

# The Continuing Development of LED Lighting Technology.



Presented by:

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At Railway Interiors expo 2009

# Presentation Structure



- 1) Technology overview.
- 2) Technology evolution and future predictions.
- 3) Factors affecting reliability.
- 4) Brief look at established LED products.
- 5) Introduction to a new leading edge product range permitting 100% LED interior lighting solutions.
- 6) Application examples.
- 7) Conclusions.



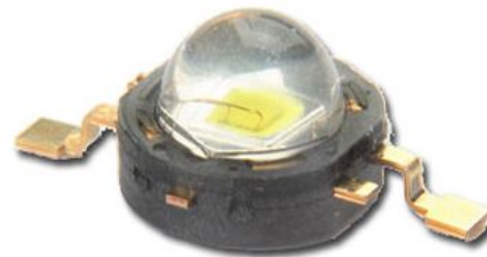
# Technology Overview

# Technology Overview



- The LED makes use of a solid state junction to produce photons (light output).
- There are no fragile filaments or gas discharge processes to fail.
- This renders the device immune from the effects of shock and vibration (perfect for rolling stock applications).

- A typical power LED:



Body dia 8mm.

- Unlike a filament lamp, the LED requires a specialist **constant current power supply** rather than a voltage regulated source.

# Technology Overview

## LED Power Supply Arrangements



There are two options for provision of the constant current:

1) Centrally located “bulk” power supply.



2) Integration of power supply electronics.



# Technology Overview

## Optics



- In order to produce a usable light output, carefully designed **secondary optics** or **diffusion techniques** are required to collect and focus the light output from the LEDs.



# Technology Overview

## Life Expectancy



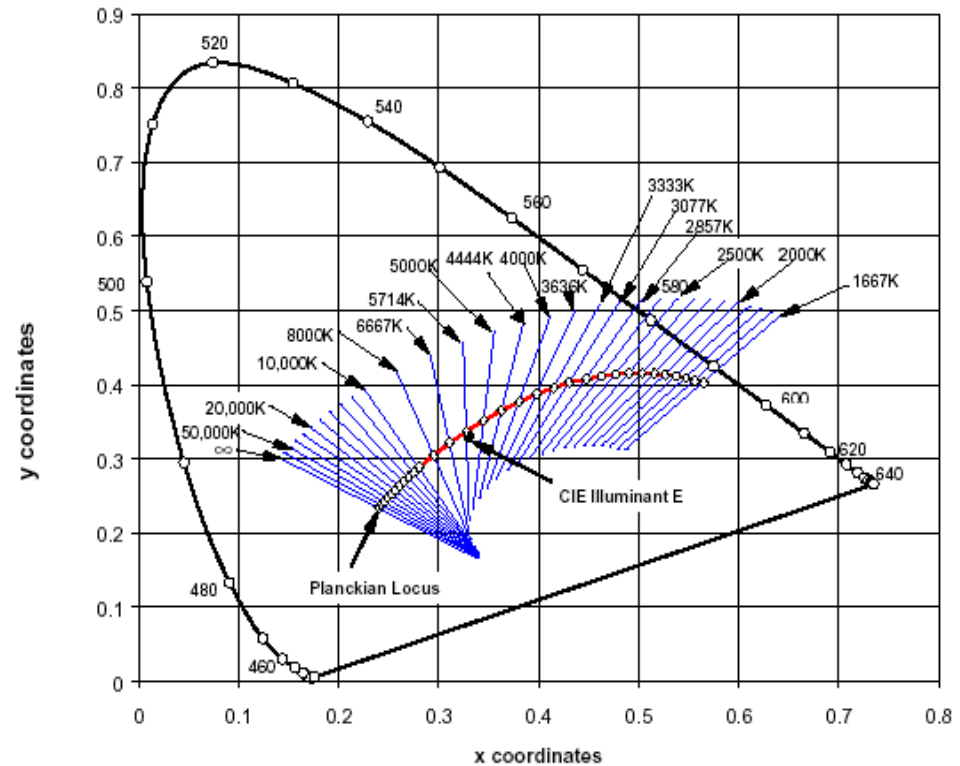
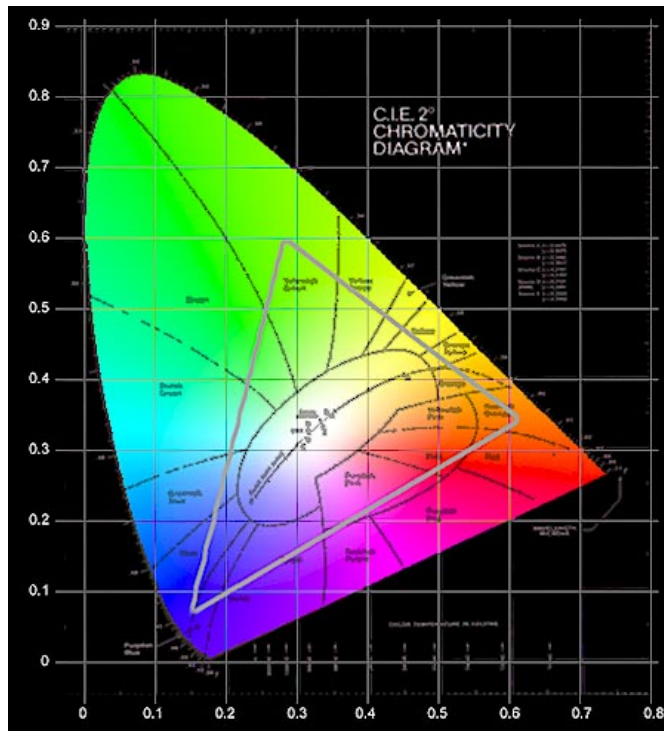
- Up to 100,000 hours to 70% of initial lumen output, **assuming optimum thermal management.**
- Millions of hours to total electrical failure.
- This compares to 3,000 hours for halogen and 20,000 hours for good quality fluorescent lamps.
- The high reliability results in **significantly reduced vehicle maintenance and operating costs.**

