Life Expectancy Evaluation and Replacement Schedule Development for LED Traffic Indicators

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Introduction

- Research funded by MoDOT
  - TRyy1001
- Motivation:
  - Replacement schedule based on field performance
  - Understanding of useful life of LEDs
  - Economical way to measure and track LED light output

Background

LED (light-emitting diode)

- Use in traffic indicators
- Benefits:

85% Energy Reduction	5-10 Year Life Expectancy
Less Maintenance	Cheaper Life-cycle Cost

Degradation

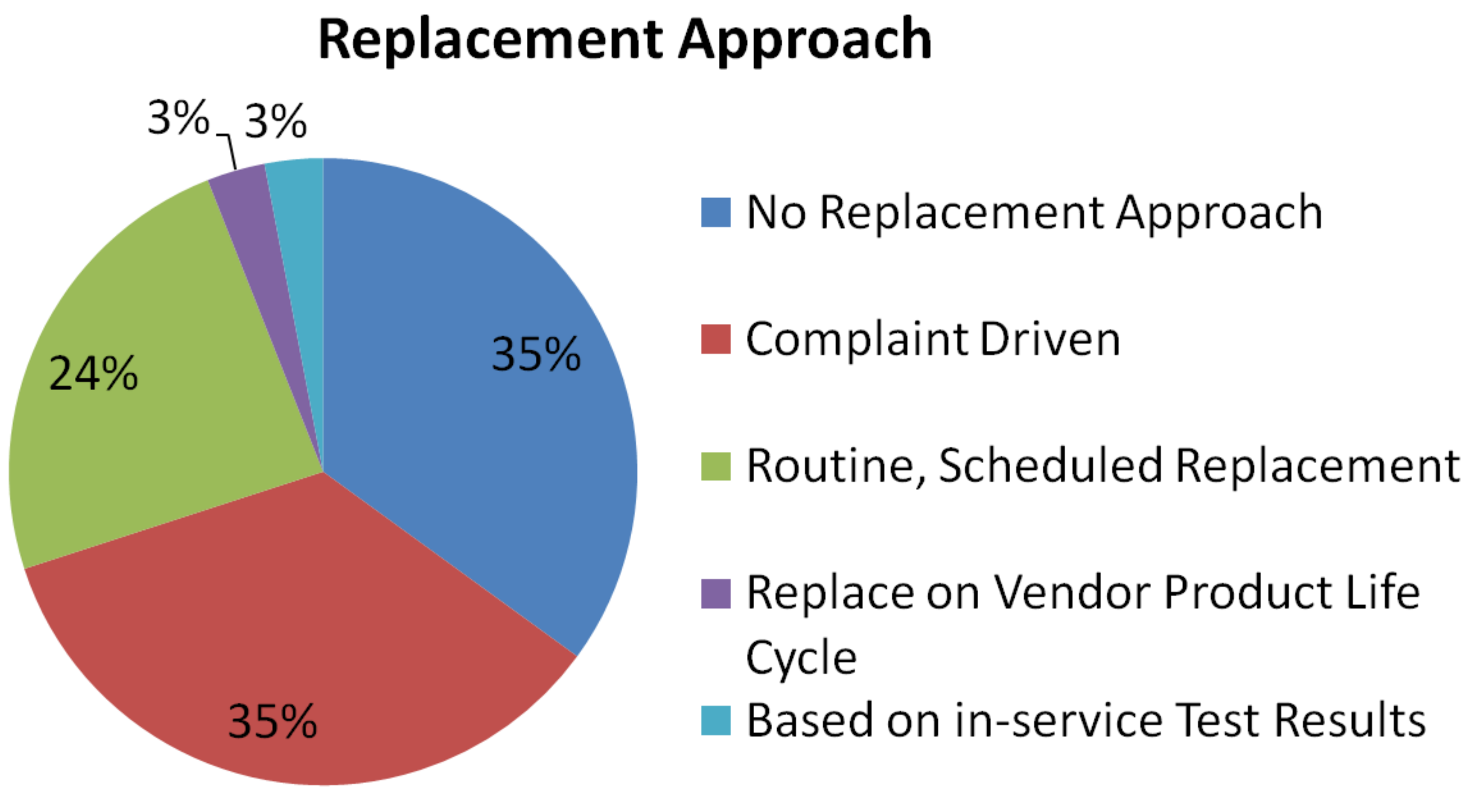
- Degradation vs. "burn out"
  - Fundamental difference between LEDs and incandescents
- Growing need for best practices in:
  - Monitoring
  - Maintenance
  - Replacement

