MED Roadway Lighting Presentation

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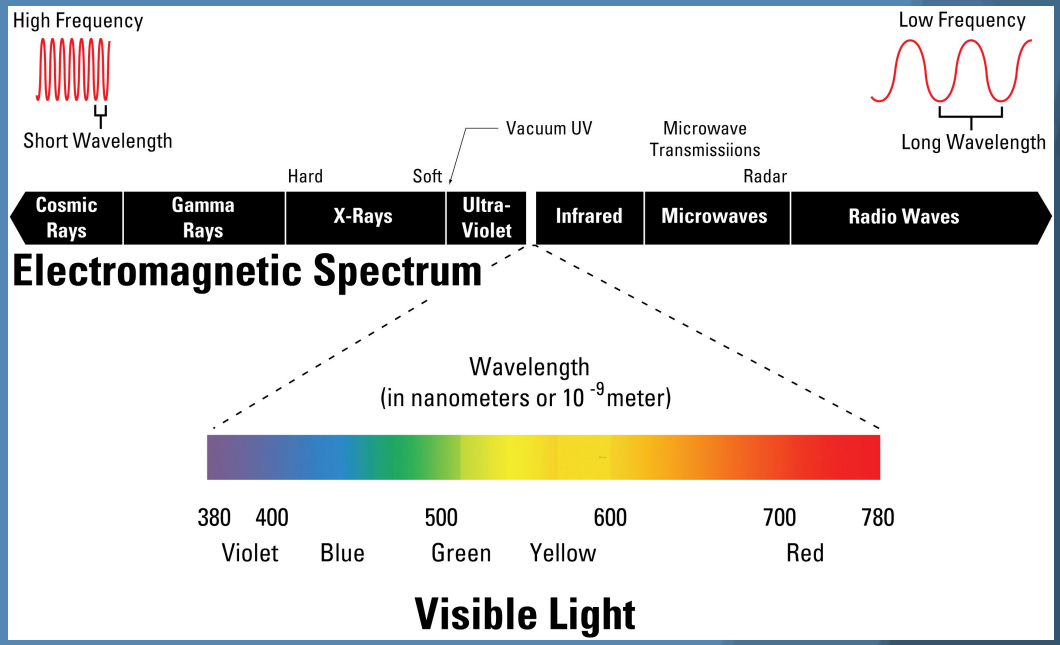
Today's Presentation

- Basic Lighting Principals
- Design Criteria and Standards
- New Technologies

Lighting Principals

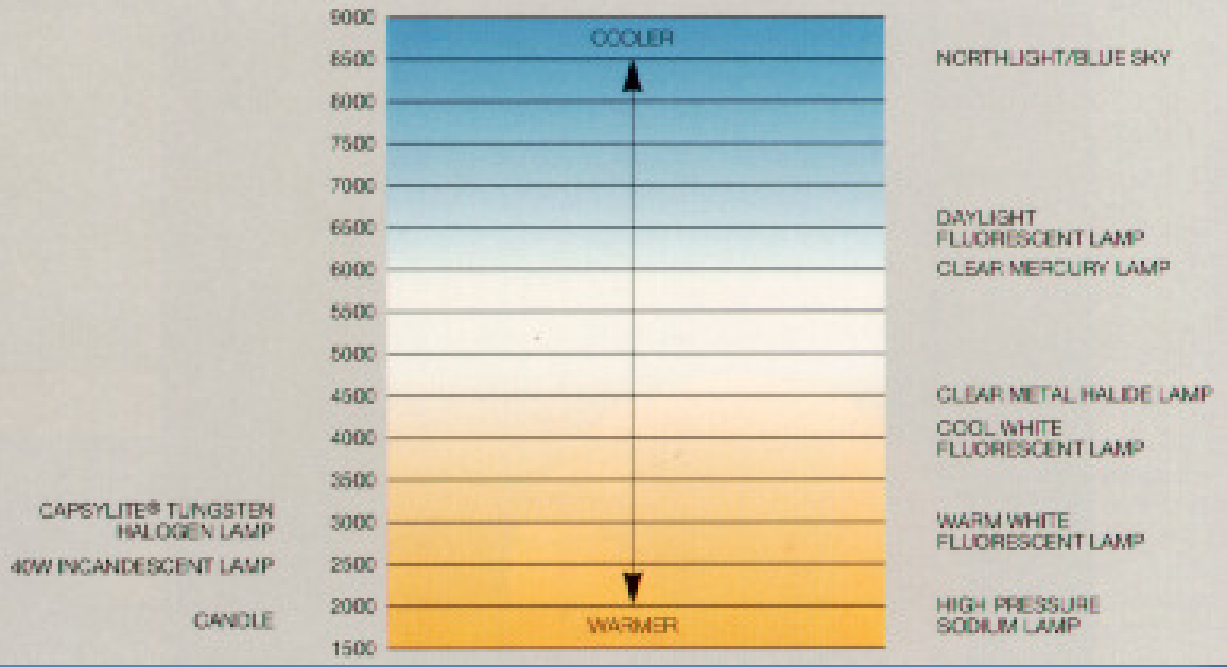
Basic Terminology

Lumen
Illuminance (Lux/fc) – Vertical / Horizontal
Luminance
Uniformity Ratio
Light Loss Factor



The Correlated Color Temperature Scale

The color appearance of various light sources can be defined in terms of color temperature, measured in "degrees" kelvin (K).



HPS vs Metal Halide

High Pressure Sodium

Object Detection

Metal Halide

Visual Clarity

Lighting Design Criteria and Standards

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Standards

- Most Cities lighting standards are dated which creates issues
- Good Ref documents exist (TAC/IESNA) to base standards and City policies on
- Lighting is not a simple science (Too much cookie cutter design)
- New Technologies are developed so quickly difficult for industry standards to keep up (ie; LED's)

Roadway Lighting

Road Area and Pedestrian Activity		Average Luminance cd/m^2	Average-to-Minimum Uniformity Ratio	Maximum-to-Minimum Uniformity Ratio	Maximum-to-Average Veiling Luminance Ratio
Road Type	Pedestrian Activity				
Freeway	--	≧ 0.6	≦ 3.5	≦ 6.0	≦ 0.3
Partial Lighting of Interchange On-Ramps/ Off-Ramps	--	≧ 0.6	≦ 3.5	≦ 6.0	≦ 0.3
Expressway-Highway	High	≧ 1.0	≦ 3.0	≦ 5.0	≦ 0.3
	Medium	≧ 0.8	≦ 3.0	≦ 5.0	≦ 0.3
	Low	≧ 0.6	≦ 3.5	≦ 6.0	≦ 0.3
Arterial	High	≧ 1.2	≦ 3.0	≦ 5.0	≦ 0.3
	Medium	≧ 0.9	≦ 3.0	≦ 5.0	≦ 0.3
	Low	≧ 0.6	≦ 3.5	≦ 6.0	≦ 0.3
Collector	High	≧ 0.8	≦ 3.0	≦ 5.0	≦ 0.4
	Medium	≧ 0.6	≦ 3.5	≦ 6.0	≦ 0.4
	Low	≧ 0.4	≦ 4.0	≦ 8.0	≦ 0.4
Local/Alleyway	High	≧ 0.6	≦ 6.0	≦ 10.0	≦ 0.4
	Medium	≧ 0.5	≦ 6.0	≦ 10.0	≦ 0.4
	Low	≧ 0.3	≦ 6.0	≦ 10.0	≦ 0.4

