

# New Frontiers in LED Lighting: Today and in the Coming Decade

**Eric Haugaard – Cree Lighting**



7



?

< 2%

4,000,000,000,000,000  
Btu

1,170,000,000,000,000  
kWh







\$37,000,000,000.00

LED



830W

Metal Halide

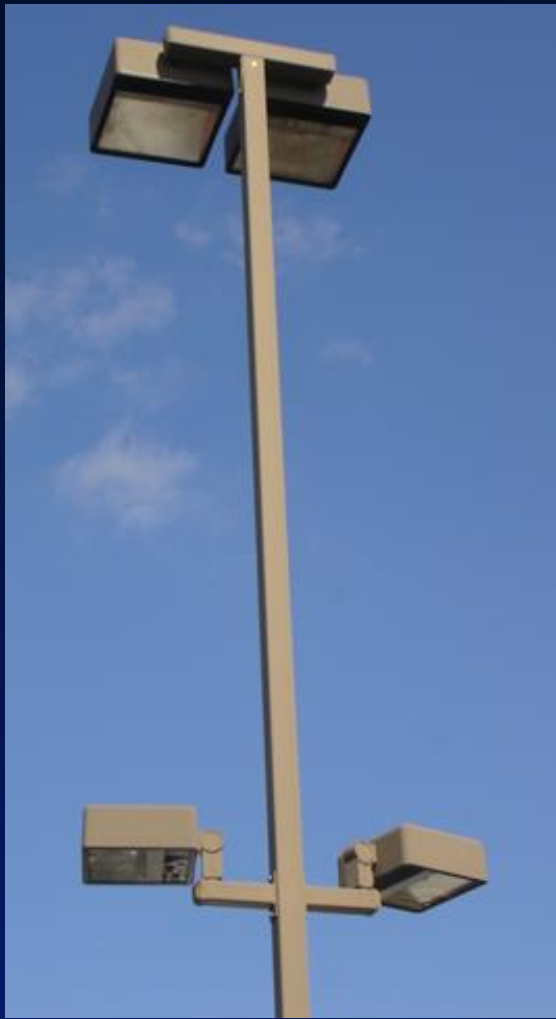


3,070W

**73% REDUCTION**

90+ CRI  
MAKES CARS LOOK AMAZING





LED



830W

Metal Halide



3,070W

# The Value of Lighting Design



Requires Complete and Comprehensive  
Product Performance Data!!!



Play Back:

Interactive Display Mode

7 Refresh

10 (Fast) Animation

0.00 Exposure

---

Statistics

Road Lighting Project  
Calc: Fc

CalcFct  
Illuminance (Fc)  
Average: 2.17 Maximum: 8.5 Minimum: 0.0  
Avg/Min: N/A. Max/Min: N/A.

Stat Areas

Parking Only  
fc: 0.000 0.000 0.000

---

Select Command  
Toolkit Statistics Units: Ft-Fc Textures Wire Overlay Model Overlay Pseudo Color Anti-Aliasing None  
11:12 AM 11/29/2011

