The Evolution of Lighting in Rail Transit

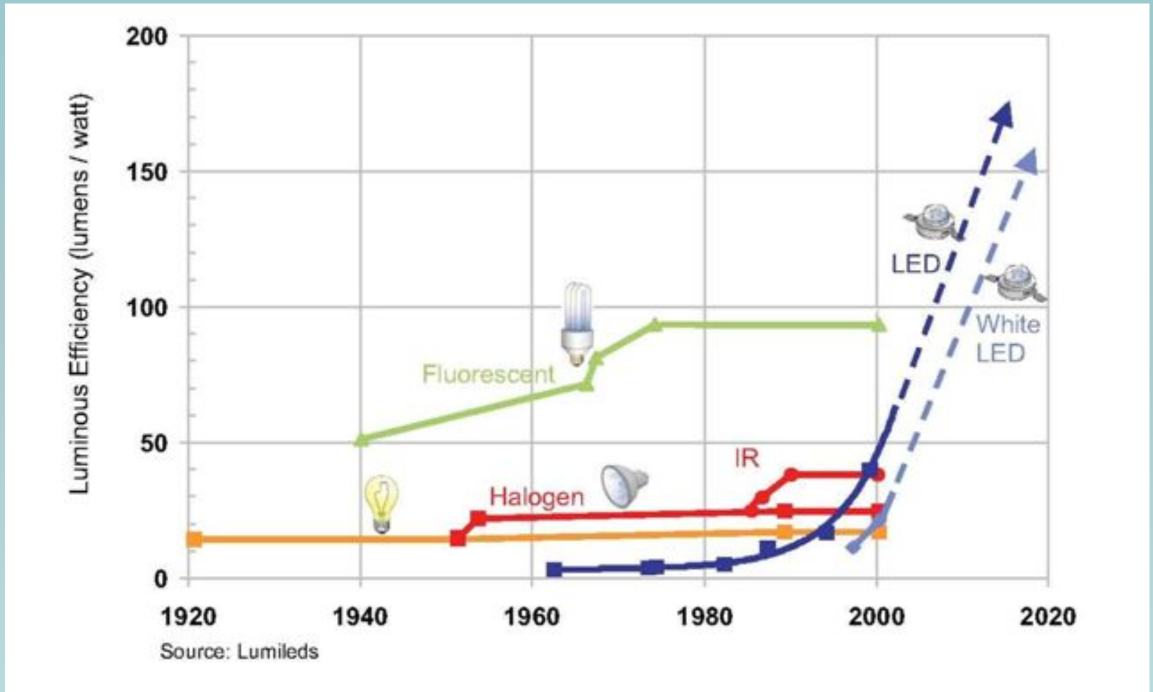
   

The earliest form of train lighting was provided by candles and Colza oil lamps. The next stage was gas lighting (Pintsch Lighting), using compressed gas stored in cylinders under the coaches. Finally, electric lighting was introduced.

Clean lighting for an environmentally friendly world!

The Evolution of Lighting in Rail Transit

- Minimal change in Incandescent and Halogen
- Fluorescent appears to have reached potential
- LED is growing exponentially



The Evolution of Lighting in Rail Transit

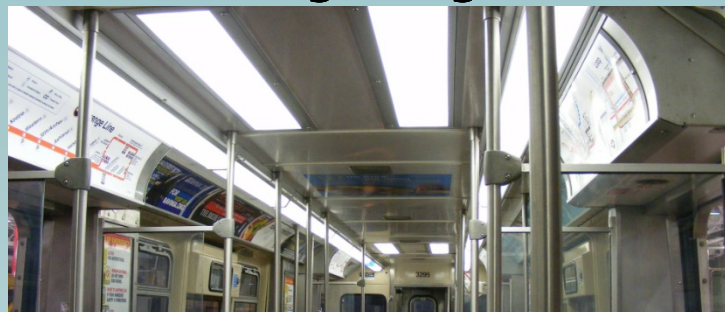
Incandescent

Fluorescent

LED

The Evolution of Lighting in Rail Transit

- Improvements over the past 10 years have allowed the growth of the use of LED lighting in new applications
  - Rail
  - Bus
  - Automotive
  - Aircraft
  - Architectural
  - Medical applications



- These successes have led to advancing LED technology and lower costs, opening additional markets

LED History

- LED = Light-Emitting Diode
- First invented in Russia in the 1920s.
- Introduced in America as a practical electronic component in 1962.