# Technology Overview

## Spectral Output



- LEDs are available with a wide choice of light output colours including variations of white.



Images courtesy of our LED Partner “Seoul Semiconductors”



# Technology Overview

## Spectral Output



Warm White                      2650 to 3500 K

Natural White                    3500 to 4500 K

Cool/Pure White                4500 to 7500 K



Cool

Natural

Warm

# Technology Overview

## Other LED Benefits



- Cool beam temperature due to absence of infra red content (30 °C versus 90 °C for halogen).
  - Results in increased passenger safety and comfort.
  - Reduced air conditioning loads.
- Low power consumption/high luminous efficacy.
  - This permits the design of highly effective emergency lighting systems with high light output and extended emergency lighting duration.

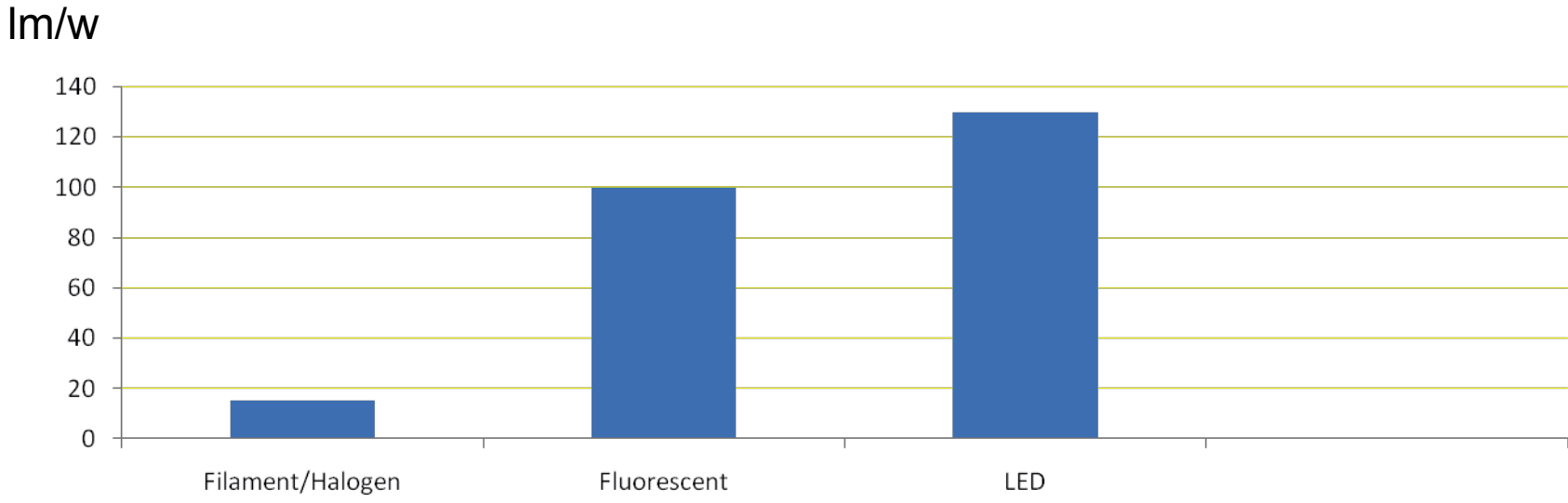
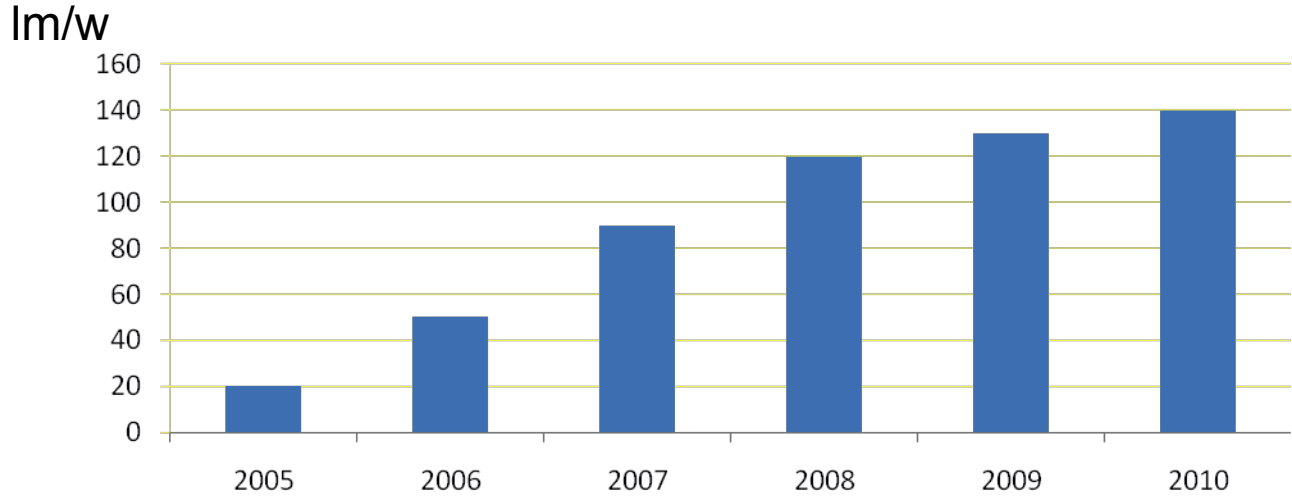


# Technology Evolution and Future Predictions.

# Luminous Efficacy



*Long Life Reliability  
does not cost the earth*





# What are the Factors Affecting Reliability?

# LED Operating Temperature (Thermal Management)



- LED life expectancy is critically dependent on operating temperature.
- The higher the LED junction temperature, the shorter the life.