# AGENDA

LEDs Do Everything Better

Science Proves It

Real World Experience Proves It

In the Future We Can Do Even More



If You Argue With Science  
You Will Lose

# Evolution in the Way We Listen to Music



Live Performance



Phonograph



Tape



Compact Disc



mp3

# Photography Revolution



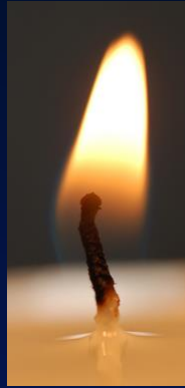
Film

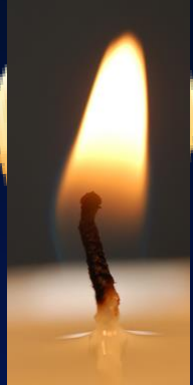


Digital Cameras



Smart Phones





- The end is near...
- Incandescent
- Fluorescent
- Metal Halide/HID



Other

Visible Light

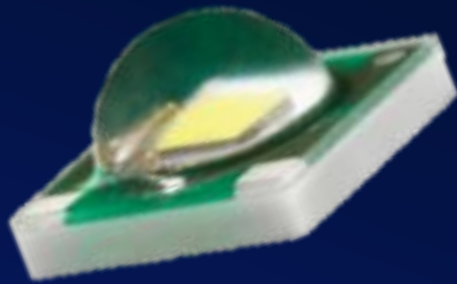






Other

Visible Light



Other

Visible Light



1940s  
Efficacy

Today  
Efficacy



