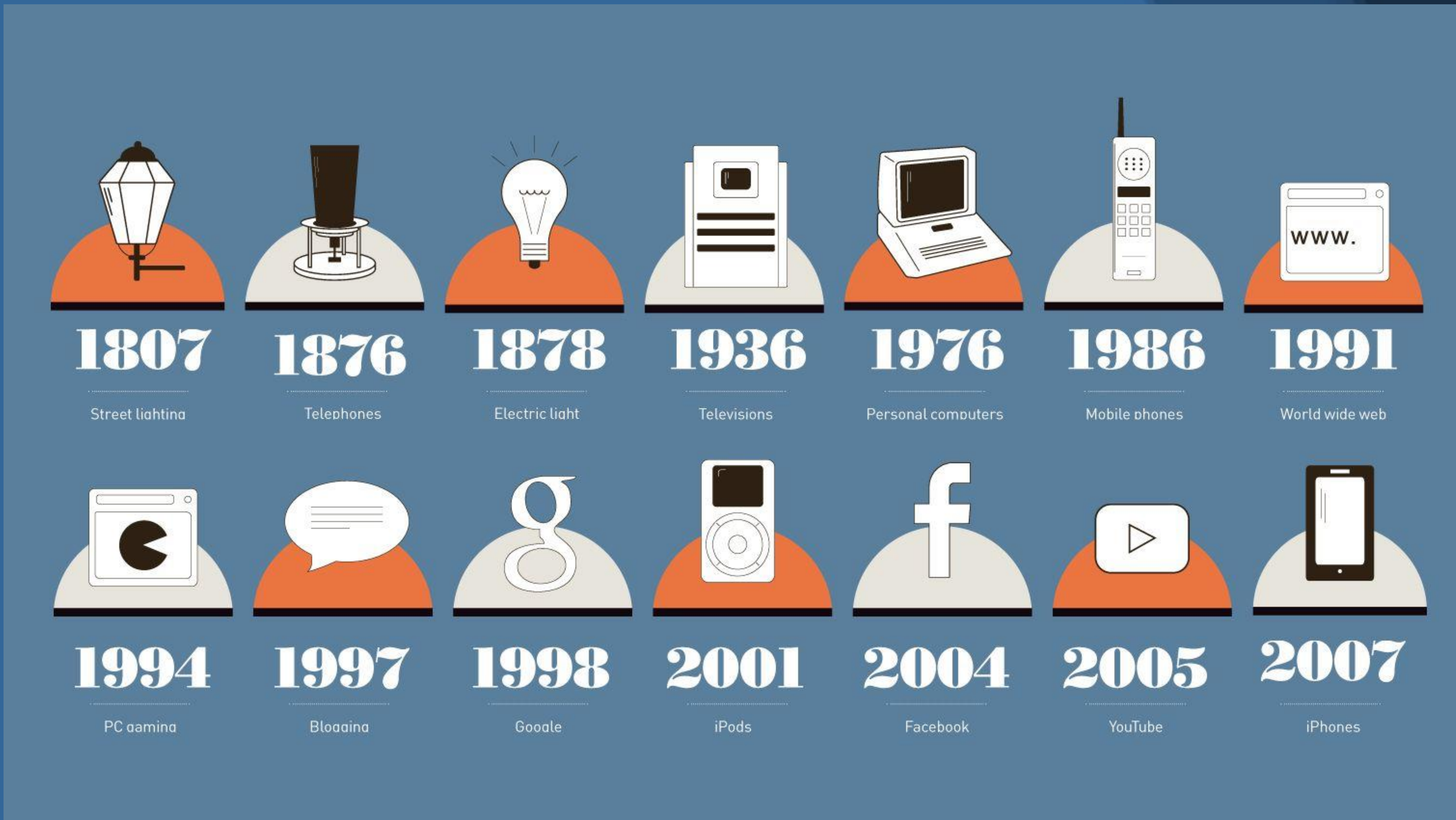
Today’s Presentation

- Lighting design and standards
- Steps to evaluate and consider a control system
- Stakeholder engagement and needs assessment
- Specifications, procurement strategies
- Metering
- Maintenance and operations
- Communication protocols and topology options.



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The World Today

- Technology – Information (Data) – Globalization
- Change is rapid (exponential)
- Technology has changed industries – *Photography Kodak vs Fujifilm*
- *We live in a "FAST FUTURE"*