Problems with LEDs in Traffic Indicators

Monitoring and Replacement

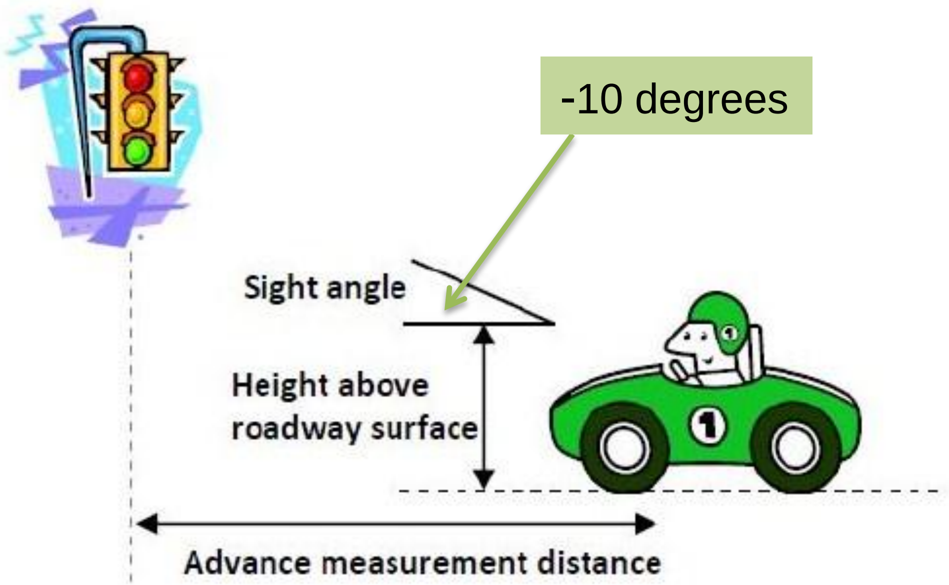
- 2007 ITE Survey
  - Public agency traffic engineers
  - Vendors and manufacturers
  - Confirmed growing issue with current state of monitoring and replacement of LEDs
    - Lack of understanding of ITE specifications
    - 60% have no monitoring & replacement procedure
    - Reactive replacement

Problems with LEDs in Traffic Indicators



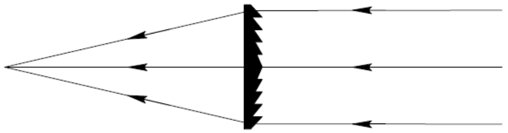
Methodology

- Field study
  - Hundreds of traffic signals across Missouri
- Original instrument created to collect data (patent filed)
  - Portable
  - Affordable
  - Measure illuminance (lux)
  - Makes study possible
  - Driver’s perspective

