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# OUTDOOR LIGHTING CONTROL SYSTEM FUNDAMENTALS

9:00am Sunday 5/3/2015

Mark Wilbur, GE Lighting Solutions

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# ATTENDEE SURVEY: BACKGROUND

- Manufacturer
- Municipal user
- Utility user
- Contractor, Consultant
- Market Analyst
- Investment, Finance
- Other

# ATTENDEE SURVEY: BACKGROUND

## Manufacturer experience

- Lighting control system
- Lighting control sub-system
- Lighting control component
- Luminaire
- Other

## User experience

- Installed system
- Pilot project
- Demonstration project
- Mock-up
- Technical review
- None

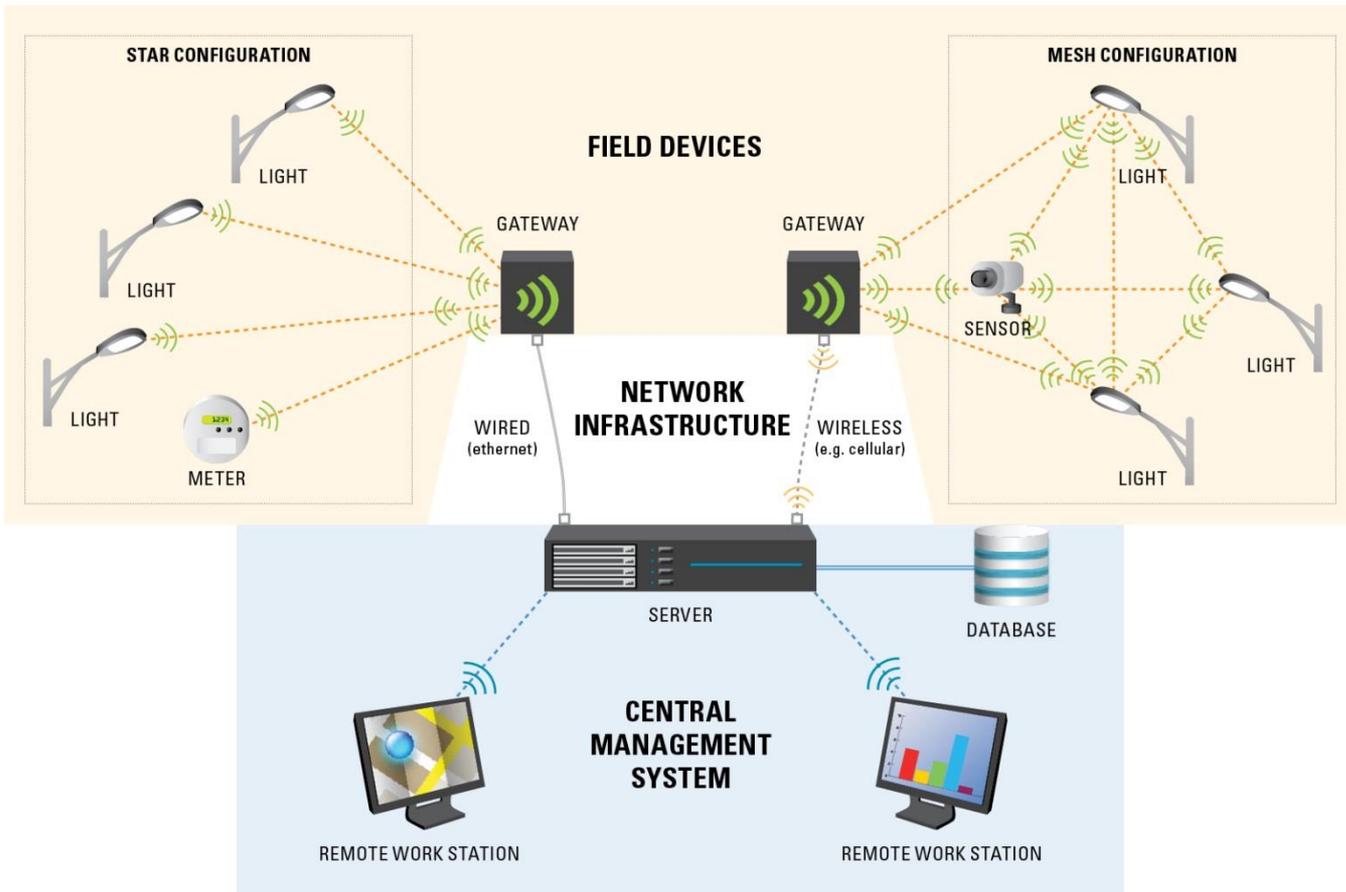
# ATTENDEE SURVEY: EXPECTATIONS

- General education
- Features and options of commercially available products
- Value propositions
- Barriers to adoption
- Planning a project
- Specific questions
- Market analysis

# WHO IS THIS COURSE DESIGNED FOR?

- Specifiers, owners, and operators of outdoor lighting systems
- System integrators, start-up and commissioning agents
- Manufacturers of non-lighting equipment that could get integrated into networked outdoor lighting systems

# A (NETWORKED) OUTDOOR LIGHTING CONTROL SYSTEM



# NETWORKED CONTROL SYSTEMS

- **Network** (from IES TM-23-11): A group of systems that function cooperatively and/or interdependently to provide a chain of command for lighting control
- **Field Device Network**: typically a Local Area Network (LAN) that connects and enables communication between (exclusively) Field Devices
- **Backhaul Network**: typically a Wide Area Network (WAN) that connects and facilitates communication between (at a minimum) one or more Field Device networks with a Central Management System.

# NETWORKED CONTROL SYSTEMS

- **Field devices:** the entire set of networked Components (hardware and embedded software, consisting of Controllers and possibly Gateways) installed in the field that, following, installation, start-up and commissioning, function together to adaptively control and remotely monitor Luminaires.
- **Central Management System:** a computer environment that functions as the core of the System by providing all shared System services, and consolidating and storing (or managing the storage of) all System data

# SYSTEM CONFIGURATION



## Installation

Devices have basic necessities for operating as intended

- Physical configurations
- Mechanical mounting
- Electrical connection
- Default values
- Provisioning

## Start-up

Devices are operating as intended, all system functions and capabilities are available to the user

- Logical configurations
- Evaluation of and configuration for environmental conditions (i.e. compatibility)
- Configuration for and verification of data exchanges (i.e. interoperability)

## Commissioning

System functions and capabilities are configured according to user desires

- Functional configurations
- Grouping, associations
- Monitoring, reporting
- Control strategies
- Schedules

# LEARNING OBJECTIVES

1. Understand the full capabilities and underlying technology building blocks of market-available outdoor lighting control systems.
2. Understand the value propositions offered by outdoor lighting control systems, current real- world barriers to adoption, and the status of relevant research, standards and regulations.
3. Understand how to align value propositions with the needs of relevant stakeholder groups, create strategies for overcoming barriers to adoption, and draft specifications that meet user needs.
4. Understand how outdoor lighting control systems can form the backbone of future Machine-To- Machine and Internet of Things ecosystems that make tomorrow's urban environments safer and more livable.

