# The Why and How of Infrared

# Infrared Sources For Airfield LED Lamps: LEDS are “Hot” But not Hot Enough

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# LED Light Sources

Long lived:  30,000 – 100,000 hrs

High lumen/watt output

- White light LEDs: 100 to 150
- Incandescents: 17
- Halogens: 22
- Compact fluorescents: 45

High energy efficiency

- Somewhat confusing – more later

# LED Light Source Problems

Generated heat is a major problem

- 1 to 2 watts dissipated in $< 0.1 mm^3$ chip
- "Not to exceed chip temperature": 150 ° C
- Output and lifetime decrease as T rises
- Required: large fixture heat capacity
- Required: large fixture convection cooling

# LED Light Source Problems

Lack of generated heat is a problem

- Required: auxiliary heaters for some airfield applications

# CONFLICTING DEVELOPMENTS

1. Energy Independence and Security Act 2007
    - Recommends phasing out PAR38 production
2. DOE mandated LED PAR38 replacement
3. EFVS depend on PAR38 “wasted” infrared
4. FAA NexGen is considering using EFVS

# MALSR PAR38 Lamps

# THE EFVS NEED FOR INFRARED

- Discussed in detail at these meetings:

  ”Airfield lighting has to do with visible, not infrared.”

- FAA NexGen plans now include consideration of EFVS.

- FAA tasked the SAE to set up an airport lighting committee.

# Committee Membership

Members from

- SAE
- Several FAA sections
- Companies that produce EFVS
- Companies that use EFVS
- Companies that produce airfield lighting systems
- Companies that are developing LED lamps

# FAA Qualified EFVS

- Only two:
  - Kollsman, an Esbit Systems of America company
  - CMC Electronics, formerly Canadian Marconi Company, presently an Esterline Group company

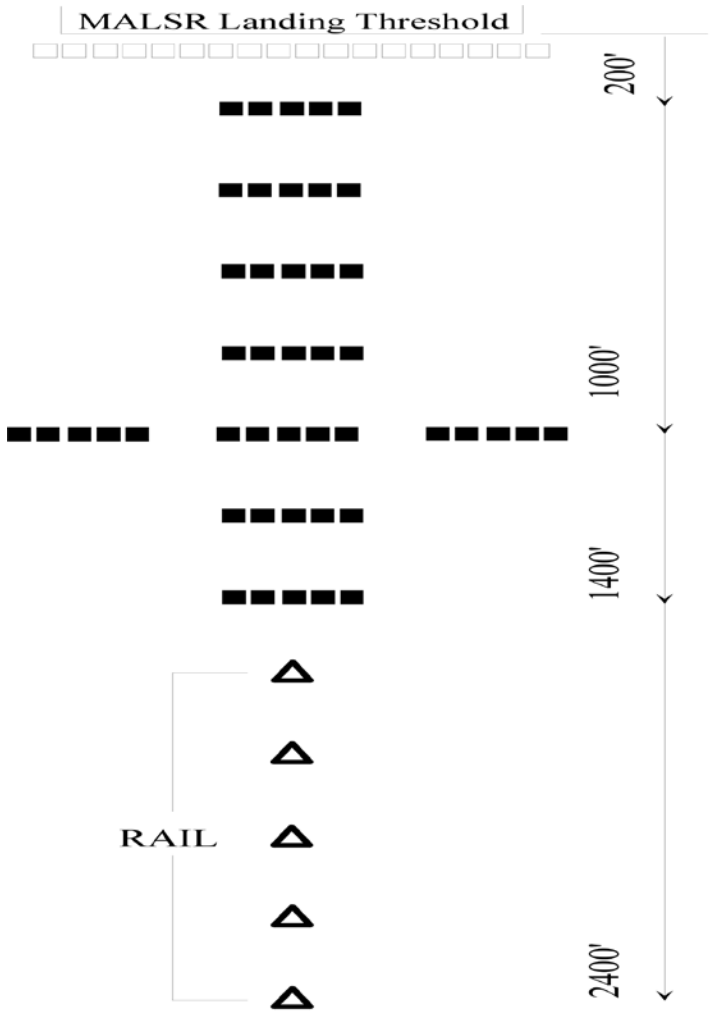
# FAA Qualified EFVS

- Approximately 1200 systems now in use, increasing at 200 per year
- Cost: $500,000 to $1,200,000 each
- Both use indium antimonide (InSb) detectors sensitive from 1 to 5 microns

# MALSR Details

- 1000 plus runways now have MALSRs.
- Up to 4000 more runways available for MALSRs.
- Each MALSR has 45 PAR38 white light lamps.
- Each has 18 PAR56 green filtered 300w lamps.
- Plans are to replace all 63 with LED lamps.