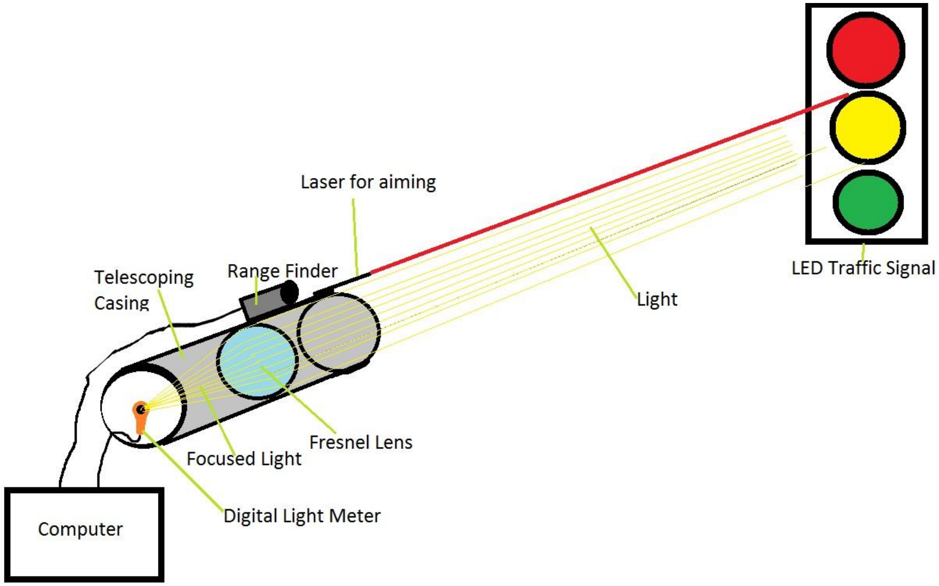


Device Methodology

- Device aimed at LED light source
  - Laser-assisted aiming
  - Range finder measures distance for lux→cd conversion
- Light is focused by Fresnel lens directly into digital light meter



- Casing keeps out ambient light
- Device interfaces with computer to store and analyze data



Data Collection and Analysis

- Comprehensive database

Intersection	*Direction*	*Indicator Head*	*Indicator*	*Manufacturer*	*Date of Installation*	*Date Measured*	*Age*	*Lux*	*Distance*

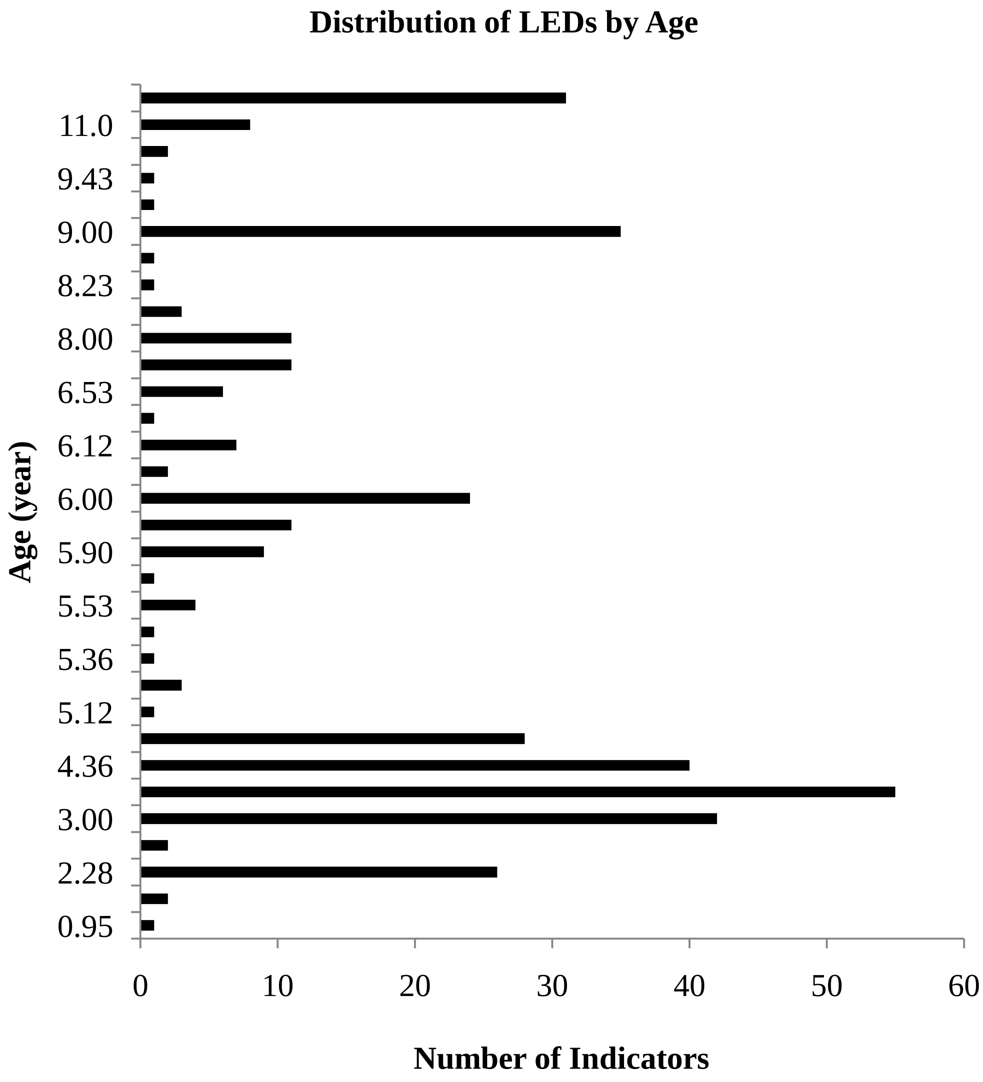
Input into inverse square law to obtain cd