# AGENDA

12

- 1) Introduction, Assessment & Adoption
- 2) Technology Fundamentals
- 3) Basic System Capabilities & Value Propositions
- 4) Demonstration Part 1
- 5) Lunch (90 minutes)
- 6) Demonstration Part 2
- 7) Market Adoption Status
- 8) Future Possibilities
- 9) Interoperability, Standards & Specifications
- 10) Q&A



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# **OUTDOOR LIGHTING CONTROL SYSTEM FUNDAMENTALS**

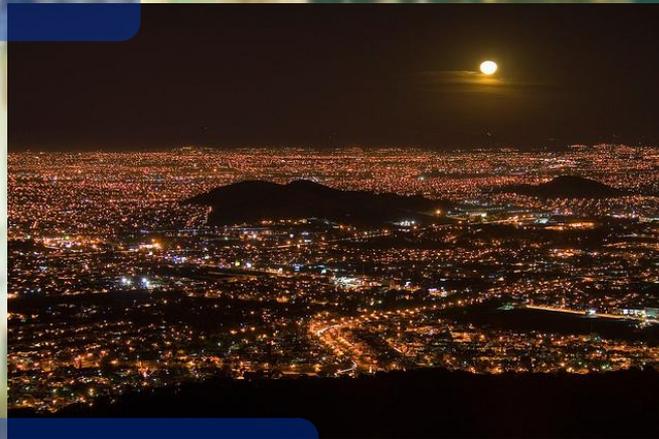
Assessment and adoption

Michael Poplawski



Cities account  
for...

70% of energy  
consumption



Lighting 20% of electricity  
consumption

# OUTDOOR LIGHTING APPLICATIONS

Roadway



Urban Streets



Residential

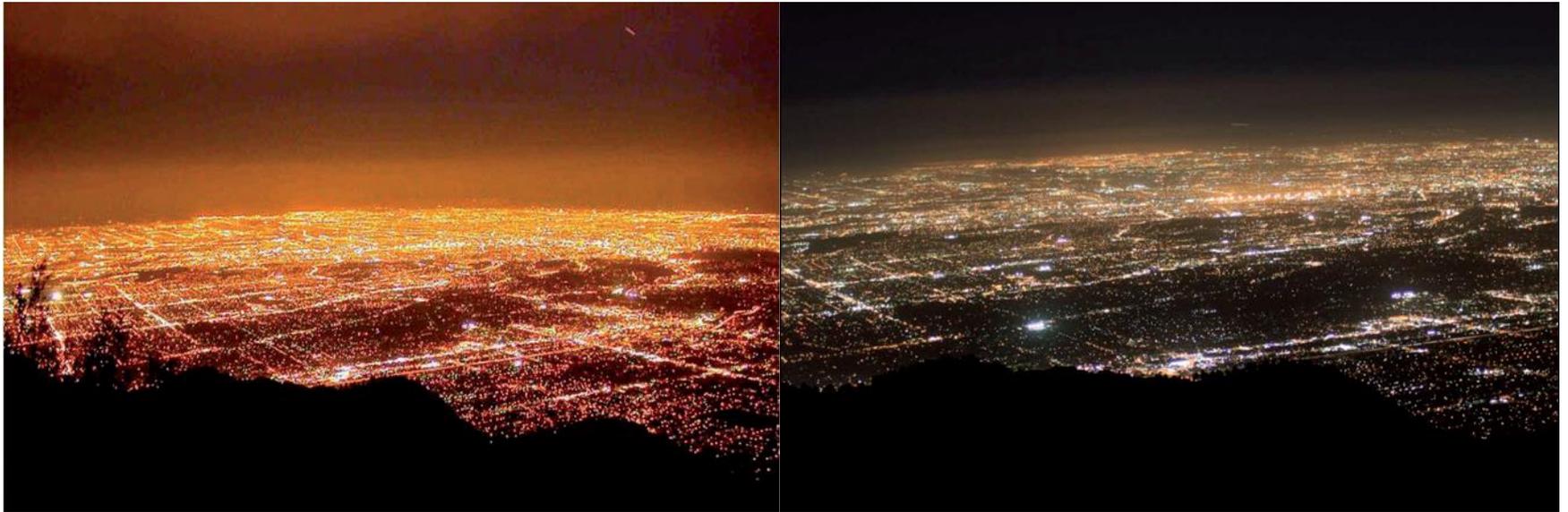


Site & Area



# LED ADOPTION

- Driven by economic circumstances
  - Reduced municipal revenues
  - Higher energy costs
  - Increasing energy efficiency regulations
- Driven by falling prices and shortened payback
- Driven by successful retrofit pilot projects
- **Clear transition path from traditional lighting to LED technology**

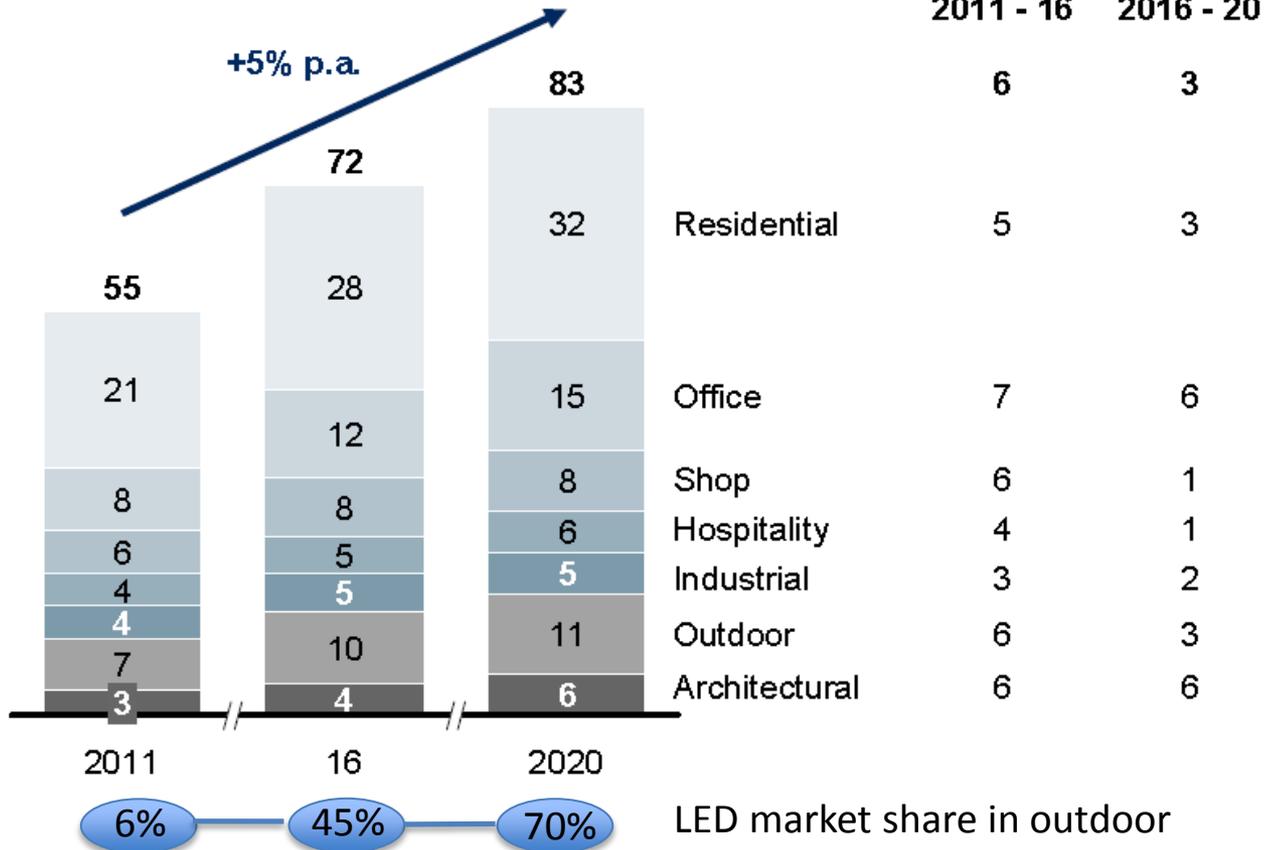


## Los Angeles Before and After LED retrofit

- LED luminaires have proven energy efficiency and reliability while providing high-quality lighting
- LA (142K), Seattle (42K), Boston (32K), Las Vegas (40K), NYC (250K)