Sidewalk Lighting

Pedestrian Activity	Maintained Average Horizontal Illuminance (lux)	Average-to - Minimum Horizontal Uniformity Ratio	Minimum Maintained Vertical Illuminance (lux)
High	≧ 20.0	≦ 4.0	≧ 10.0
Medium	≧ 5.0	≦ 4.0	≧ 2.0
Low	≧ 3.0	≦ 6.0	≧ 0.8

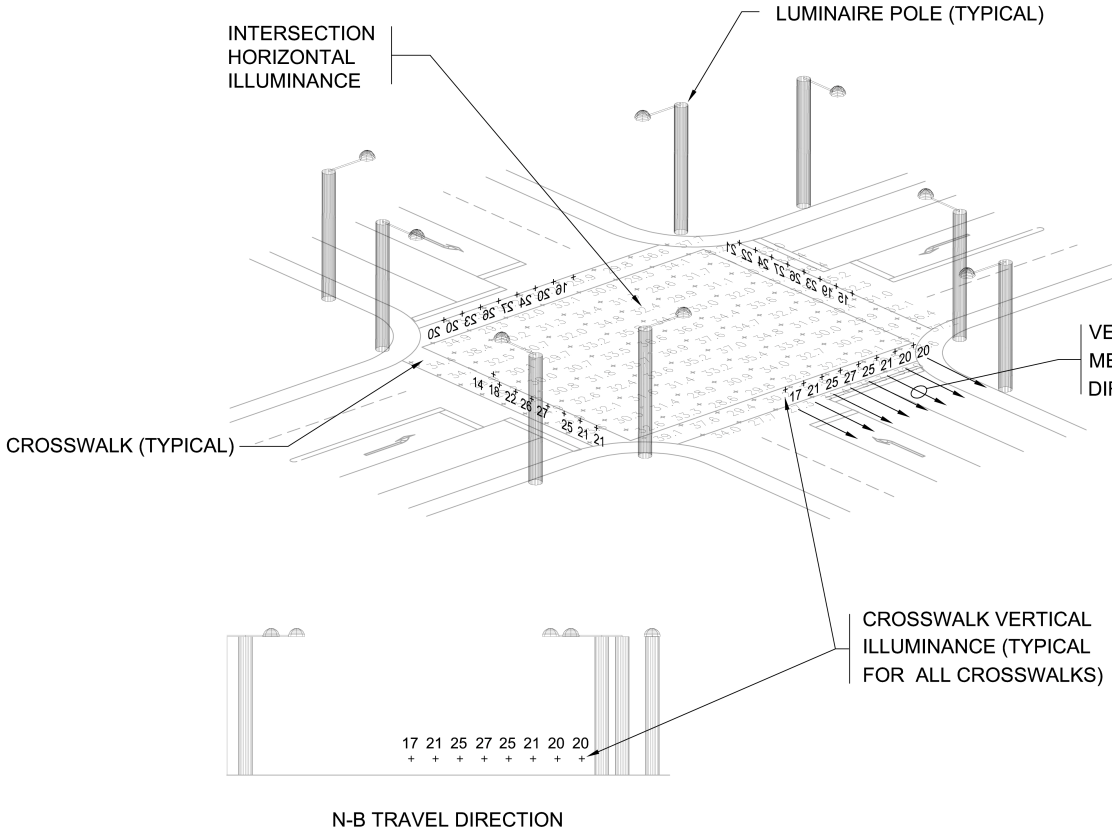
Recommendations and Discussion Roadways and Sidewalks

Sidewalk lighting levels can be misleading as the reflective properties of the sidewalks and buildings can impact the overall brightness and ones visibility. Ones visibility can be improved by the very light building finishes which reflect light much better than dark finishes.

Intersection Lighting

Roadway Classification	Average Maintained Illuminance at Pavement by Pedestrian Conflict (lux)			Average-to-Minimum Uniformity Ratio
	High	Medium	Low	
Arterial/Arterial	34.0	26.0	18.0	≦ 3.0
Arterial/Collector	29.0	22.0	15.0	≦ 3.0
Arterial/Local	26.0	20.0	13.0	≦ 3.0
Expressway-Highway/Arterial	31.0	25.0	18.0	≦ 3.0
Expressway-Highway/ Expressway-Highway/	28.0	24.0	18.0	≦ 3.0
Expressway-Highway/Collector	26.0	21.0	15.0	≦ 3.0
Expressway-Highway/Local	23.0	19.0	13.0	≦ 3.0
Collector/Collector	24.0	18.0	12.0	≦ 4.0
Collector/Local	21.0	16.0	10.0	≦ 4.0
Local/Local	18.0	14.0	8.0	≦ 6.0