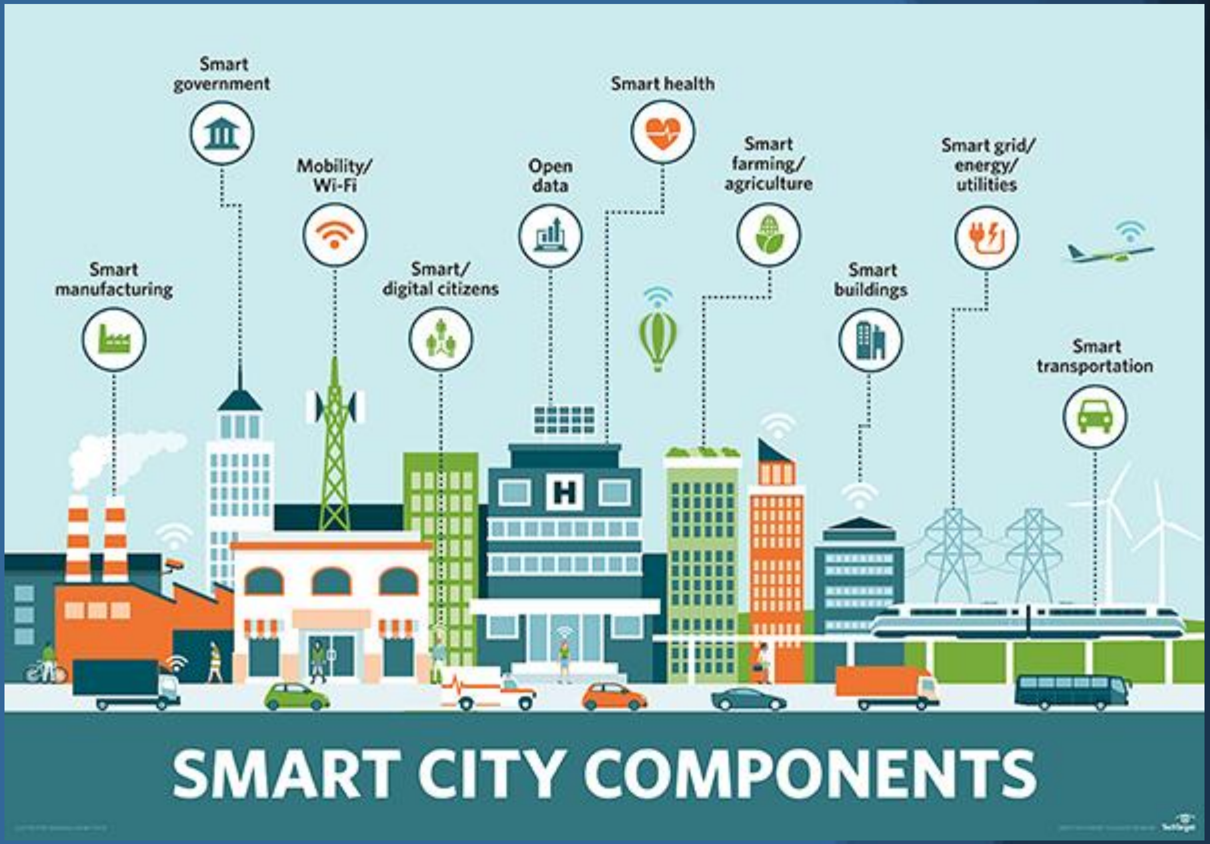
- Are you prepared???

Be Aware Of

- I am not a network expert.
- Street lighting is my expertise.
- Lighting controls have been developed and standards have not kept pace (SALC Conference)
- Technology Looking for Applications
- Networks and systems require ongoing support

Streetlights Meet IT World

- Smart Grid, Smart Cities, Smart Metering, Smart Street Lighting…
- Everything is getting smart??
- Is it real??
- Lighting meets IT world




Smart Parking
Smart Health
Waste Management
Public Safety
Smart Buildings
Open Data
Education
Traffic Management
Smart Environment
Electromagnetic Emissions
Internet of Things
Smart Energy
Gas & Water Leak Detection
Smart Street Lights
SMART CITY
Air Pollution
Water Quality
Intelligent Shopping
Smart Home
Electric Vehicle Charging

Why Street Lights

Street lights are everywhere. They make a great home for network devices.

Transition to Controls

With move to LED, many cities are implementing controls

Smart City

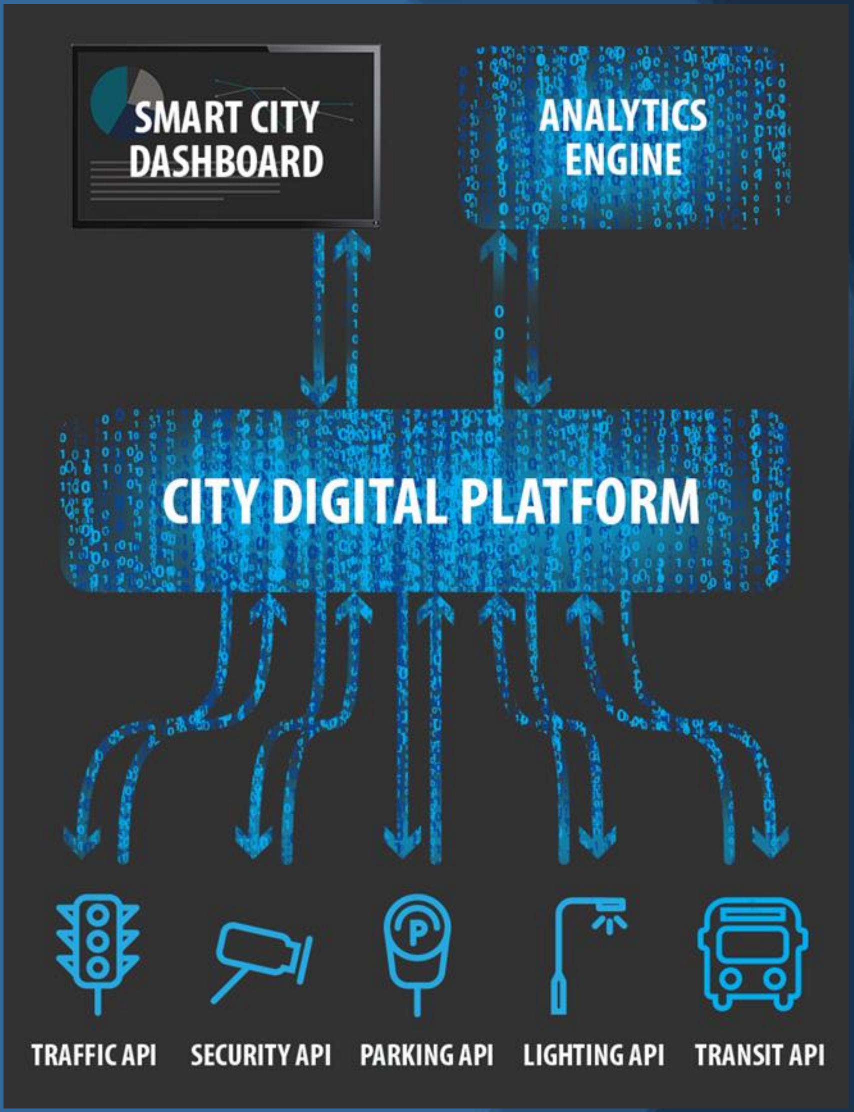
- Integrate multiple Information Communication Technologies and Internet of things solutions
- Goal/benefit to improve quality of life by using urban informatics and technology to improve the efficiency of services
- Why multiple communication technologies? There is no single network that can cover all applications.