Luminous Intensity (cd) = Illuminance (lux) x Distance^2 (m)

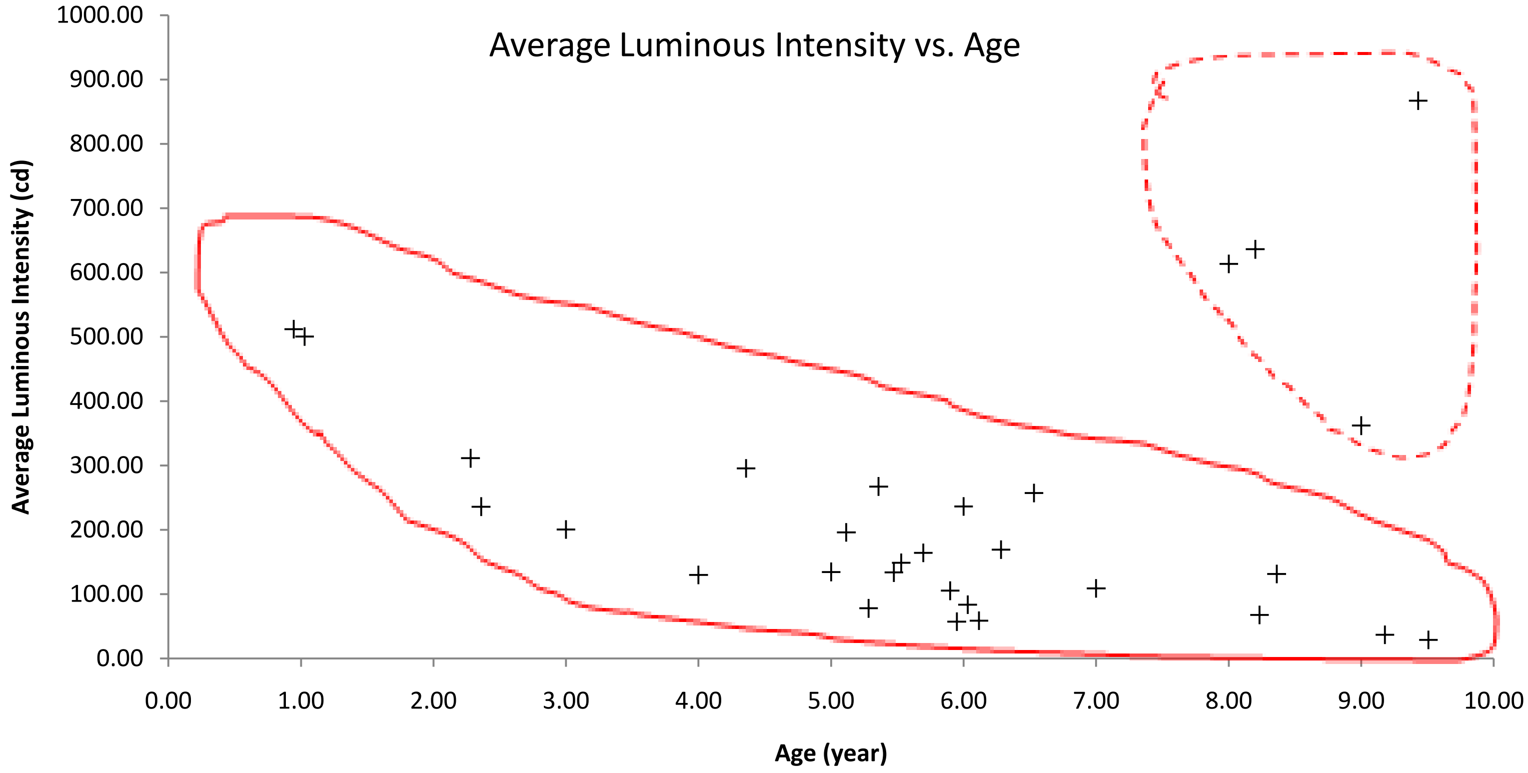
Data Collection and Analysis

Manufacturer	Circular Green	Circular Red	Circular Yellow	Green Arrow	Yellow Arrow	*Subtotal*	
ACT	1					**1**	**0.3%**
DIAL	10	67	30	56	28	**191**	**51.3%**
GE	68	34	5	25	12	**144**	**38.7%**
LTEK			34		1	**35**	**9.4%**
PHILIPS		1				**1**	**0.3%**
Subtotal	**79**	**102**	**69**	**81**	**41**	**372**	
	21.2%	**27.4%**	**18.5%**	**21.8%**	**11.0%**		**100%**

Data Collection and Analysis



Development of Useful Life Models



Degradation

2 Factor Analysis

- Degradation dependent on 2 factors and their interaction
  1. Manufacturer
  2. Indicator Type

10 Subgroups

- Circular Green – Dialight (10)
- Circular Green – GE (68)
- Green Arrow – Dialight (56)
- Green Arrow – GE (25)
- Yellow Arrow – Dialight (28)
- Yellow Arrow – GE (12)
- ~~Circular Red – Dialight (67)~~
- ~~Circular Red – GE (34)~~
- ~~Circular Yellow – Dialight (30)~~