Semiconductor Junction

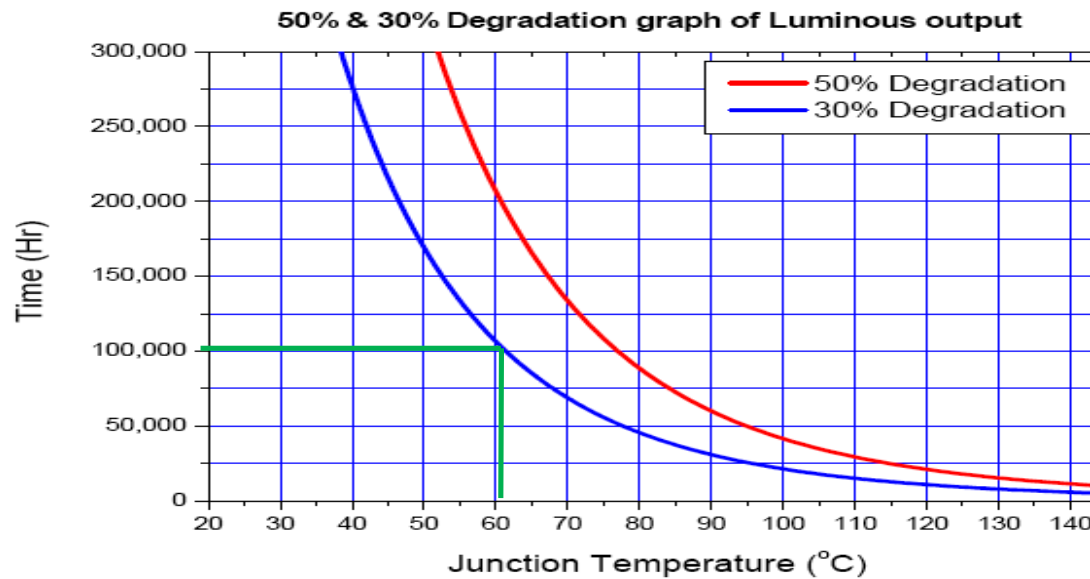


- For a reliable product, heat has to be efficiently removed from the light producing semiconductor junction.

# Thermal Management



- This life expectancy curve from a leading LED manufacturer stresses the importance of correct thermal management.

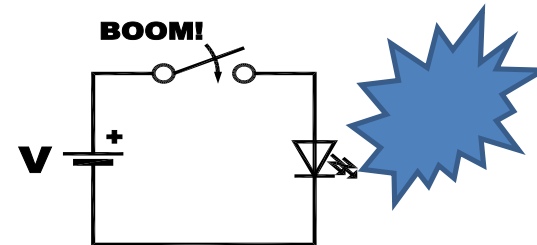


- Illustrating that with good thermal design, long service life can be realised.

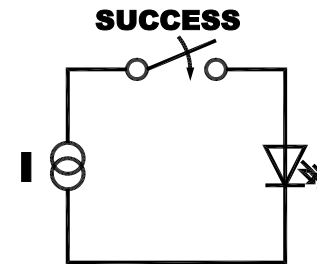
# Electrical Drive Conditions



- The LED performs electrically as a diode junction.
- There is no built in mechanism to limit current in the forward direction.
- Therefore, connection to a standard voltage regulated power supply is not recommended!

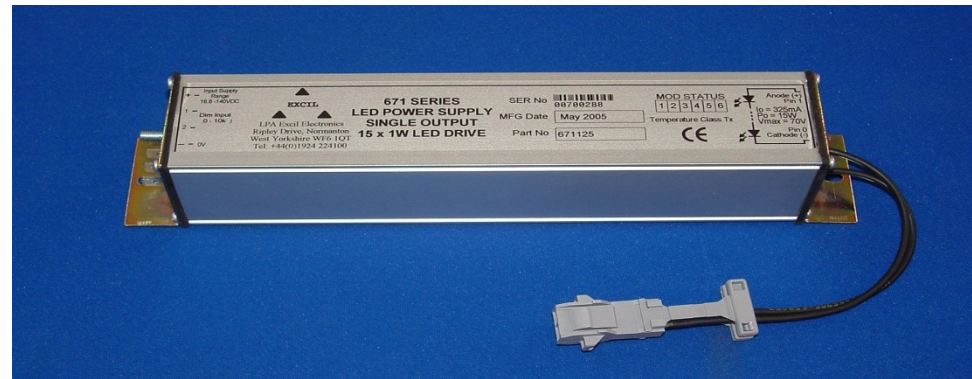


- The device requires a specialist “Constant Current” power supply. Ideally, the current should be held constant over the full range of vehicle supply variation.





