THE SCIENCE OF:

EFFECTIVE SCENE LIGHTING

AGENDA

- Intro… Who am I?
- What is scene lighting?
  - Types of lighting, history, and technology
- How is lighting measured
- Real-world lighting… how to improve visibility
- Bringing it home; things to think about when on-scene or building a new rig

WHY LISTEN TO THE SURFER GUY

- Firefighter / EMT, Mills River NC and Buncombe County Rescue Squad
- NC Hazardous Materials Technician and member of North Carolina Association of Hazardous Materials Responders
- Committee Chair, Fire Apparatus Manufacturers Association
- NFPA 1901 and 1906 Technical Committee Member
  - Standard for Automotive Fire Apparatus
  - Standard for Wildland Fire Apparatus

WHO AM I

- President, HiViz LED Lighting
  - Manufacture LED Scene and Work Lighting
  - Fire Market HQ in Fletcher. NC
  - Global headquarters Auburn. WA
  - Supplier of Scene Lighting to all major OEM manufacturers of Fire Apparatus
  - OEM Manufacturer for both WillBurt and Commandlight fixtures for light towers
  - Manufacturing partner, Tele-Lite (Halogen and LED)

WHAT IS SCENE LIGHTING?

THE TECHNOLOGY FIREFIGHTERS USE TO MAKE WORKING AFTER DARK POSSIBLE

"SCENE LIGHTING"

WHAT IS SCENE LIGHTING?

In general, "scene lighting" refers to the system of lights and fixtures used to illuminate large areas of a scene such as a fire ground, vehicle accident or hazmat incident.

- Apparatus body-mounted flood lights
- Removable Tripods and Portable Lights
  - Battery Powered, Generator Mounted, etc
- Light towers (both pull-behind and apparatus mounted)
- Brow Lights, Side Scene Lights, Load Lights, Work Lights, Aerial Tip Lights

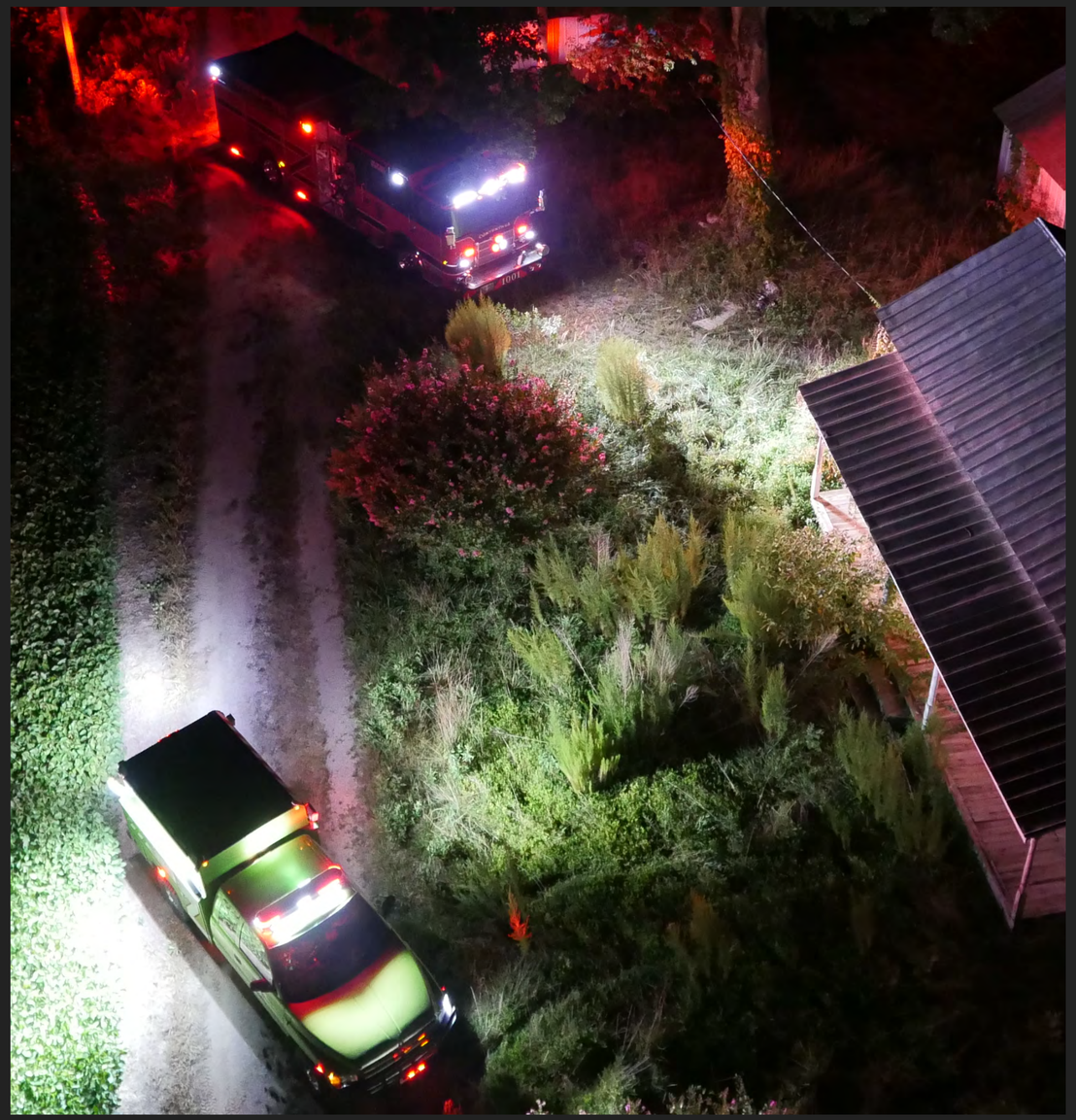
SCENE HAZARDS

- Subject of the incident
- Power Lines
- Environmental (holes, mud, rocks, etc)
- Structural Collapse
- Hazardous Materials
- Damaged Vehicles / Machinery
- Bystanders
- Patients

... this list goes on

WHY SCENE LIGHTING

- It is impossible to plan for every hazard in your fire district
- Calls are going to go out, you're going to be tasked with bringing incidents under control
- EVERY call requires a plan, and every plan requires an understanding of the incident
  - It is impossible to do an effective job in planning tactics for resolution without being able to see the incident scene.



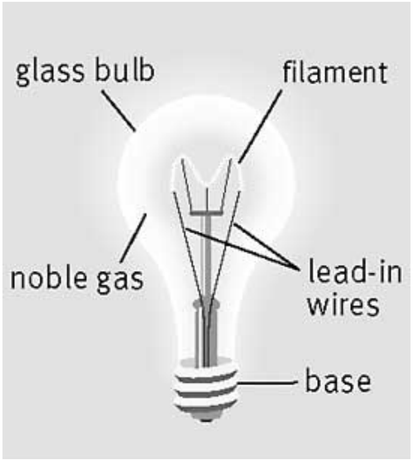
THE SCIENCE OF EFFECTIVE SCENE LIGHTING

SCENE LIGHTING BASICS

HISTORY OF LIGHTING

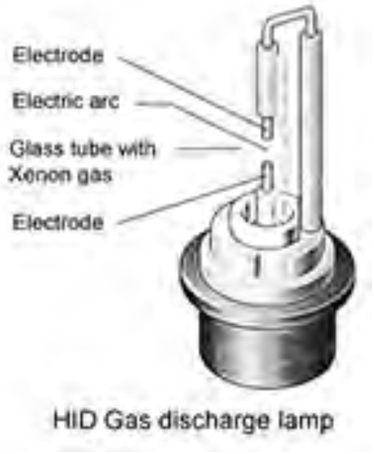
MODERN TECHNOLOGY

INCANDESCENT



H.I.D.

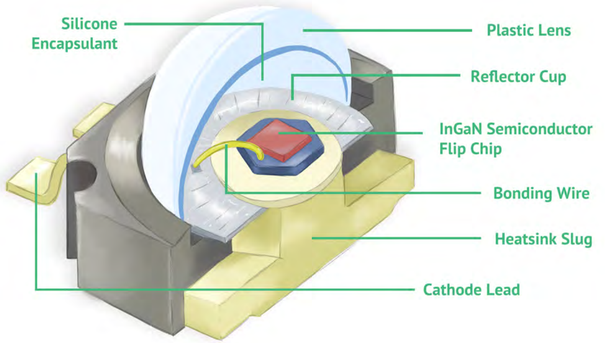
HIGH INTENSITY DISCHARGE



HID Gas discharge lamp

L.E.D

(LIGHT EMITTING DIODE)



INCANDESCENT / QUARTZ HALOGEN

Oldest of the “modern” technologies

Pros:

- Lowest Cost Option
- Can be extremely bright
- Linear load, simple resistive circuit (good for generators, zero electrical noise)

Cons:

- Short service life
- Impacted negatively by vibration
- High operating temperature
- Does not like water (thermal shock)

500w, 750w, 1000w, and 1500w lamps common in fire service

H.I.D. / METAL HALIDE

Relatively limited use on fire apparatus

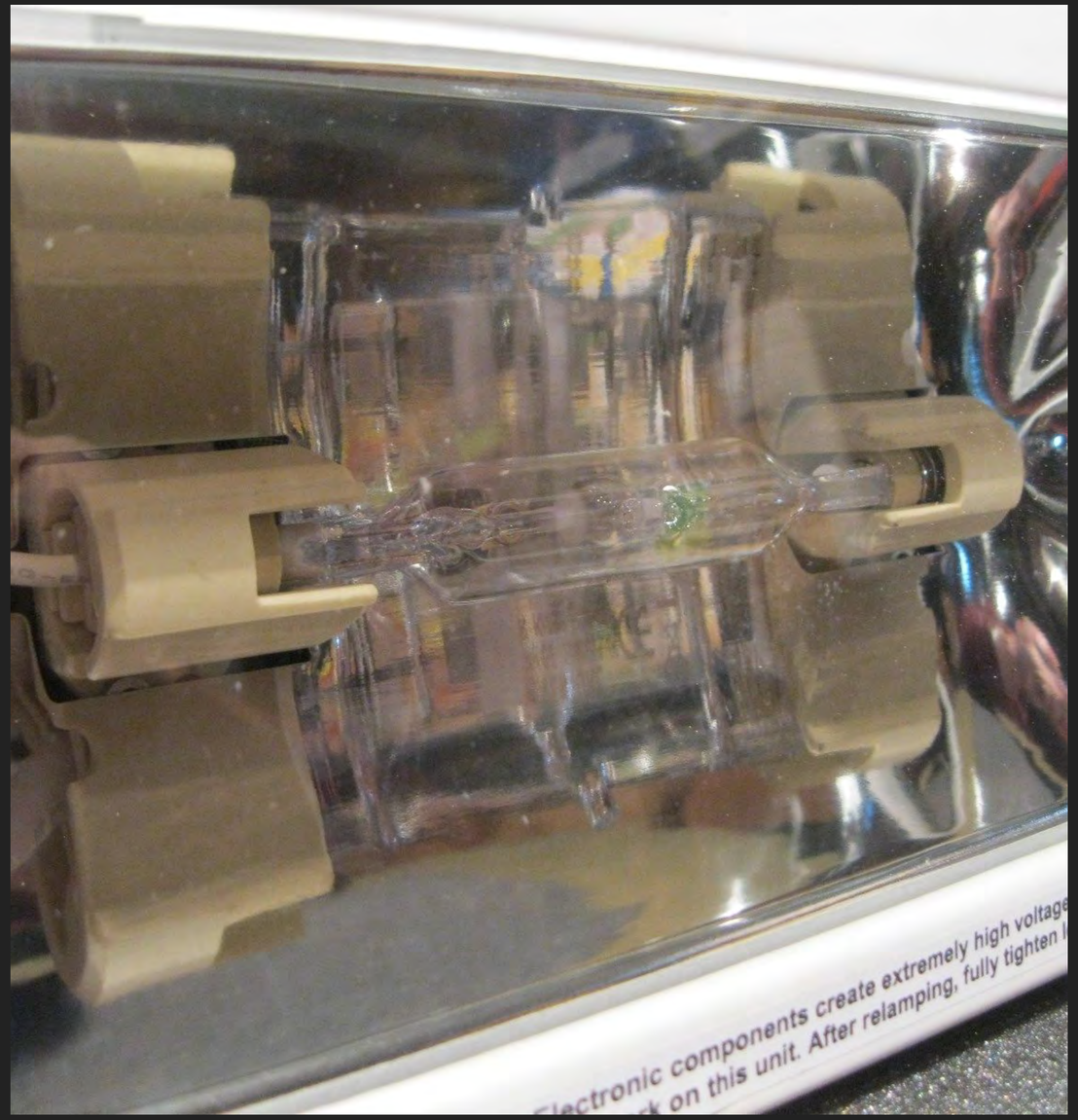
Pros:

- More efficient than Incandescent
- Can be extremely bright; think trailer-drawn light plants
- Typically high color temp

Cons:

- Takes time to warm up
- High inrush current
- Typically no hot restrict
- Electrically noisy
- Limited parts supply

Typically 35, 55, or 70 watts in automotive applications. 450 or 1000w in large light plant applications.