# MALSR LAMP LAYOUT



# Early Green LED Threshold Lamp

# Early PAR38 LED Replacement

# LED Replacements For PAR Lamps

300 watt green filtered PAR56 replacements

Early prototypes:  26 1w LEDs + 20w PS

Yesterday: 6  3w LEDS + 10w PS

60 watt and150 watt PAR38 replacements

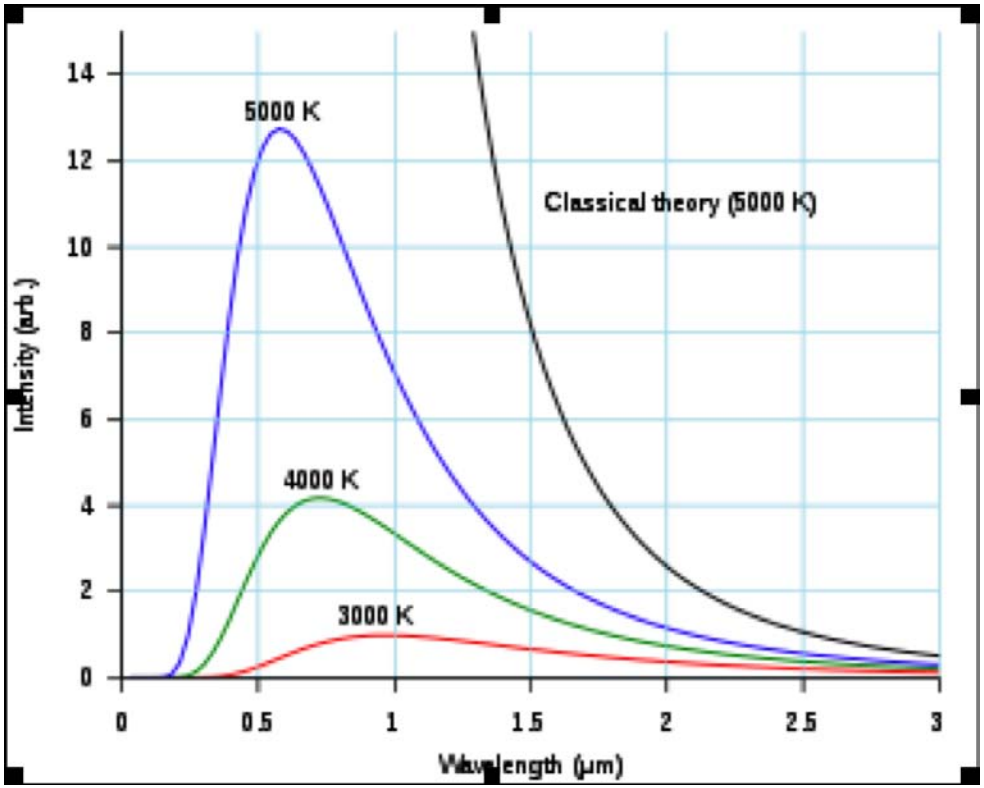
Early prototypes: 9 3w LEDs + 13w PS

Yesterday: 6  3w LEDs + 10w PS

# The Heart of the Problem

- Most of the PAR lamp radiation is infrared.
- The infrared allows EFVS to “see” through fog.
  - Penetration distance proportional to
- This makes EFVS important for NexGen plans.
- LEDs do not emit infrared.
- EFVS cannot “see” LED PAR replacements.