Intersection Calculation Example



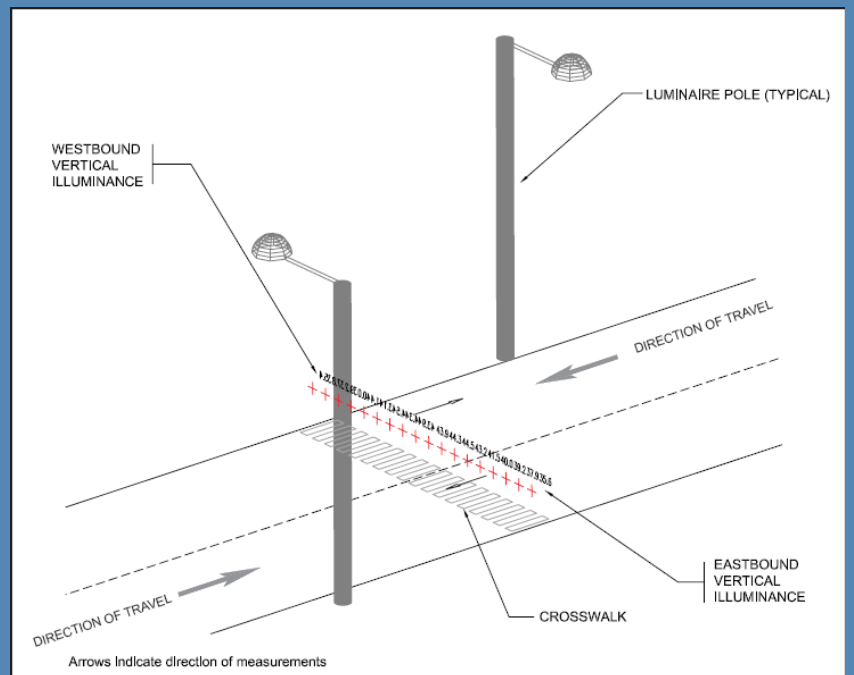
OUTPUT RESULTS

GRID	MAINTAINED AVERAGE	UNIFORMITY RATIO (AVG./MIN.)
INTERSECTION HORIZONTAL ILLUMINANCE	32.7 lux	1.2:1
W-B VERTICAL ILLUMINANCE ON CROSSWALK	22.0 lux	N/A
E-B VERTICAL ILLUMINANCE ON CROSSWALK	22.0 lux	N/A
N-B VERTICAL ILLUMINANCE ON CROSSWALK	22.2 lux	N/A
S-B VERTICAL ILLUMINANCE ON CROSSWALK	22.3 lux	N/A

Vertical Illumination

- It was found that in Switzerland, a level of 40 vertical lx was used in all crosswalks.
- This level reduced nighttime vehicle to pedestrian crashes by 66%.

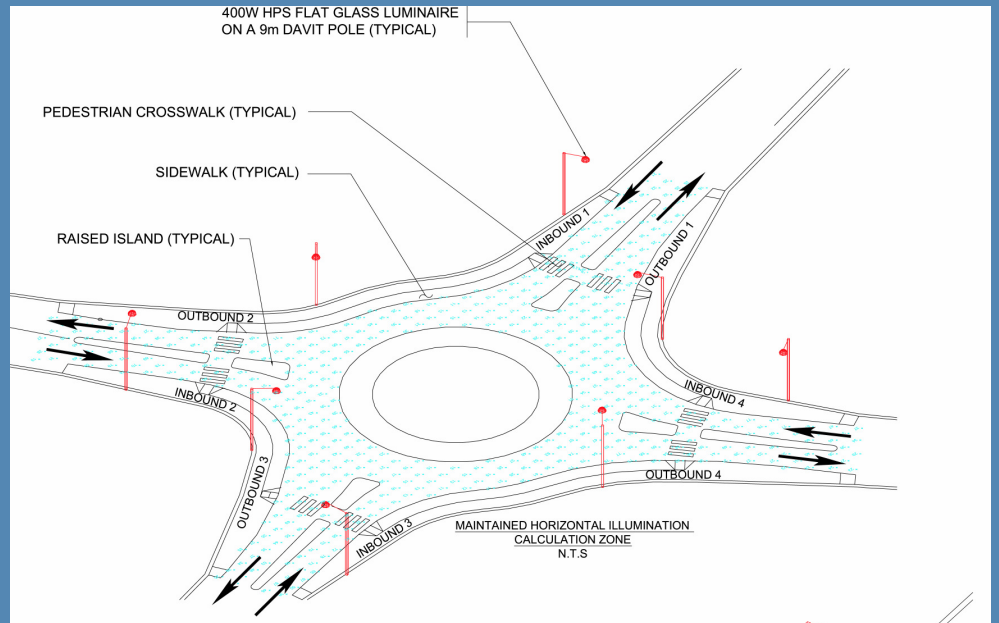
Mid Block Crosswalk Lighting



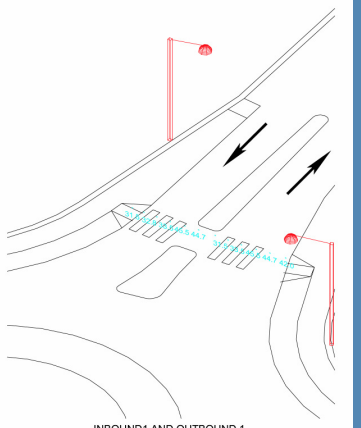
OUTPUT RESULTS	
GRID	MAINTAINED AVERAGE
W-B VERTICAL ILLUMINANCE	41.1 lux
E-B VERTICAL ILLUMINANCE	41.1 lux

Roundabouts

Roundabouts



STATISTICS						
Description	Symbol	avg	Max	Min	Max/Min	Avg/Min
Inbound 1 (Vertical)	+	43 lux	47 lux	35 lux	1.3:1	1.2:1
Outbound 2 (Vertical)	+	41 lux	48 lux	32 lux	1.5:1	1.3:1
Inbound 2 (Vertical)	+	40 lux	45 lux	33 lux	1.4:1	1.2:1
Outbound 3 (Vertical)	+	41 lux	46 lux	33 lux	1.4:1	1.2:1
Outbound 1 (Vertical)	+	41 lux	47 lux	31 lux	1.5:1	1.3:1
Inbound 2 (Vertical)	+	41 lux	44 lux	34 lux	1.3:1	1.2:1
Outbound 4 (Vertical)	+	40 lux	46 lux	30 lux	1.5:1	1.3:1
Inbound 4 (Vertical)	+	40 lux	45 lux	34 lux	1.3:1	1.2:1
Roundabout (Horizontal)	+	42 lux	82 lux	14 lux	5.8:1	3.0:1



INBOUND1 AND OUTBOUND 1
MAINTAINED VERTICAL ILLUMINATION CALCULATION ZONES (TYPICAL)
N.T.S.

LED's

LED's

- Mostly pilot and demonstration projects.
- Los Angeles- 30,000 lights installed, 130,000 to go - Largest in deployment in US
- Nova Scotia Pilot Project – 1,100 lights – Maybe the largest in Canada

- Department of Energy – US
- NRCAN (Natural Resources Canada) – Canada
- BC Hydro - BC

Products

LRL Satellite Series

Cobra Head

Issues

Cost - Better quality LED street lights can be over ***$1,000*** whereas a typical cobra head luminaire is typically around ***$200.***

Light Loss Factor - LED luminaires have varying heat management systems which are a function of thermodynamics (not a typical lighting designers background). The higher the junction temperature, the higher its light loss factor. IESNA LM-80 reports defines a test method to define the rate of loss of output over time at different junction temperatures. ***This is key as it is used to define the light loss factor applied to the design***

Standardization - LED roadway luminaires are relatively new to the market and as such their is a lack of proven specifications. ***Products vary in design and optics.***

Lack of Proven Long Term Performance - As LED roadway luminaires are new to the industry, long term performance has not been confirmed. ***This leads to some level of risk to the owner.***

Flat rate lighting – Utility must develop flat rates for LED's

Calculations

Many wattage and distributions exist so to optimize benefits and provide the required levels computer lighting calculations must be undertaken.