THE SCIENCE OF EFFECTIVE SCENE LIGHTING

L.E.D.

The latest Buzz Word in Fire/Rescue

Pros:

- Extremely Efficient (60-130lm/watt)
- Very Versatile
- Small relative fixture size for fixture output
- Maintenance free Operation
- Can produce as much or more light than other sources,
  - budget and thermal management re the only limiting factors

Cons:

- Takes time to warm up
- High inrush current
- Typically no hot restrict
- Electrically noisy
- Limited parts supply

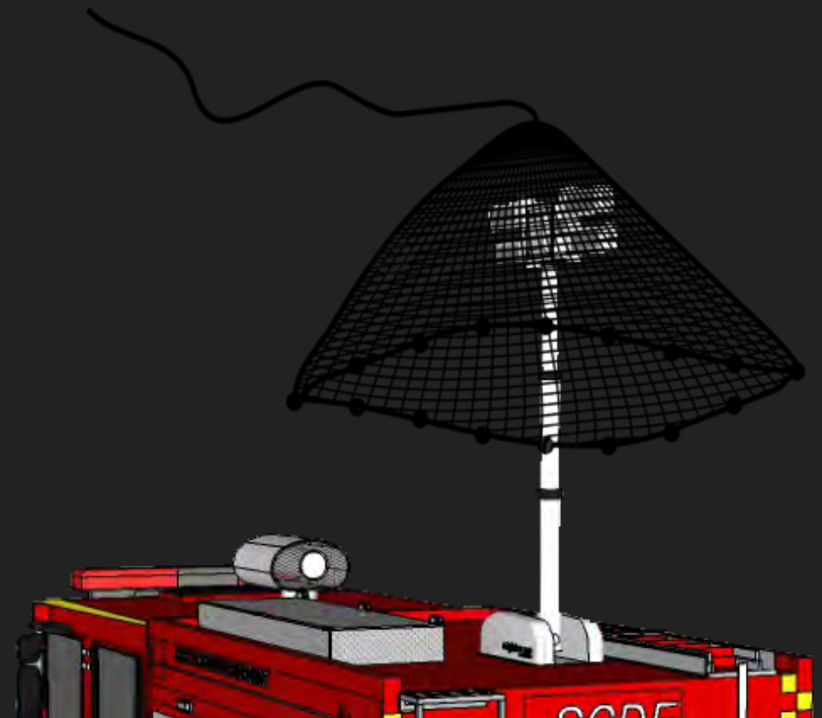
Typically 35, 55, or 70 watts in automotive applications. 450 or 1000w in large light plant applications.

THE SCIENCE OF EFFECTIVE SCENE LIGHTING

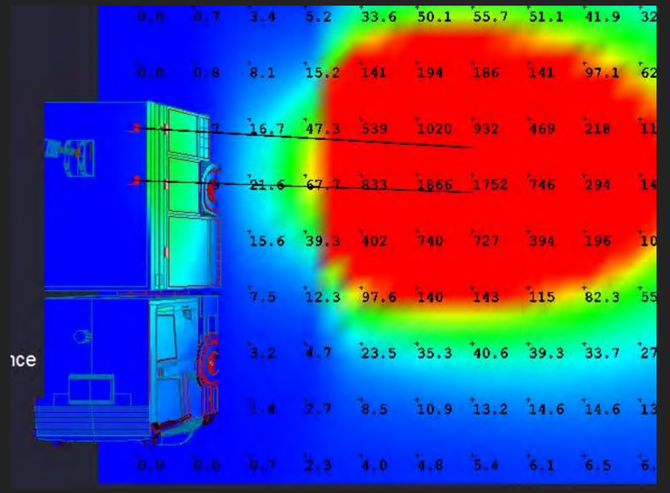
MEASURING LIGHT OUTPUT

MEASURING LIGHT OUTPUT: LUMENS VS LUX

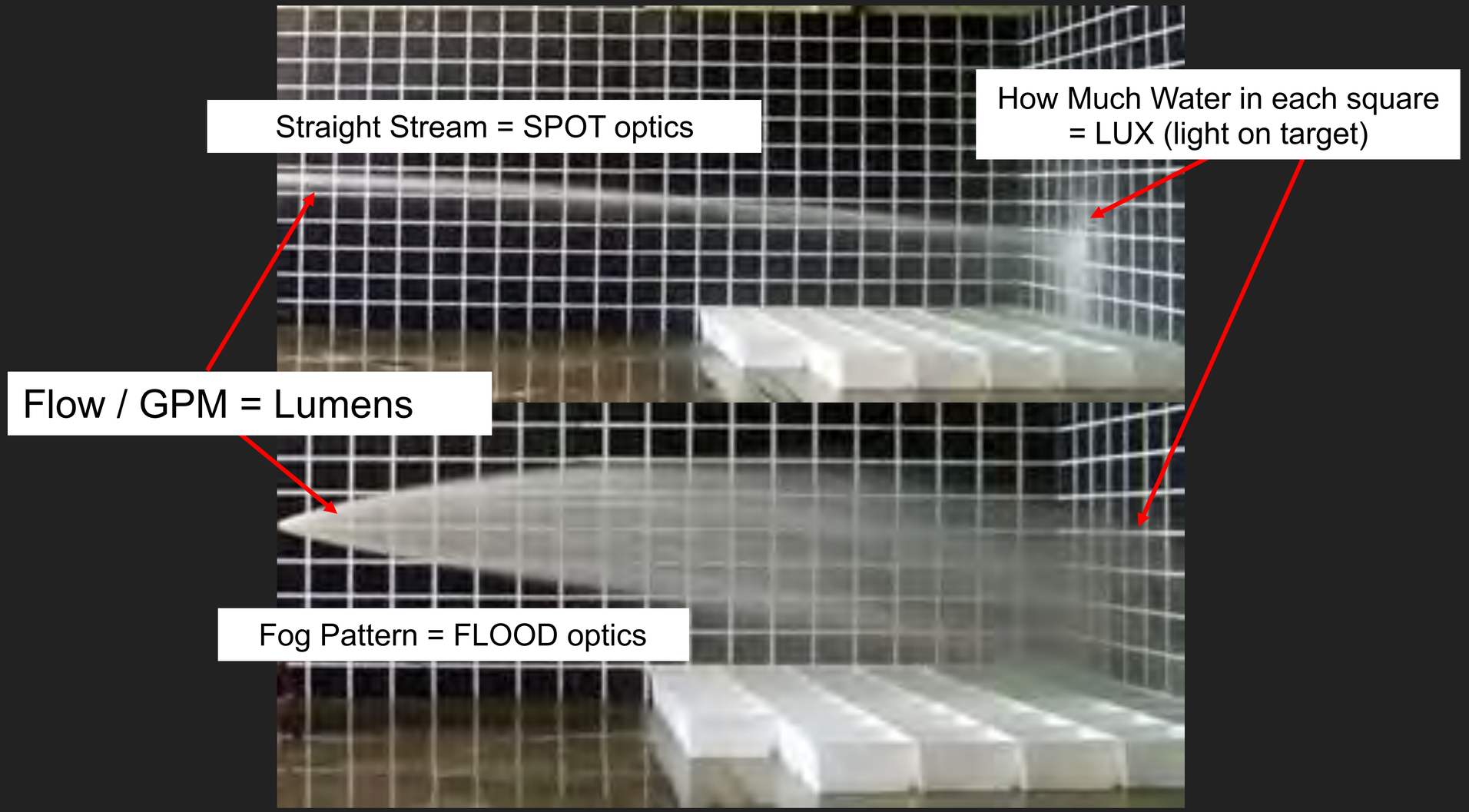
- Lumens
  - Total Amount of Light produced at the SOURCE



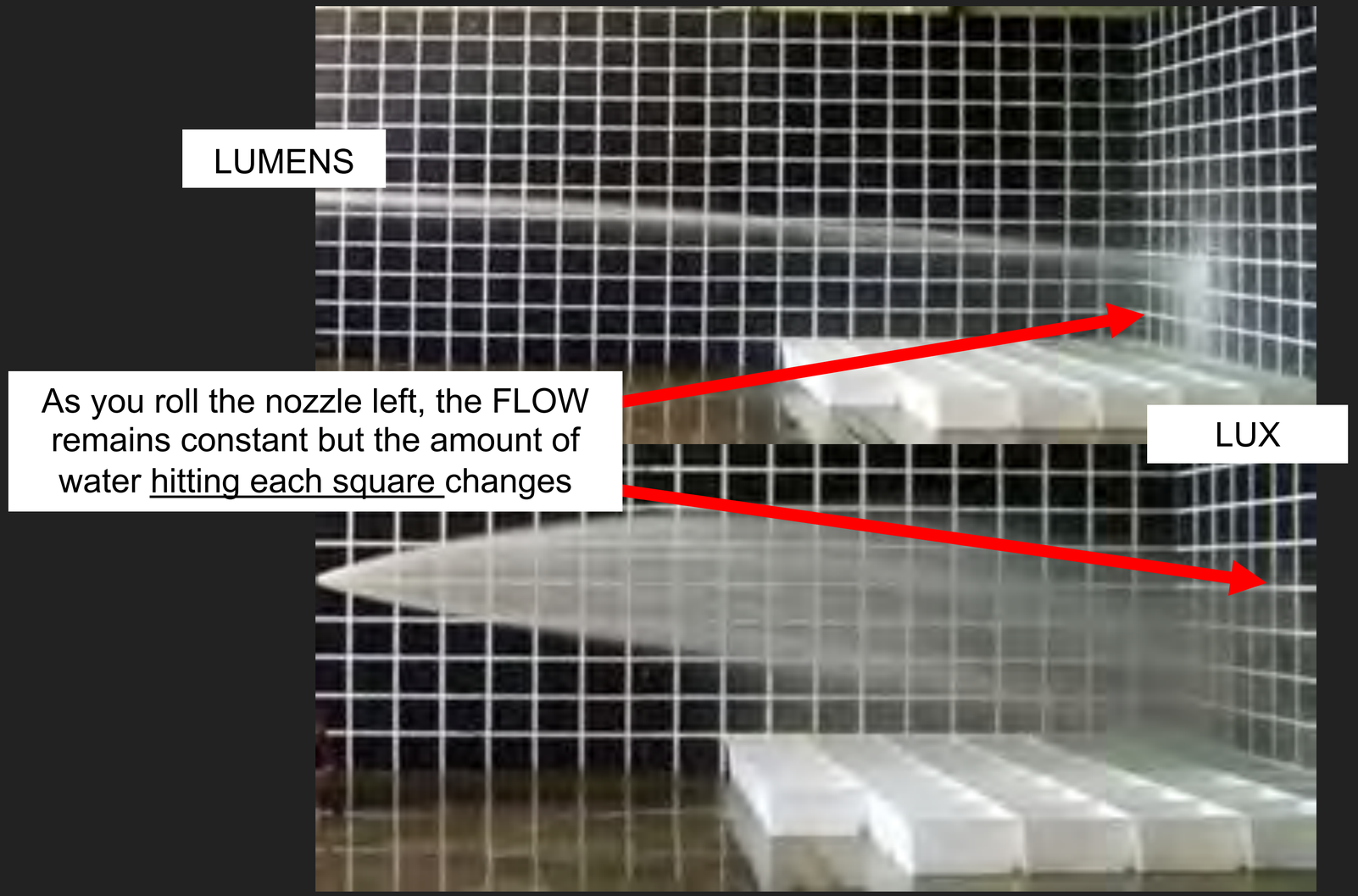
- Lux (or Foot Candles)
  - Measured light at any given point. Light on TARGET



MEASURING LIGHT OUTPUT: LUMENS VS LUX



MEASURING LIGHT OUTPUT: LUMENS VS LUX



MEASURING SCENE LIGHTING... WHY LUMENS

- If lux is the measurement for light on target, why is every single scene light in this industry advertised with a rating in “Lumens” vs “lux”??!
- **(video demo at the following link if being viewed in PDF form: https://www.dropbox.com/s/4i9xeq2wxy8oky9/light%20meter.m4v?dl=0)**

GOT IT…SO WHEN WRITING A SPEC, JUST PICK THE LIGHT WITH THE MOST LUMENS, RIGHT?