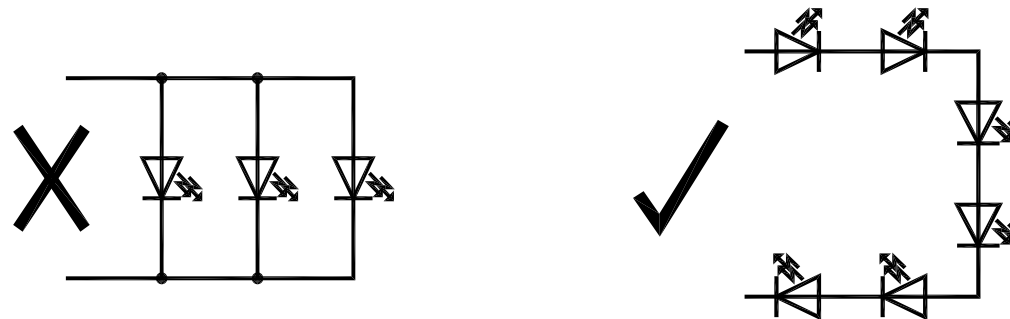
# The LPA-Excil LED Power Supply Solution



- Attains constant current output over the input range 16.8 to 140V DC.
- Also available in AC supply input variants (160 to 264V).
- Complies with railway industry standards including EMC, shock and vibration, transients, environmental and safety etc.
- Comprehensive electrical protection features.
- In the field MTBF currently stands at **1.83 Million hours**.

# Circuit Connection

- Because LEDs require constant current drive, devices must be connected in series.
- Parallel connection will result in unequal current share due to differing forward voltages, this will result in poor reliability.



- Because devices are in series, precautions must be taken to ensure that device failure does not result in failure of the whole chain of LEDs.

# High Brightness Versus Signal LEDs



- Two general LED categories exist:



Power types  
(High brightness)



Standard or  
“signal types”

- Power types have been developed specifically for the illumination market.
- Where reliability is a prime consideration, only power types should be considered.
- Power LEDs offer:
  - Better luminous efficacy (lm/W).
  - Better lumen maintenance and hence longer life.
  - Better and more controllable colour binning.
  - Superior colour rendering – Illustrated on the next slide.

# Colour Rendering Index (CRI)



- Rated on a scale of 0 to 100.
- 0 is monochrome, 100 is perfect natural colour.
- LED's typically achieve a CRI between 70 and 93.
- Fluorescent lamps have a typical CRI between 65 and 85.



CRI=93

CRI=70

Images courtesy of our LED Partner "Seoul Semiconductors"

# Compliance With Railway Standards



- The railway environment is very arduous and product must be designed specifically to meet the standards:
  - EMC **EN50121-3-2**
  - Shock and vibration **EN61373**
  - Surge and transient **EN50121-3-2, EN50155 + RIA12**
  - Lighting **EN13272**
  - Environmental and safety **EN50155**
  - Crash standards **AV/ST/9001**
  - + Many more....
  - **Commercial grade product is not suitable!**

# Reliability

## An Award Winning Example



Long Life Reliability  
does not cost the earth

- SNCF (France):



- AGC train, trial started February 2008 (21 months in service).
- 185 integrated power supply triple LED down lights installed.
- The LED down lights replaced the original build halogen units.
- To date there have been **zero** failures.
- With conventional halogen lamps, there would have been **at least four lamp failures** per fitting over this period with all the associated material and maintenance costs.

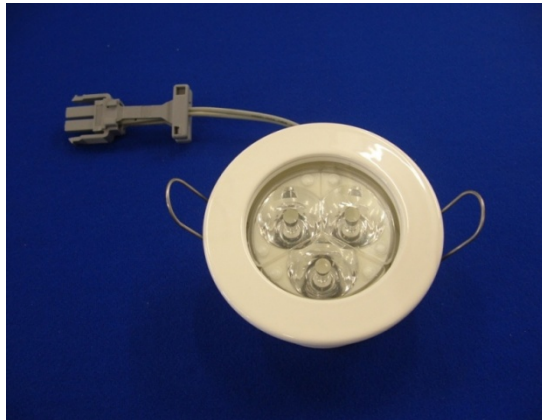


Established LED Products  
(many years of in service proving).