- ~~Circular Yellow – LTEK (34)~~

Lab Analysis

	Average Luminance (cd)	ITE Threshold (-2.5 degrees)	Average Ratio (R:Y:G)	ITE Recommended Ratio (R:Y:G)
12" Red Dialight	376	365	1.0	1.0
12" Yellow Leotek	**515**	910	1.4	2.5
12" Green Dialight	551	475	1.5	1.3

Regression Equations

Type	Regression Equation	Solution (yrs)
Circular, Green, Dial	Y = -32.415X + 531.07	8.45
Circular, Green, GE	Y = -28.139X + 386.6	4.61
Arrow, Green, Dial	Y = -12.681X + 154.61	8.95
Arrow, Green, GE	Y = -9.8846X+116.46	7.63
Circular, Red, Dial	Y = -10.932X +190.99	***
Circular, Red, GE	Y = -6.8846X+507.27	***
Circular, Yellow, Dial	Y = -22.332X + 298.37	***
Arrow, Yellow, GE	Y =-33.366X + 274.37	5.85
Arrow, Yellow, Dial	Y = -5.9974X + 115.56	6.09

Results

- Replacement Schedule for Dial

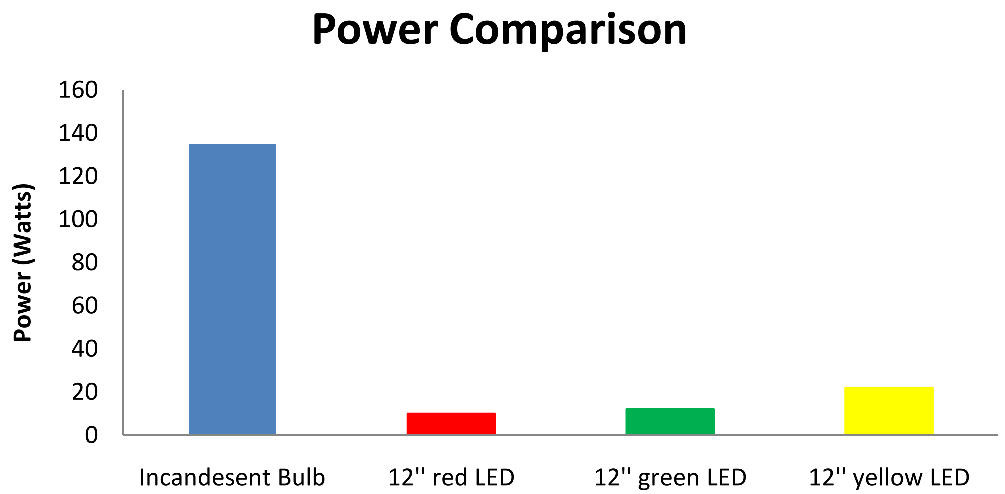
Type	*Age for Replacement (yrs)*	*ITE Threshold (cd)*
Circular, Green	(8 years, 9 years)	257
Arrow, Green	(8 years, 9 years)	41
Arrow, Yellow	(5 years, 6 years)	79