1940s  
Efficacy

Today  
Efficacy



1940s  
Efficacy

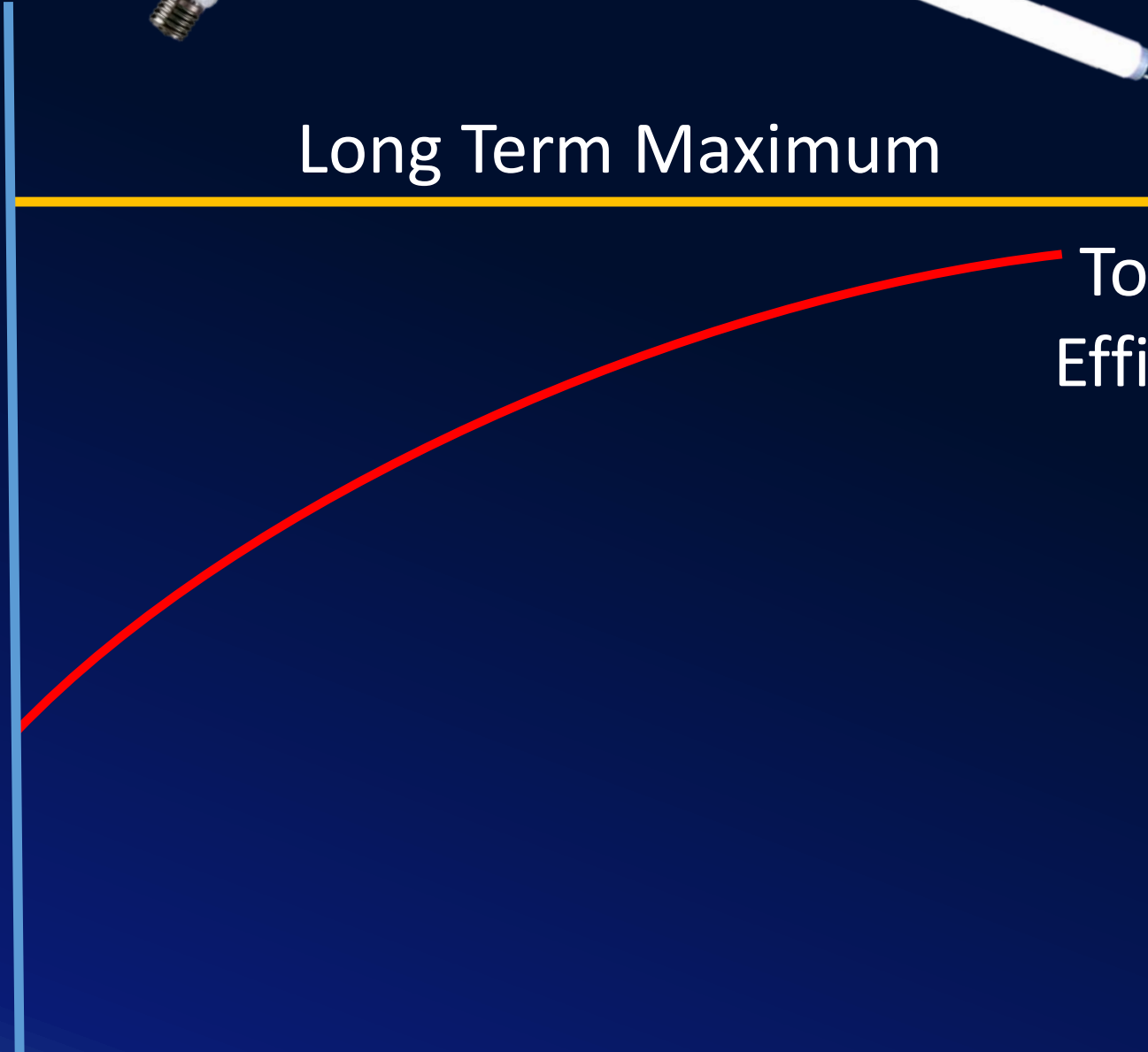
Today  
Efficacy



Long Term Maximum

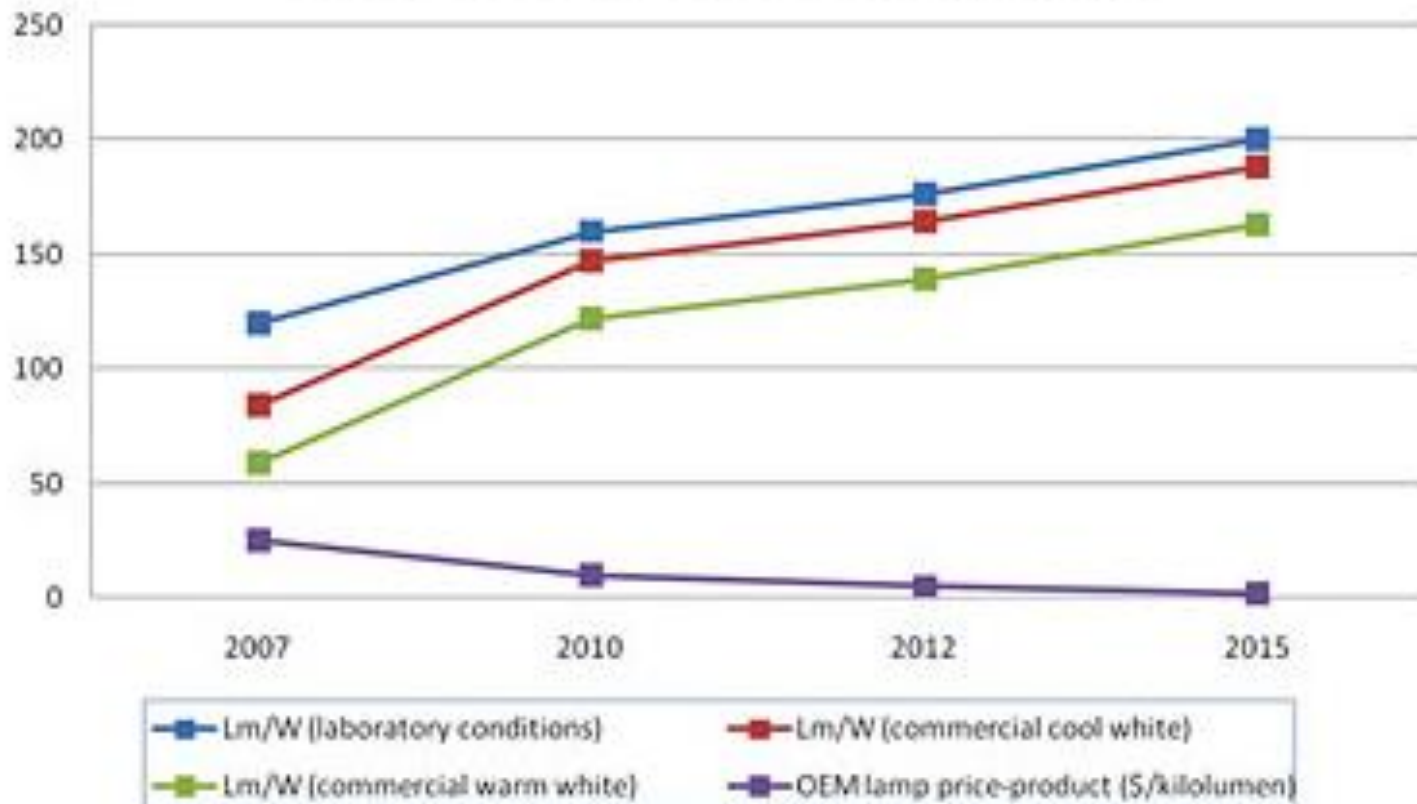
Today  
Efficacy

1940s  
Efficacy

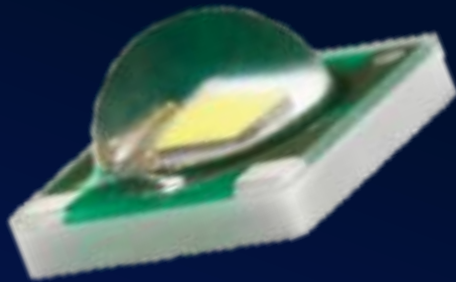


# 2009 DOE Projections

## LED Device Performance Projections



**300 LPW**

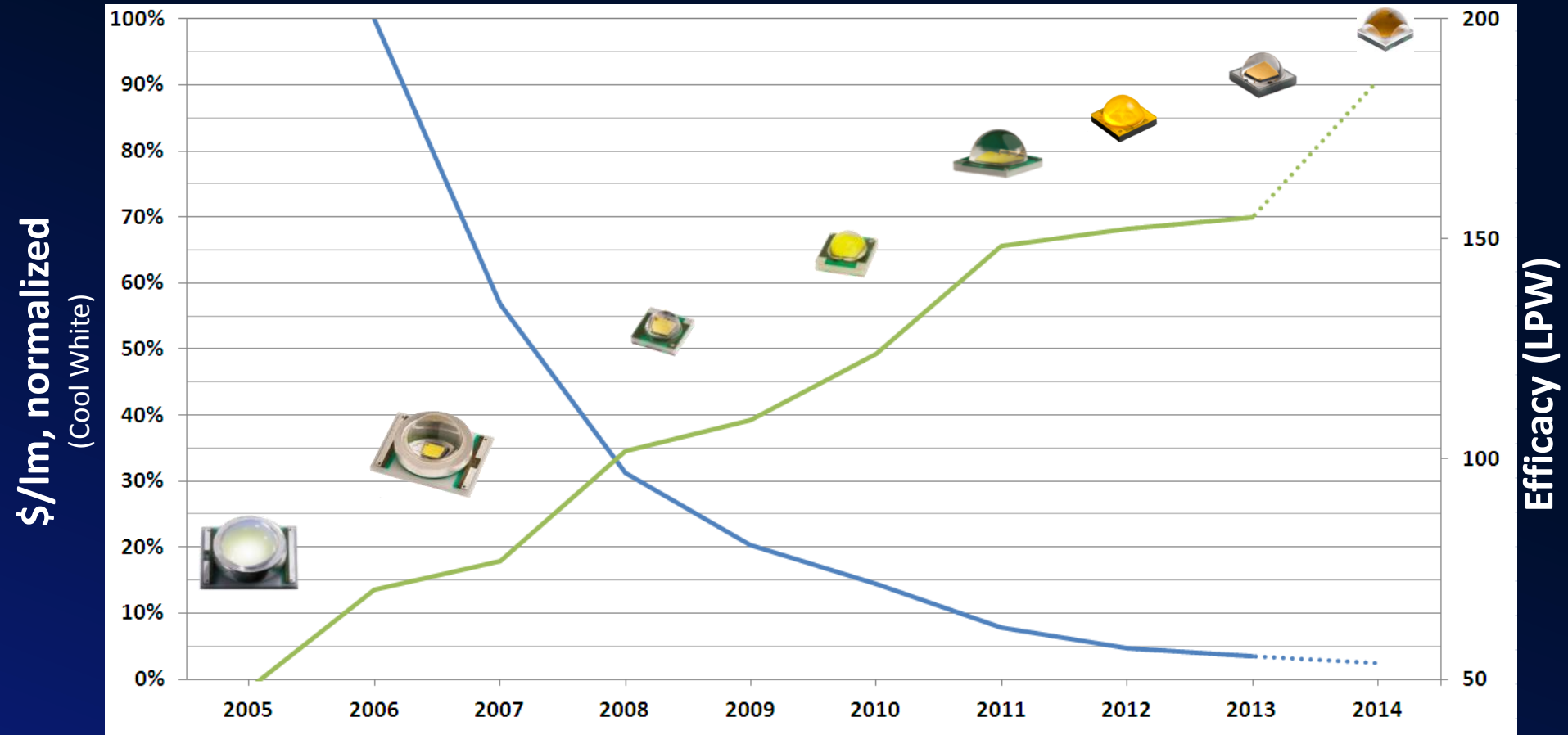


2014  
Efficacy

2007  
Efficacy

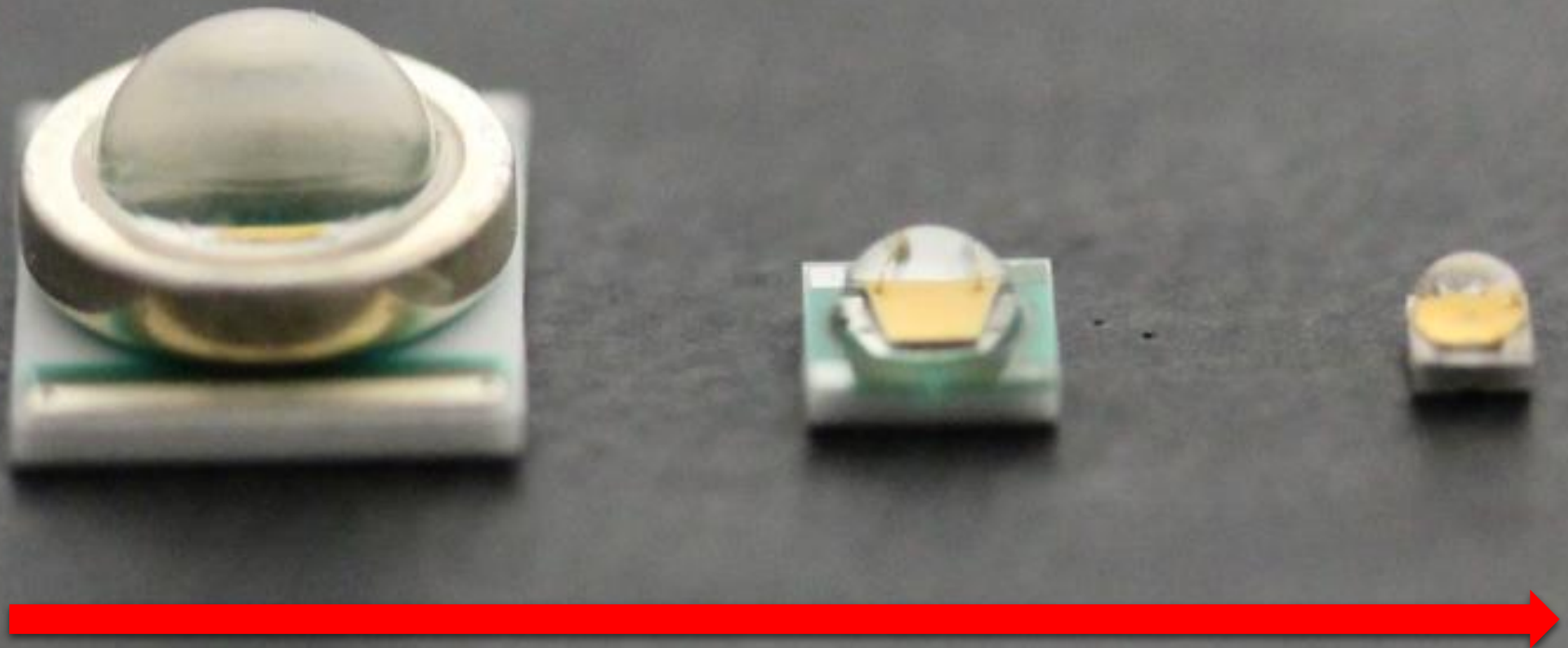


# LED Device Value Evolution



Annual Improvement in \$/lm @ 100 LPW	43%	45%	35%	29%	45%	40%	27%
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# Different Die and Package, Same Performance

