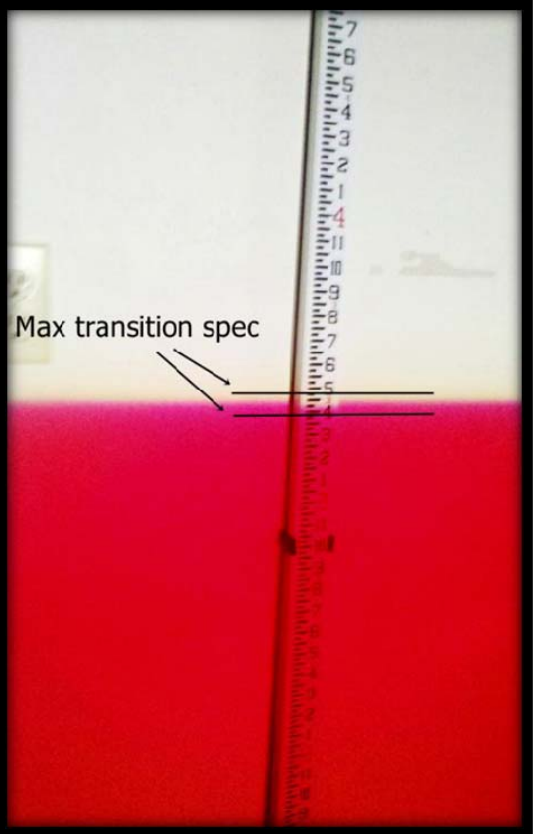
Optical Design - Transition

Why is this important?

- Linear is the easier path to a sharp red/white transition
- Linear LEDs are spread out = improved ambient cooling = consistent LED output
- More compact design