# LED LIGHTING MARKET IS GROWING FAST

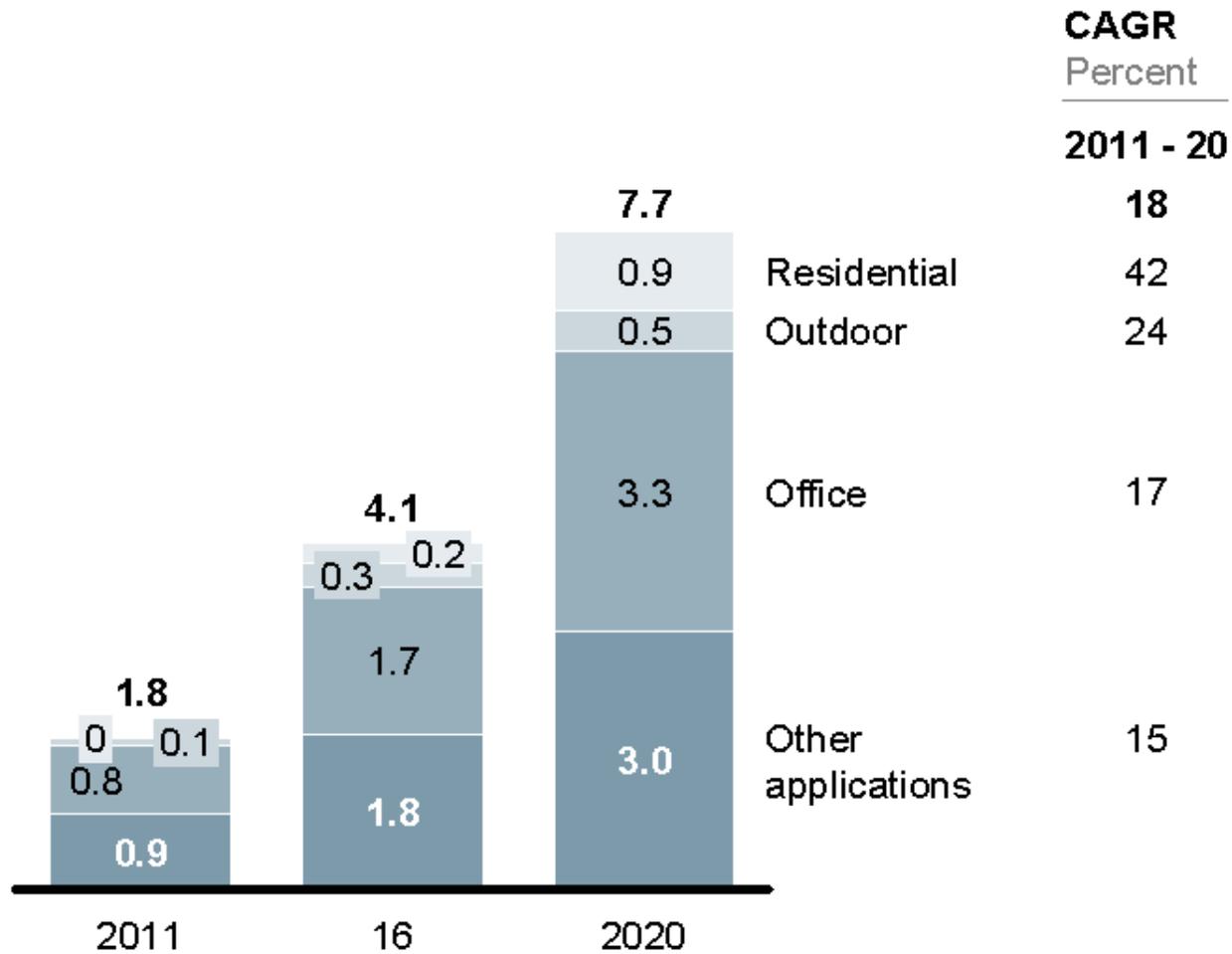
**General lighting market size<sup>1</sup> by application**  
EUR billions



[http://www.mckinsey.com/~media/mckinsey/dotcom/client\\_service/automotive and assembly/lighting\\_the\\_way\\_perspectives\\_on\\_global\\_lighting\\_market\\_2012.ashx](http://www.mckinsey.com/~media/mckinsey/dotcom/client_service/automotive_and_assembly/lighting_the_way_perspectives_on_global_lighting_market_2012.ashx)

# STRONG GROWTH EXPECTED FOR LIGHTING CONTROLS

EUR billions



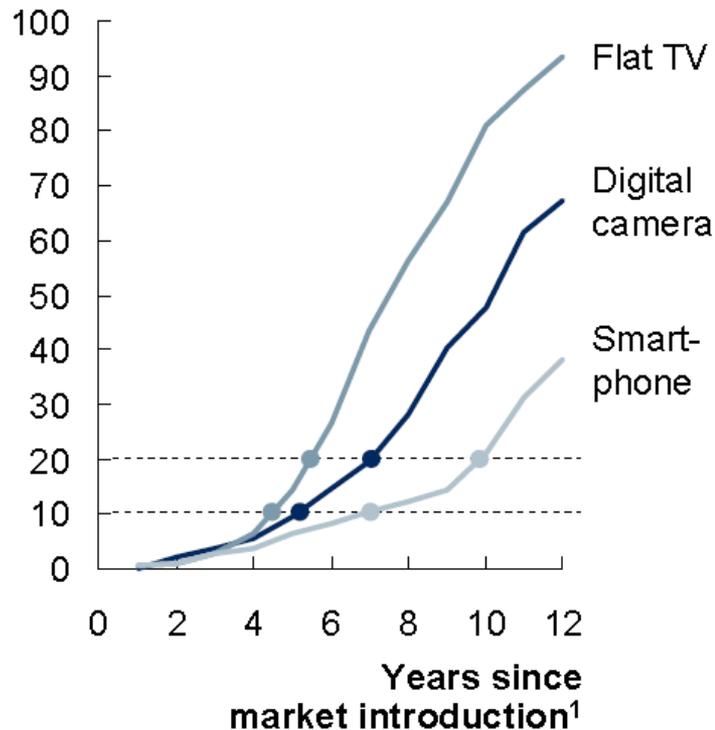
[http://www.mckinsey.com/~media/mckinsey/dotcom/client\\_service/automotive and assembly/lighting\\_the\\_way\\_perspectives\\_on\\_global\\_lighting\\_market\\_2012.ashx](http://www.mckinsey.com/~media/mckinsey/dotcom/client_service/automotive_and_assembly/lighting_the_way_perspectives_on_global_lighting_market_2012.ashx)

# NEW TECHNOLOGY ADOPTION

Once new technology penetration hits 5 to 10%, the market penetration tends to accelerate