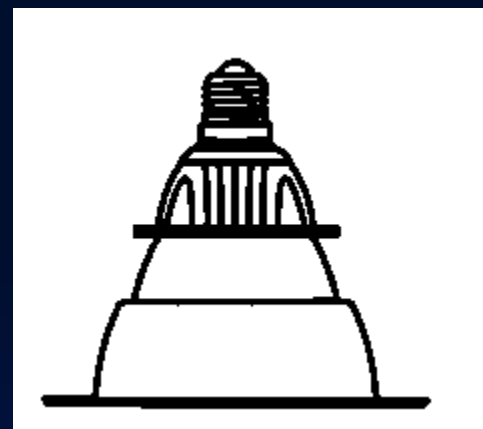
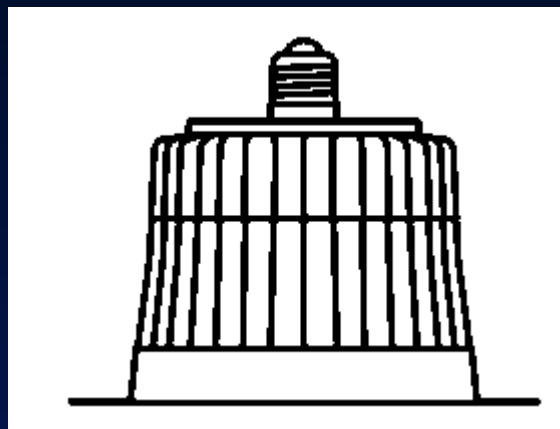


**96% Reduction in Size (volume)**

# Example of the Cost Impact of Increasing LED Performance

2007

- 42 LEDs
- 650 lm
- 12W



2011

- ~~8 LEDs~~
- 650 lm
- ~~10.5W~~

~~10W~~

9.5W



>\$100 Commercial  
Wholesale



\$19.97

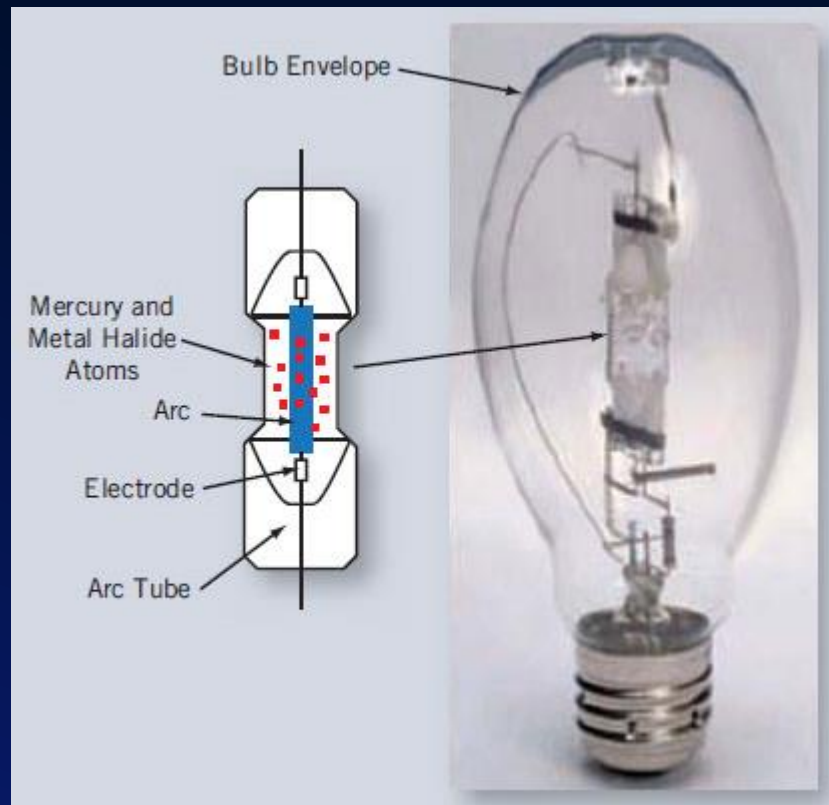
~~\$39.97~~

~~\$49.97~~ Retail

The same thing is happening in other segments of LED lighting

# Light Emitting Plasma

## Electrode-less HID



Group	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
Period 1	1																	2	
1	H																		He
2	3	4											5	6	7	8	9	10	
	Li	Be											B	C	N	O	F	Ne	
3	11	12											13	14	15	16	17	18	
	Na	Mg											Al	Si	P	S	Cl	Ar	
4	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	
	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr	
5	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	
	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe	
6	55	56	57*	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	
	Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn	
7	87	88	89**	104	105	106	107	108	109	110	111	112		114		116		118	
	Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	Uun	Uuu	Uub		Uuq		Uuh		Uuo	

*Lanthanides	58	59	60	61	62	63	64	65	66	67	68	69	70	71
	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
**Actinides	90	91	92	93	94	95	96	97	98	99	100	101	102	103
	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

○ Non Metals	● Noble Gases
● Alkali Metals	● Metalloids
● Alkaline Metals	● Halogens
● Transition Metals	● Other Metals
● Rare Earth Elements	

# Can LED Solutions do Everything Better?

- Color Quality
- Energy Consumption
- Service Life
- And More!!!

# AGENDA

LEDs Do Everything Better

Science Proves It

Real World Experience Proves It

In the Future We Can Do Even More

# Quotes from the Professional Sceptics

- “LED solutions will never provide the color quality that incandescent provides”
- “LED will never obsolete linear fluorescent solutions”
- “LED solutions will never be viable for high output illumination applications”



# Exceptional Color Quality Possibilities



Color Like Nature Meant it to Be!