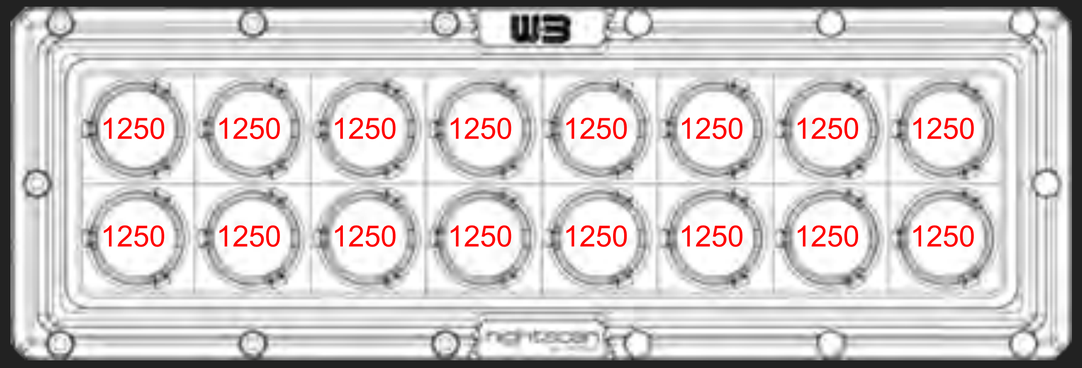
…EVERY FIREFIGHTER EVER

WRONG!

IN THE FIRE INDUSTRY, NOT ALL LUMENS ARE CREATED EQUAL!

LUMENS: RAW VS EFFECTIVE

- Most manufacturers in the fire industry do not measure light output in lumens
- The industry standard for coming up with advertised light output is to multiply the rating of the LED by the chip manufacturer, and multiplying it by the number of LEDs in the fixture.

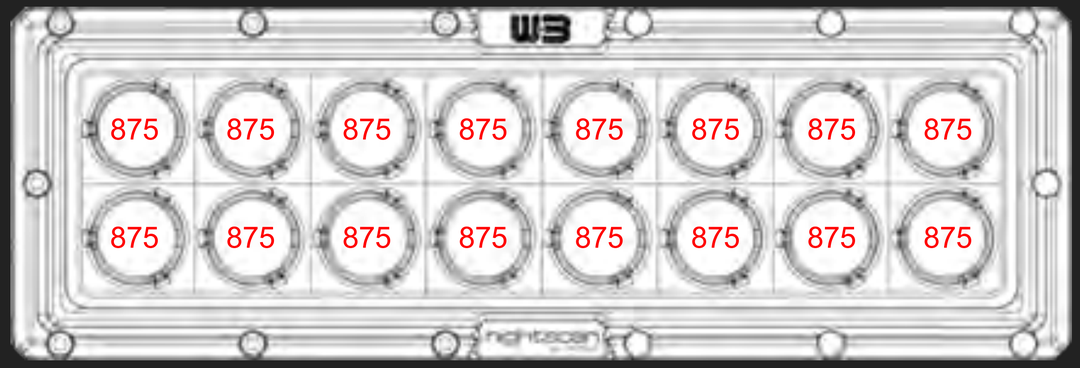


Raw Lumens 16 LEDs each rated by the **chip manufacturer** as capable of producing 1250 lumens each

16 X1250 = 20,000 lumens

LUMENS: RAW VS EFFECTIVE

- Start with 100% (20,000 Raw Lumens)
  - 10% optic loss (18,000 lumens left over)
  - 10% thermal loss (16,000 lumens left over)
  - 10% electrical loss (14,000 lumens left over)
- **End with 70% of original RAW light output**

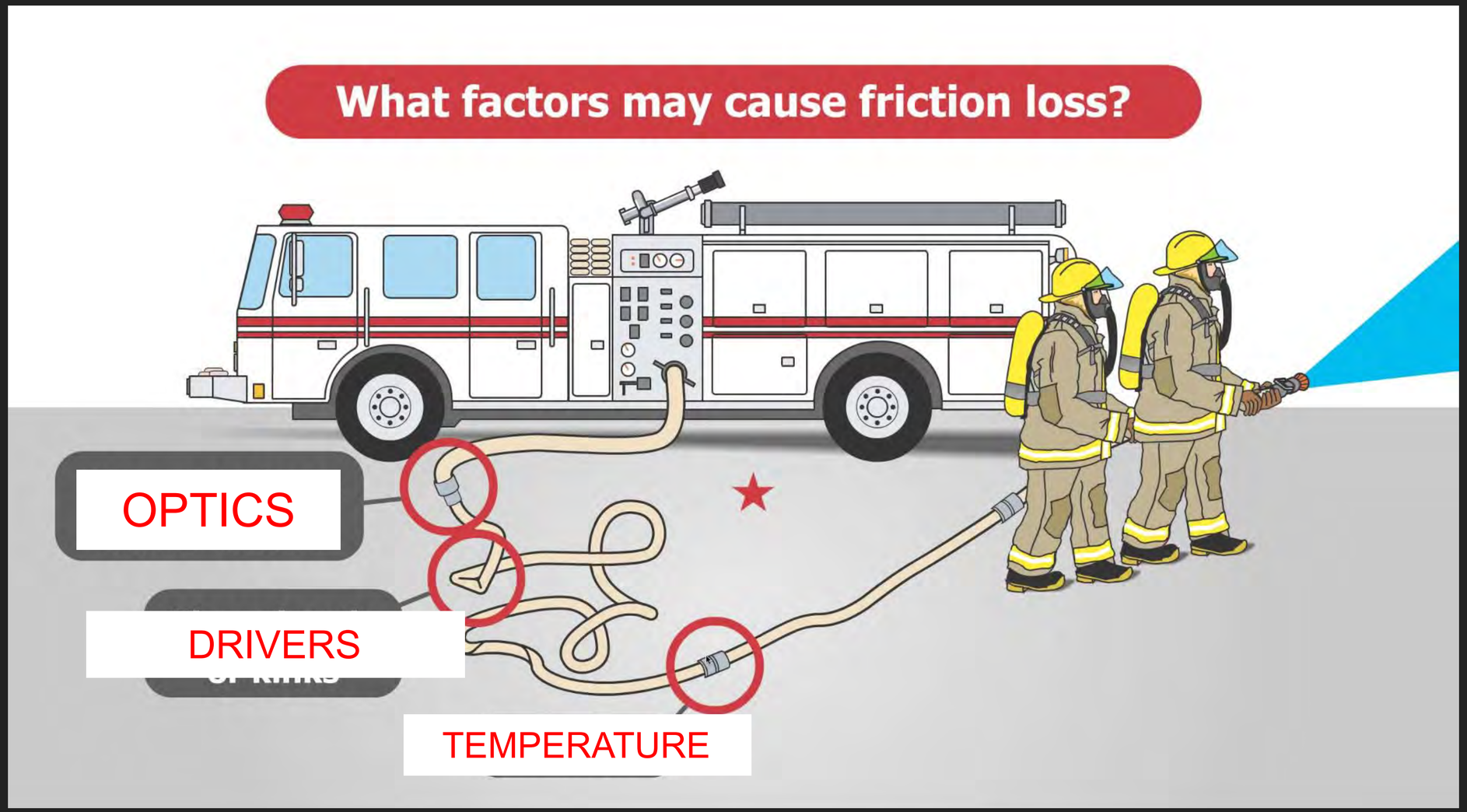


Effective Lumens

Take in to account the **REAL WORLD** factors that effect performance

16 X875 = 14,000 Effective lumens

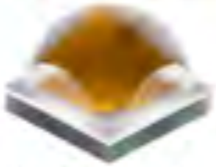
MEASURING LIGHT OUTPUT: RAW VS EFFECTIVE



MEASURING LIGHT OUTPUT: TEMPERATURE OF THE CIRCUIT

CREE

Cree® XLamp® XP-L LEDs



XP-L High Density LED

PRODUCT DESCRIPTION

XLamp® XP-L LEDs are available in two versions: High Density and High Intensity.

The XLamp® XP-L High Density (HD) LED is the highest performing discrete in Cree's High Density (HD) class of LEDs, delivering the next generation of lumen output and efficacy in the compact 3.45 mm x 3.45 mm XP footprint. Cree's HD LEDs, optimized to deliver maximum lumen output in a small form factor, enable lighting manufacturers to improve the performance of any

FEATURES

- Available in white, 70-CRI white, 80-CRI white, 85 CRI white and 90-CRI white
- ANSI-compatible chromaticity bins
- Binned at 85 °C
- Maximum drive current: 3000 mA
- Low thermal resistance: 2.2 °C/W
- Wide viewing angle: 125° (XP-L High Density), 115° (XP-L High Intensity)
- Unlimited floor life at ≤ 30 °C/85% RH
- Reflow solderable - JEDEC J-STD-020C
- Electrically neutral thermal path
- RoHS and REACh compliant

EE

HARACTERISTICS - XP-L HIGH DENSITY (T_J = 85 °C)

wing table provides order codes for XLamp XP-L High Density LEDs. For a
ee the Bin and Order Code Formats section (page 27). For definitions of
icity Kits section (page 26).

Chromaticity		Minimum Luminous Flux (lm) @ 1050 mA			
Kit	CCT	Code	Flux (lm) @ 85 °C	Flux (lm) @ 25 °C*	65 CRI Typical
51	6200 K	V6	480	535	XPLAWT-00-0000-000
		V5	460	513	XPLAWT-00-0000-000
		V4	440	491	XPLAWT-00-0000-000
		V3	420	468	XPLAWT-00-0000-000
		V2	400	446	
53	6000 K	V6	480	535	XPLAWT-00-0000-000
		V5	460	513	XPLAWT-00-0000-000
		V4	440	491	XPLAWT-00-0000-000
		V3	420	468	XPLAWT-00-0000-000
		V2	400	446	
		V6	480	535	XPLAWT-00-0000-000

MEASURING LIGHT OUTPUT: TEMPERATURE OF THE CIRCUIT

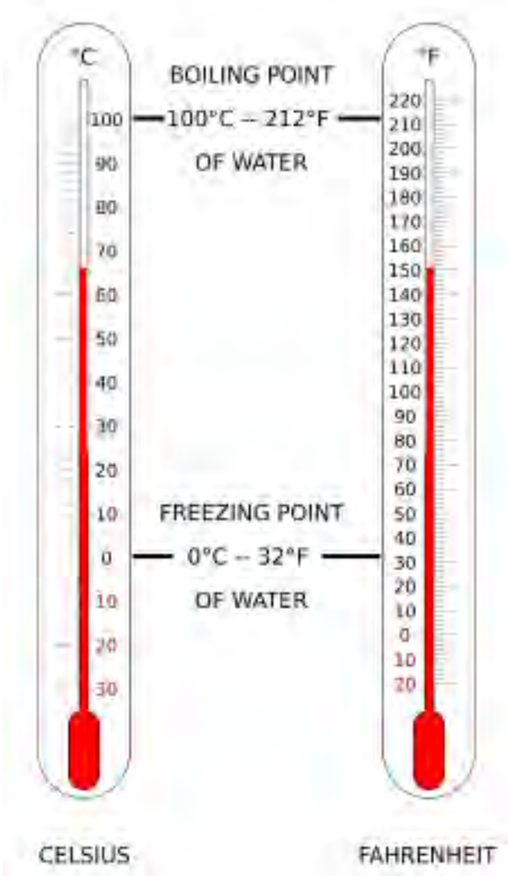
Junction Temperature
(where the LED attaches to the circuit board)

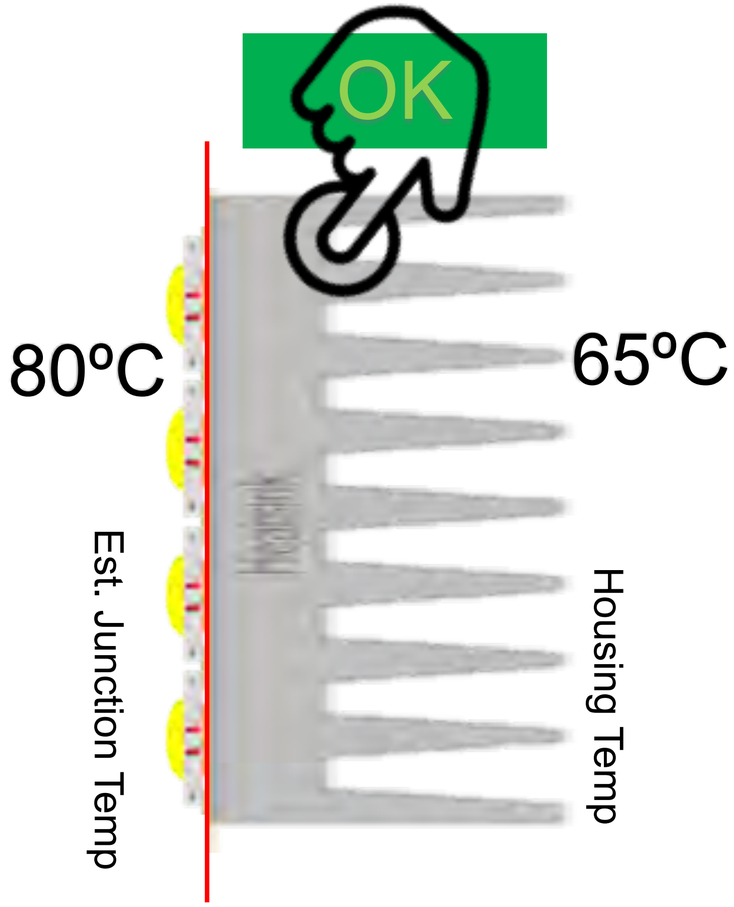
Housing Temperature
Temperature of the metal heat sink