City Digital Platform

Integrate multiple Information Communication Technologies and Internet of things solutions in a secure fashion to manage a city's assets.

The City Digital Platform

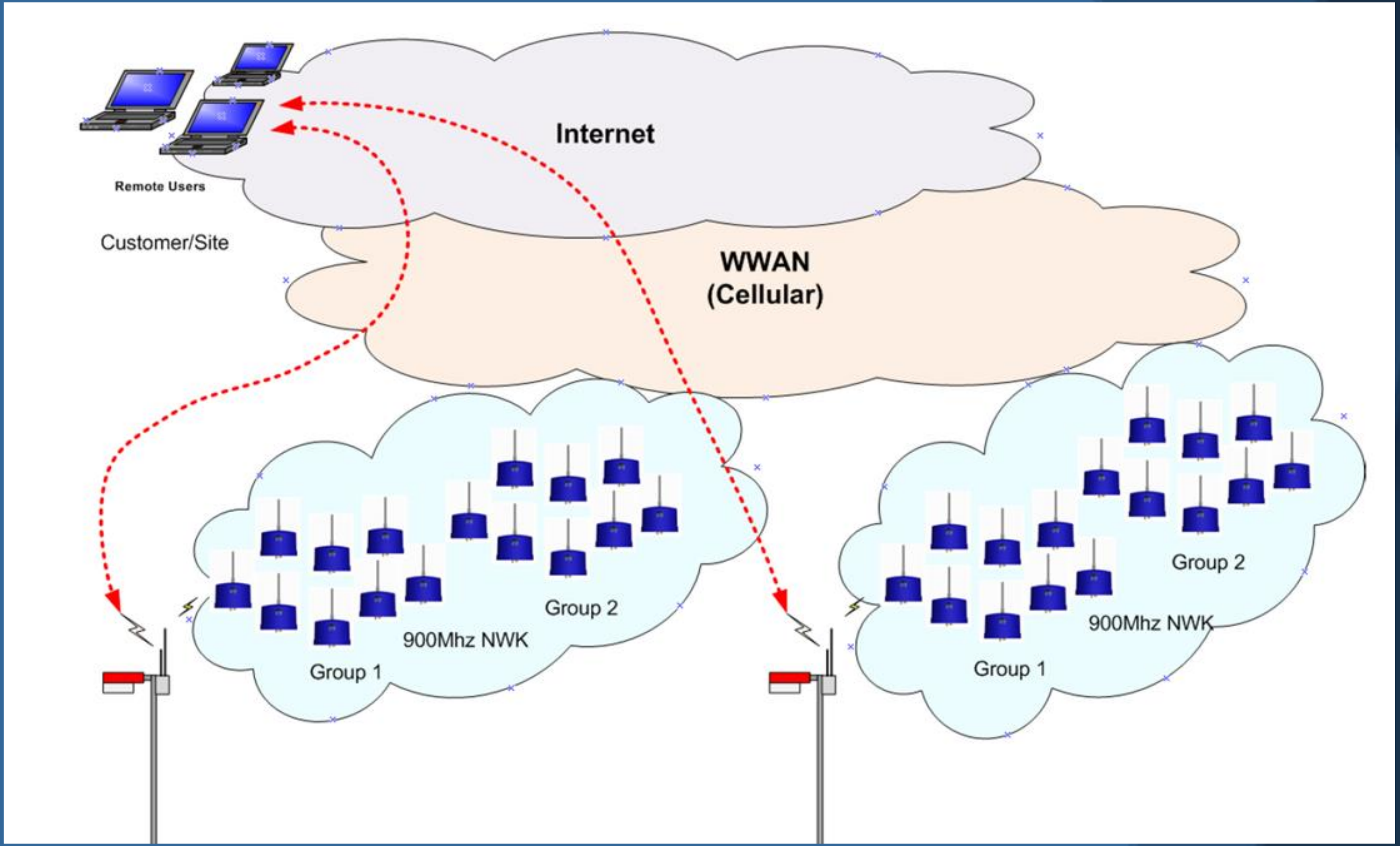
- High level city dashboard view for data from variety of applications
- Enables customers to collect and analyze data
- Create new programs to effect change