Today's computer lighting design software is easy to use however a qualified electrical engineer or lighting designer should do the calculations, ***not the supplier***.

Calculations

Location	Existing Fixture	Wattage Used Per Fixture	LED Roadway Replacement Fixture	Wattage Used Per Fixture	Energy Savings	Number of Fixtures Replaced	Total Wattages	
							Before	After
Annapolis	100W HPS	137	S96M	88	36%	102	13,974	8,976
Annapolis	70W HPS	94	S48M	44	53%	10	940	440
Annapolis	400W HPS	465	S96M	88	81%	15	6,975	1,320
Annapolis	100W HPS	137	S96M	88	36%	8	1,096	704
Yarmouth	100W HPS	137	S96M	88	36%	24	3,288	2,112
HRM	150W HPS	193	S96M	88	54%	40	7,720	3,520
HRM	100W HPS	137	S96M	88	36%	14	1,918	1,232
HRM	150W HPS	193	S96M	88	54%	27	5,211	2,376
HRM	70W HPS	94	S48M	44	53%	32	3,008	1,408
HRM	70W HPS	94	S96M	88	6%	32	3,008	2,816
Yarmouth	70W HPS	94	S72M	66	30%	34	3,196	2,244
Yarmouth	250W HPS	292	S96M	88	70%	2	584	176
Bridgewater	70W HPS	94	S48M	44	53%	31	2,914	1,364
Bridgewater	70W HPS	94	S48M	44	53%	13	1,222	572
Bridgewater	150W HPS	193	S96M	88	54%	16	3,088	1,408
Wolfville	100W HPS	137	S96M	88	36%	7	959	616
Grand Pre	100W HPS	137	S96M	88	36%	3	411	264
Truro	100W HPS	137	S96M	88	36%	16	2,192	1,408
Stanfield Airport	250W HPS	292	S96M	88	70%	14	4,088	1,232
Stanfield Airport	150W HPS	193	S96M	88	54%	11	2,123	968
Berwick	250W HPS *	292	S96M	88	40%	60	4,088	2,464
Parrsboro	400W HPS	465	S96M	88	81%	20	9,300	1,760
Parrsboro	100W HPS	137	S72M	66	52%	19	2,603	1,254
Parrsboro	250W HPS	292	S96M	88	70%	11	3,212	968
Port Hawkesbury	250W HPS	292	S96M	88	70%	10	2,920	880
Richmond County	70W HPS	94	S96M	88	6%	7	658	616
Amherst	100W HPS	137	S96M	88	36%	90	12,330	7,920
Springhill	70W HPS	94	S48M	44	53%	4	376	176
Springhill	100W HPS	137	S72M	66	52%	6	822	396
St Peters	100W HPS	137	S72M	66	52%	9	1,233	594
Arachat	100W HPS	137	S48M	44	68%	9	1,233	396
New Glasgow	250W HPS	292	S96M	88	70%	17	4,964	1,496
New Glasgow	100W HPS	137	S48M	44	68%	43	5,891	1,892
Antigonish	100W HPS	137	S72M	66	52%	60	8,220	3,960
Lunenburg	100W HPS	137	S72M	66	52%	60	8,220	3,960
HRM	70W HPS	94	S48M	44	53%	10	940	440
HRM	150W HPS	193	S96M	88	54%	24	4,632	2,112
HRM	100W HPS	137	S72M	66	52%	10	1,370	660
HRM	100W HPS	137	S72M	66	52%	34	4,658	2,244
Bedford	150W HPS	193	S96M	88	54%	15	2,895	1,320
Bedford	100W HPS	137	S72M	66	52%	15	2,055	990
Dartmouth	150W HPS	193	S96M	88	54%	7	1,351	616
Dartmouth	250W HPS	292	S96M	88	70%	8	2,336	704
Dartmouth	150W HPS	193	S96M	88	54%	18	3,474	1,584
Dept of Trans IR	180W LPS	220	S96M	88	60%	48	10,560	4,224
Dept of Trans IR	180W LPS	220	S96M	88	60%	34	7,480	2,992
HRM	100W HPS	137	S96M	88	36%	1	137	88
Note: At Berwick location, LED Roadway changed 14 x 250W HPS fixtures to 28 x S6200 fixtures								
						Totals	**1,100**	**175,873**	**81,862**

Total Estimated Energy Savings 53%

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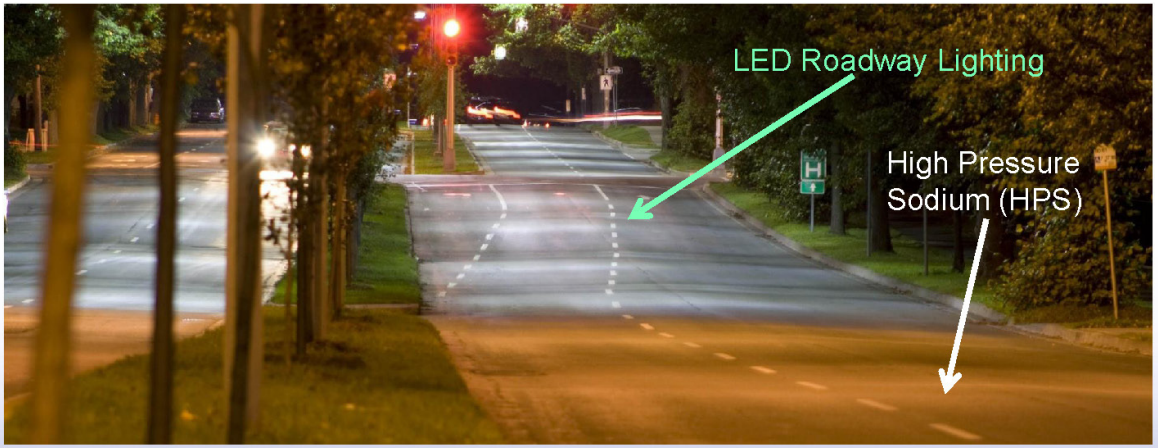
Results

An energy savings of ***53%*** will be gained from retrofitting the 1100 existing cobra head luminaires with the LRL Satellite luminaires.