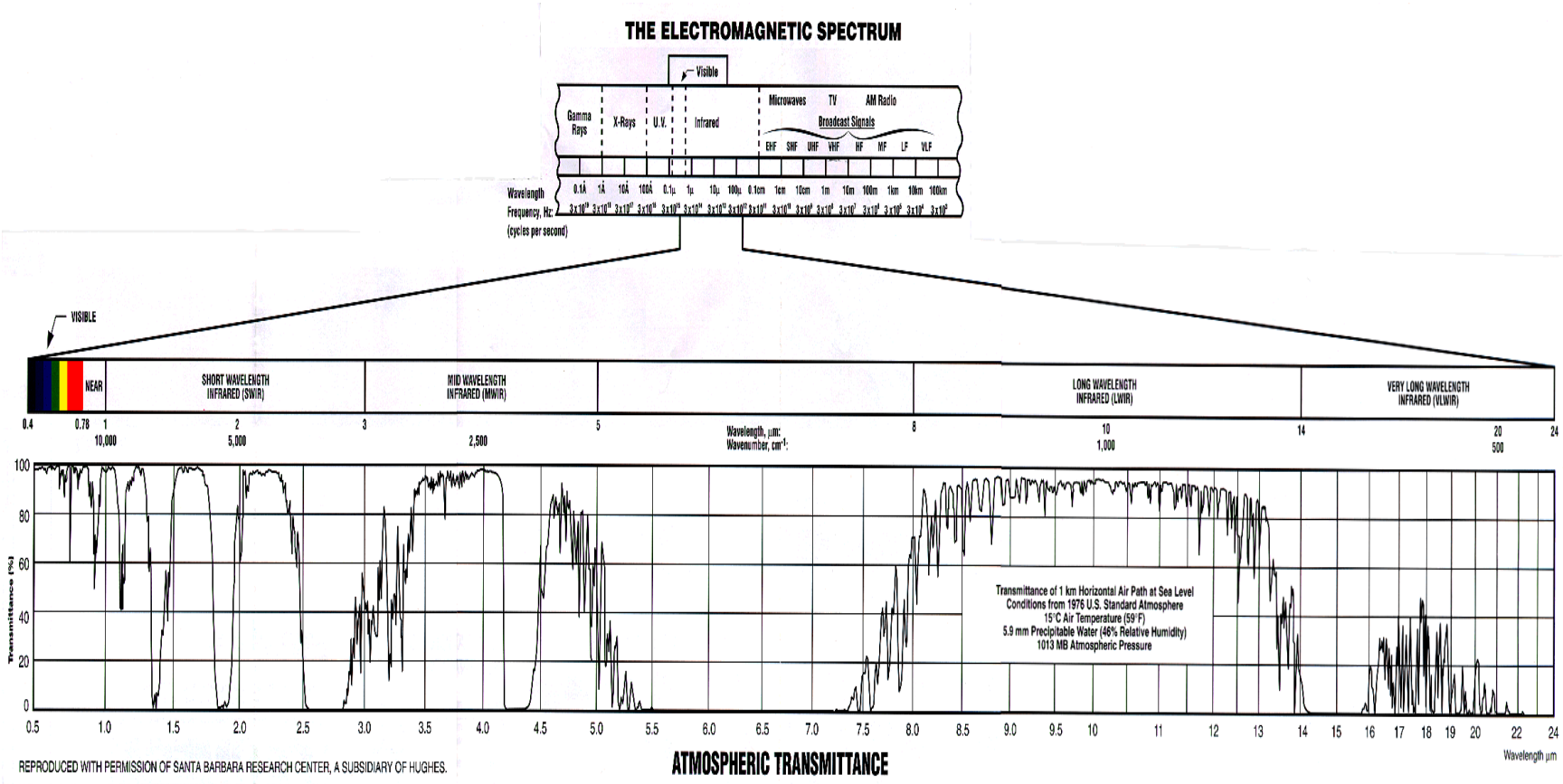
# Black Body Spectrum



# Radiated Energy of a 3000K Black Body

| At λ shorter than: | | In Δλ range: | |
|---|---|---|---|
| 0.7μ | 8% | Visible | 8% |
| 1.2μ | 46% | 0.7 to 1.2 | 38% |
| 2.4μ | 82% | 1.2 to 2.4 | 36% |
| 3.4μ | 92% | 2.4 to 3.4 | 10% |
| 5.0μ | 97% | 3.4 to 5.0 | 5% |
| | | >5.0 | 3% |