Light-emitting diode	
Red, green and blue LEDs of the 5mm type	
	
Type	Passive, optoelectronic
Working principle	Electroluminescence
Invented	Nick Holonyak Jr. (1962)
Electronic symbol	
	
Pin configuration	Anode and Cathode

Advantages of LED’s

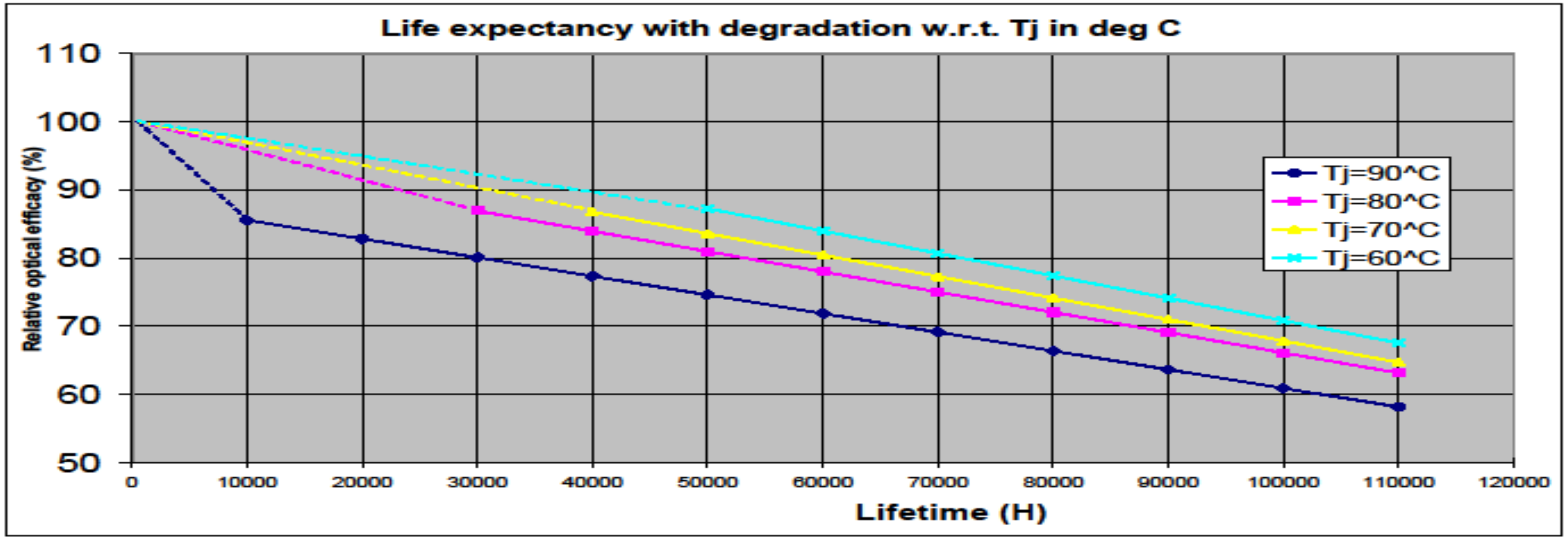
- Design Lifetimes ~ 25,000 – 100,000 hrs.
- Low Heat Emission
- Contain no filaments or glass
  - Resistant to breakage with external physical shock
- No environmental issues compared to fluorescents and incandescent
  - No Mercury vapors
  - No Disposal fees
- Maintenance impact
  - No ballasts
  - Longer intervals between maintenance
- Design impact
  - Less weight

Maintenance Comparison

- LED longer life = replaced less frequently.
- LED light sources don't tend to fail catastrophically, instead light output degrades gradually over time.