Halifax, Nova Scotia (Robie St) - 55% Energy Savings



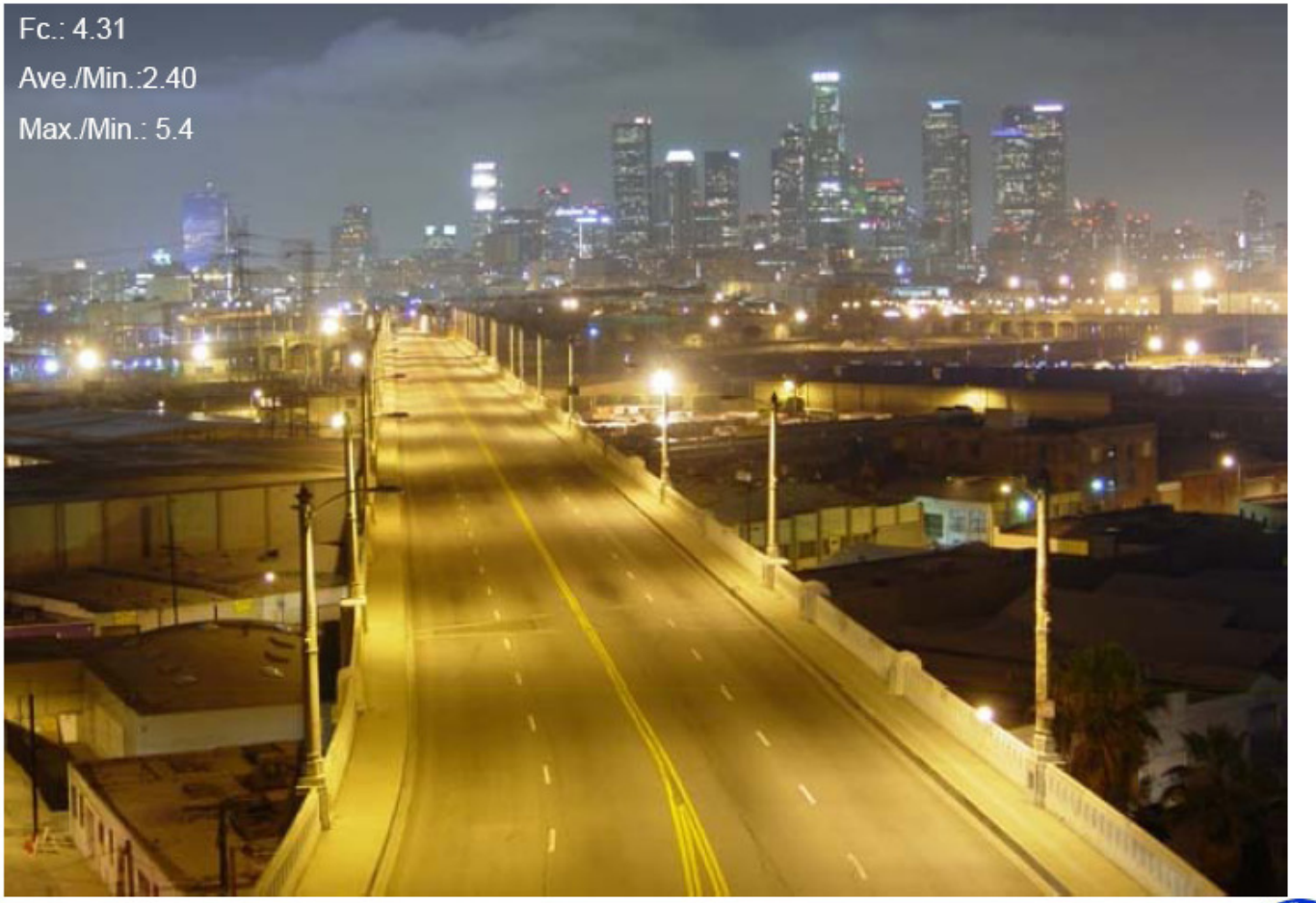
196 Watts
HPS - 150W Bulb

88 Watts
Satellite™ 96 LED-280mA


THE JADE GARDEN


THE JADE GARDEN

Before and After Pictures of Program

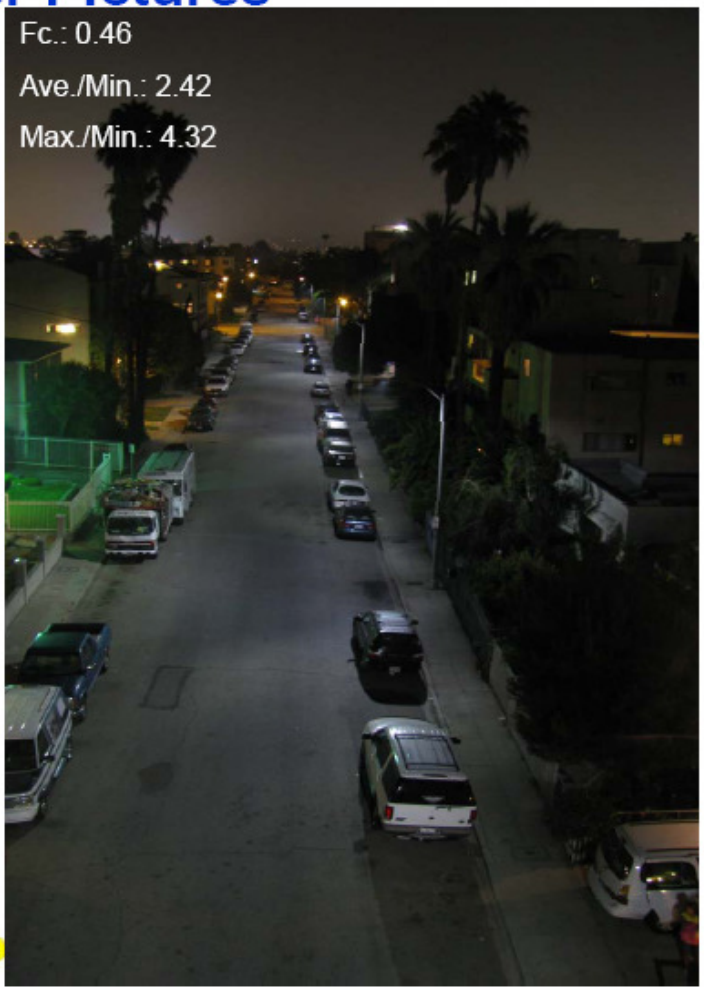


BEFORE (200 W HPS)
6th Street Bridge over Los Angeles River

Before and After Pictures of Program

AFTER (LED)
6th Street Bridge over Los Angeles River

Before and After Pictures

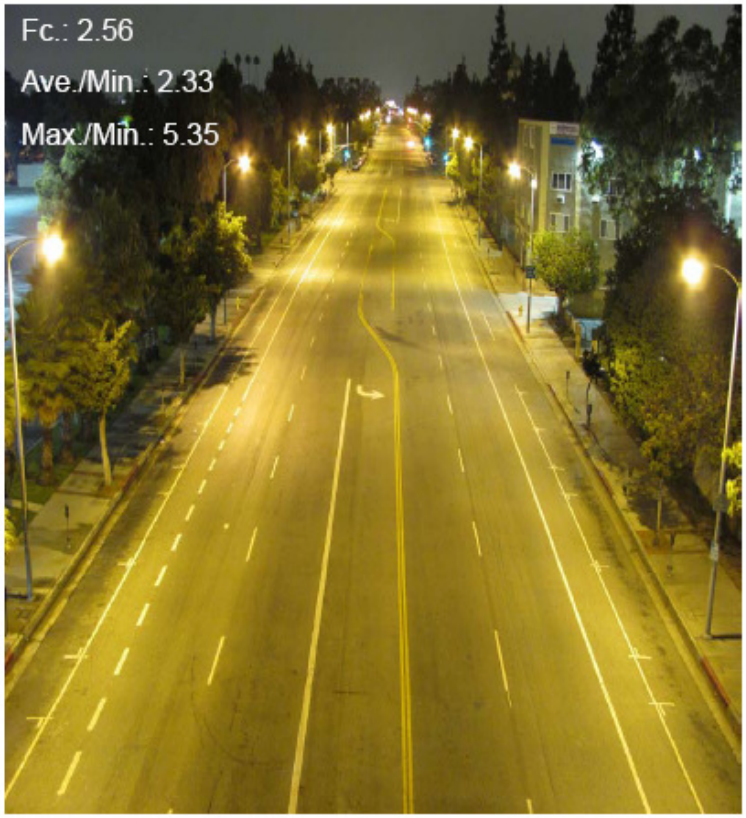


BEFORE (100 W HPS)

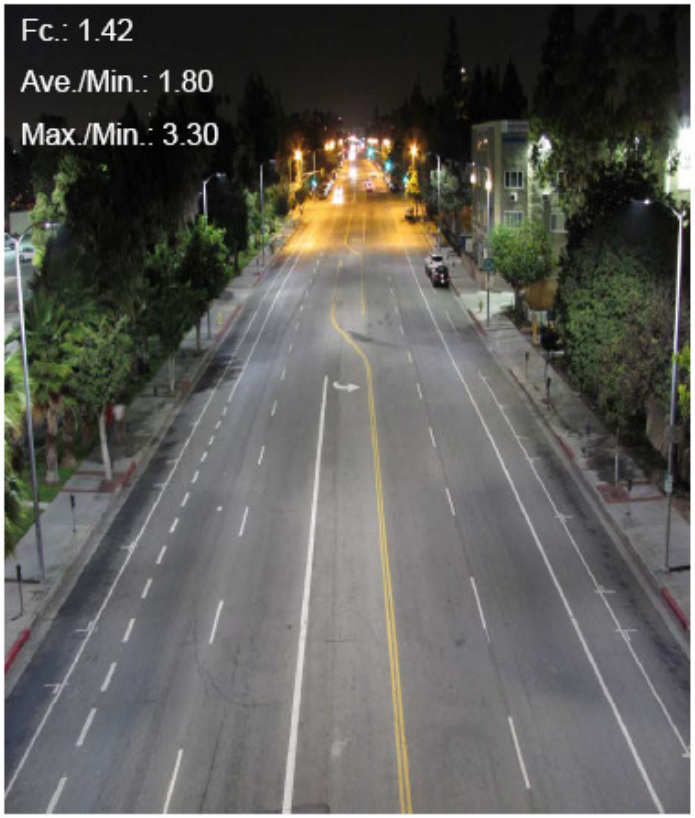
La Mirada Ave. – Seward St. to Wilcox Ave.

AFTER (LED)

Before and After Pictures of Program



BEFORE (310 W HPS)



AFTER (LED)

Hoover St. – 32nd St. to 30th St.

Keys to Deployment

Good specifications – Not all product equal. Product vary in quality and optical performance

Products selection – Select based on performance

Color Temperature – Trend towards lower color temperature. Suggest 4000K.

Warranty – Trend to 10 years

Thermo management – Junction temperature

Adaptive Lighting

What is Adaptive Lighting?

"The ability to vary lighting levels to suit activity levels."