# Optical Transmission of the Atmosphere

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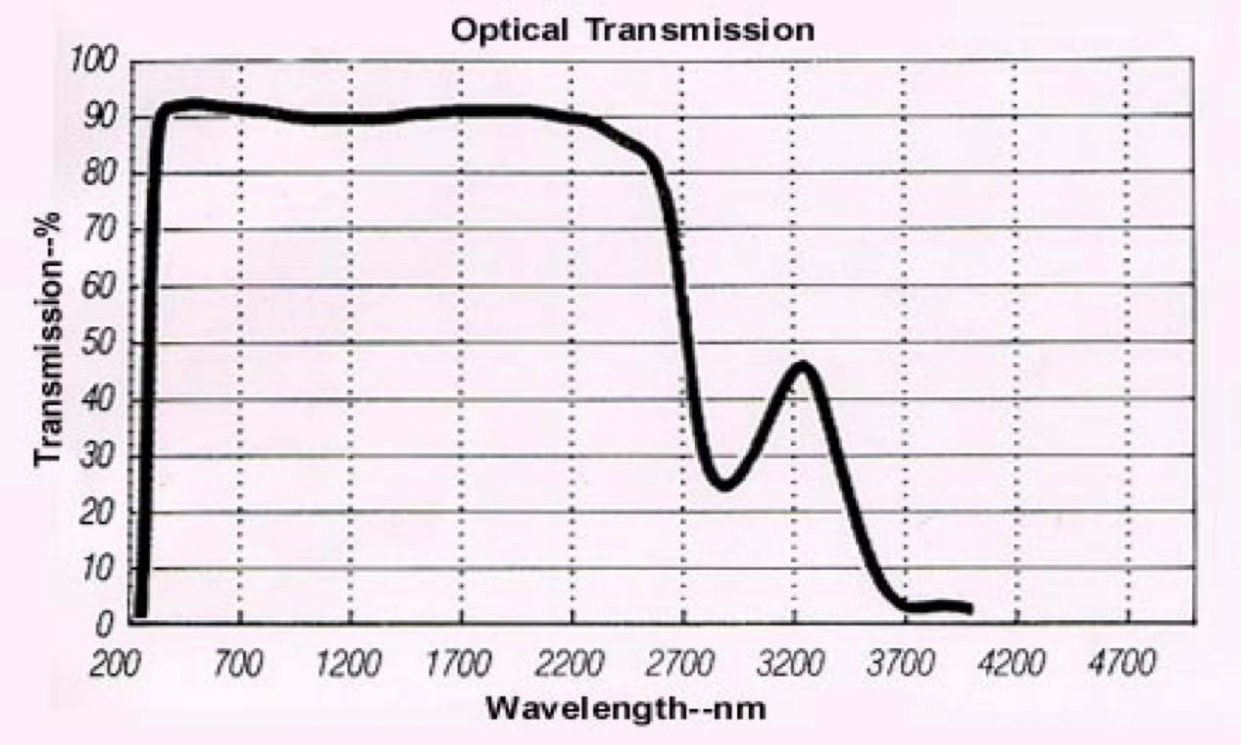