## New technology penetration in high-tech products

Percent; unit basis; global figure



## Years to achieve an initial 10% penetration

5 years

5 years

7 years

## Penetration uptake by another 10%

1 year

2 years

3 years



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**HOW SHOULD ONE GO ABOUT  
CONSIDERING AND PLANNING FOR THE  
ADOPTION OF AN OUTDOOR LIGHTING  
CONTROL SYSTEM?**

# A RECOMMENDED END-TO-END ADOPTION PROCESS



- Needs & goals
- Data acquisition
- Scoping & ideation
- Audit

- Priorities
- Requirements
- Evaluation criteria
- Business and partnership models

- Technology/solution
- Performance modeling
- Scenario analysis

- Installation
- Start-Up
- Commissioning
- System integration

- Measurement and verification
- Operational optimization
- Maintenance services

# INFRASTRUCTURE ASSESSMENT



# IDENTIFY ASSETS

- Review existing information
  - Typical data formats: Excel, GIS files
- Asset Verification
  - Validate existing assets (visualization can help)



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# LIGHTING ASSET DATA ACQUISITION

- Depending on the quality and/or ownership of the data, a new asset data collection step may be required
- Asset data collection methods
  - Field data collection of pole location (GPS) and asset information
  - Done prior-installation (e.g. using mobile tools) or enabled by control system (post installation)



# ASSET DATA

Typical data points per pole location:

- ID: Unique identifier
- Location (Latitude, Longitude)
- Lamp Type: HPS, LED, Metal Halide, Mercury Vapor, ...
- Lamp Wattage: 100 W, 75 W, 50 W, ...
- Volts: 120-277V
- Style: cobra head, decorative, architectural, ...
- Additional information (e.g. pole condition, photocell, arm length)



# LIGHTING ENERGY AND COST EVALUATION

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- Energy & Sustainability Impact
  - kWh/year consumed
  - CO2 impact: Emission factor
    - $6.89551 \times 10^{-4}$  metric tons CO<sub>2</sub> / kWh
- Operational Costs
  - Energy cost
    - Estimates: Operating hours x power x energy price
  - Maintenance costs
    - Re-lamping: components + labor



# LIGHTING QUALITY EVALUATION

- Lighting measurements
  - Typically at sample locations
- Refer to standard practices
  - IES RP-8-XX



# REQUIREMENTS SPECIFICATION



# GOALS AND PRIORITIES

- Identify stakeholders and document main goals and priorities
  - Energy savings, sustainability
  - Maintenance savings
  - Lead technology deployment
  - Others???
- Understand the value of technology
  - LED and controls



# DIFFERENT VIEWS AND INTERACTIONS

- Mayor
- Finance
- Building owner
- City maintenance team
- Public works department
- Site manager
- Electrician
- IT



# DIFFERENT NEEDS AND BENEFITS

- Energy savings
- Cost savings (\$)
- Control
- Monitoring
- Maintenance optimization
- CO2 carbon reduction
- Light pollution reduction
- Safety



# DOCUMENT REQUIREMENTS

- Use cases and application requirements
- Example:
  - Users want to define the time intervals and levels to be applied.
  - The system shall support dimming and it shall be possible to specify a target dimming level and times for the dimming actions.
- Important to set mandatory and optional features
- Supporting resources
  - DOE Model Specification



# EVALUATION METRICS

- ROI (Return On Investment): measures the rate of return on money invested
  - Considers economic factors only and focuses mainly on initial costs
- Shift to new metrics that take into account other factors and long term view
  - TCO (Total Cost of Ownership)
  - TVO (Total Value of Ownership)



# BUSINESS MODELS

Model	What	Advantage	Disadvantage
Supplier-to-customer direct	Municipality purchases the products/services directly from manufacturers/ suppliers.	Complete transparency of costs involved  Direct line of communication with system experts	Municipality responsible for the capital investment  Municipality takes on project risk
Public energy service deal (PES)	Utilities team up with municipalities.  Often the utility sub-contracts the lighting (installation and maintenance) to servicing companies.	All parties strongly incentivized to achieve energy savings  Municipalities deal with one company and utilities can create economies of scale	Applicability depends on ownership models (areas under local vs. federal/state control)
Energy performance contract (EPC)	Municipality outsources lighting project completely in exchange for guaranteed energy savings.  Most commonly a partnership with an energy servicing company (ESCO).	No capital investment required from municipalities: ESCO provides financing and takes on the risk  Guaranteed energy savings and maintenance	Long contract period required to pay off the capital investment  Mostly deployed between private parties
Public-private partnership (PPP)	Similar to an EPC, but municipalities retain a stake in the project.  Municipalities partner with a major PPP, or tender for large PPP projects that comprise a significant lighting element (such as city street lighting)	Municipality maintains equity share in the project  Performance and energy/maintenance savings guaranteed by private partners	Municipalities also take on some of the risk  Most often used for projects broader than just outdoor lighting



Source: The LED Future – outdoor Lighting for sustainable and livable cities, White paper

# SOLUTION DESIGN & SELECTION



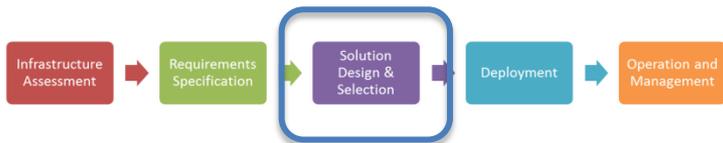
# DEFINE SYSTEM CAPABILITIES

- Map use cases and application requirements to technical requirements and system capabilities
  - Example: adaptive lighting requires a system that supports dimming.
- Understand options/capabilities available and value propositions



# PERFORMANCE ANALYSIS

- Technical
  - Energy consumption and expected savings compared to baseline
  - System reliability (up time)
  - Response time
- Economic/financial
  - Evaluate ROI, TCO/TVO metrics
- Regulatory and Standards
  - System meet minimal lighting requirements (e.g. as defined in IES RP-8-XX)
  - Interoperability standards



# NEW SERVICES

- Financial Services
  - private vs. public financing
- Maintenance Services
  - performance contracts
  - Lighting as a Service
- Technical Solutions Services
  - System operation and optimization services (e.g. network management, troubleshooting, re-commissioning)



# DEPLOYMENT

- Project management
- Installation, start-up, and commissioning
- System integration



# OPERATION & MANAGEMENT

- Monitoring
  - Measurements
  - Performance verification
- Maintenance
- System optimization (re-commissioning)





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## Q & A

Assessment and adoption

Michael Poplawski



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# **OUTDOOR LIGHTING CONTROL SYSTEM FUNDAMENTALS**

Technology Fundamentals

Mark Wilbur

# OUTDOOR LIGHTING FIELD DEVICES

- Basic
  - Photocontrols, photoelectric cells, photocells, Astronomical clocks
  - On/off only
- Advanced (but non-networked)
  - On/off and dimming
- Networked
  - One-way or two-way communication
  - Remote control
  - Remote monitoring