Technology has been the barrier to varying street lighting levels.
Today's wireless technologies make it possible

Potential Benefits of an Adaptive Street Lighting System:

- Reduced Energy Consumption
- Obtrusive Light Reduction
- Power Consumption Monitoring
- Streamlined Asset Management
- Alerts of wire theft

How Can One Vary Light Levels?

Road and Pedestrian Conflict Area		Pavement Classification (Minimum Maintained Average Values)			Uniformity Ratio	Veiling Luminance Ratio
Road	Pedestrian Conflict Area	R1 lux/fc	R2 & R3 lux/fc	R4 lux/fc	E_{avg}/E_{min}	L_{vmax}/L_{avg}
Freeway Class A		6.0/0.6	9.0/0.9	8.0/0.8	3.0	0.3
Freeway Class B		4.0/0.4	6.0/0.6	5.0/0.5	3.0	0.3
Expressway	High	10.0/1.0	14.0/1.4	13.0/1.3	3.0	0.3
	Medium	8.0/0.8	12.0/1.2	10.0/1.0	3.0	0.3
	Low	6.0/0.6	9.0/0.9	8.0/0.8	3.0	0.3
Major	High	12.0/1.2	17.0/1.7	15.0/1.5	3.0	0.3
	Medium	9.0/0.9	13.0/1.3	11.0/1.1	3.0	0.3
	Low	6.0/0.6	9.0/0.9	8.0/0.8	3.0	0.3
Collector	High	8.0/0.8	12.0/1.2	10.0/1.0	4.0	0.4
	Medium	6.0/0.6	9.0/0.9	8.0/0.8	4.0	0.4
	Low	4.0/0.4	6.0/0.6	5.0/0.5	4.0	0.4
Local	High	6.0/0.6	9.0/0.9	8.0/0.8	6.0	0.4
	Medium	5.0/0.5	7.0/0.7	6.0/0.6	6.0	0.4
	Low	3.0/0.3	4.0/0.4	4.0/0.4	6.0	0.4