Optical Design - Transitions

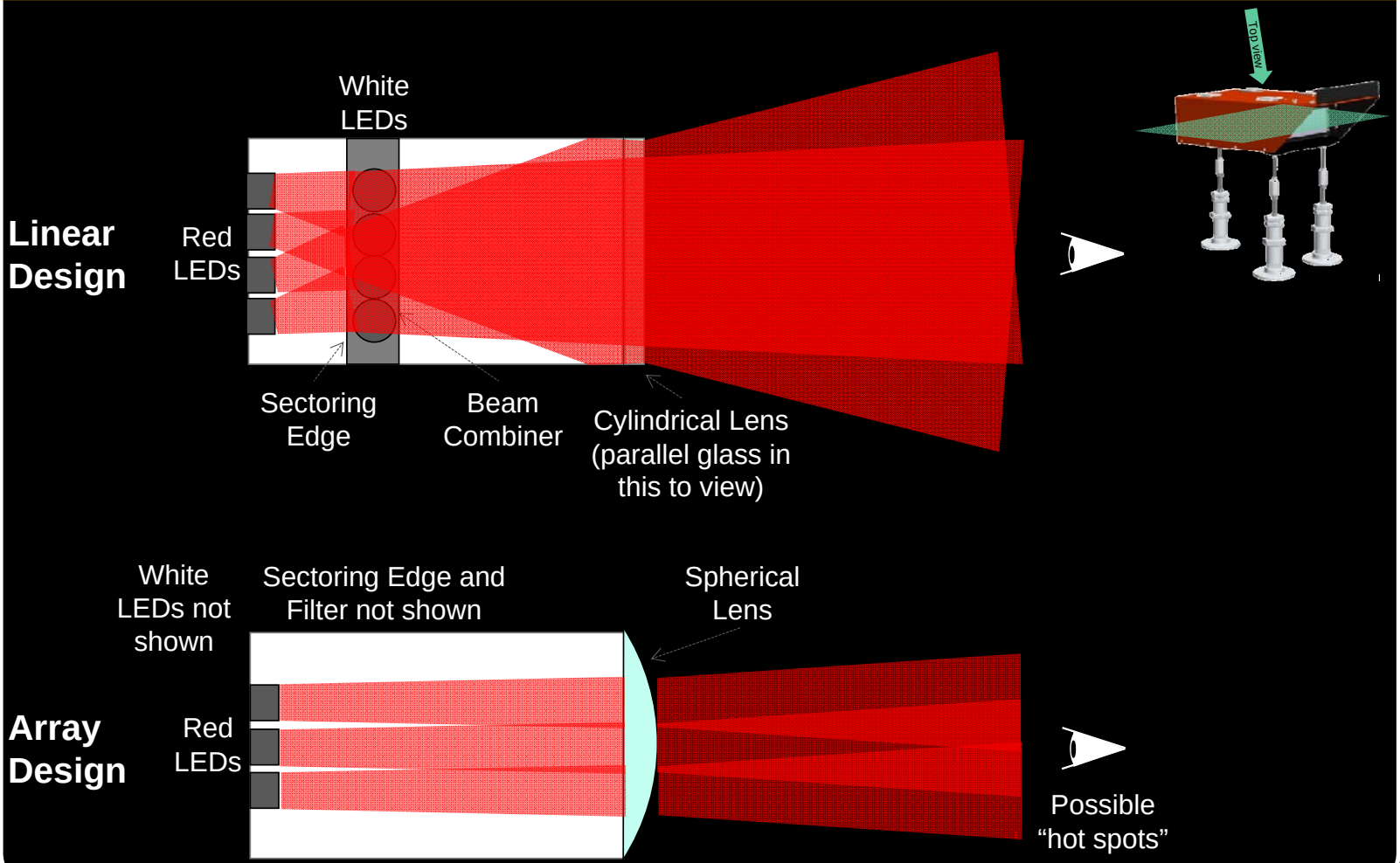




Optical Design - Hot Spots & Failures

- Signal must be horizontally wide & consistent
- Signal must be consistent during failures
  - FAA E-3007 (PAPI), 3.3.1.2.4: “LHA shall be considered to be unserviceable if greater than 25% of either red or white LEDs have failed”
  - Bypass diodes to route electrical signal around failed LEDs

Optical Design - Hot Spots & Failures

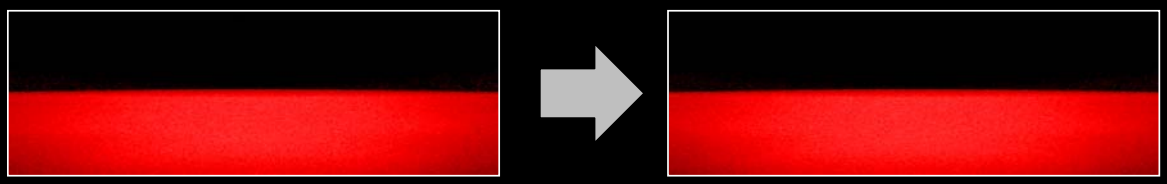


Optical Design - Hot Spots & Failures

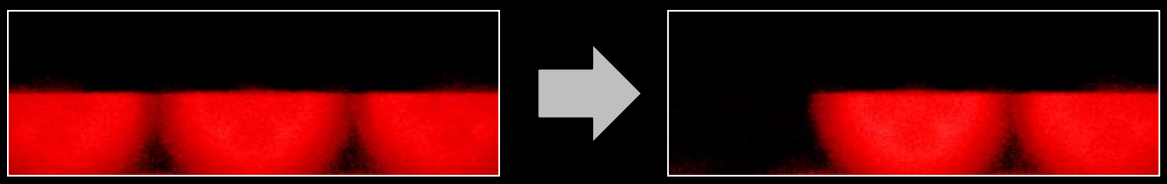
What if an LED fails or the lens is dirty:

- 1 out of 8 LEDs out (13% less output)

Linear Design



Array Design



Optical Design - Hot Spots & Failures

What if an LED fails or the lens is dirty:

- 75% of the output is shielded

Why do these optical details matter?

1. Provide the best possible signal to the aviator
    - Under all conditions
    - Over the life of the LHA

2. Minimize power consumption
    - Lowest cost, most robust solar system

Can solar be robust?

There are 3 keys to making a solar PAPI reliable and still cost efficient:

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#2 Location = Simulation

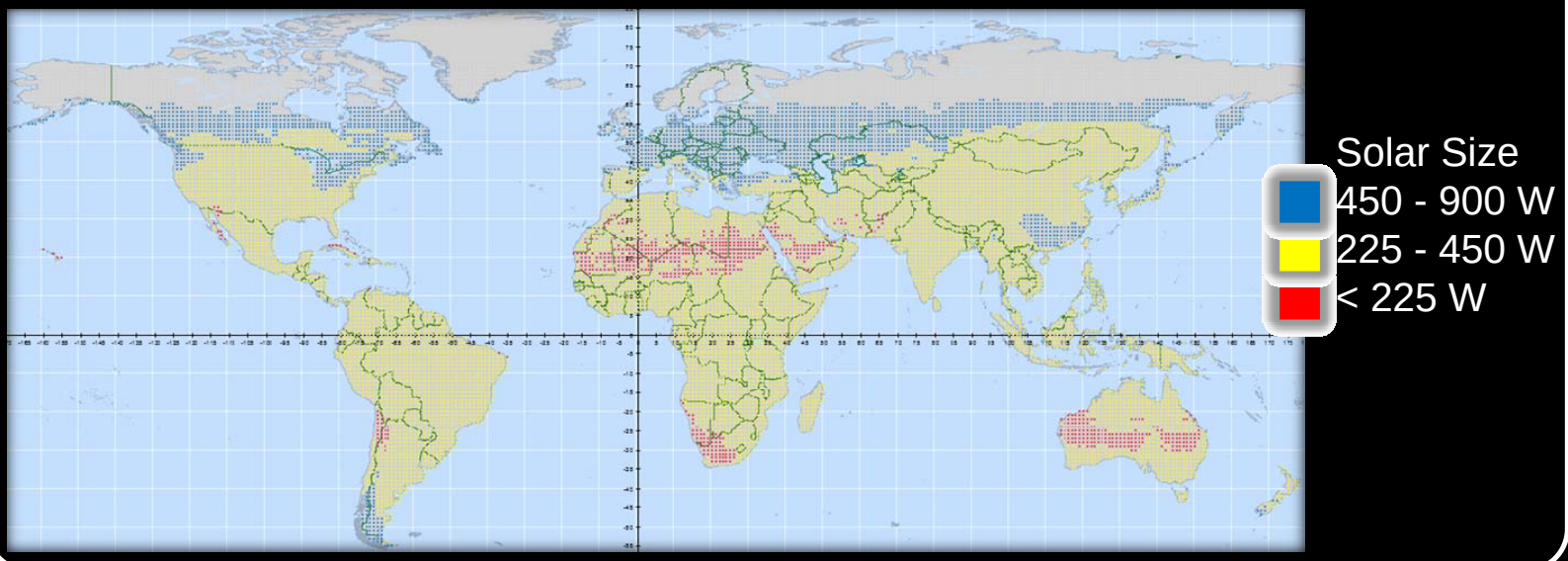
Solar products **CANNOT** be robust without a simulation to determine capability