# PHOTOCELLS

- On at dusk and off at dawn
- Dominant deployed outdoor lighting control



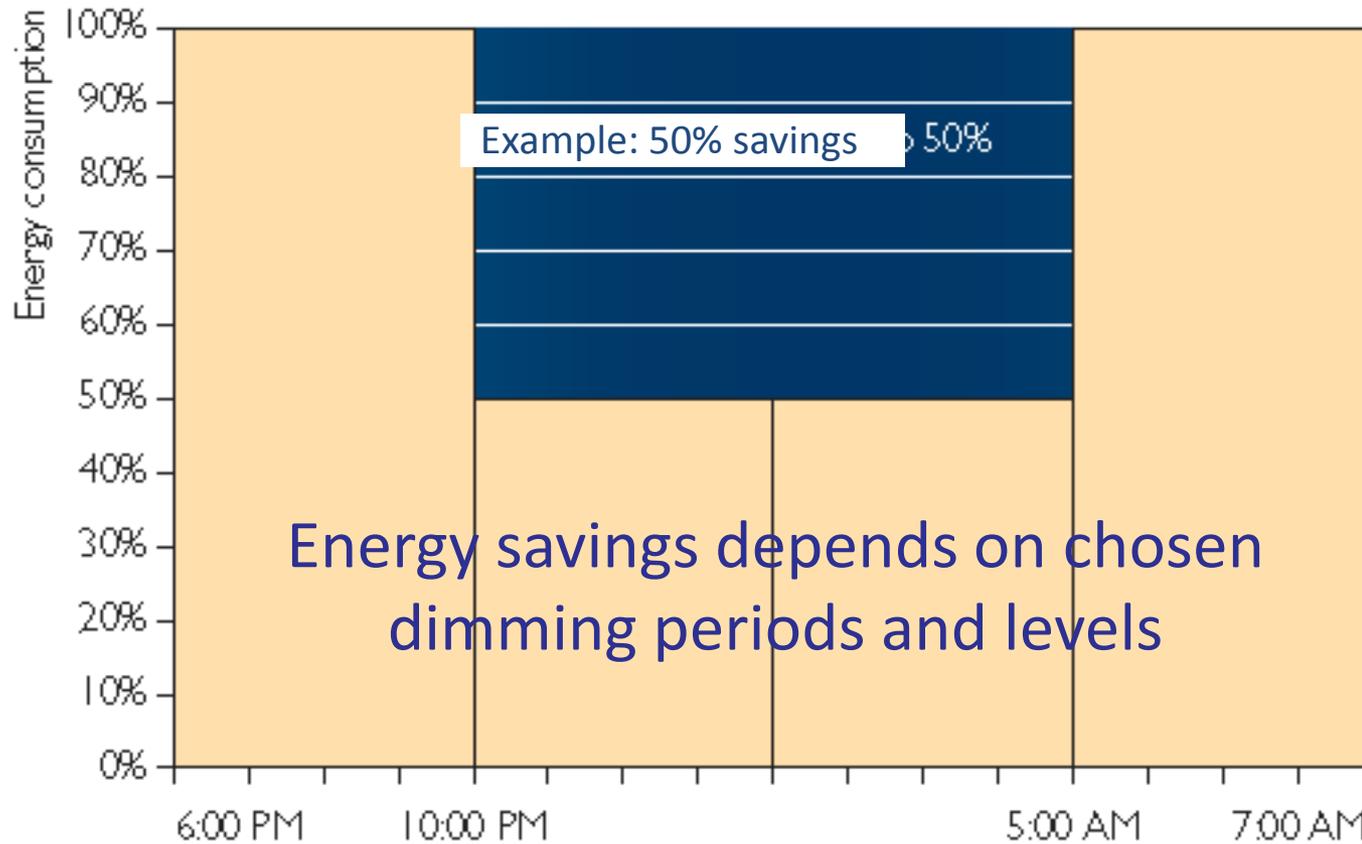
# ASTRONOMICAL CLOCKS

- Devices that determine (typically from a database) the expected time of sunrise and sunset for a given calendar date (i.e. day, month, year) and geographical location
- On/off based on expected sunset and sunrise times, without the use of a photocell
- Typically allows programming of offsets around sunset and sunrise times and shifts due to daylight saving time
- Do not compensate for cloudy days, or other variables that affect light levels around sunrise and sunset

# ADVANCED NON-NETWORKED CONTROLS

- Sunrise/sunset trimming (or offset)
  - Modified on/off times
  - Shorter on duration
- Part-night dimming
  - Typically pre-determined, scheduled time, configured at or prior to installation
  - Typically pre-determined, fixed dimmed light level, configured at or prior to installation

# PART-NIGHT DIMMING EXAMPLE



# NETWORKED FIELD DEVICES

Networked devices (hardware and embedded software, consisting of Controllers and possibly Gateways) installed in the field that, following purchase, installation, start-up and commissioning, function together to adaptively control and remotely monitor Luminaires.

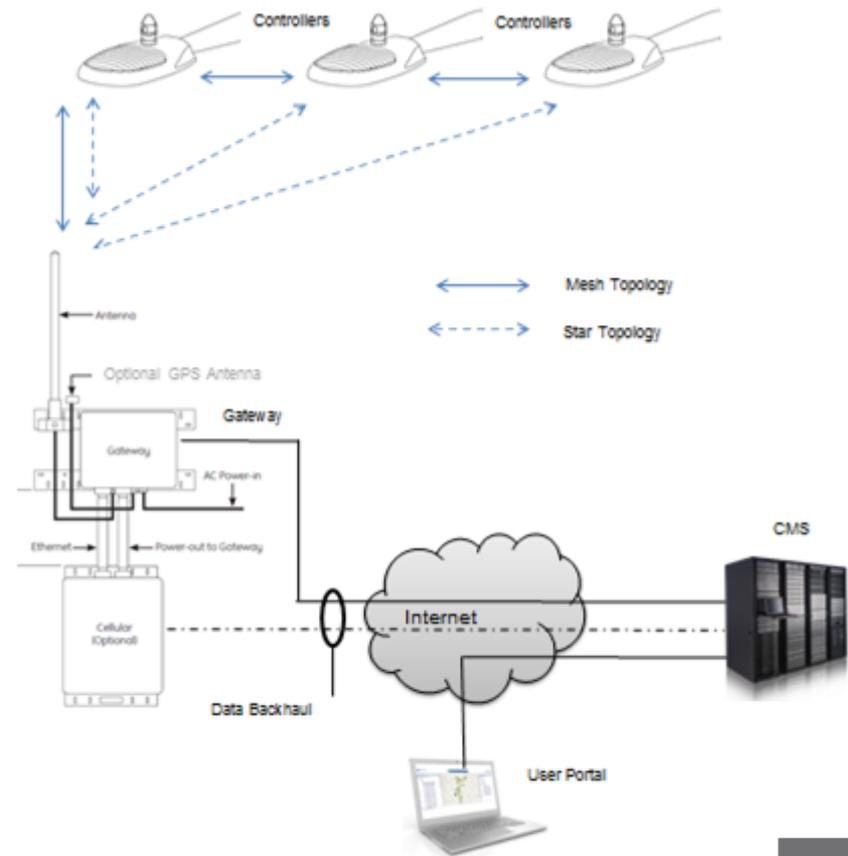


FIGURE 1  
Typical Deployment

# FIELD DEVICES

**Controller** - the device that originates a command to execute a lighting change. Most commonly associated with a lighting control station or control console, a controller may also be a sensor or other automatic device operating without human interaction.

- Physically monitors and controls Luminaires installed at Control Points
- Reacts and responds to logical and physical inputs
- Makes control decisions using internal algorithmic and logic functions
- Communicates via a network protocol

**Gateway** - a device designed for interfacing between two communication networks that use different protocols, such as BACnet to DALI, or DMX512 to 0-10VDC. A Gateway may contain devices such as protocol translators, impedance matching devices, rate converters, fault isolators, or signal translators as necessary to provide system interoperability.