Seven Years...  
Millions and Millions of  
Square Feet

The Formula for Success =

Improved Illumination Performance

+

Justifiable Economics

“No Brainers”

# Parking Structures



Improved Illumination Performance

+

Justifiable Economics



# Parking Structures With Occupancy Controls





Troffers



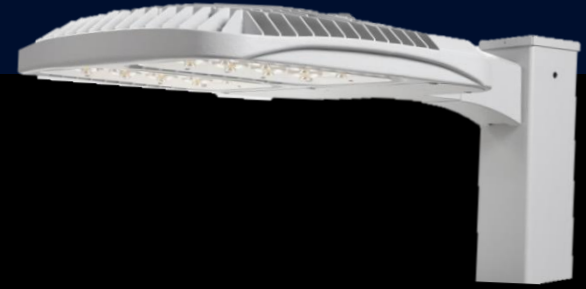
Improved Illumination Performance

+

Justifiable Economics



# Parking Area



Improved Illumination Performance

+

Justifiable Economics



# Downlights



Improved Illumination Performance

+

Justifiable Economics



# Street Lighting



Before



After

Improved Illumination Performance

+

Justifiable Economics



# High Bay Lighting



Improved Illumination Performance

+

Justifiable Economics



Economic and Illumination  
performance benefits are  
overwhelming in these applications

New Frontiers...

Applications that have become  
viable only recently

LED



830W

Metal Halide



3,070W





Improved Illumination Performance

+

Justifiable Economics



**Metal Halide**  
**4000K ~65 CRI**  
**R9 <0**



**LED**  
**5000K 90+ CRI**  
**R9 50+**



# Metal Halide Color and CRI Shift



# High Mast Lighting



Improved Illumination Performance

+

Justifiable Economics



# High Mast



# Hockey Arena

Beautiful Illumination Quality

- Instant On

- Instant Re-Strike



Improved Illumination Performance

+

Justifiable Economics





37 Minute Delay  
\$\$\$



# Countless Lamp Service Incidents Eliminated



Improved Illumination Performance

+

Justifiable Economics





*1929 commemorative of*

*filament  
works*

*Edison's  
first  
lamp  
of  
1879*



*the  
Wizard  
of Menlo  
Park*



\$



# Lights Like a Light Bulb



**Which One is Incandescent and Which is the LED Bulb?**

# Lights Like a Light Bulb



**How about these?**

# AGENDA

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New Paradigm



Can LED Lighting  
Solve Big Problems?

# BIG Problems to Solve

Broadband Speed & Access

Building Automation & Control

Slow & Wasteful Building Construction

# BIG Problems to Solve

Broadband Speed & Access

Building Automation & Control

Slow & Wasteful Building Construction

# More Interconnected Devices



## More devices

everything connected

~ **25**  
Billion

Interconnected  
device forecast  
in 2020<sup>2</sup>

~ **7**  
Billion

Cumulative smartphone  
forecast between  
2013-2017<sup>1</sup>

Courtesy of Qualcomm

# Avoiding Data Brown-Outs



## Richer content

more video

Bestseller example:



**5.93 GB**

Movie (High Definition)



**2.49 GB**

Movie (Standard Definition)



**0.0014 GB**

Homepage



**1.8 GB**

Game for Android



**0.14 GB**

Soundtrack



**0.00091 GB**

Book

Courtesy of Qualcomm

Industry preparing for  
**1000x**  
data traffic growth\*

Courtesy of Qualcomm

It is Difficult to Add Capacity





colars

Captionz

6620 6789

www.CaptionzIndia.com









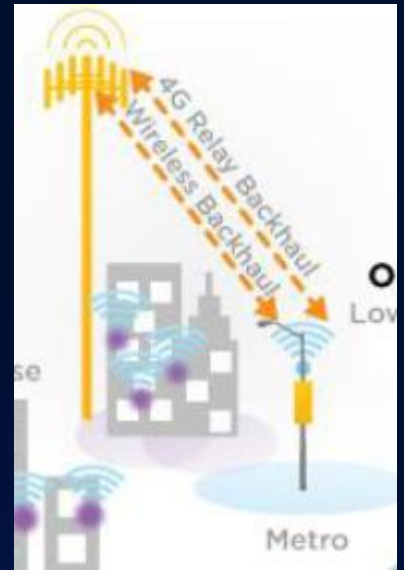
Analog Communications  
Voice is the Only App