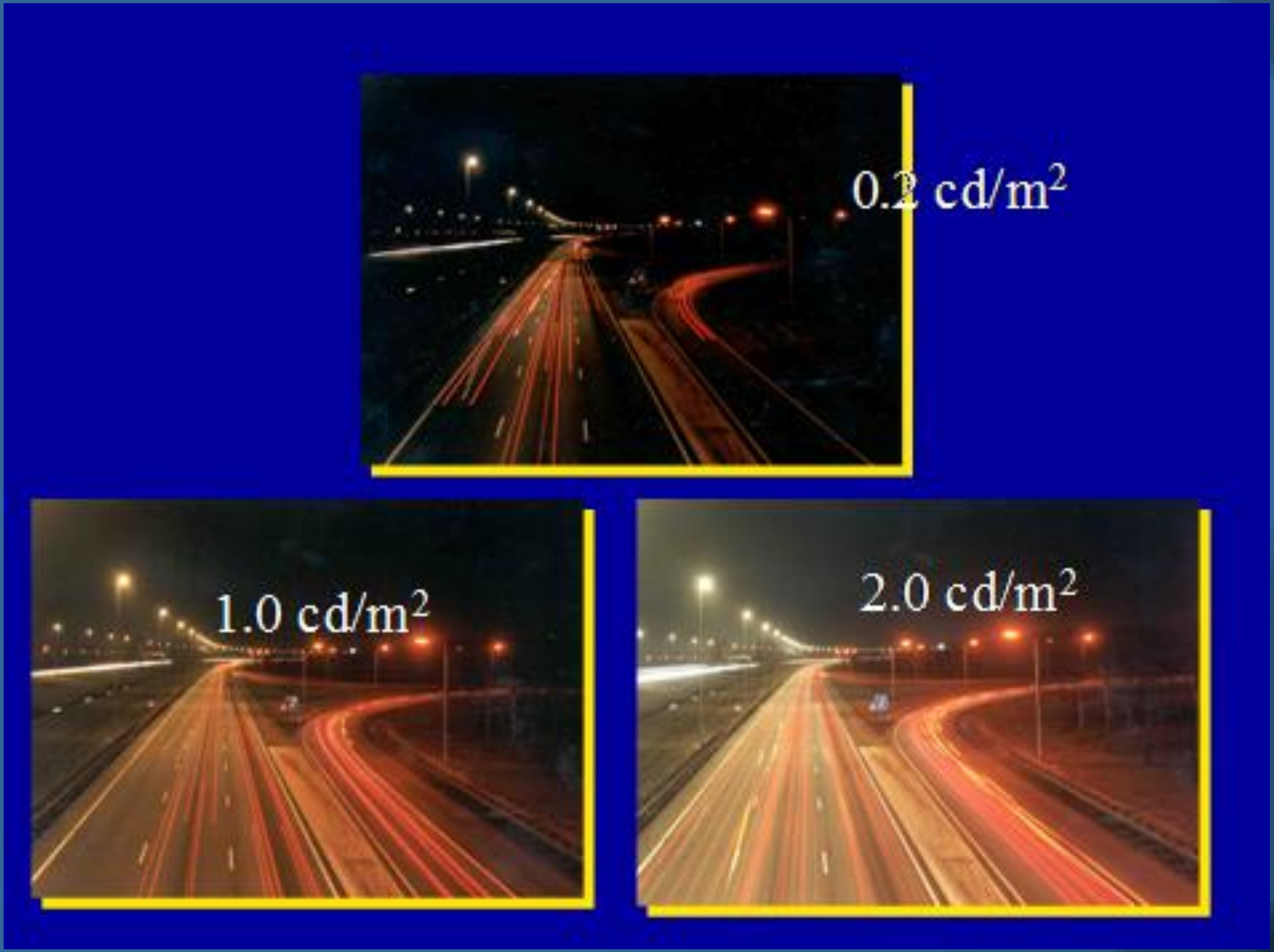
Adaptive Lighting (Smart Street Lighting)

The ability to vary lighting levels to suit *activity levels* (the environment)

- Becoming accepted practice in many published documents however research is lacking
- Standards have not keep pace with technology
- To date it is a *Technology Looking for Applications*


Remote Users
Internet
Customer/Site
WWAN
(Cellular)
Group 2
900Mhz NWK
Group 1
Group 2
900Mhz NWK
Group 1

Adaptive Lighting Example



Applications		Benefits
1	Reduce Lighting Output to Maintained Levels	Energy Savings (5-10%) - Light Pollution Reduction
2	Dimming Areas Over Lighted to Meet Uniformity	Possible Energy Savings (5-30%) - Light Pollution Reduction
3	Match Light Output to Pedestrian Activity Levels	Significant Energy Savings (20-30%) - Light Pollution Reduction

Design Considerations - Adaptive Controls

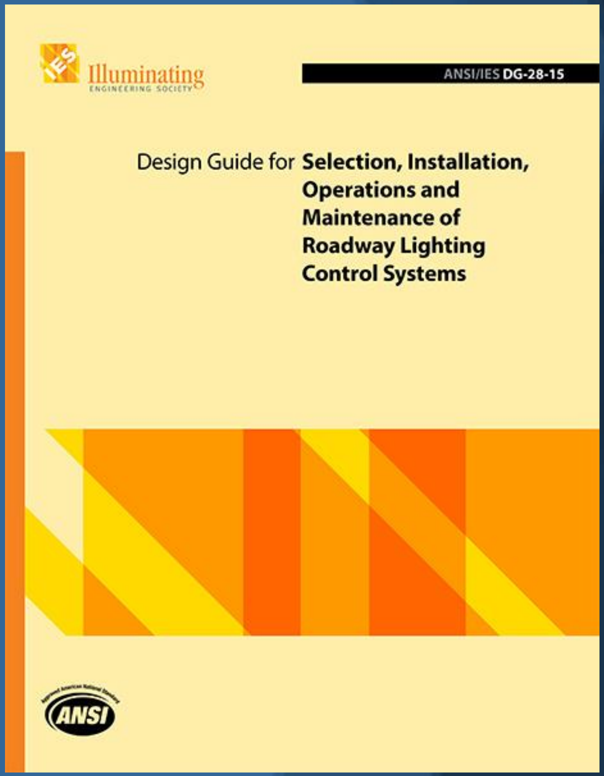
- Reduced Energy Consumption – BC Hydro Studies show 20% to 30% on average for most Cities while still meeting required light levels.
- Obtrusive Light Reduction – Less light off site while people are sleeping
- Power Consumption Monitoring – Can be used to validate costs
- Streamlined Asset Management – Benefits maintenance