H-Temp ≃ 80% of J-Temp

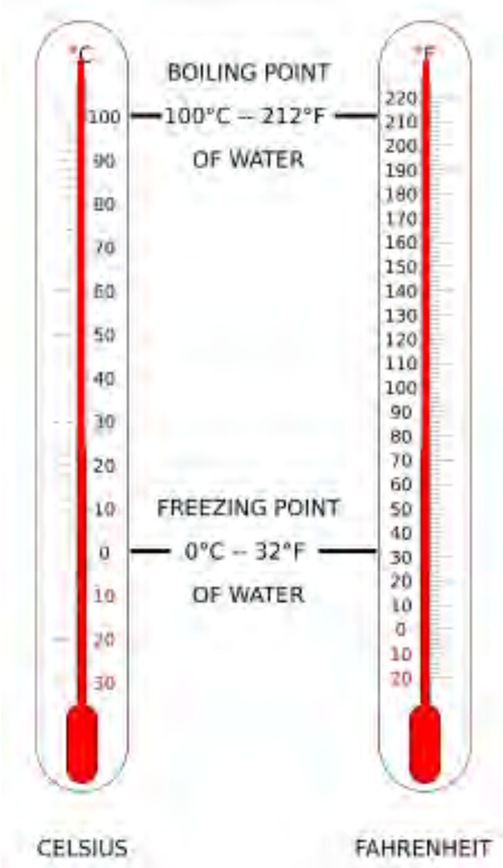
OR H-Temp / 0.8 ≃ J-Temp

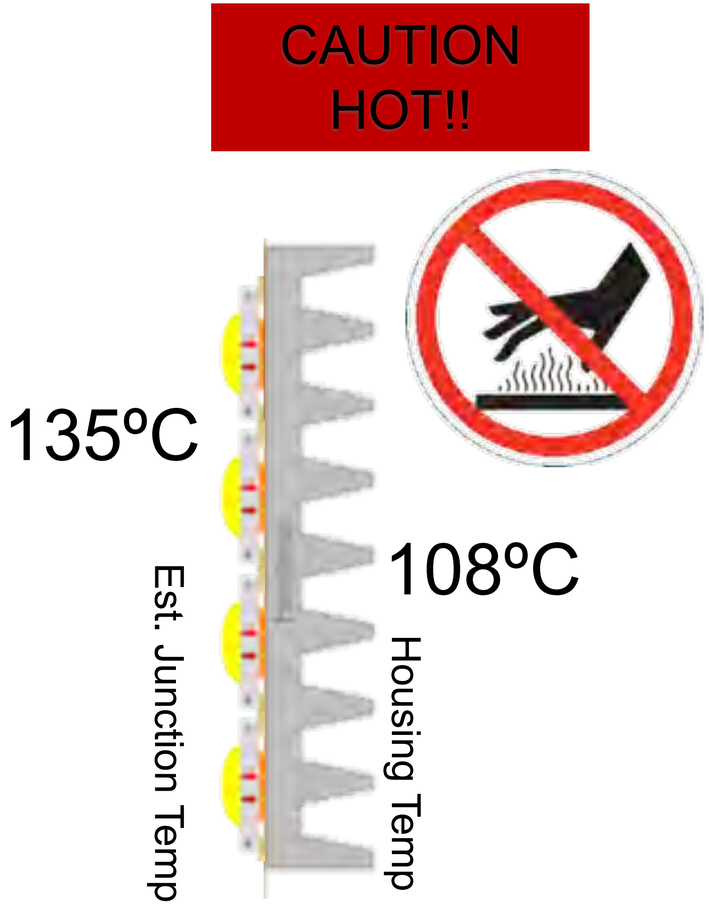
MEASURING LIGHT OUTPUT: TEMPERATURE OF THE CIRCUIT





MEASURING LIGHT OUTPUT: TEMPERATURE OF THE CIRCUIT

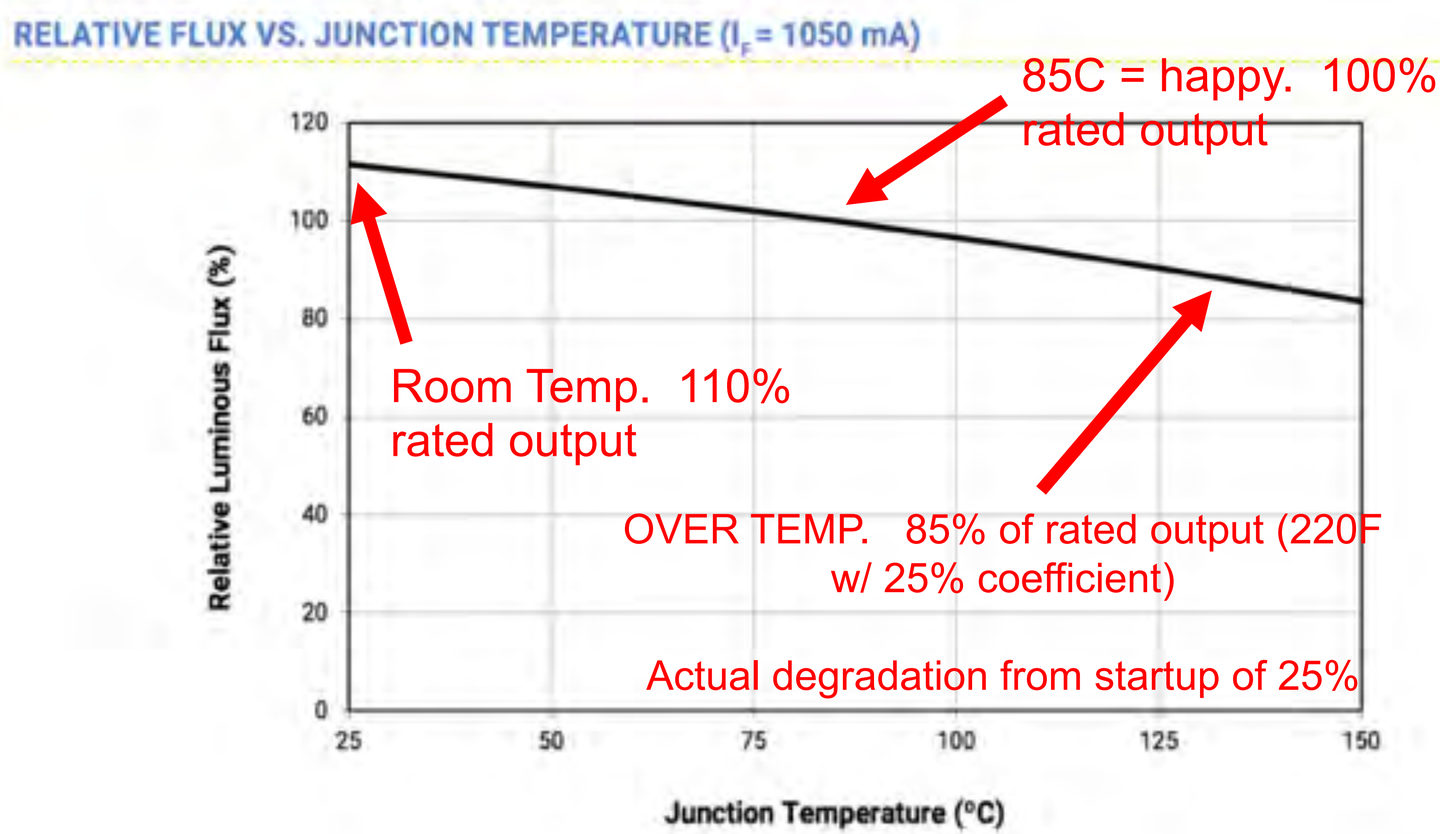




Less mass and more drive current equal significantly higher operating temperatures.

MEASURING LIGHT OUTPUT: TEMPERATURE OF THE CIRCUIT

- What happens when a fixture gets too hot?
  - Thermal Crash (less light when hot, returns when cooled down)
  - Predictable irreversible reduction in useable service live (does not return when cooled down)
  - Damage to other components on the circuit board (power supplies, drivers, etc)



IF VIEWED IN PDF FORM VS. LIVE, SEE VIDEO BELOW

- https://www.dropbox.com/s/6kc550003o2jqad/Thermal%20Degredation%204K.m4v?dl=0

- If this presentation is viewed in PDF form Vs. Live, check out the above link for a better explanation of this phenomenon. the take away is there is a reason the FireTech brand uses such large heat sink's.
- Other brands of scene lights that are much thiner than the FireTech brand suffer from significant thermal degradation as shown in this video.