Digital Communications  
Voice is One of Many Apps



Analog Lighting  
Lighting is the Only App

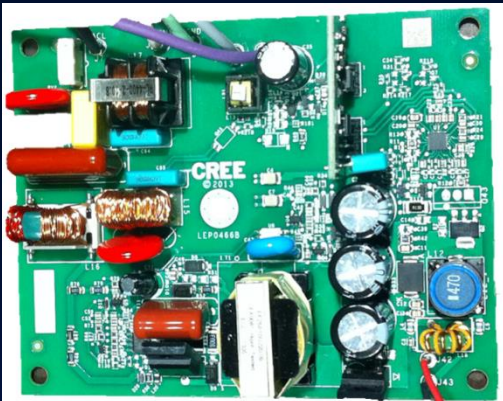


“Digital” LED Lighting  
Lighting is One of Many Apps

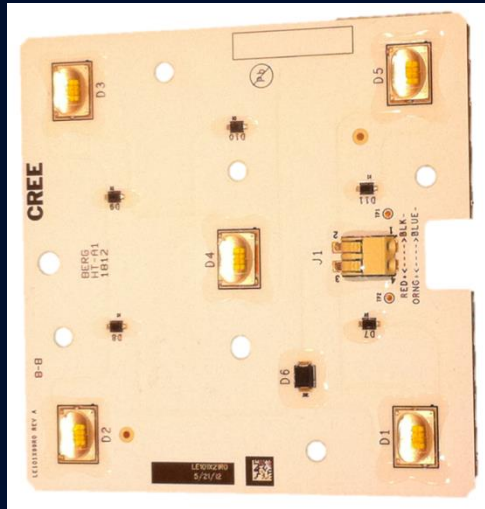
# Roadway Luminaires



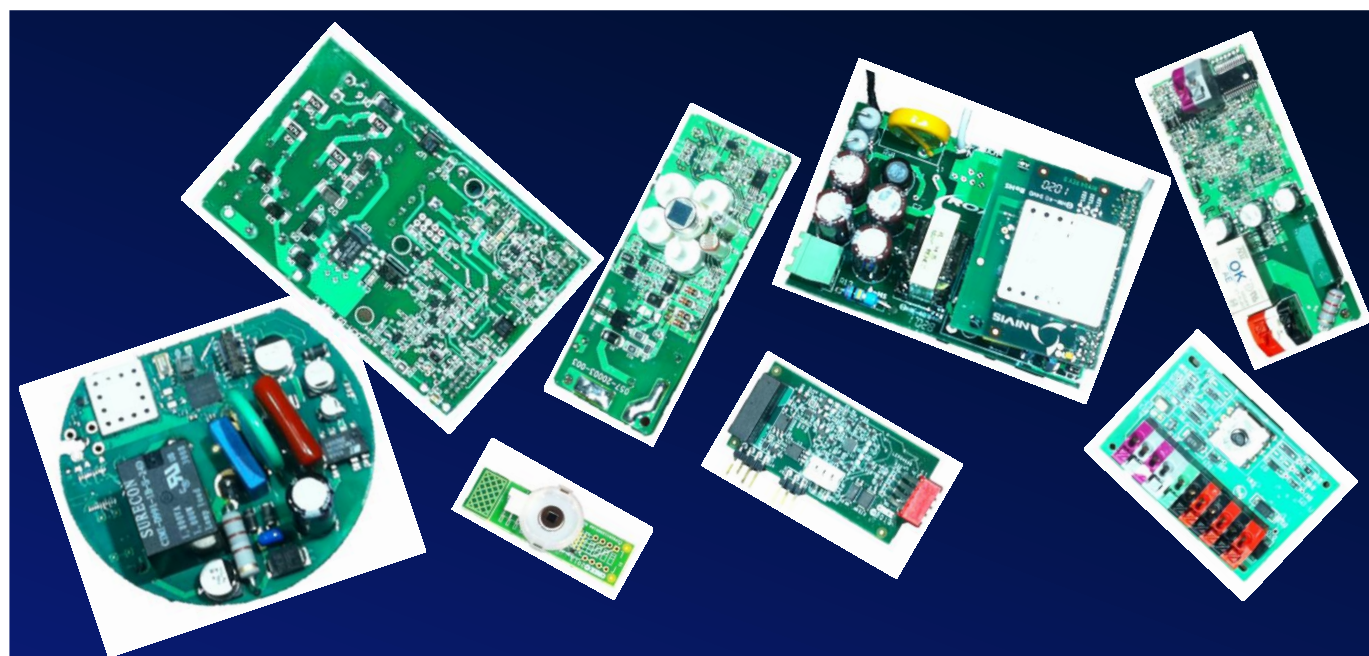
LED Driver



Packaged LED Chips



- Daylight Sensing
- 0-10V Dimming
- Wireless Control
- Occupancy Sensing



# Industry Standard Twist-Lock Photo Control

Receptacle

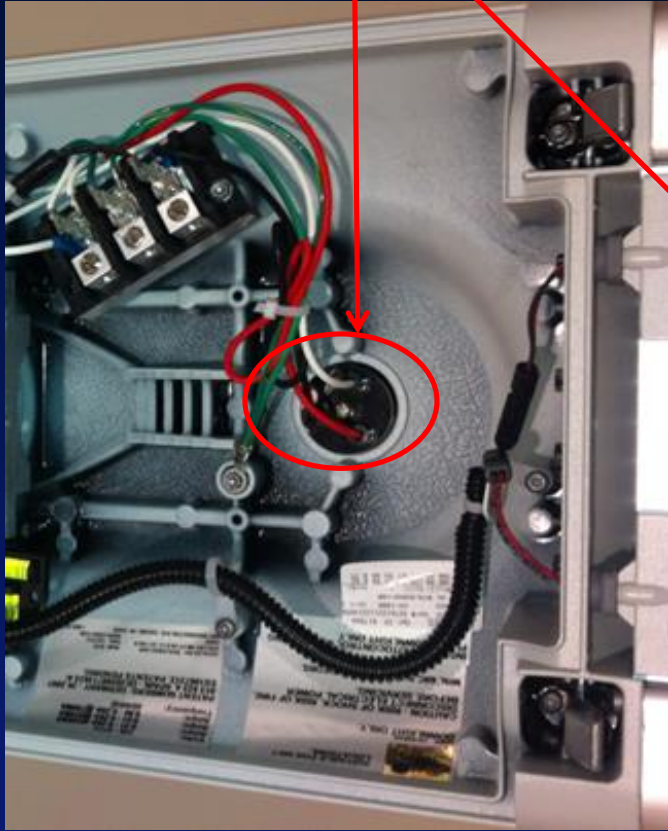


Photo control  
(Weakest Link?)