- Replacement Schedule for GE

Type	*Age for replacement (yrs)*	*ITE Threshold (cd)*
Circular, Green	(4 years, 5 years)	257
Arrow, Green	(7 years, 8 years)	41
Arrow Yellow	(5 years, 6 years)	79

Energy Saving

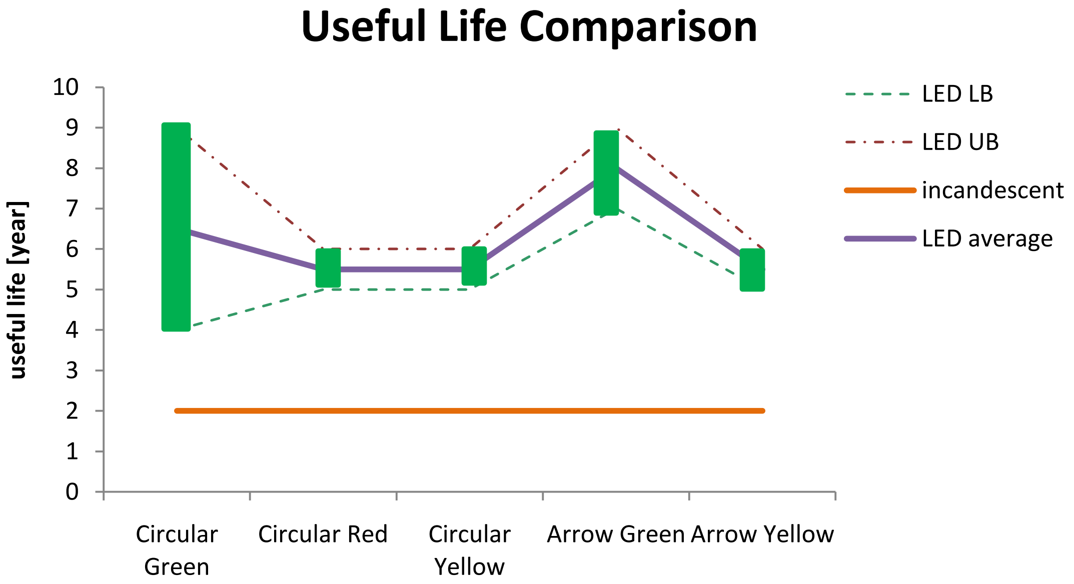
- Energy savings from replacing incandescent lights with LED signals are considerable.



- Annual energy savings ($)
  - Red: $70/signal; Green: $64/signal; Yellow: $7/signal (due to lower utilization than red and green signals)
  - Electricity costs have been reduced to 1.2 million per year

Extended Useful Life

- LED signals last for approx. 7-9 years before they drop below ITE standard.
- Incandescent bulbs burn out on average in two years