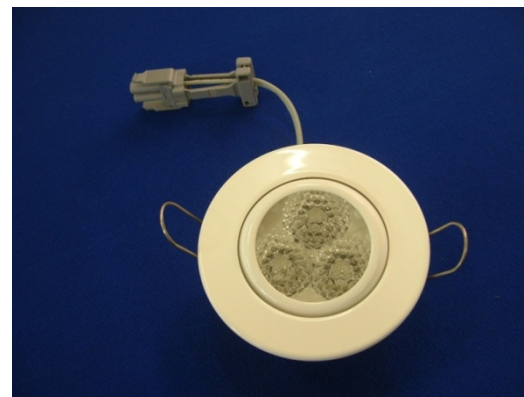
# Product Examples

## General LED Down Lights

### Triple and Single LED



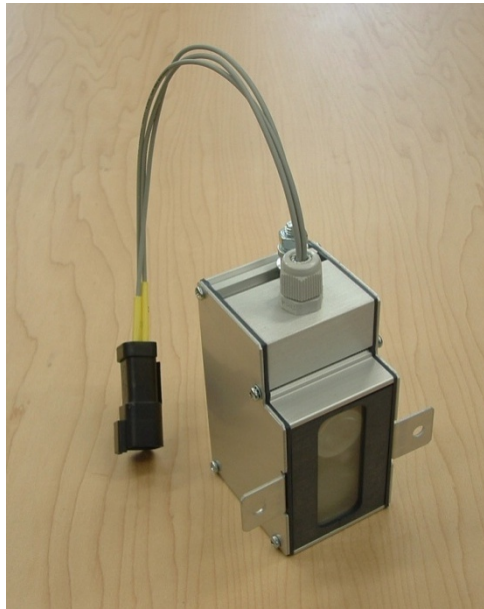
Tens of thousands in service.





# Product Examples

## Standard Step Light - Rail



- Meets Department of Transport guidelines for vehicle accessibility.
- Produces in excess of 100 lux at the egress point.
- Integrated power supply for 67 to 140V DC continuous operating range.
- Utilises two high brightness white LEDs.

# Product Examples

## Self Contained LED Emergency Light



Provides in excess of three hours emergency lighting duration from built-in rechargeable batteries in the event of power failure.

Complies with Euro norm lighting standard EN13272.

# Bespoke Products



IDF (NAT).



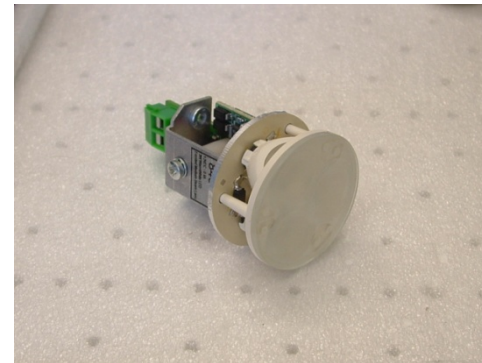
AGC LED replacement for halogen.



Balcony Light.



Eurostar LED replacement for halogen.



ZTER LED replacement for halogen.

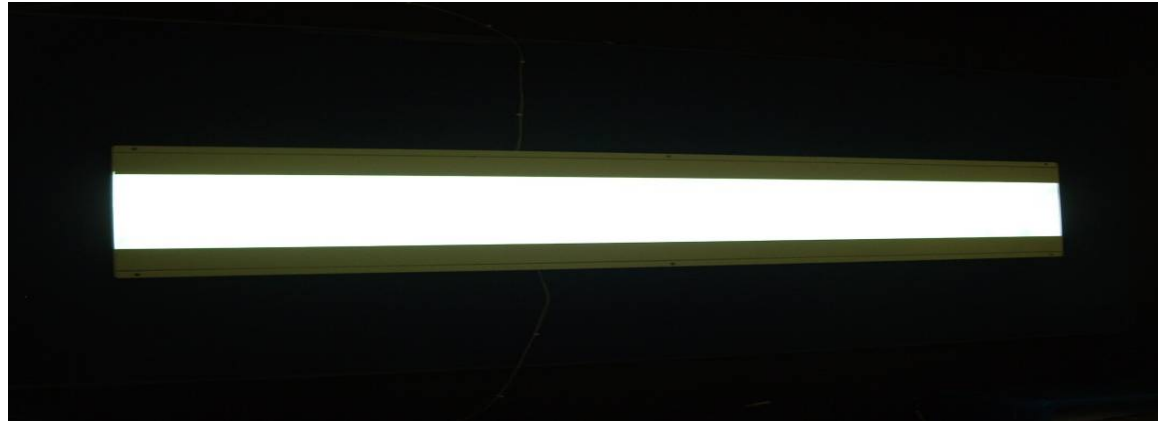


# Leading Edge Product Range Permitting 100% LED Interior Lighting Solutions.

These products address the utility illumination requirement.