Top View Position

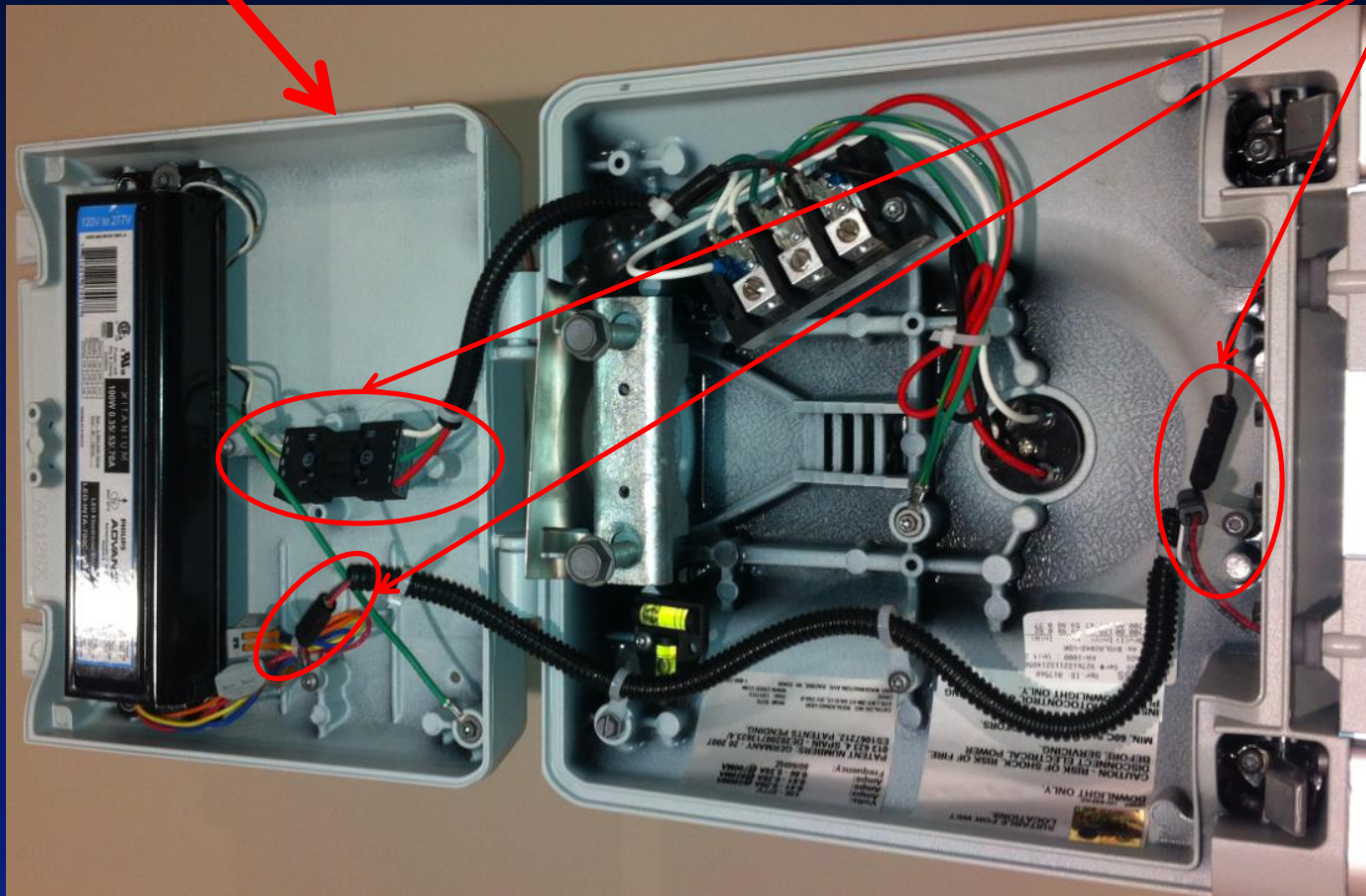




Do they need to be serviceable???

# The Cost and Risk of Serviceability Features

- Removable Door (tool-less) With Serviceable Driver



- IP Rated Connectors

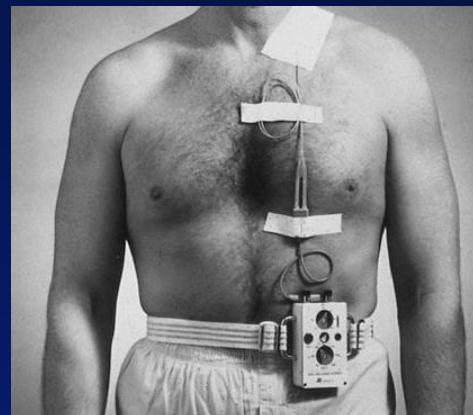


# Do We Live in a World Where High Reliability Electronics Are Assumed?

Engine Control Units (ECU) / Powertrain Control Units (PCM)



## Heart Pacemakers



In 1958, [Arne Larsson](#) (1915–2001) became the first to receive an implantable pacemaker. He had a total of 26 devices during his life and campaigned for other patients needing pacemakers.

Opportunities Indoors...

# BIG Problems to Solve

Broadband Speed & Access

Building Automation & Control

Slow & Wasteful Building Construction

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Slow & Wasteful Building Construction

Problem #1 to Solve:  
MAKE LIGHTING CONTROLS  
EASY!!

# Switched Lighting System

## Design

**Layout fixture locations**

**Layout switch locations & zones**

## Installation

**Install fixtures**

**Install switches**

**Pull line voltage to fxt & switches**

## Commissioning

**Energize ltg. circuits at panel**



# Traditional Lighting Controls

## Design

Layout fixture locations

Layout switch locations & zones

Select control protocol/approach

Determine daylight zones

Select daylight sensors

Locate daylight sensors

Select occupancy sensors

Locate occupancy sensors

Create one-line for submittal

Create/review controls submittal

## Installation

Install fixtures

Install switches

Pull line voltage to fxt & switches

Install occupancy sensors

Install daylight sensors

Connect fixtures to control bus

Connect sensors to control bus

Connect sensors to power

Install and power gateway

Connect control bus to hub

## Commissioning

Energize lgt. circuits at panel

Address all fixtures

Group fixtures in zones

Associate zones with switch

Associate zones w/dlight sensor

Associate zones w/occ sensor

Verify occ sensor placement

Calibrate daylight sensors

# LED Enabled Simple Controls

## Design

Layout fixture locations

Layout switch locations & zones

## Installation

Install fixtures

Install switches

Pull line voltage to fxt & switches

## Commissioning

Energize ltg. circuits at panel

**Push One Button to Commission**

## Enabled by:

Wireless Communication

Light Communication (LiFi)