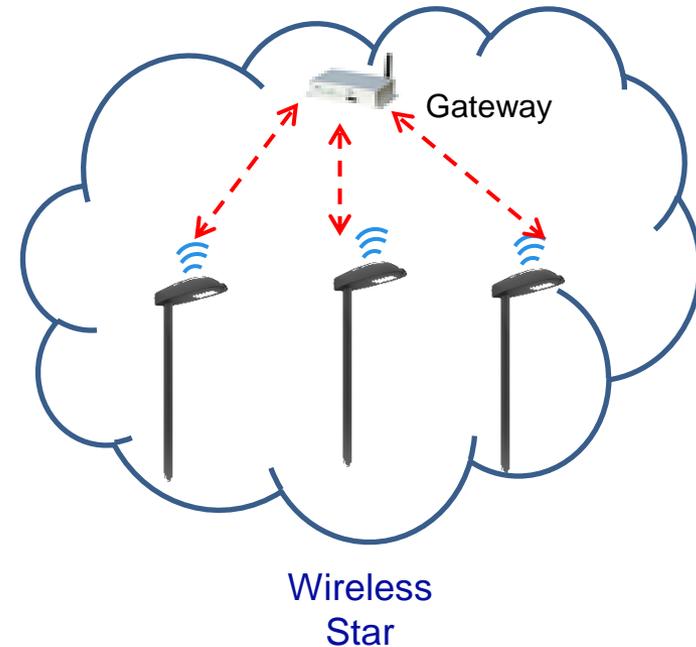
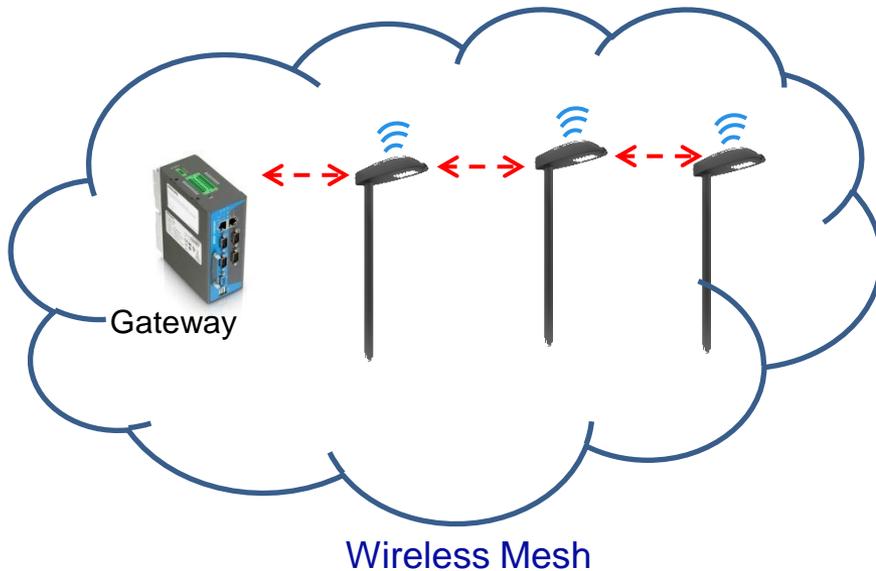
- Serves (at a minimum) as the interface between one or more Field Devices and a Central Management System
- Typically translating from a wireless Field Device protocol to a standardized Wide Area Network (WAN) protocol, such as WiFi (i.e. IEEE 802.11xx), Ethernet (i.e. IEEE 802.3), or LTE Cellular (i.e. 3GPP Releases)

# NETWORKED FIELD DEVICES



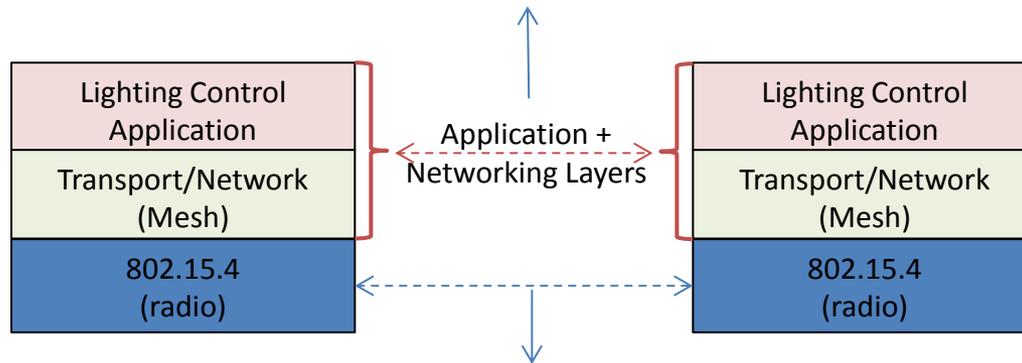
# CONNECTIVITY

- Technologies
  - Wireless
  - Wired (Power Line Carrier)
- Network Topology
  - Star
  - Mesh



# WIRELESS CONNECTIVITY PROTOCOLS

- Application + (Mesh) network layers
  - Typically proprietary implementations



- Radio (Physical + MAC) Layers
- Typical standard implementations
  - IEEE 802.15.4 (used in ZigBee), IEEE 802.11 (WiFi)
  - Some modified, proprietary versions

# EXISTING AND EMERGING WIRELESS STANDARDS

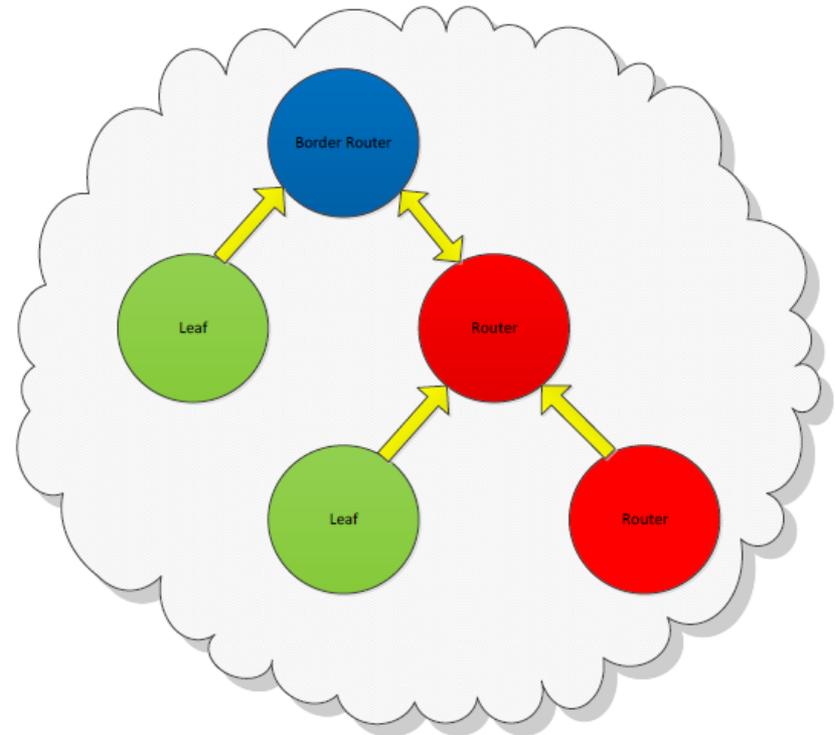
	<b>IEEE 802.15.4 family</b>	<b>IEEE 802.11 family</b>	<b>Cellular (3G)</b>
Data rates	20, 40, 100, 250 Kbps	Depends on standard version: 2, 5, 11, 54, 72, 150, and up Mbps ...	DL: 2-28 Mbps UL: 384 Kbps -11Mbps
Spectrum	868-870 MHz (EU) 902-928 MHz (US) 2.4 GHz (Worldwide)	2.45 GHz 5 GHz	Various
Range/ Coverage	100 m – 1.5 Km Depends on frequency band	10 – 250 m	Growing coverage (depends on deployment)
Primary Applications	Building/home automation, sensor/actuator networks, healthcare, games, etc (usually low data rates and low power devices)	Wireless broadband/Internet access	Mobile broadband, M2M applications in the future
Standard Development	15.4 (most used in existing products) 15.4g new extension for smart utility networks (high data rates and range for outdoor applications)	802.11a/b/g/n and others... New sub-GHz spec under development (11ah), expected 2015	Evolving (3G, LTE, LTE advanced, ...)