MEASURING LIGHT OUTPUT: TEMPERATURE OF THE CIRCUIT

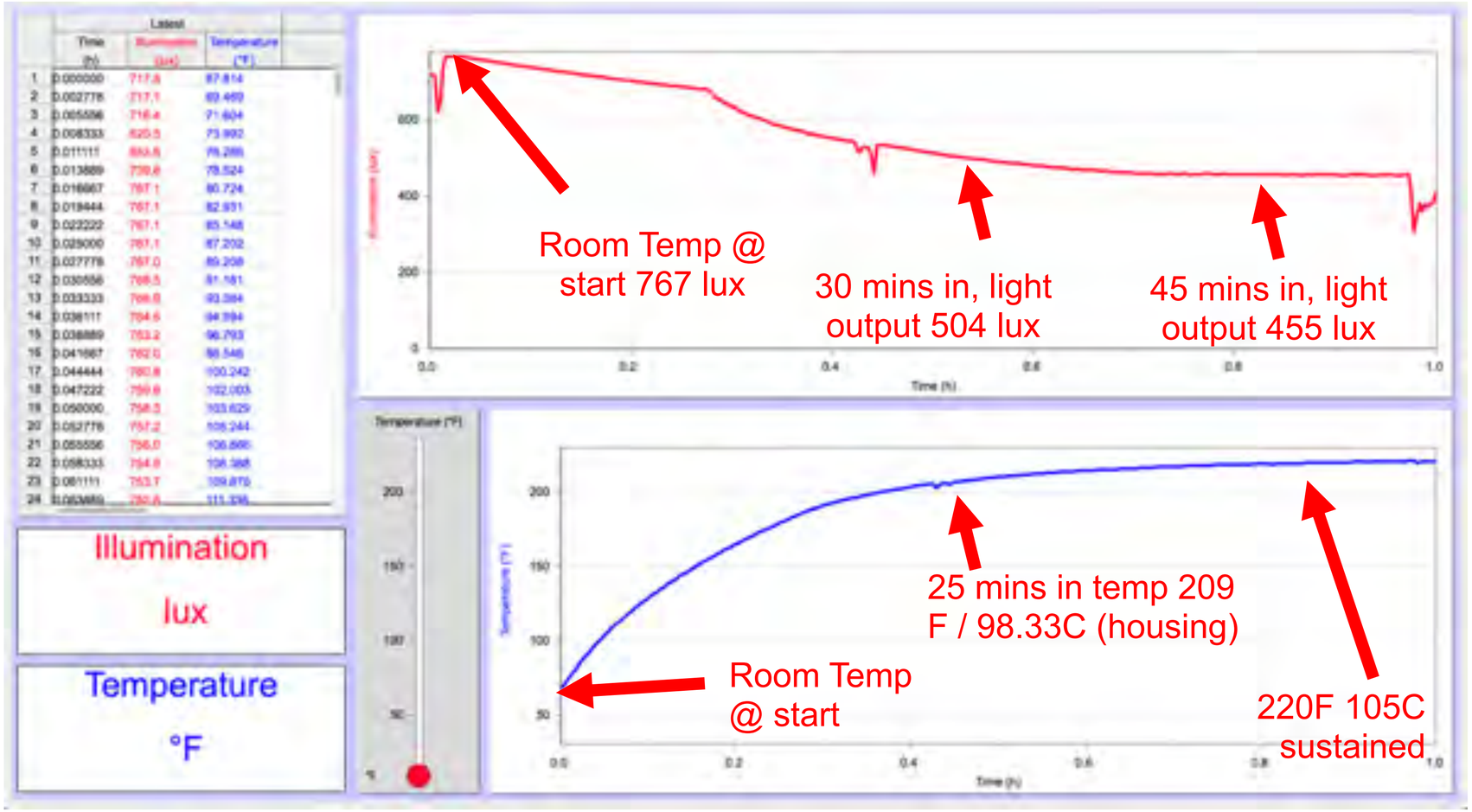
FireTech LED Scene Light

17.24% reduction in output over 45 mins

Assumed J-Temp of 92C

MEASURING LIGHT OUTPUT: TEMPERATURE OF THE CIRCUIT

Other brand "28,000 lumen"
Fire market LED Scene Light

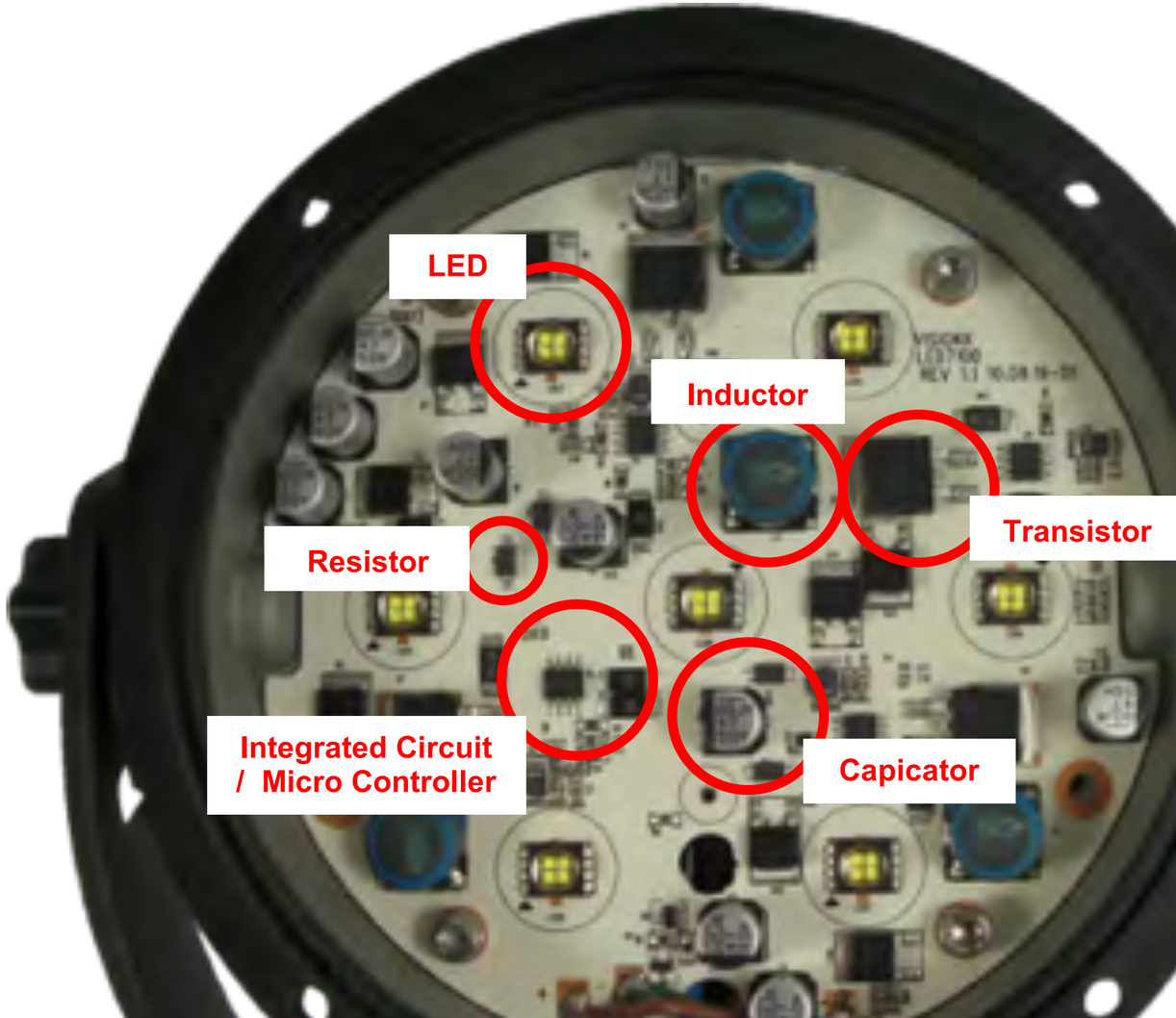


40% reduction in output over 45 mins
Assumed Jtemp of 135C

Wattage at Start: ~255 Wattage after 1 hour: 148

IMPACT OF TEMPERATURE

- The LED itself typically makes up only around 10% of the components in modern fixture driver circuit
- Each LED relies on the other parts on the board
- Often, manufacturers underestimate the impact the heat from the LED has on the other components, and premature failures of auxiliary driver components cause the entire fixture to suffer!



THE SCIENCE OF EFFECTIVE SCENE LIGHTING

PRACTICAL APPLICATION

PRACTICAL APPLICATION

- We know how scene lights are measured
- We know the different types of source technology available today
- We know what to look for in reliable scene lights

Now lets explore the
APPLICATION

PRACTICAL APPLICATION

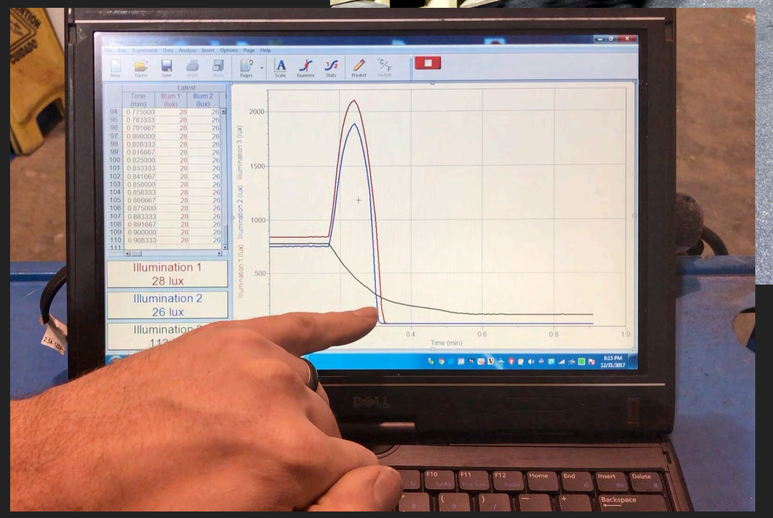
- Reduce Glare: Put more light **on target** than in **the eyes** of the firefighter
- **Do not** waste light in areas you can not use it
- Minimize the number of “highs” and “lows”
- Consider how the shape of the beam will effect oncoming traffic

PRACTICAL APPLICATION: REDUCE GLARE

- Put more light **on target** than in **the eyes** of the firefighter
  - Leverage Elevation to your advantage

(practical demo; Zach the light mannequin. Video link below:

https://www.dropbox.com/s/vcdb70ytw9xvfot/Zach%20Video%202.m4v?dl=0)



PRACTICAL APPLICATION: RESEARCH

- **Do not** waste light in areas you can not use it

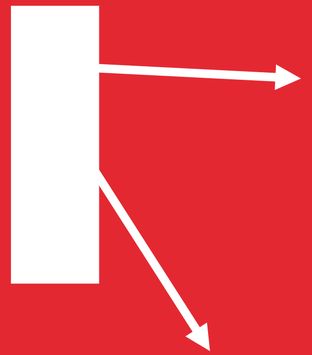
  Research the application prior to specifying a light package. If the truck is a pumper, and you're operating with 200' of cross-lay, consider that if the incident is 900' away, 95% of the time you will be able to bring the apparatus closer.

PRACTICAL APPLICATION: SHAPE OF LIGHT

- Consider the shape of the beam and the location the fixture will be mounted

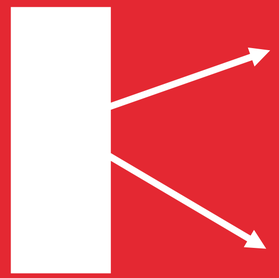
ASYMMETRIC OPTICS

SHINES LIGHT "DOWN AND OUT"



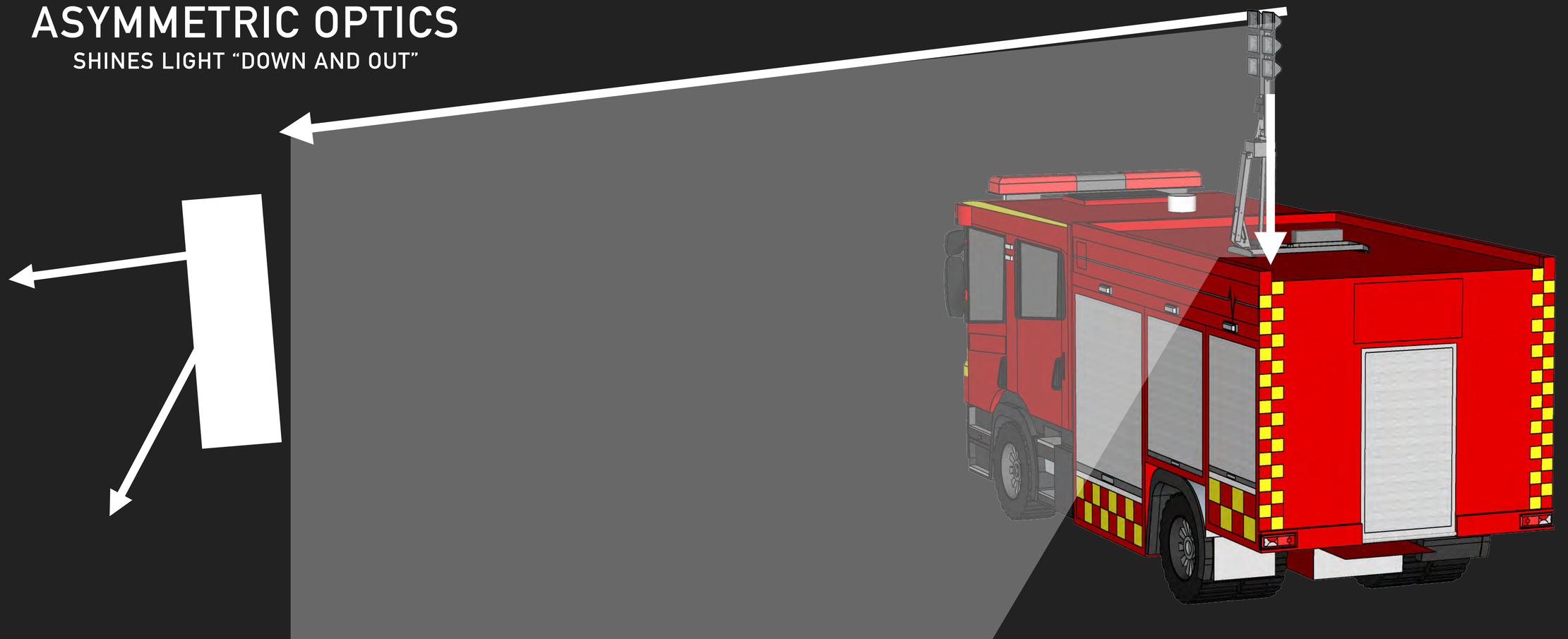
SYMMETRICAL OPTICS

LIGHT SHAPED LIKE A TRAFFIC CONE



PRACTICAL APPLICATION: SHAPE OF LIGHT

- Consider the shape of the beam and the location the fixture will be mounted
  - Don’t waste light in areas you cant use it!