Adaptive Lighting (Smart Street Lighting) - History

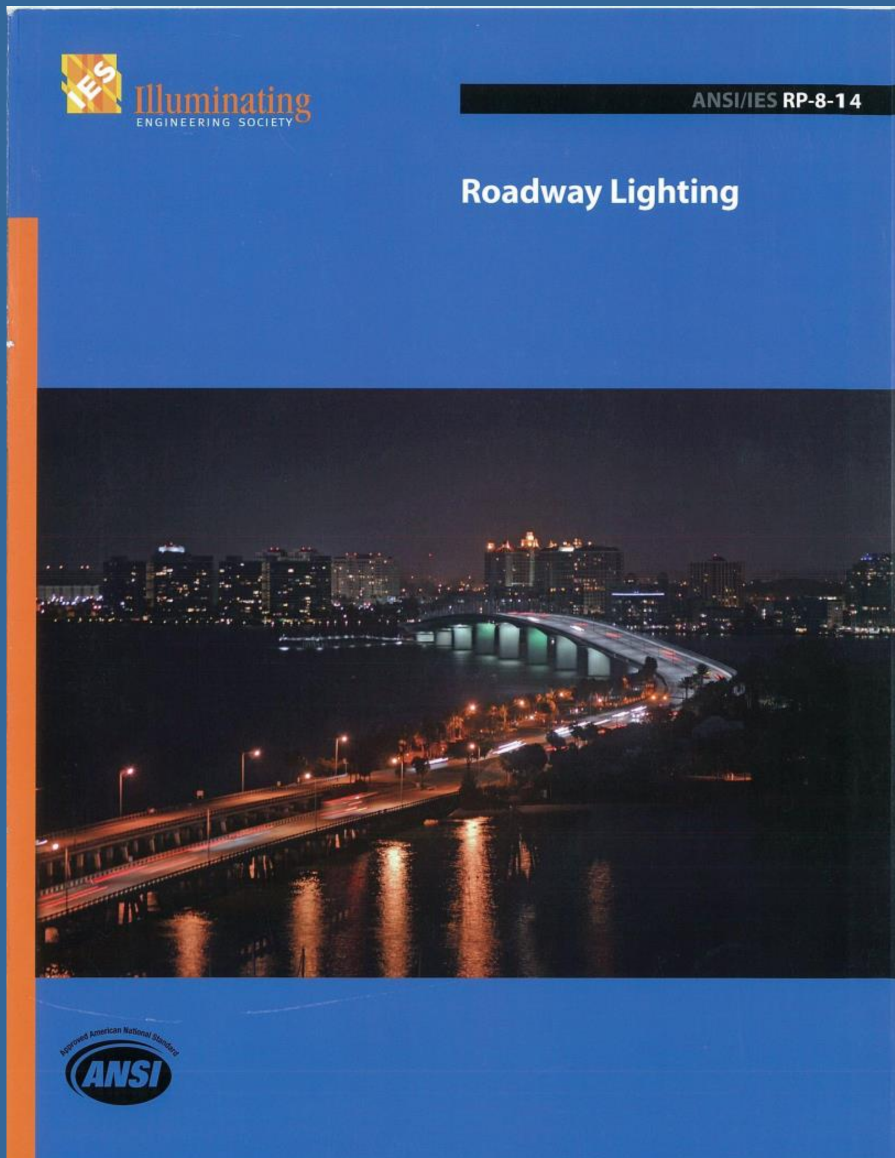
- Early pilot in Prince George in 2003-04.
- Pilots undertaken by NRCan for 20 Cities – 2010-11
- Large deployments undertaken with the adoption of LED's
- DMD have operated a test system for the last 8 – 10 years