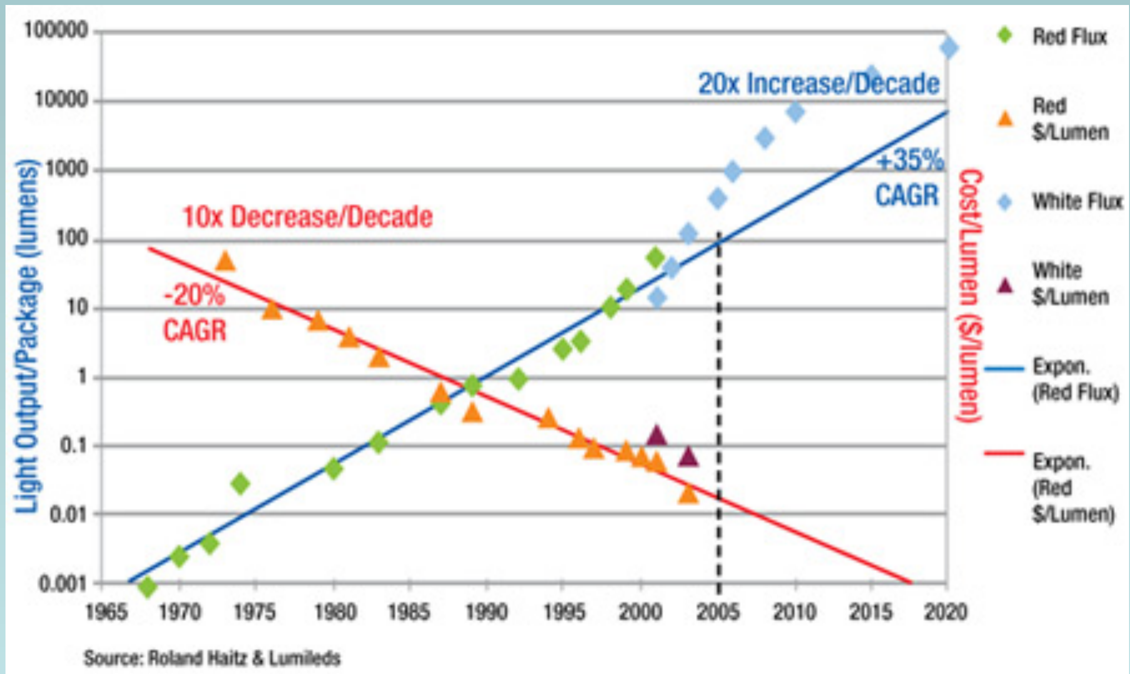
	Type	Typical Life Expectancy
	Incandescent	500 - 5,000 Hours
	Conventional Fluorescent	10,000 - 30,000 Hours
	LED	50,000 - 90,000+ Hours

LED Life Expectancy



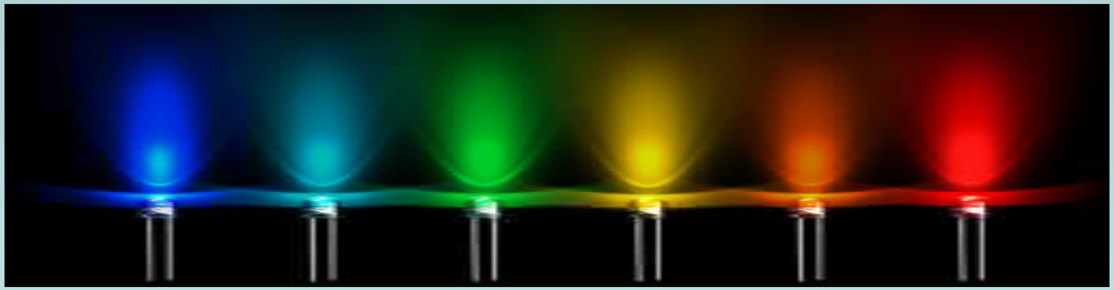
LED Costs vs. Luminous Efficiency

- Over the past 40 years the cost of an LED light source has dramatically decreased due to increases in Luminous efficiency vs. other light sources.
- Light output increases 20x per decade.
- Cost decreases 10x per decade.



LED’s are Available from IR to UV

	Color	Voltage [V]	Applications
	Red	1.63 < V < 2.03	Signaling / Tail Lights
	Yellow	2.10 < V < 2.18	Signaling / Indicators
	Green	2.18 < V < 4.0	Signaling / Indicators
	Blue	2.48 < V < 3.7	Signaling / Indicators
	White	V = 3.5	Signaling / Marker Lights / Interior Lights

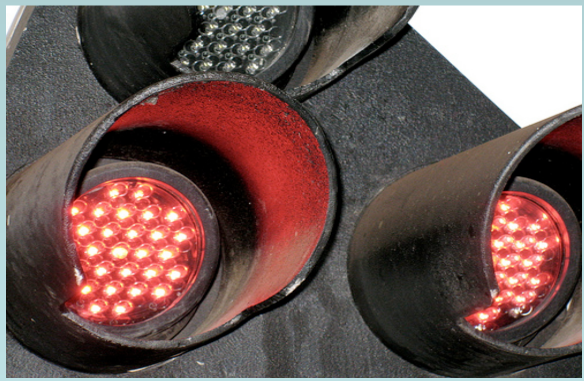


LED's in Transit Industry

- LED exterior lights
  - Tail Lights
  - Marker Lights
  - Stairwell Lights
  - Indicator Lights
- LED Destination Signs
  - Amber and Color Styles in Service
- LED Interior Lighting-Emerging in Transit
  - Reading Lights
  - Main Passenger Lights