# MESSAGE (PACKET) ROUTING

**Border Router (Gateway):**  
aggregates packets and connects  
to external networks i.e. internet

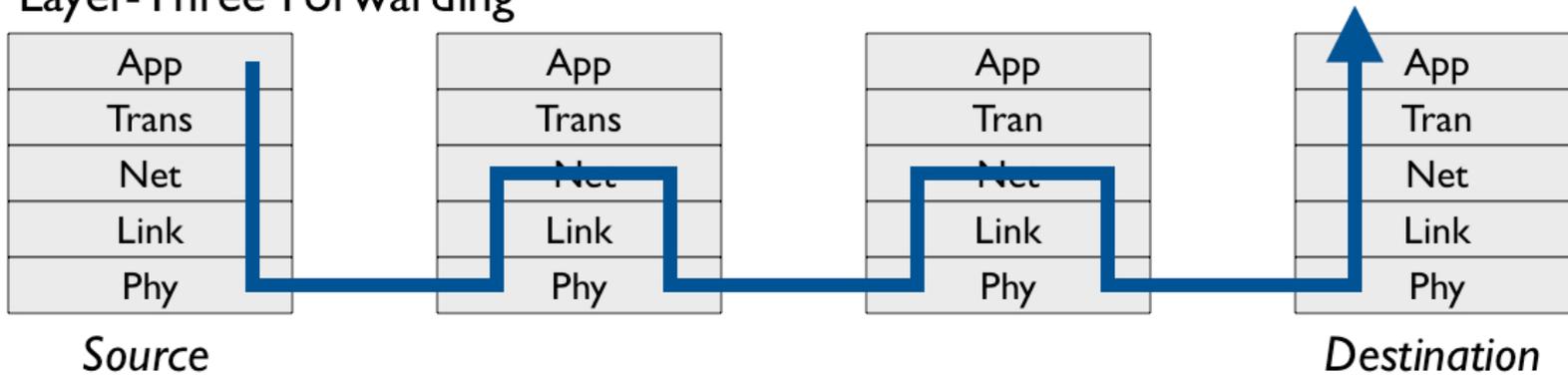
**Router (Controller):** generates and  
forwards (repeats) adjacent node's  
packets