# The LumiPanel™

(Patent Pending)



- 17 years “fit and forget” solution.
- Superior luminous efficacy to fluorescent systems.
- Up to 40% power savings compared to fluorescent.
- Only 20mm depth.
- BS6853 cat 1a fire rated.
- IP65 sealed.
- True homogenous light source.

# LumiStrip™



Developed to be utilised within new or existing luminaire assemblies as an alternative to fluorescent lamps with all the benefits of LED technology.

100,000 hours service life to 70% initial output.

Offers around a 20 to 25% power saving compared to fluorescent lamp and ballast arrangements.

Fully type tested and railway compliant.

# Power Consumption Comparison, Single Luminaire, Normalised Light Output.



	<b>1200mm LumiPanel™</b>	<b>1200mm LumiStrip™ Lexan diff</b>	<b>1200mm T8 Fluorescent Lexan diff</b>
Av Illum@2.2m* (lux)	115	115	115
Power consumption (Watts)	28.4	32.5	42.4
% Power Consumption Compared to LumiPanel™	100%	115%	149%

\* Average of 30 readings across a 3 metre illuminated plane at a distance of 2.2 m from the luminaire. The quantity of readings and distance from the source ensures accuracy.

## Life Cycle Cost Comparison - Fluorescent/LumiStrip™/LumiPanel™

Based on a single typical vehicle comprising:  
 2 rows of 14 fluorescents  
 2 rows of 14 LumiStrip™  
 1 row of 14 LumiPanel™

	Fluorescent Luminaire	LumiStrip™	LumiPanel™	
Approximate Luminaire Length	1250mm			
Quantity Of Luminaires Per Car	28	28	14	
<b>Maintenance Costs</b>				
Maintenance Cycle Period	15			Years
Daily Operational Time	16			Hours
Total Operation Time*	87,600			Hours
Fluorescent Life Expectancy	15,000			Hours
LED Lumen Maintenance (to 70% of initial illuminance)	100,000			Hours
Maintenance Cost Per Luminaire**	£5.33	£1.67	£0.83	
Life Cycle Costs Per Luminaire	£26.65	£8.35	£4.15	
Total Life Cycle Maintenance Cost Per Car***	£746	£234	£58	
<b>Energy Consumption</b>				
Total Car Power Consumption	1204	896	588	Watts
Percentage Reduction In Energy Per Car Against a Fluorescent Solution	26			%
Total Energy Per Year	7,031	5,233	3,434	kWh/h
Cost per kWh/hr	£0.076			
Total Energy Cost Per Year	£534	£398	£261	
Total Life Cycle Energy Costs	£8,016	£5,965	£3,915	
Total Life Cycle Costs Per Car	£8,762	£6,199	£3,973	
Total saving due to reduced energy and maintenance costs of an LED based solution against a Fluorescent solution	0	£2,563	£4,789	



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\* Based on 16 hours operation per day and 365 days per year for 15 years.

\*\* Maintenance cost based on the following assumptions

Fluorescent Solution -	Lamp Replacement - £2.00 materials
	Lamp Replacement plus
	Cleaning front and back of diffuser - 4 minutes
LumiStrip™ -	Cleaning front and back of diffuser - 2 minutes
LumiPanel™ -	Cleaning front of diffuser - 1 minute
	All with a maintenance rate of £50/hr

\*\*\* Total maintenance operations in 15 years is 5 (excluding initial fit). It is assumed that the LumiStrip™ and LumiPanel™ will be cleaned every 15,000 hours.