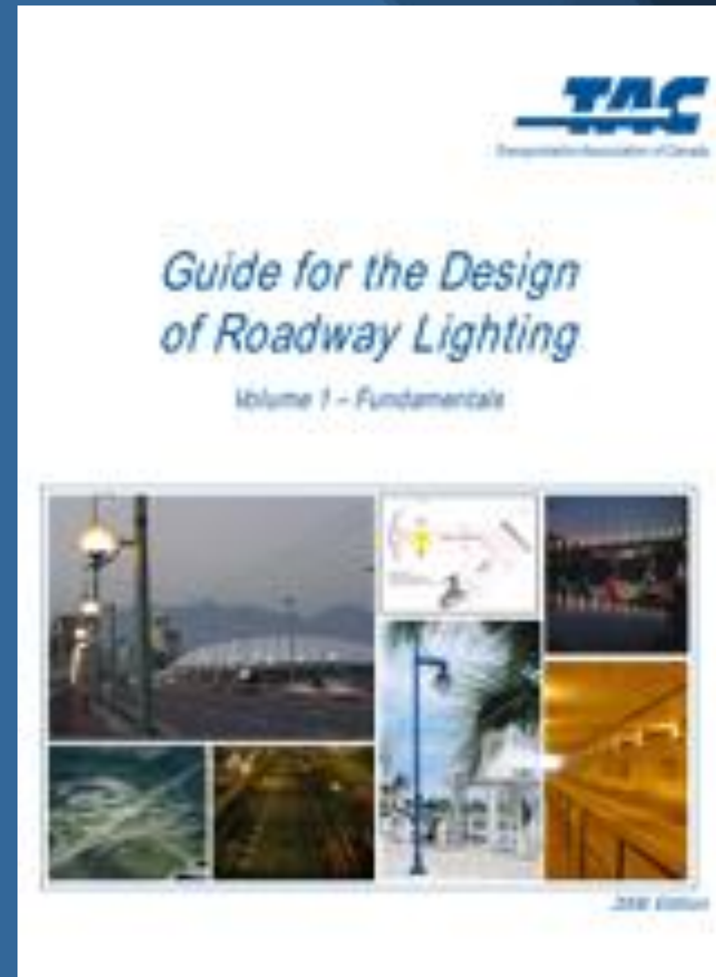
References

- TAC – Light Level Reduction and Energy Efficiency Guide
- NHCRP 05-22 Guidelines for Solid-State Roadway Lighting
- US Department of Energy - DOE Municipal Solid-State Street Lighting Consortium
- FHWA Studies
- IESNA – DG-28 and TM-23 Protocols



Roadway Levels





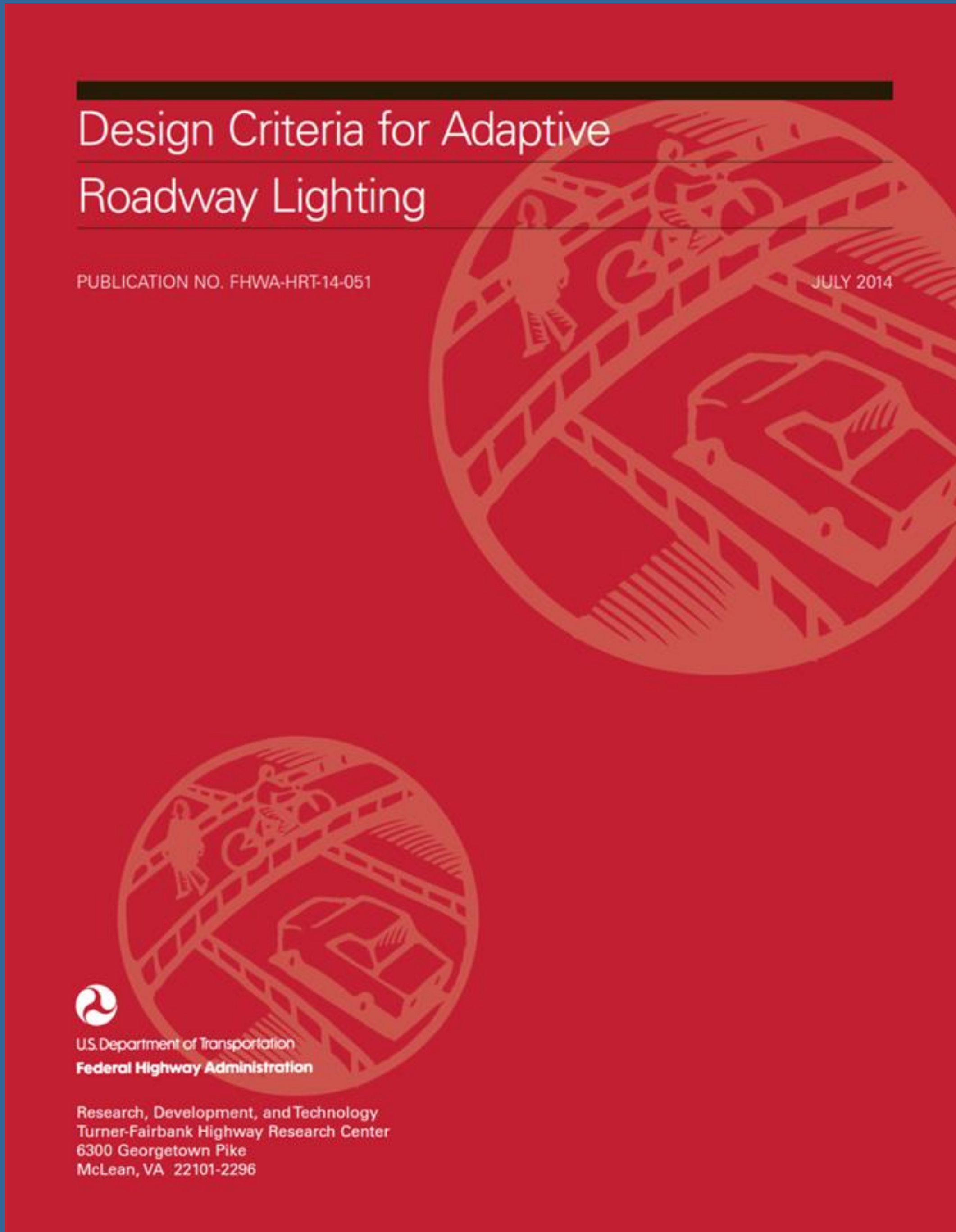
Roadway Levels

Table 2. Lighting Design Criteria for Roadways

ROAD CLASSIFICATION	AVG. LUMINANCE L_{avg} (cd/m^2)	AVG. UNIFORMITY RATIO L_{avg}/L_{min}	MAX. UNIFORMITY RATIO L_{max}/L_{min}	MAX. VEILING LUMINANCE RATIO LV_{max}/L_{avg}
FREEWAY CLASS A	0.6	3.5	6.0	0.3
FREEWAY CLASS B	0.4	3.5	6.0	0.3
EXPRESSWAY	1.0	3.0	5.0	0.3