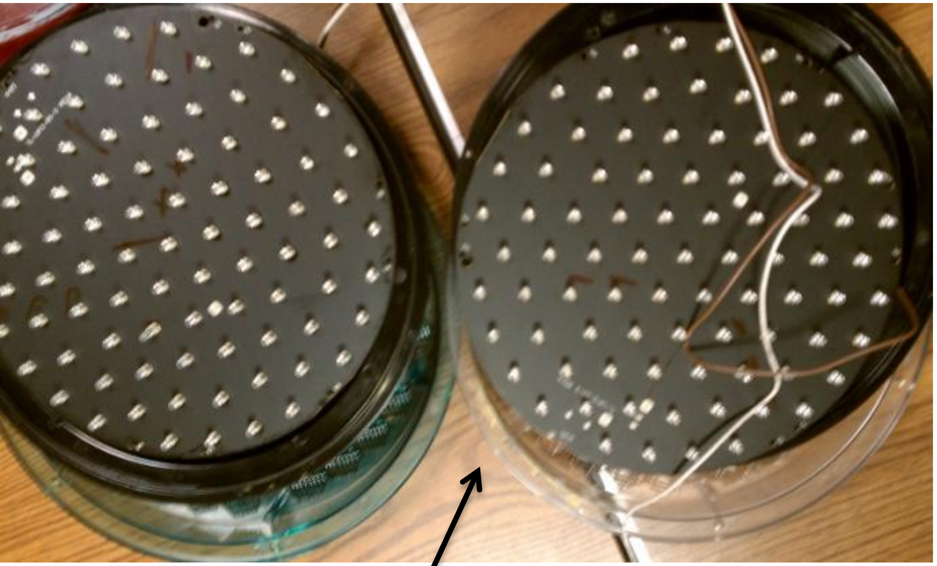


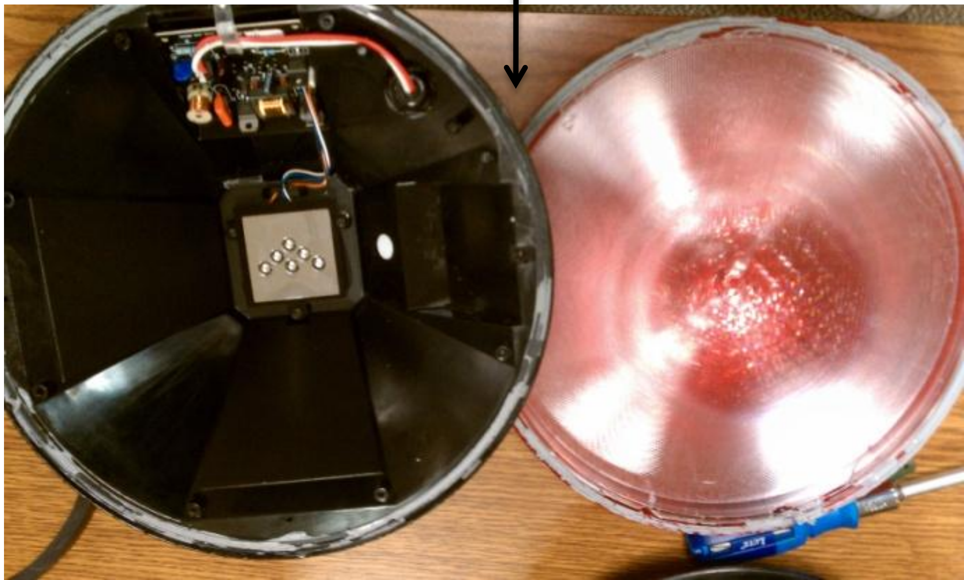
Reduced Maintenance Costs

- LED signals substantially reduce the chance of emergent replacement/reparation
  - don’t burn out like incandescent bulbs
- The interval of scheduled replacement is reduced from 2 years to approx. 7 years!
  - Labor hours have been reduced to approximately 170K per year.
  - It may be further reduced by implementing the replacement schedules developed in the LED traffic signal project

Conclusions

Differences in LED Manufacturing





Newer "Incandescent Look" Design with only 6 LEDs

Older LED Design with 200 individual LEDs

Conclusions

- LEDs are superior to incandescents
- LED degradation varies based on 2 factors
  - Manufacturer
  - Indicator type
- Group replacement → Reduced maintenance cost
- DOTs facing reduced budgets
- Recommend 7 year group replacement of all LEDs on an intersection by intersection basis
- Comprehensive database to track light intensity readings

Future Work

- Continued longitudinal study of same sample of LEDs over a longer period of time
- Investigate the effects of varied manufacturer design on LED performance and degradation
- LED Road Luminaires

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Questions?

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