- Location = insolation, day length, temperature
- Insolation (kW-hr./m^2/day)
  - Amount of solar energy striking an area per day
  - “Sun-hours”
- Solar panel tilt & rotation
- Energy out < energy in
- Autonomy = duration a product can operate with no solar

Simulation

Autonomous operation:

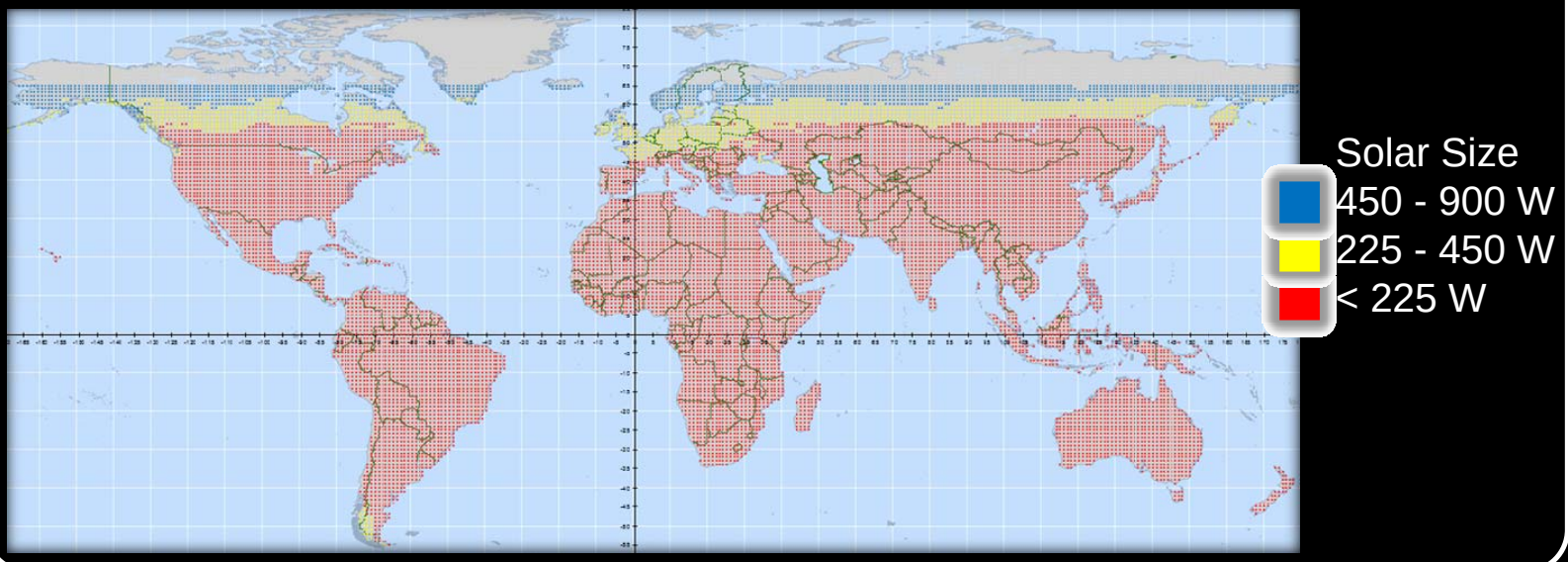
- NASA air data for 22 yrs.
- Design for worst month/week
- 4 LHA PAPI: 25% day + 5% night



Simulation

On-demand operation with ARCAL / PAL:

- Use case greatly affects solar size
- 4 LHA PAPI: 100% intensity (7 mic clicks) x 4 activations per day



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Several ways to reduce power consumption:

- LEDs' conspicuity may allow for lower intensity steps to be used
- ARCAL / PAL: on-demand
- Wireless control: on-demand & feedback

Solar PAPI - Downsides

- Initial cost of solar system
- Solar system can be large for poor solar regions and extended 100% intensity
- Cabling = trenching, conduit, & concrete
- Batteries do need replacing
- Not FAA certified

Case Study #1

- Temporary airfield
- Deployable solar system
- Hybrid solar & generator
- Wireless control

Case Study #2

- Permanent airfield
- 2x LHA
- Fixed solar system
- Wireless control

Case Study #3

- Temporary airfield
- Lake / ice runway
- Generator
- Arctic kit

Questions?

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