Table 3. Lighting Design Criteria for Streets

STREET CLASSIFICATION	PEDESTRIAN AREA CLASSIFICATION	AVG. LUMINANCE L_{avg} (cd/m^2)	AVG. UNIFORMITY RATIO L_{avg}/L_{min}	MAX. UNIFORMITY RATIO L_{max}/L_{min}	MAX. VEILING LUMINANCE RATIO LV_{max}/L_{avg}
MAJOR	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	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



Design Criteria for Adaptive Roadway Lighting

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JULY 2014

U.S. Department of Transportation
Federal Highway Administration

Research, Development, and Technology
Turner-Fairbank Highway Research Center
6300 Georgetown Pike
McLean, VA 22101-2296

www.dmdeng.com

DESIGN CRITERIA FOR STREETS (S-CLASS)

Base Value for Class: 6

Table 23. Street design level selection criteria.

Parameter	Options	Criteria	Weighting Value
Speed	High	> 45 mi/h (70 km/h)	1
	Moderate	35–45 mi/h (55–70 km/h)	0.5
	Low	< 35 mi/h (55 km/h)	0
Traffic Volume	High	> 15,000 ADT	1
	Moderate	5,000–15,000 ADT	0
	Low	< 5,000 ADT	-1
Median	No	No median	1
	Yes (or one-way)	Must be glare blocking	0
Intersection/Interchange Density	High	> 5 per 1 mi (1.6 km)	1
	Moderate	1–5 per 1 mi (1.6 km)	0
	Low	< 1 per 1 mi (1.6 km)	-1
Ambient Luminance	High	LZ3 and LZ4	1
	Moderate	LZ2	0
	Low	LZ1	-1
Guidance	Good	> 100 mcd/m^2 lx	0
	Poor	< 100 mcd/m^2 lx	0.5
Pedestrian/Bicycle Interaction	High	> 100 pedestrians per h	2
	Moderate	10–100 pedestrians per h	1
	Low	< 10 pedestrians per h	0
Parked Vehicles	Yes	Parked vehicles present	1
	No	No parked vehicles present	0

Table 24. S-Class lighting design levels.

Class	Average Luminance (cd/m^2)	Max UR (avg/min)	Max UR (max/min)	Veiling Luminance Ratio
S1	1.2	3	5	0.3
S2	0.9	3.5	6	0.4
S3	0.6	4	6	0.4
S4	0.4	6	8	0.4
S5	0.3	6	10	0.4

1 cd/m^2 = 0.292 ft-lamberts

DESIGN CRITERIA FOR ROADWAYS (H-CLASS)

Base Value for Class: 5

Table 21. Roadway design level selection criteria.

Parameter	Options	Criteria	Weighting Value
Speed	Very High	> 60 mi/h (100 km/h)	1
	High	45–60 mi/h (75–100 km/h)	0.5
	Moderate	< 45 mi/h (75 km/h)	0
Traffic Volume	High	> 30,000 ADT	1
	Moderate	10,000–30,000 ADT	0
	Low	< 10,000 ADT	-1
Median	No	No median	1
	Yes	Must be glare blocking	0
Intersection/Interchange Density	High	< 1.5 mi (2.5 km) between intersections	1
	Moderate	1.5–4 mi (2.5 km–6.5 km) between intersections	0
	Low	> 4 mi (6.5 km) between intersections	-1
Ambient Luminance	High	LZ3 and LZ4	1
	Moderate	LZ2	0
	Low	LZ1	-1
Guidance	Good	> 100 mcd/m^2 lx	0
	Poor	< 100 mcd/m^2 lx	0.5

Table 22. H-class lighting design levels.

Class	Average Luminance (cd/m^2)	Max UR (avg/min)	Max UR (max/min)	Veiling Luminance Ratio
H1	1	3	5	0.3
H2	0.8	3.5	6	0.3
H3	0.6	3.5	6	0.3
H4	0.4	3.5	6	0.3

1 cd/m^2 = 0.292 ft-lamberts

Table 25. Residential/pedestrian design level selection criteria.

Parameter	Options	Criteria	Weighting Value
Speed	High	> 45 mi/h (70 km/h)	1
	Moderate	35–45 mi/h (55–70 km/h)	0.5
	Low	< 35 mi/h (55 km/h)	0
Traffic Volume	High	> 7,500 ADT	0.5
	Moderate	3,000–7,500 ADT	0
	Low	< 3,000 ADT	-0.5
Intersection/Interchange Density	High	> 5 per 1 mi (1.6 km)	1
	Moderate	1–5 per 1 mi (1.6 km)	0
	Low	< 1 per 1 mi (1.6 km)	-1
Ambient Luminance	High	LZ3 and LZ4	1
	Moderate	LZ2	0
	Low	LZ1	-1
Pedestrian/Bicycle Interaction	High	> 100 pedestrians per h	1
	Moderate	10–100 pedestrian per h	.5
	Low	< 10 pedestrians per h	0
Parked Vehicles	Yes	Parked vehicles present	.5
	No	No parked vehicles present	0
Facial Recognition	Required	Facial recognition required	1
	Not Required	Facial recognition not required	0

Table 26: P-class lighting design levels.