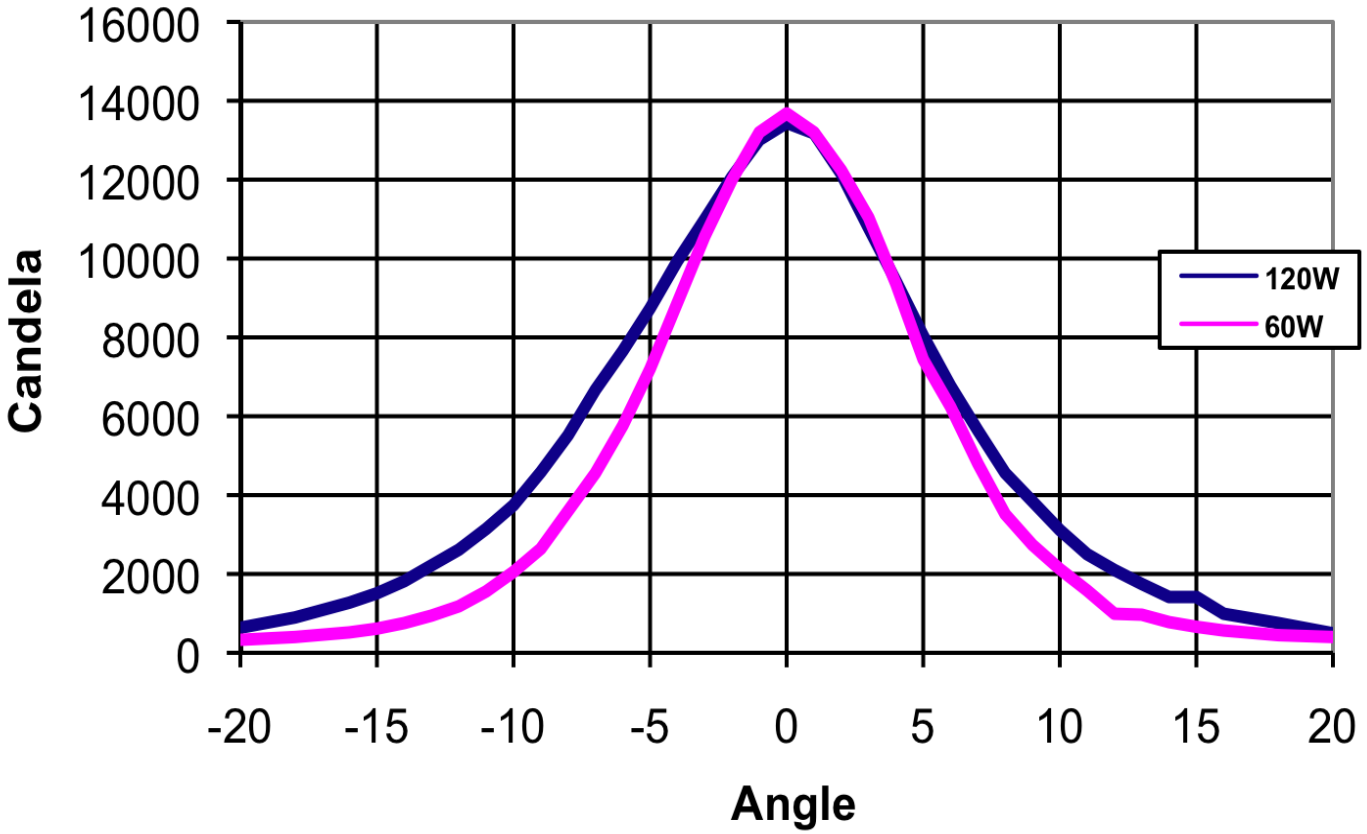
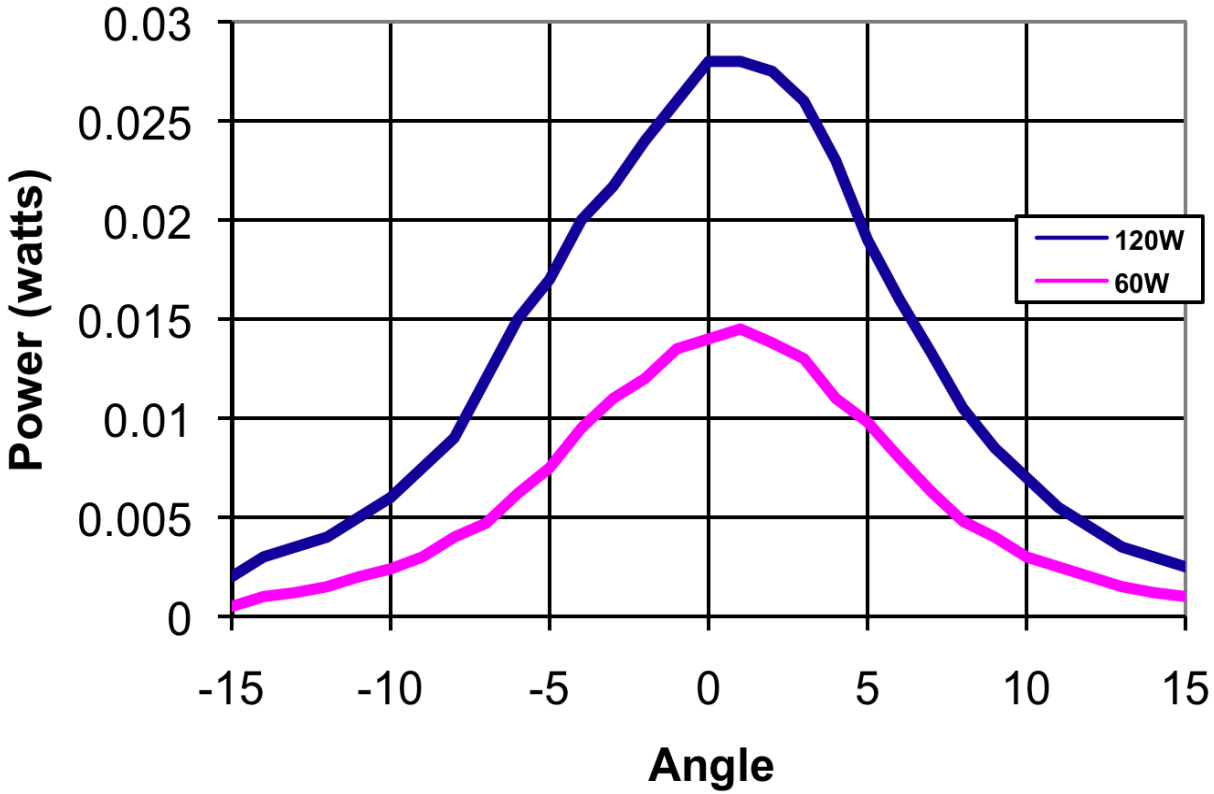
# Transmission of the Lamp Envelope