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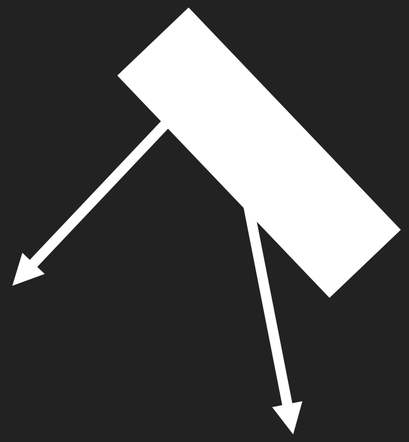

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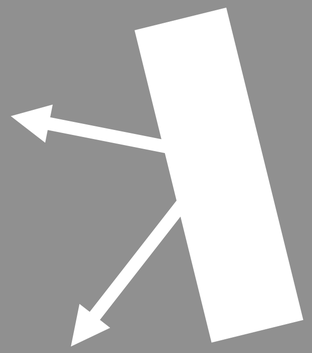

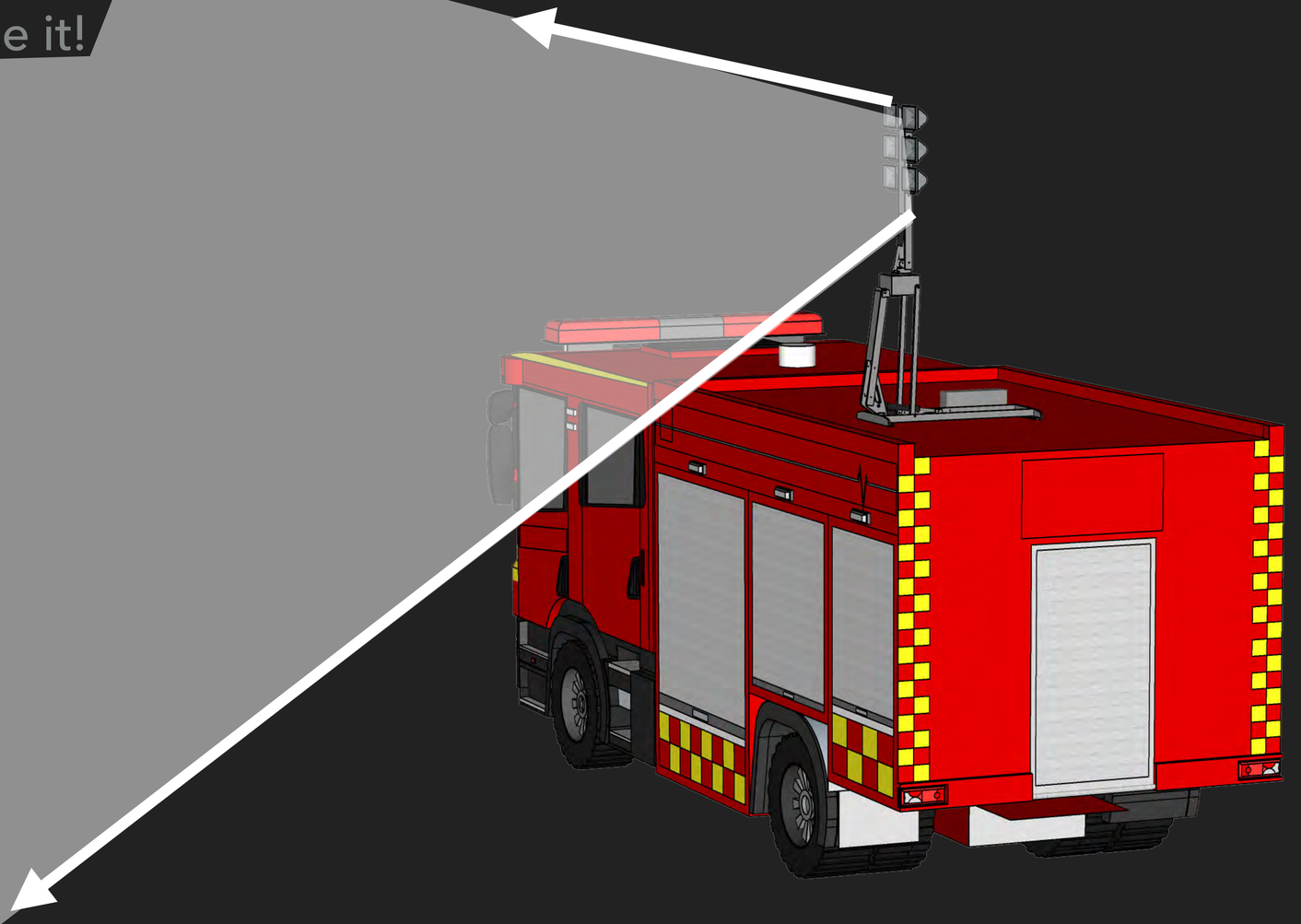

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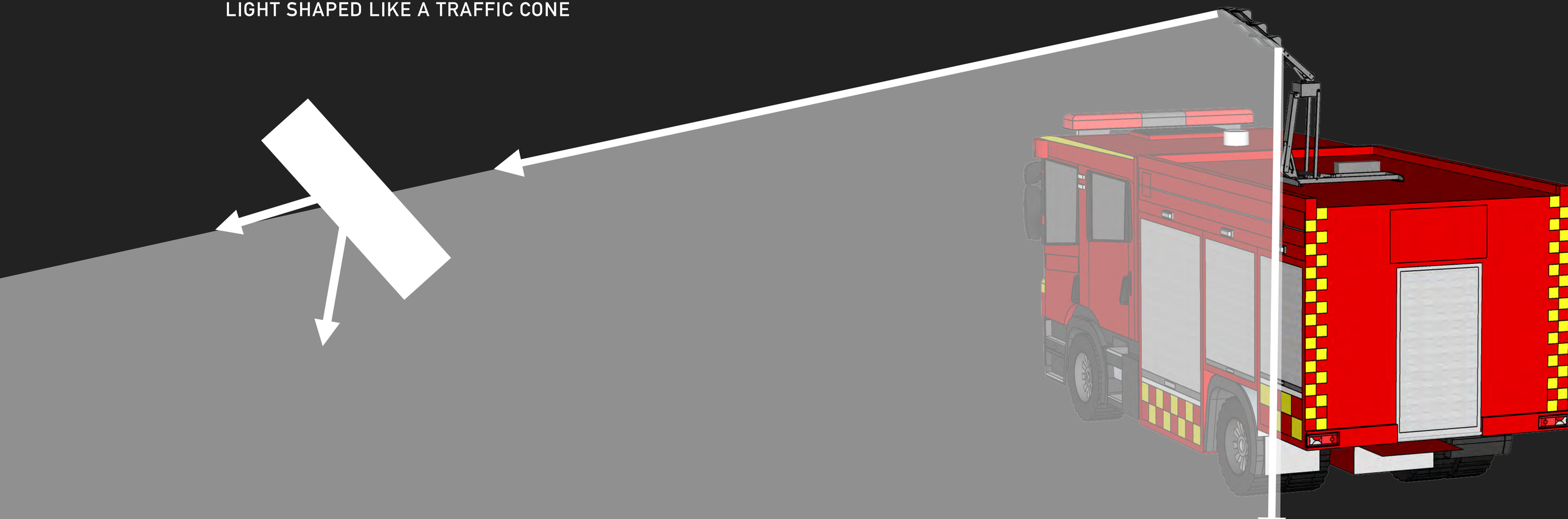

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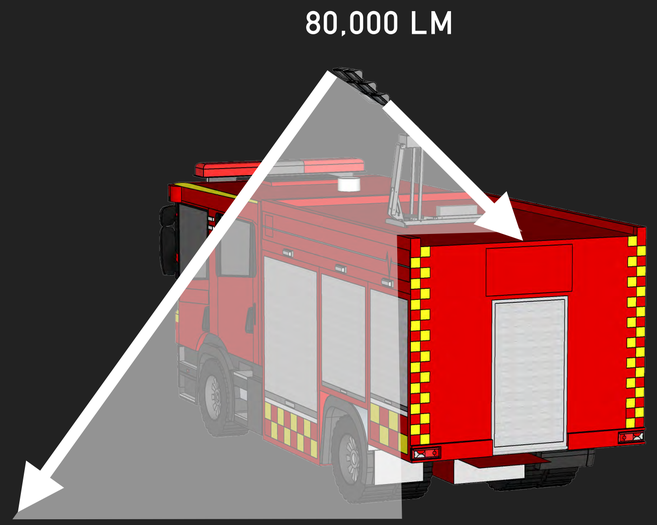
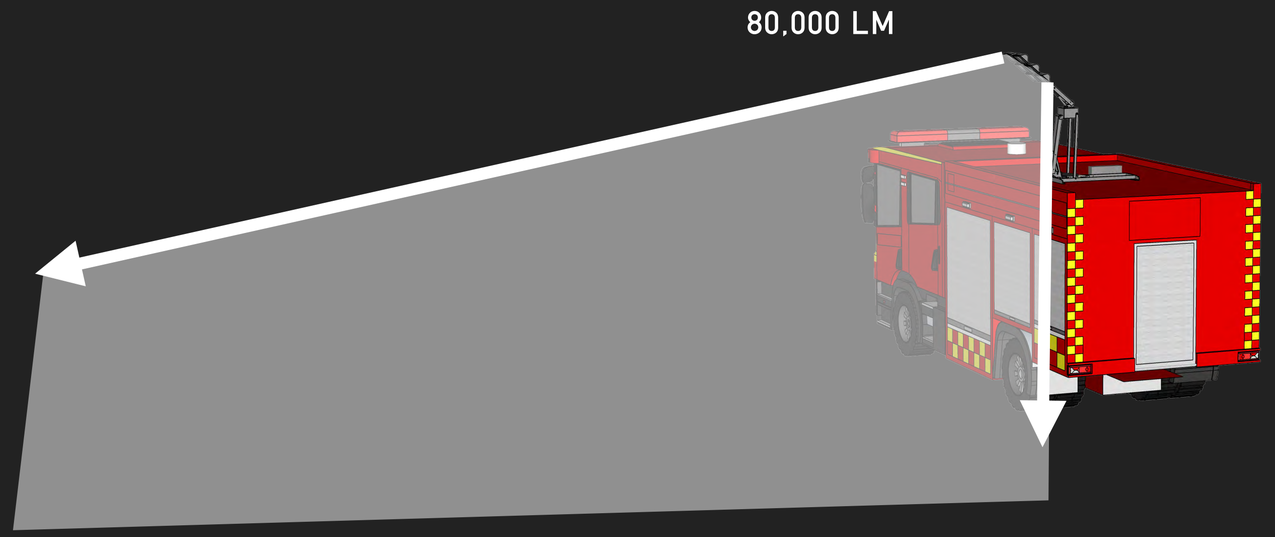


SAME # OF LUMENS, MAJORITY OF LIGHT ON ROOF OF TRUCK

SYMMETRICAL OPTICS

LIGHT SHAPED LIKE A TRAFFIC CONE



SAME # OF LUMENS, MINIMAL LIGHT ON THE ROOF OF THE APPARATUS

PRACTICAL APPLICATION: SHAPE OF LIGHT

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ASYMMETRIC OPTICS

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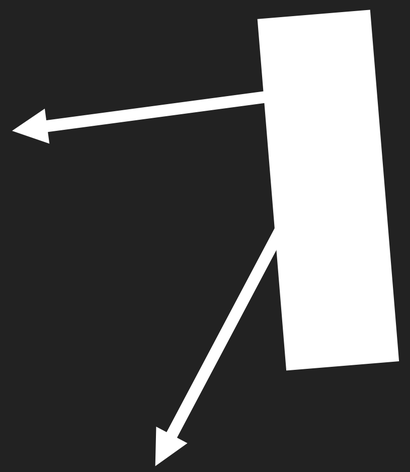