Potential for Dimming of 1/3 to 1/2 Based on IESNA Pedestrian Conflict Levels

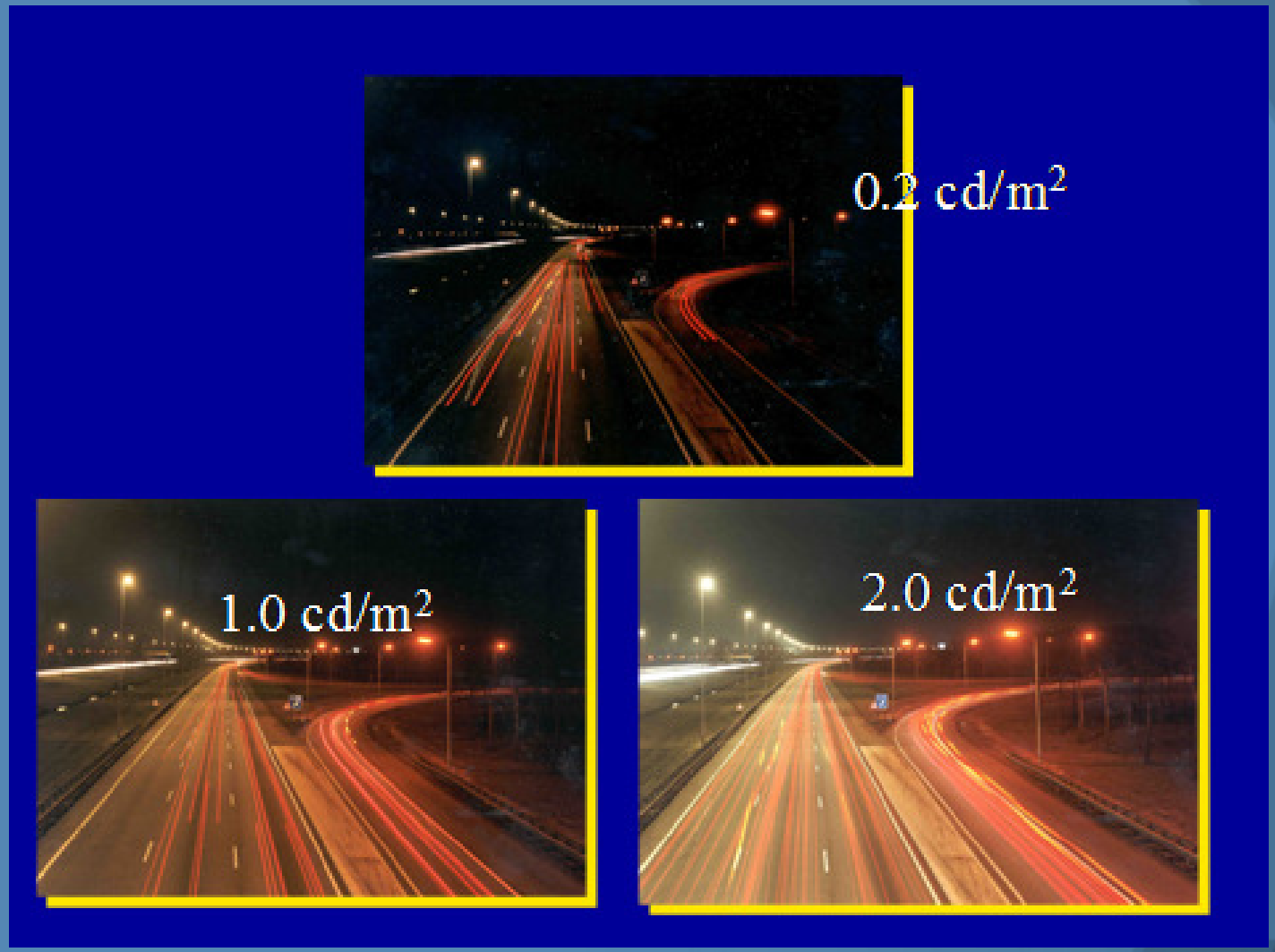
The Big Picture

Why vary lighting levels in off peak periods?

It has been estimate 64 million street lights exist in North America. Estimated power consumed in a year would be approximately 51billion kWh. Just imagine 20% reduction in off peak hours.

That's 5 billion kWh hours per year

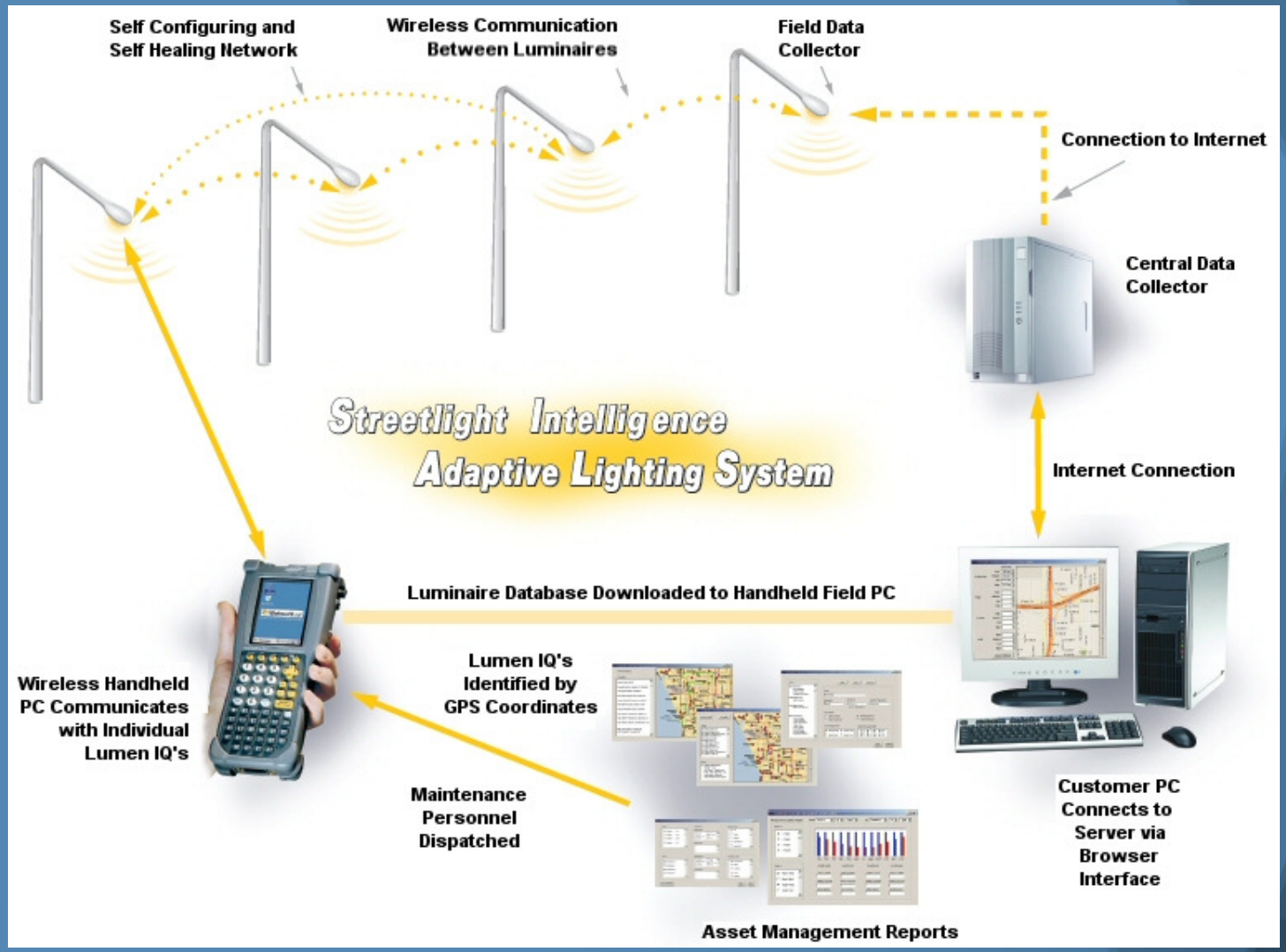
Adaptive Lighting (new term):