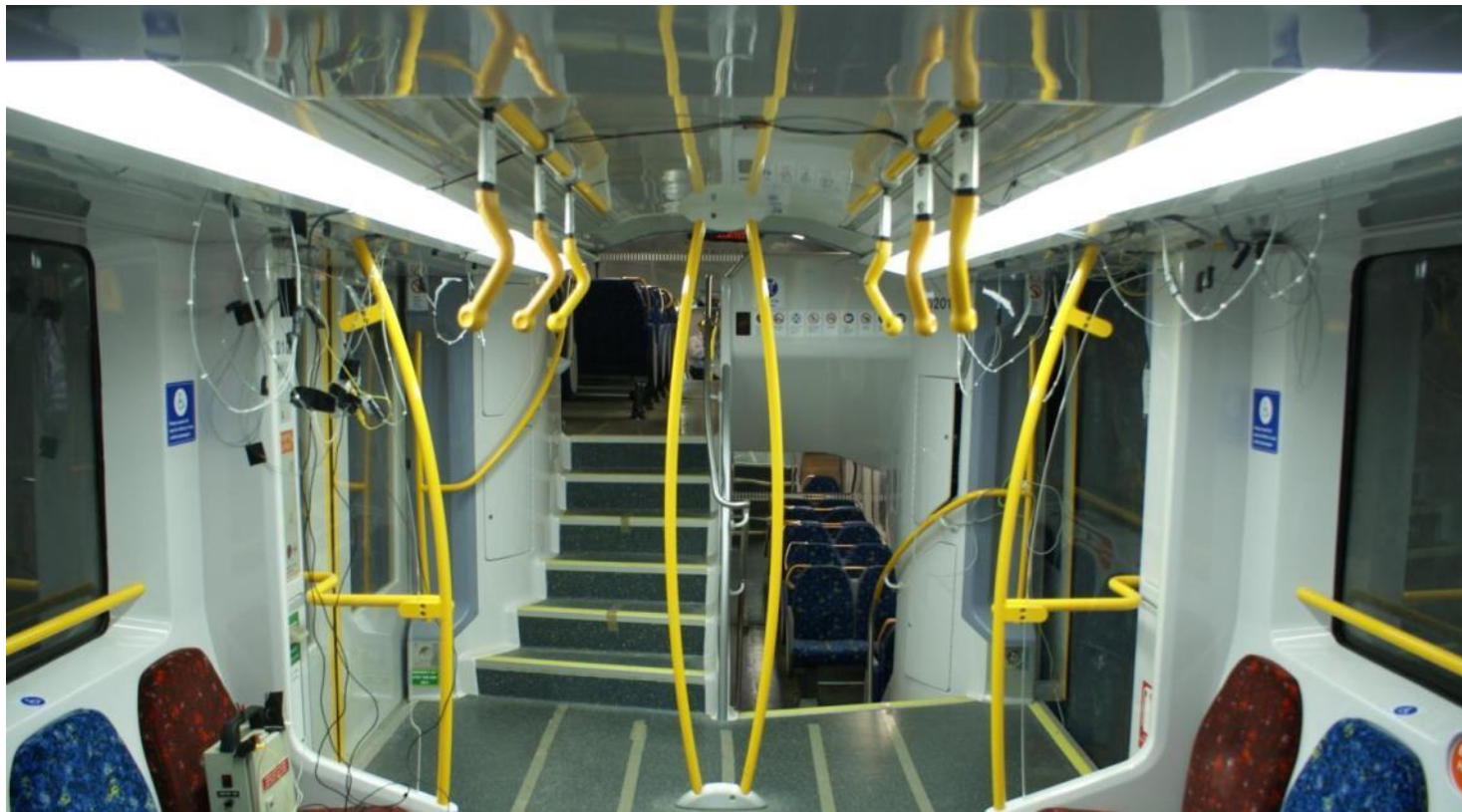


# Application Examples.

# Application Examples

## DEDIR/Edi Rail PPP

### Australia-Double deck vehicles.



# Application Examples

## GNER MK3-UK



# Application Examples

## NAT (IDF)-SNCF



# Application Examples

## AGC (commuter train)-SNCF



# Application Examples

## Mooviter (Inter-City)-SNCF



# Application Examples

## Dubai Metro



# Application Examples

## Panorama Car/Via Rail Canada





# Application Examples

## TGV R /SNCF



# Application Examples In Progress

Alstom AGV/NTV (Successor to TGV)  
Vestibules/Saloon/Toilets/Cabs/Restaurant



# Conclusions

What advantages do LEDs offer ?



- Ultra high reliability, 17 years fit and forget solution.
  - Significantly reduced vehicle maintenance and operating costs.
  - Case studies have illustrated that the payback period can be under 2 years.
  - Low power consumption.
    - Offers huge energy savings.
    - Maximises emergency lighting performance.
  - Reduced environmental impact (elimination of lamp disposals).
  - Low temperature light beam resulting in a more comfortable and less hazardous passenger environment.
- All crucial factors in competitive rolling stock operation.



Thank You

Any Questions ?