LED’s in Transit Industry

Indicators and signs
– LED displays
– Traffic lights and signals



Lighting
– Marker Lights
– Platform Indicators
– Headlights (Future)

LED Power Consumption

Fluorescent VS LED Power Consumption Comparison		
	Watts per (1) foot	Watts per (4) foot
F32, T8 Fluorescent Tube	8.74	34.96
(1) Foot LED Board	7.5	30.0
Energy Savings	**1.24**	**4.96**

The Power consumption numbers were taken from actual readings in a (4) foot fixture.

LED Design Considerations and Features

- For the LED design selection, the following should be carefully considered.
  - Brightness to meet specifications
  - Even light levels throughout the vehicle
  - Even color temperature and appearance
  - Long life and reliability in the extremes of transit conditions

LED Design Considerations and Features

- Smooth lighting across the length of the vehicle
  - No hot spots to cause glare and discomfort for the passengers
  - No dark spots to give uneven light levels
- Fits within existing design envelope
  - No need for redesign of the car, will interface with existing design
- Meets or exceeds all APTA specifications
- Two LED,s per inch vs. longer tubes
  - Redundant light source, one LED failure will have no impact on light levels

LED Design Considerations and Features

- Convenient LRU replacement
  - Short modular strips vs. long glass tubes
- Reduced maintenance costs
  - No ballasts
  - Long life LED’s
- No environmental issues
  - Mercury vapors
  - Disposal fees
- White translucent lens and LED location should be designed to provide uniform illuminance to the car interior, while minimizing objectionable glare and brightness ratios.

LED Design Considerations and Features

- Light Emitting Diodes (LED) fixtures should conform to the requirements of the National Energy Policy Act, utilize white LED’s that meet the following standards:
  - LED lighting should utilizes solid state current power supplies.
  - LED system should meet the 4000 Kelvin ASI C 78.377A standard provide neutral/cool white light with a CCT within 3,710 to 4,260 Kelvin.
  - LED’s should be from a single CCT/Color bin.
  - LED boards should incorporate the power supplies.
  - LED’s should be driven by a constant current circuit with a setting of 65% or less of their maximum current rating.
  - LED’s should not be multiplex driven.
  - LED light fixture should not affect operation of any camera or cell phone in the train vehicle.

LED Design Considerations and Features

- Thermal management should provide a maximum of 20°C delta increase from the LED junction to ambient.
- LED board should have a feature to adjust for aging. In case of replacement of a new LED board in an old installation, the LED board should be harmonized with the light level of adjacent LED boards.
- Failure of up to three LED's should not turn off the balance of LED's on the LED board assembly and should be virtually unnoticeable to passenger.
- The overhead LED fixtures should produce a smooth, diffused light output and the LED boards should be designed to not have any visible hotspot or stripes in the max light output.
- LED assembly should be inaudible to passengers and guide animals.
- LED Assembly emissions should not exceed the specified EMI levels.

LED Design Considerations and Features

- LED assembly should illuminate in less than one second.
- LED assembly should not sustain any damage or reduced life expectancy due to defective, damaged or non-working LED's.
- LED boards should not be damaged by the intermittent or continuous application of reverse polarity direct current up to specified Vdc.
- LED assembly should withstand all LVPS transients without damage or reduction in life.
- LED assembly should be capable of withstanding a hi-pot test between terminals and case and between input and output connections of 1,075 Vac or 1,850 Vdc for one minute.
- Service and removal of the LED boards should be conducted from the front of the fixture and should not require any special tools.
- LED's should be installed on a PC board that requires a thermal pad between the LED board and the housing assembly.