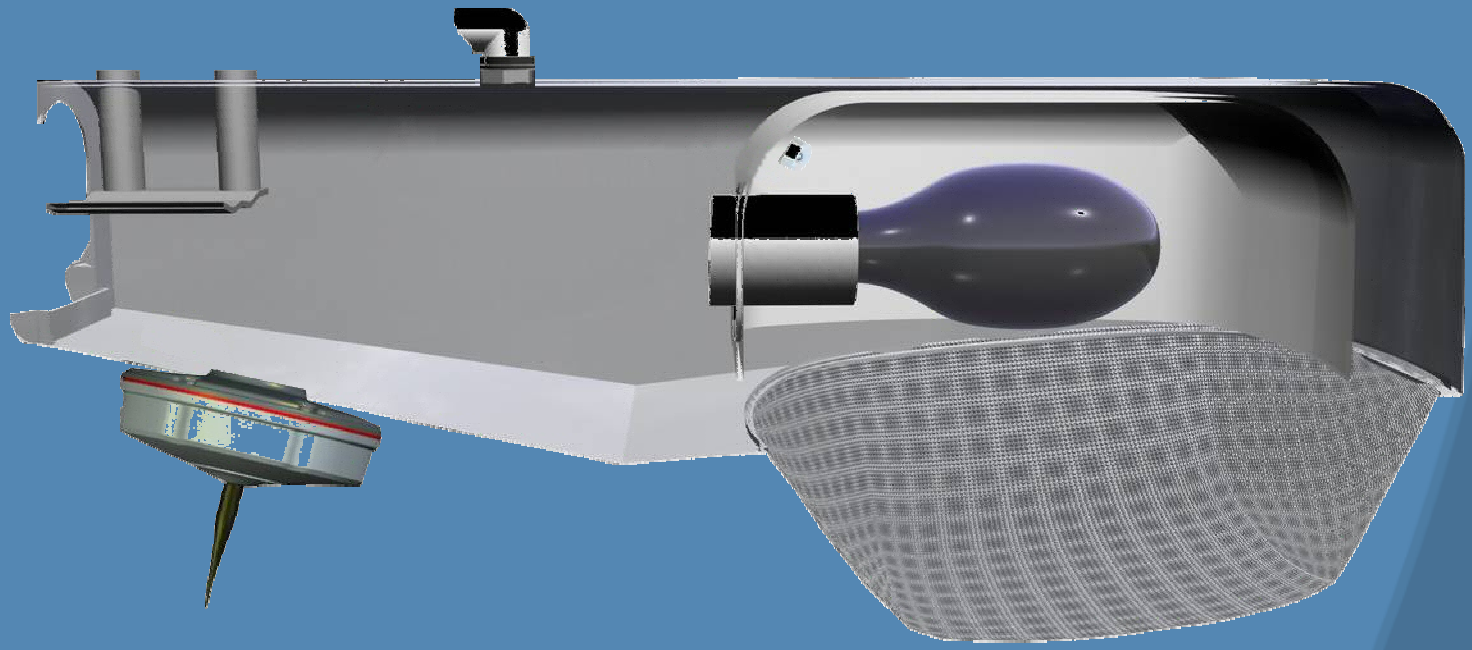
Adaptive Street Lighting System – Potential Energy Savings

Application		Advantages
1	Reduce Lumen Output of Lamps to Maintained Levels	• Energy Savings • Obtrusive Light Reduction
2	Reduce levels on over lighted roads to levels required	• Potential Energy Savings • Obtrusive Light Reduction
3	Match Lumen Output to Variable Pedestrian Activity Levels	• Significant Energy Savings • Obtrusive Light Reduction

Adaptive Street Lighting System



Adaptive Street Lighting System Overview



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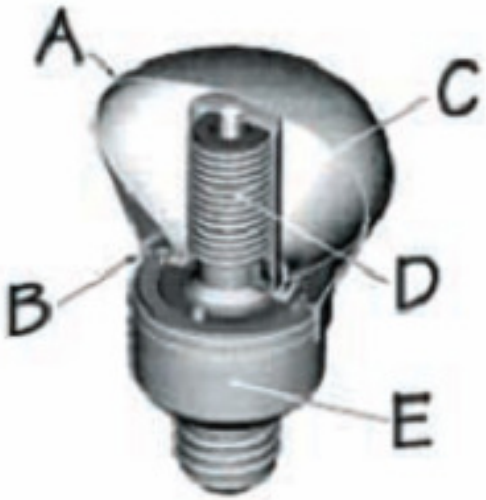
E Lamps (Induction)

E Lamps (Induction):



A. Phosphor Coating
B. Plastic Housing
C. Electron/Ion Plasma
D. Induction Coil
E. Electronics

E Lamps (Induction)

- Advantages include instant start (hot or cold), excellent color, minimal color shift over the life of the lamp, super long life, reduced maintenance
- Disadvantages include very high cost, large lamp size limiting retrofit options, limited number of wattages and voltages available, and lamps will require special disposal as they contain mercury vapor.

Solar Lighting

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Solar Lighting

Very High cost

Battery technology

Not enough output to properly light a road

Long Term Future

Electronic Ballasts

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Electronic Ballasts

- Replaces traditional magnetic type
- Emerging technology – Limited number of wattages
- Improve efficiency (10% to 20%)
- Can improve color and lamp life

Beware of this technology as to date
we have found a high failure rate
In roadway applications (ref tests
By BC Hydro and City of Oakland)

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Q & A