# PAR38 Candela Output Patterns



# PAR38 Energy Output Patterns



# Why LEDs??

| | |
|---|---|
| Electrical input | 3 watts |
| Visible output | 1 watt |
| Infrared output | Negligible |

# Electrical vs Optical Power

| Optical Source | Electrical Input | Optical Output | Efficiency |
|---|---|---|---|
| PAR38 Wattmizer | 120 watts | 7 watts | 6% |
| PAR38 Halogen | 60 watts | 4 watts | 7% |
| White Light LED | 3 watts | 1 watt | 33% |

# FAA SAE Committee Taskings

The most important for LED lamp developers:

"Lighting equipment that produces the appropriate level of photometric output …….**but also emits …….an IR signature detectible by current EFVS systems.**"

# Current IR Signatures in 1.2–2.4μ Range

- 120 Watt PAR38

  Peak w/sr: (~ 0.4 x 600 w/sr) 240 w/sr

  ±8° cone integrated power

  (~ 0.4 x 23 watts) 9 watts

- 60 Watt PAR38

  Peak w/sr: (~ 0.4 x 312 w/sr) 125 w/sr

  ±8° cone integrated power

  (~ 0.4 x 12 watts) 5 watts

# FAA LED Replacement “Wish List”

- One-to-one “ for today’s MALSRs
- Built-in IR sources
  - Solid state
  - Long lived
  - Low cost
  - Energy efficient

# Available IR Sources

- Infrared LEDs
- Infrared lasers
- Infrared Incandescents

# Energy Efficiency

- Solid state devices are more efficient.

  Or are they??

- Incandescents are ruled out.

  Or are they???

# Energy Efficiency

- "LEDs and lasers are more efficient than incandescents."

BUT only in terms of visible output:

~ 0.3 versus ~0.05 optical watt per electrical watt

# Energy Efficiency

- **Regarding infrared output:**

  **Incandescents are more efficient than LEDs and lasers:**

  **~ 0.7 versus ~0.3 optical watt per electrical watt**

# Cost

- LEDs and lasers
  - Several watts infrared
    - 1 to 10 – $$$ –$$$$ now
    - 60,000 – $$ eventually ???
- Incandescents
  - Several watts infrared
  - Long lived
    - 1 to 10 – $$ now
    - 60,000 – $ now

# Conclusion

- FAA task for LED lamp developers

  "Lighting equipment that…..also emits….an IR signature detectible by current EFVS systems."

- Solution: Small, lamp mountable incandescent

  Immediate, practical, cost effective

- Solution: Infrared laser or LED

  Long term, less "energy efficient", $$ ???