LED Design Considerations and Features

- Does the System meet specified guidelines?
- Is it reliable?
  - What reliability testing performed
  - Environment Testing
- Is it maintainable?
  - Modular design
  - Sealed lens to prevent dust build up
- Ease of installation?
  - Reduction of OEM installation time
  - Ability to complete field retrofits

Direct vs. Diffused Lighting Design

- Direct lighting
  - Individual LED’s are visible
  - Single failed LED’s are noticeable
  - Hot spots visible to passenger and causing glare on windshield

- Diffused lighting
  - LED’s are not visible
  - Single failed LED’s not visible
  - Optics can be used to direct the light away from the windshield of the car to eliminate glare

Direct vs. Diffused Lighting Design

Diffused lighting – smooth appearance with no glare!

Direct lighting – harsh glare and hot spots!

Diffused LED Lighting Installation

Fluorescent Lighting!

Diffused LED Lighting!

Diffused LED Lighting Installation

Fluorescent Lighting!

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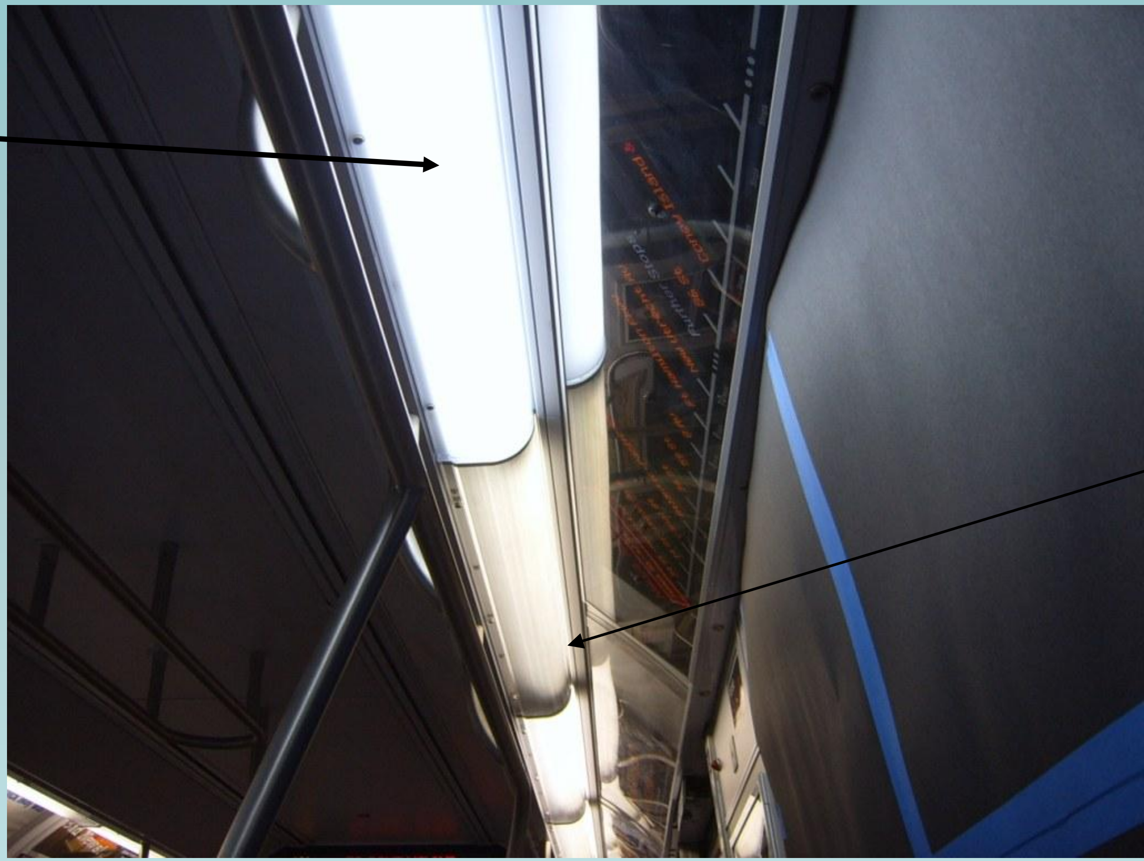

Fluorescent Lighting!

Conclusion…

- LED's are flexible while providing innovative designs
- LED Lighting technology has advanced and now meets APTA standards
- Pricing is becoming more competitive
- The ROI for LED versus fluorescent maintenance cost is positive
- The passenger will see the aesthetic improvement in technology
- The technology will continue to exponentially improve

The Evolution of Lighting in Rail Transit

It's the biggest revolution in the lighting industry since Thomas Edison patented the electric lamp. And it's not surprising, given that LEDs last up to 50 times longer than traditional electric bulbs.