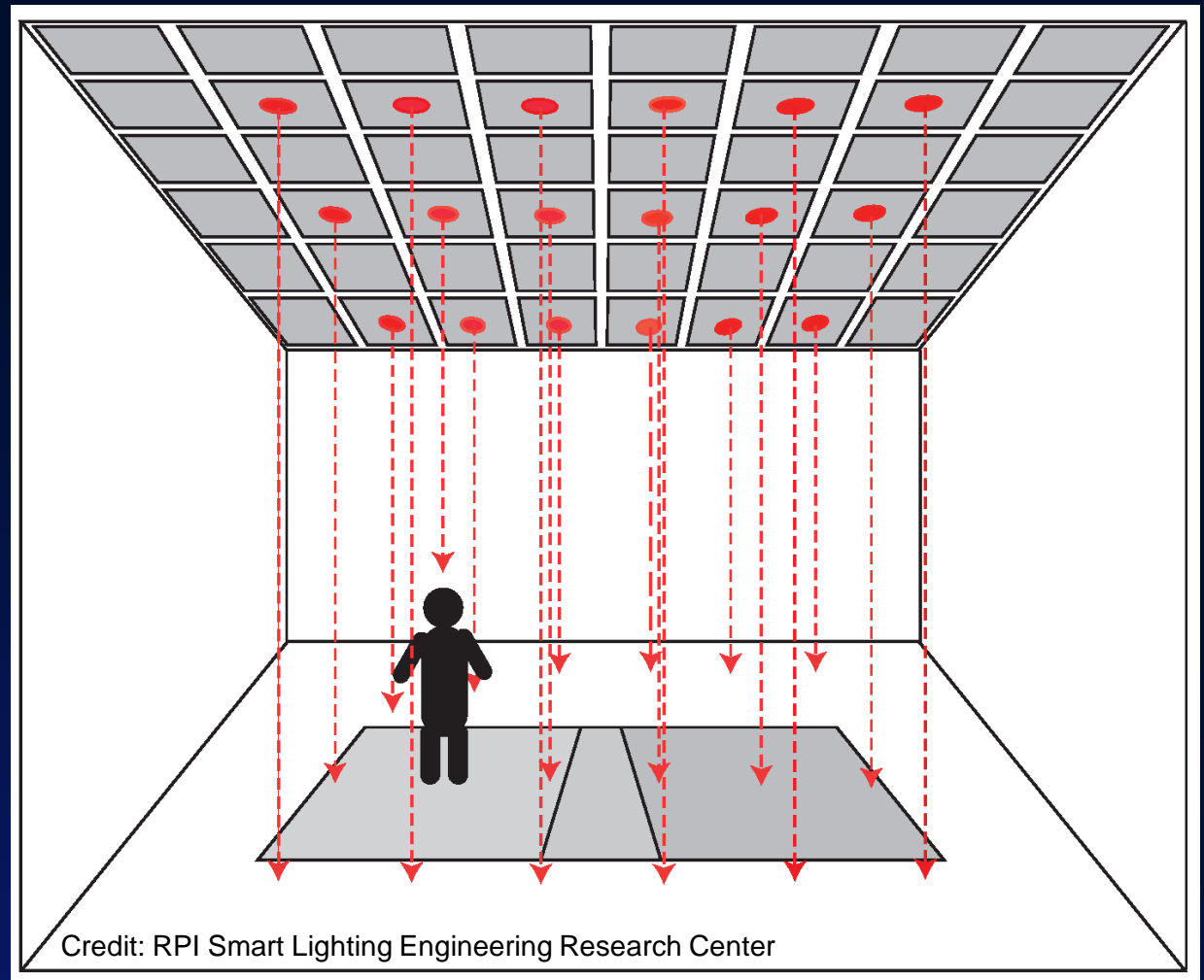
Extensive SOFTWARE Development

What Else?

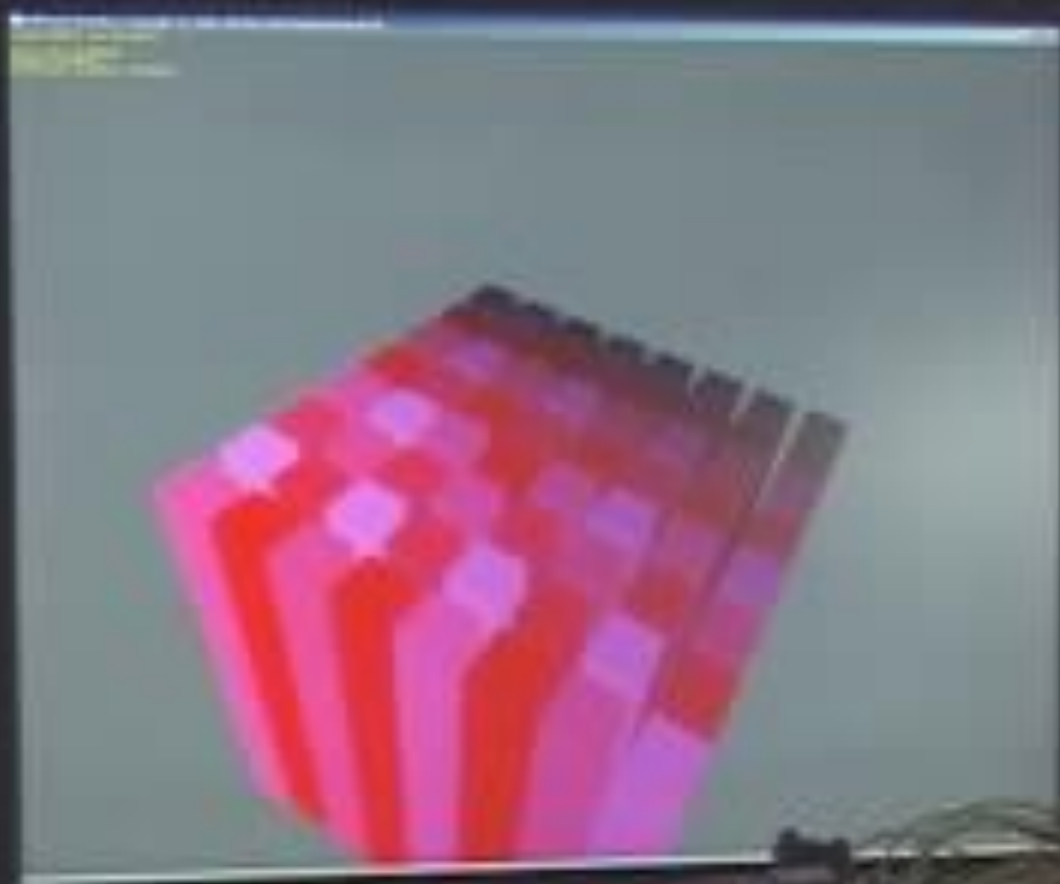
MAKE THEM SMARTER!!

# Improved Sensor Functionality

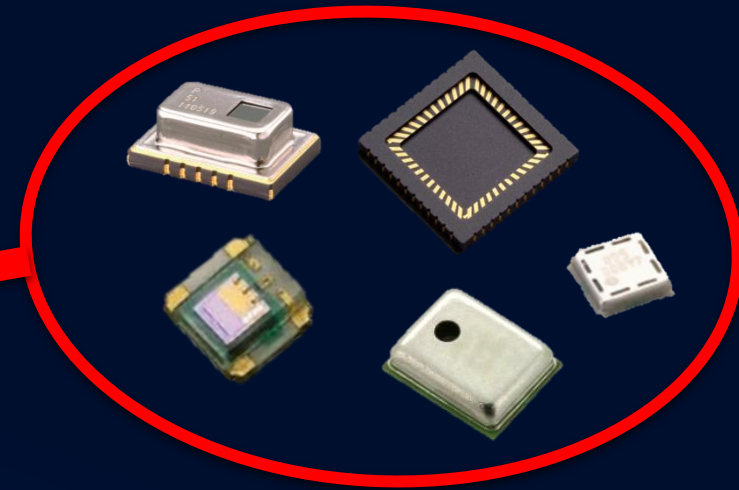
- Occupancy
- Temperature
- Smoke
- CO
- Sound
- Daylight
- Man Made Light
- Etc...



Higher Density Space Mapping Possibilities



# LED Array With Sensors



- Capable of Detecting
  - Heat
  - Light
  - Sound
  - Image
  - CO

# BIG Problems to Solve

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Construction Practices Haven't  
Changed Much in Decades





Can LED luminaires enable  
system consolidation and  
improvements to building  
automation and control?

HVAC

DATA

LIGHTING

LIFE SAFETY

Etc...



## LEDs Do Everything Better

- Science Proves It
- Real World Experience Proves It

In the Future We Can Do Even More

< 2%



> 98%

“...discontent is the first necessity of progress.”

-Thomas Edison

“Find an Obvious  
Opportunity  
and Address it”

Thank You!

**Eric Haugaard – Cree Lighting**