Class	E Average (Lux)	E Vertical (minimum point)	Ratio E_{avg}/E_{min}
P1	10	5	4
P2	5	2	4
P3	4	1	4
P4	3	0.8	6
P5	2	0.6	10

Design Considerations

Residential Streets (most are to lowest level 0.3 cd/m2) – Consider Car headlamps and Driver Safe Stopping Distances and dim in off peak periods (say midnight to 5AM)

These roads comprise a significant inventory in a typical city. Lighting research focused on highways and freeways (FHWA)

Lighting is of value so turning lights off may diminish ones “feeling of security”. Santa Rosa, California.

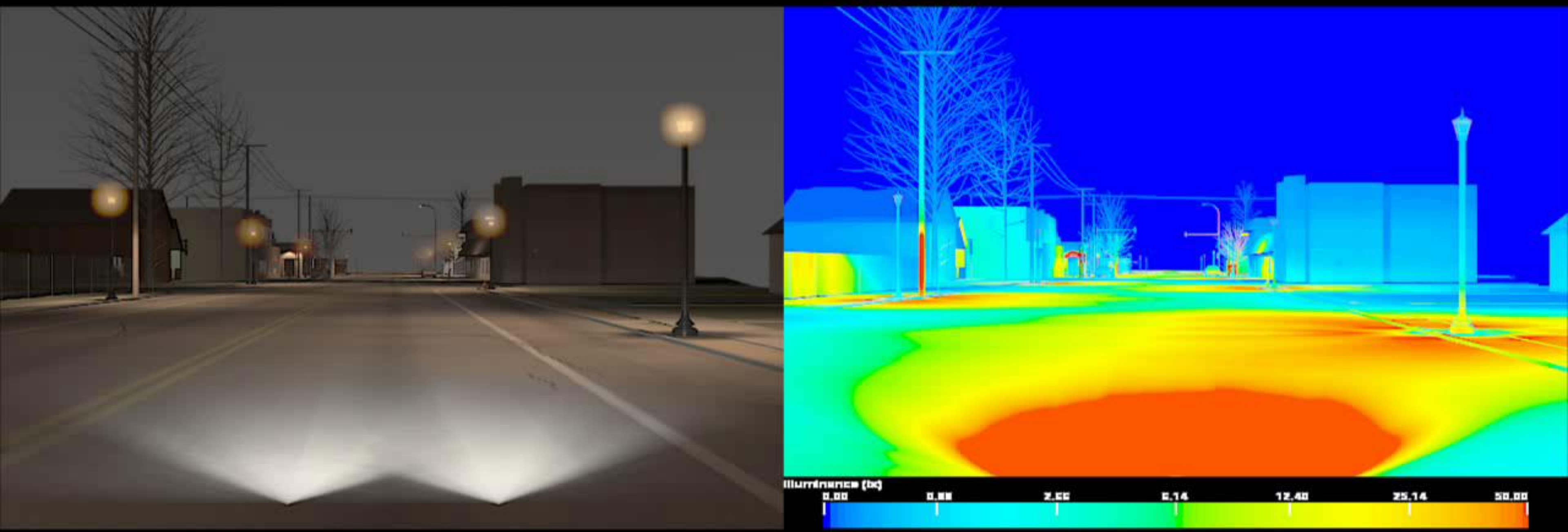
Consider 30-60% dimming off peak via adaptive system

Table 1: AASHTO Stopping Sight Distance (Wet Pavement)

Stopping Sight Distance M (Ft) by Percent Grade (%)							
		Downgrade			Upgrade		
Traffic Speed km/h (mph)	0	3	6	9	3	6	9
35 (20)	35 (115)	35 (116)	40 (120)	40 (126)	35 (109)	35 (107)	35 (104)
40 (25)	50 (155)	50 (158)	50 (165)	55 (173)	45 (147)	45 (143)	45 (140)
50 (30)	60 (200)	65 (205)	65 (215)	70 (227)	60 (200)	60 (184)	55 (179)
60 (35)	80 (250)	80 (257)	85 (271)	90 (287)	75 (237)	70 (229)	70 (222)
65 (40)	95 (305)	95 (315)	100 (333)	110 (354)	90 (289)	85 (278)	80 (269)
75 (45)	110 (360)	115 (378)	120 (400)	130 (427)	105 (344)	100 (331)	100 (320)
80 (50)	130 (425)	135 (446)	145 (474)	155 (507)	125 (405)	120 (388)	115 (375)
90 (55)	150 (495)	160 (520)	170 (553)	180 (593)	145 (469)	140 (450)	135 (433)
100 (60)	175 (570)	185 (598)	195 (638)	210 (686)	165 (538)	160 (515)	150 (495)
105 (65)	200 (645)	210 (682)	220 (728)	240 (785)	190 (612)	180 (584)	170 (561)
115 (70)	225 (730)	235 (771)	250 (825)	275 (891)	210 (690)	200 (658)	195 (631)
120 (75)	250 (920)	265 (866)	285 (927)	305 (1003)	235 (772)	225 (736)	215 (704)

Source: A Policy on Geometric Design of Streets & Highways, AASHTO, Washington DC, 2004. Chapter 3 Elements of Design.

The speed and distance columns only correspond to their metric or English equivalent, i.e., if determining the SSSD for a posted speed in kilometer per hour (km/h), use the value shown in m, if using miles per hour (mph), use the value shown for ft.



Illuminance (lx)
0.00
6.14
12.40
25.14
50.00

Freeways and Highways

- One factor which could allow for reduced levels is reduced speed.
- Speed sensors could be used to sense low speeds and adjust and dim light levels during these low speed periods.