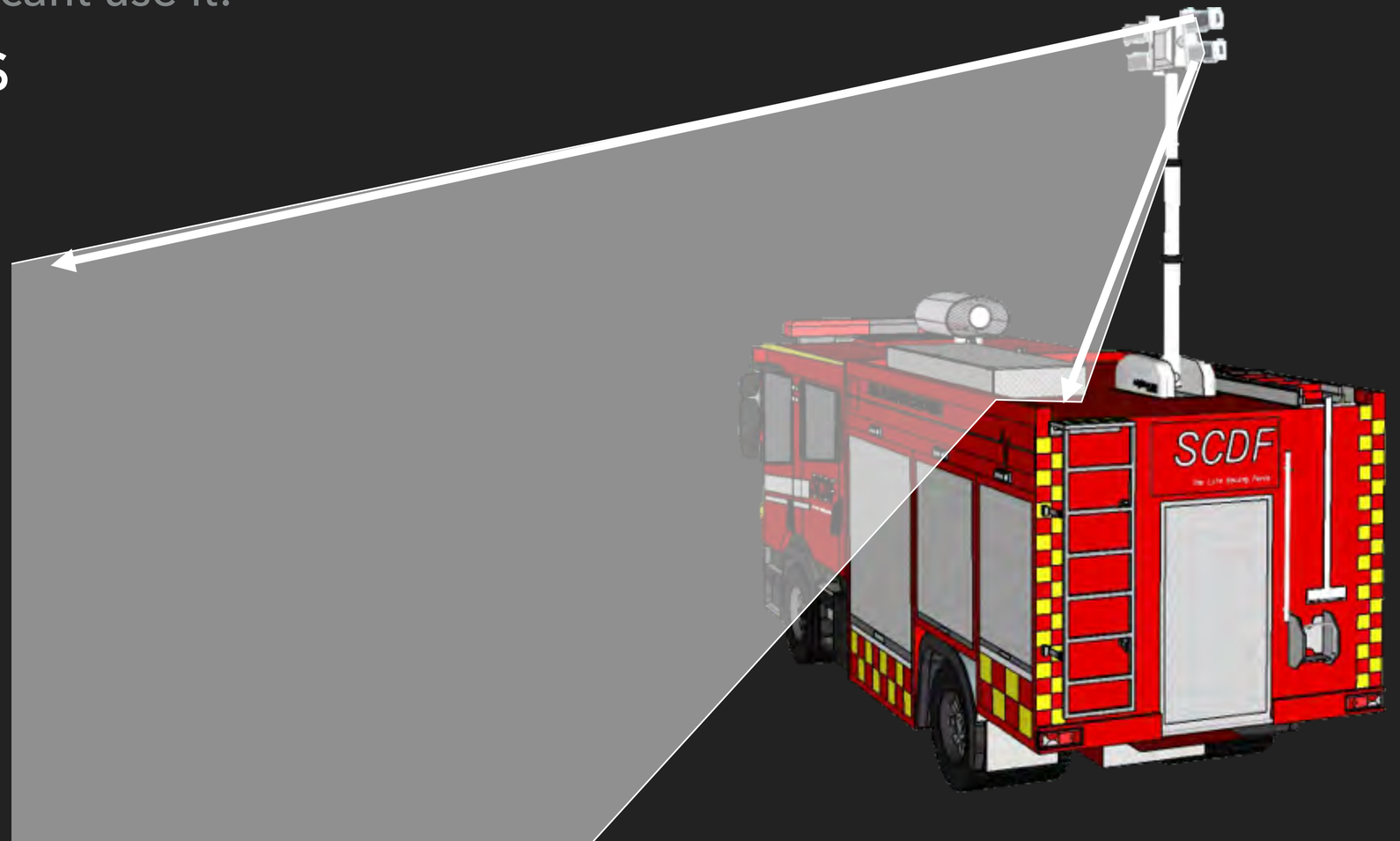

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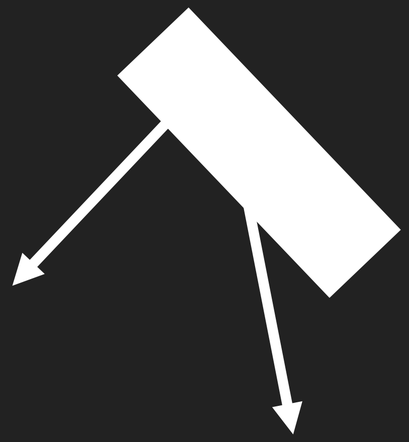
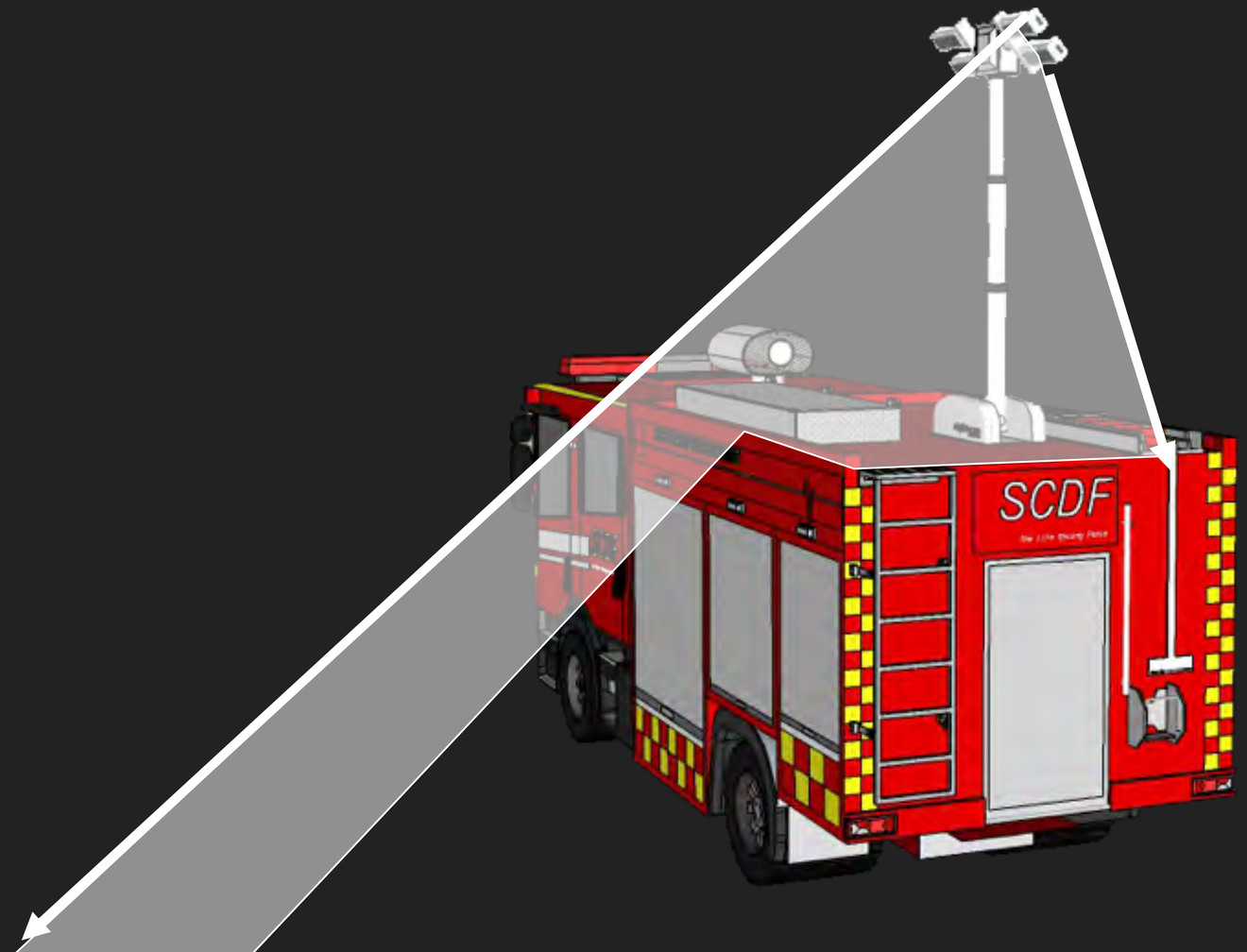
ASYMMETRIC OPTICS

SHINES LIGHT “DOWN AND OUT”



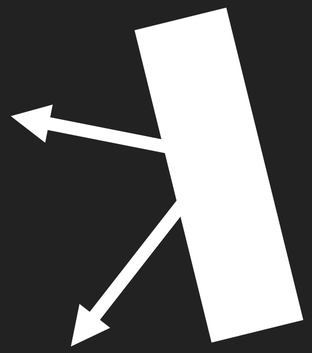


PRACTICAL APPLICATION: SHAPE OF LIGHT

- Consider the shape of the beam and the location the fixture will be mounted
  - Don’t waste light in areas you cant use it!

SYMMETRICAL OPTICS

LIGHT SHAPED LIKE A TRAFFIC CONE



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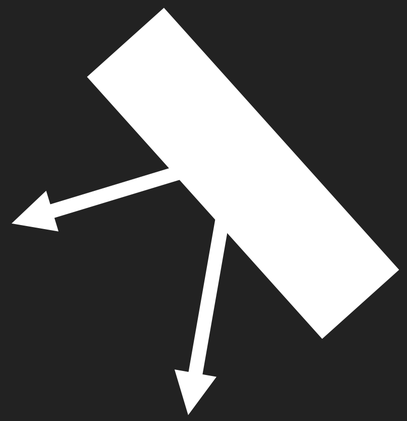

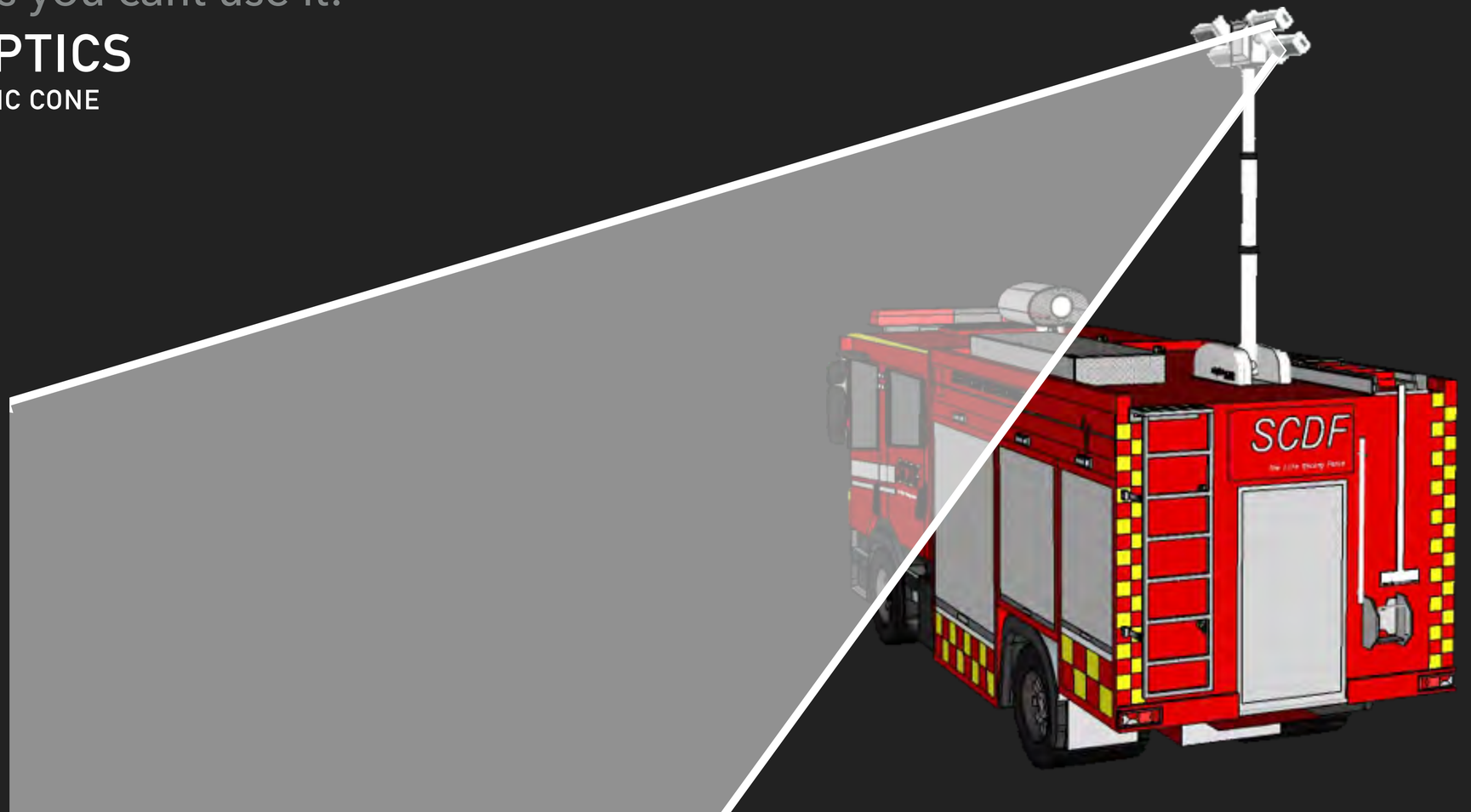

PRACTICAL APPLICATION: SHAPE OF LIGHT

- Consider the shape of the beam and the location the fixture will be mounted
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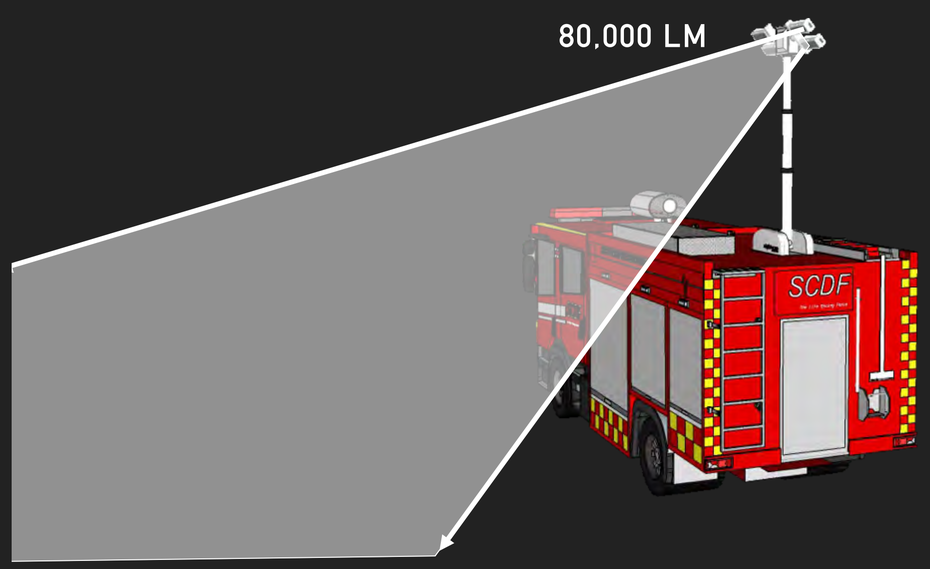
ASYMMETRIC OPTICS

SHINES LIGHT “DOWN AND OUT”

SAME # OF LUMENS, MAJORITY OF LIGHT ON ROOF OF TRUCK

SYMMETRICAL OPTICS

LIGHT SHAPED LIKE A TRAFFIC CONE



SAME # OF LUMENS, MINIMAL LIGHT ON THE ROOF OF THE APPARATUS

PRACTICAL APPLICATION: SHAPE OF LIGHT

- Consider the shape of the beam and the location the fixture will be mounted
  - Don’t waste light in areas you cant use it!

ASYMMETRIC OPTICS

SHINES LIGHT “DOWN AND OUT”

ROLL UP DOORS

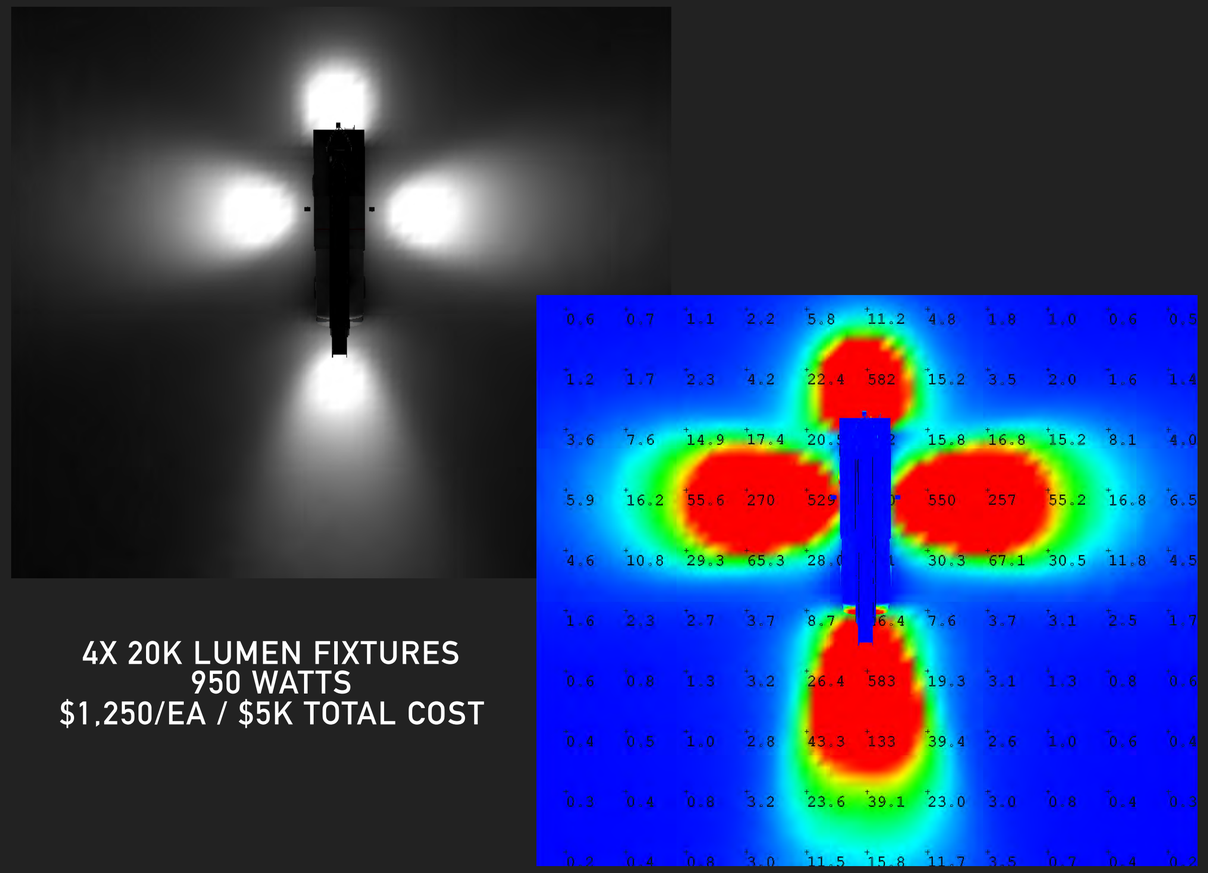
SYMMETRICAL OPTICS

LIGHT SHAPED LIKE A TRAFFIC CONE

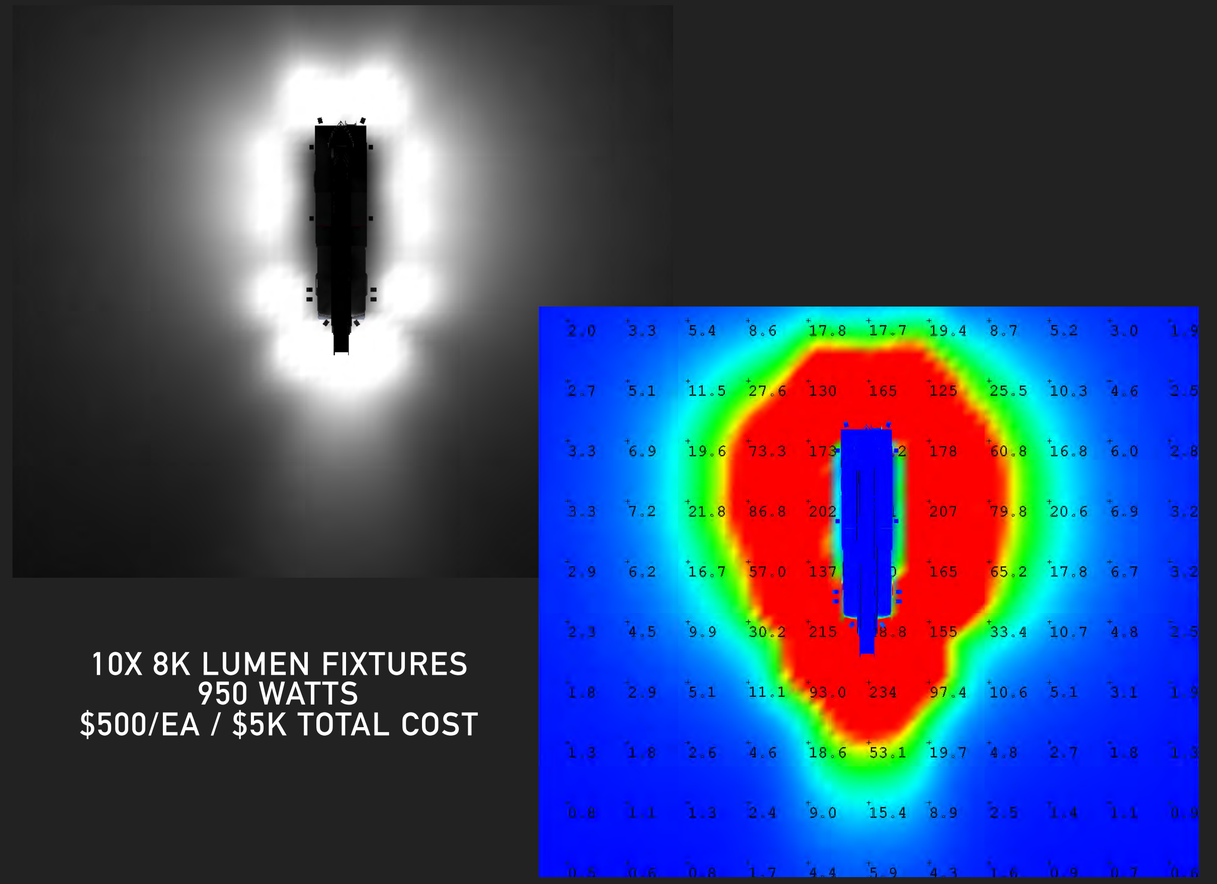
SLAM DOORS

PRACTICAL APPLICATION: MAKE THE LIGHTING EVEN

- Minimize the number of “highs” and “lows”



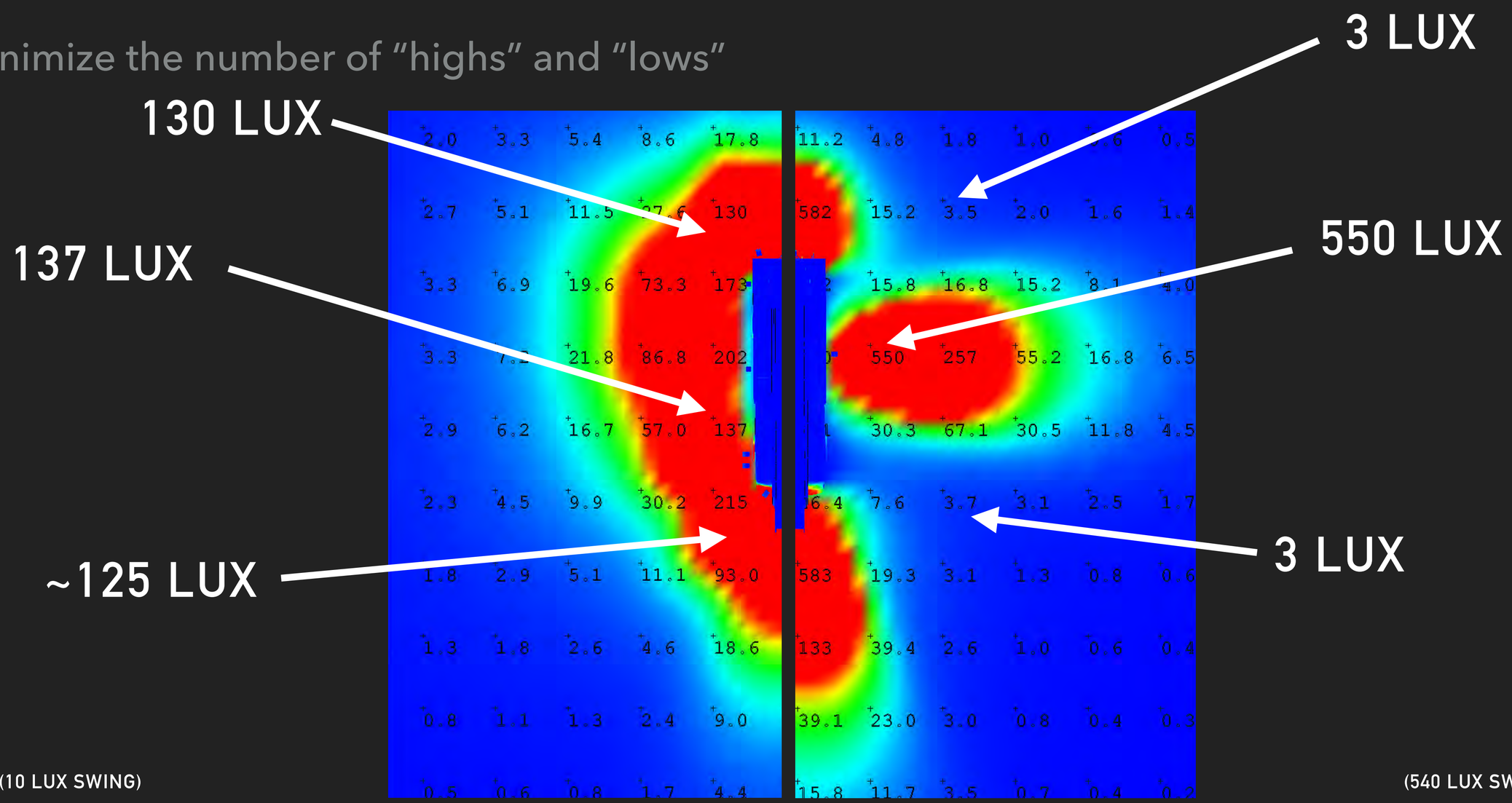
4X 20K LUMEN FIXTURES
950 WATTS
$1,250/EA / $5K TOTAL COST



10X 8K LUMEN FIXTURES
950 WATTS
$500/EA / $5K TOTAL COST

PRACTICAL APPLICATION: MAKE THE LIGHTING EVEN

- Minimize the number of “highs” and “lows”



PRACTICAL APPLICATION: MAKE THE LIGHTING EVEN

- Consider how the shape of the beam will effect oncoming traffic

PRACTICAL SUMMARY

- Height is key to reducing glare
- Slam Doors? Or Front of cab?
  - Go with Symmetrical optics
- Roll up’s or clear view to the ground?
  - Asymmetric is your friend
- Temperature is the #1 killer of LEDs
- Fixture Placement is more important than fixture performance

IF YOU DONT HAVE THE TIME TO DO IT RIGHT, WHEN WILL YOU HAVE TIME TO DO IT OVER?

. . .The average service life of a Fire Apparatus in the US is 25 years

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THANK YOU

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