**Leaf (Controller):**  
transmits/receives messages

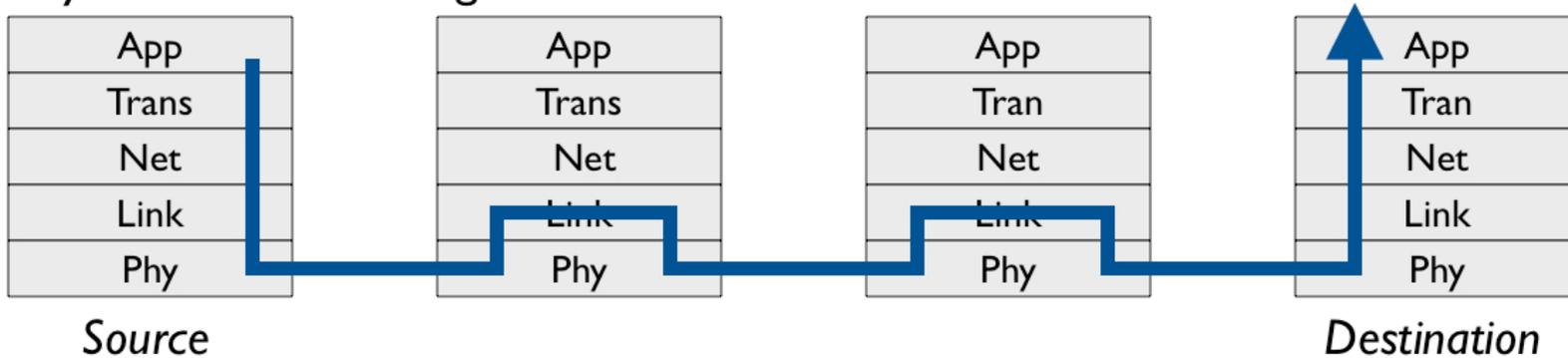


# MESSAGE (PACKET) FORWARDING MODELS

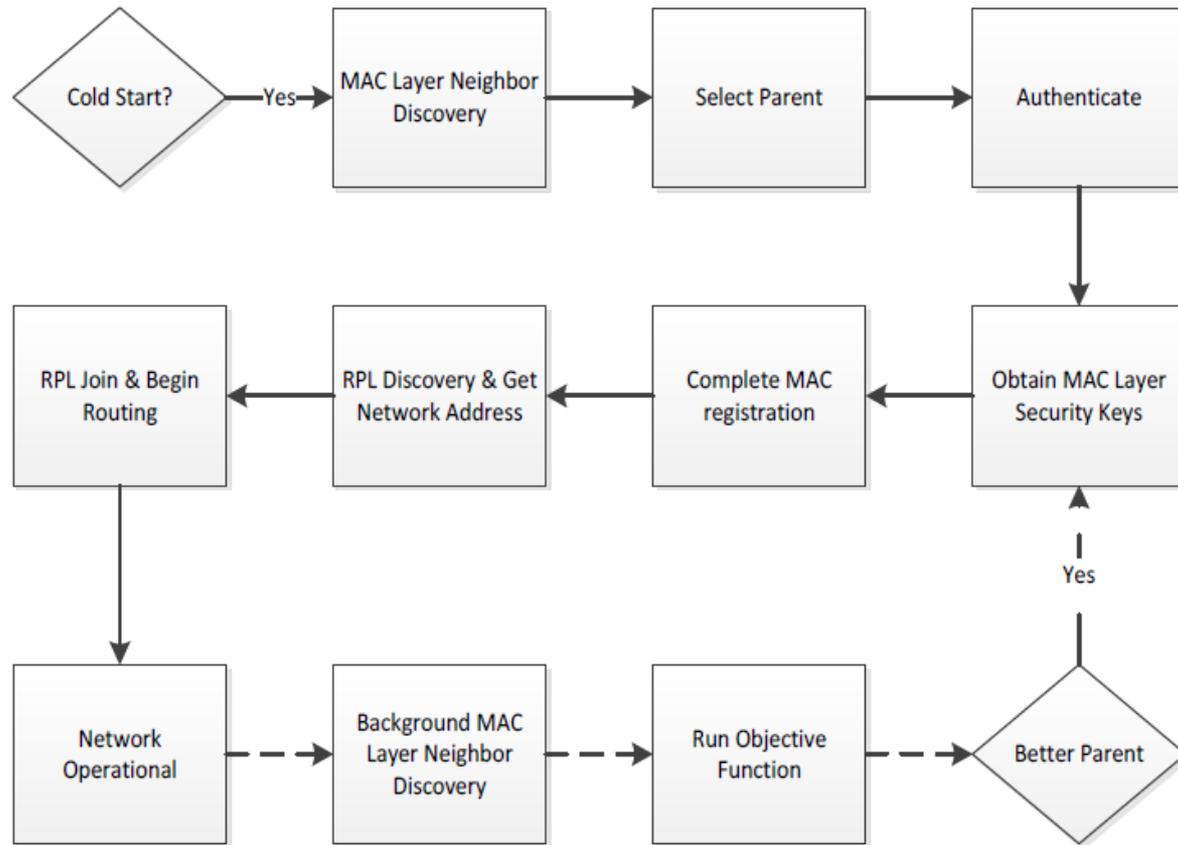
## Layer-Three Forwarding



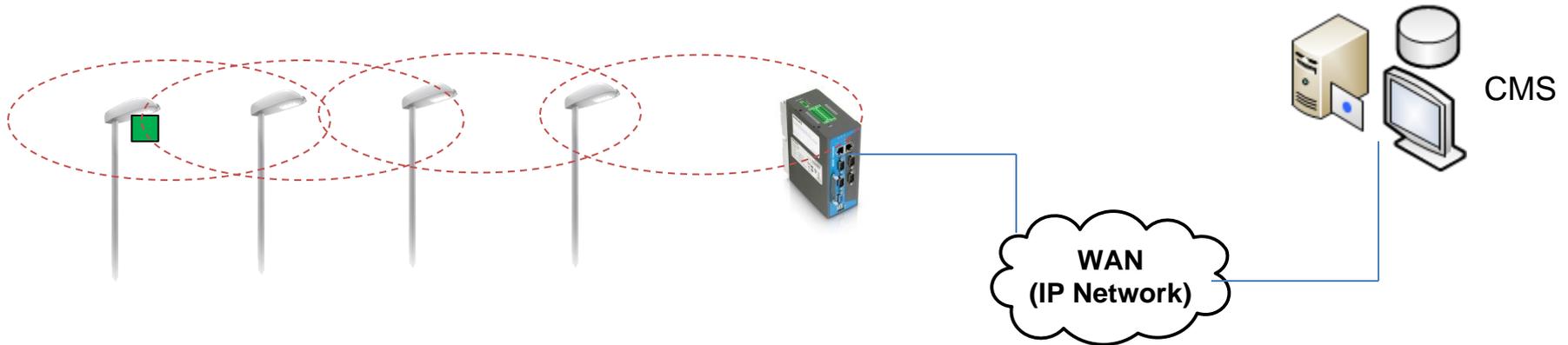
## Layer-Two Forwarding



# MESH NETWORK FORMATION

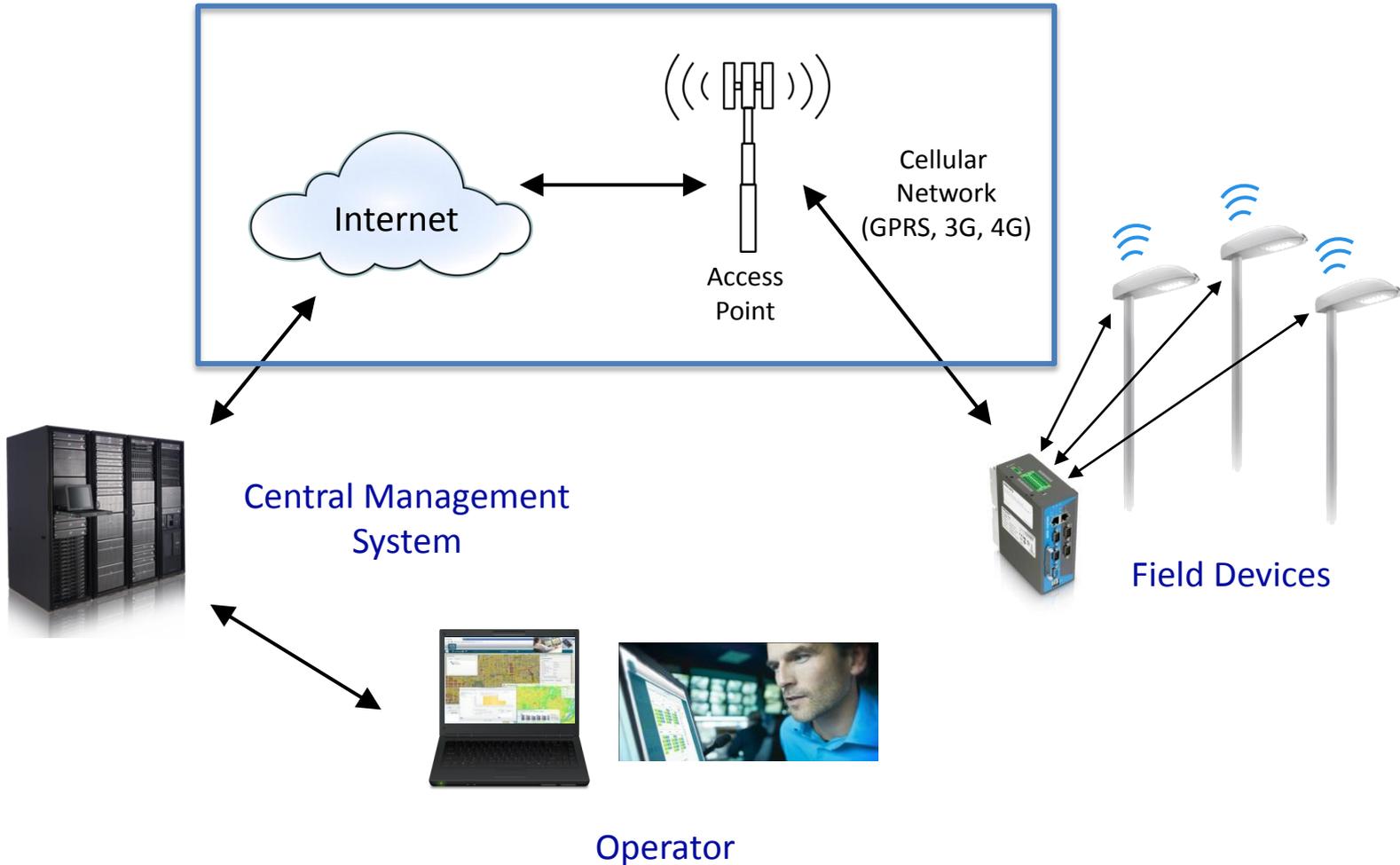


# WIRELESS MESH CONNECTIVITY



- Mesh networks use packet forwarding to increase range and robustness
- Performance factors to consider in the network deployment
  - communication range of nodes
  - interference robustness
  - scalability
  - security

# BACKHAUL COMMUNICATION NETWORKS



# BACKHAUL COMMUNICATION OPTIONS

- Cellular
  - GRPS, 3G, LTE/4G
  - Wide availability and coverage
  - Must consider propagation conditions at gateway locations to avoid coverage holes
- Wired (Fiber)
  - IEEE 802.3 (Ethernet)
  - Limited availability and (pole) coverage in outdoor environments
  - Fastest and most reliable

# NETWORK SECURITY

Secure deployment and commissioning

- To prevent the connection of malicious devices to the system

Encryption of data

- To prevent eavesdropping on the communications in the system

Authentication

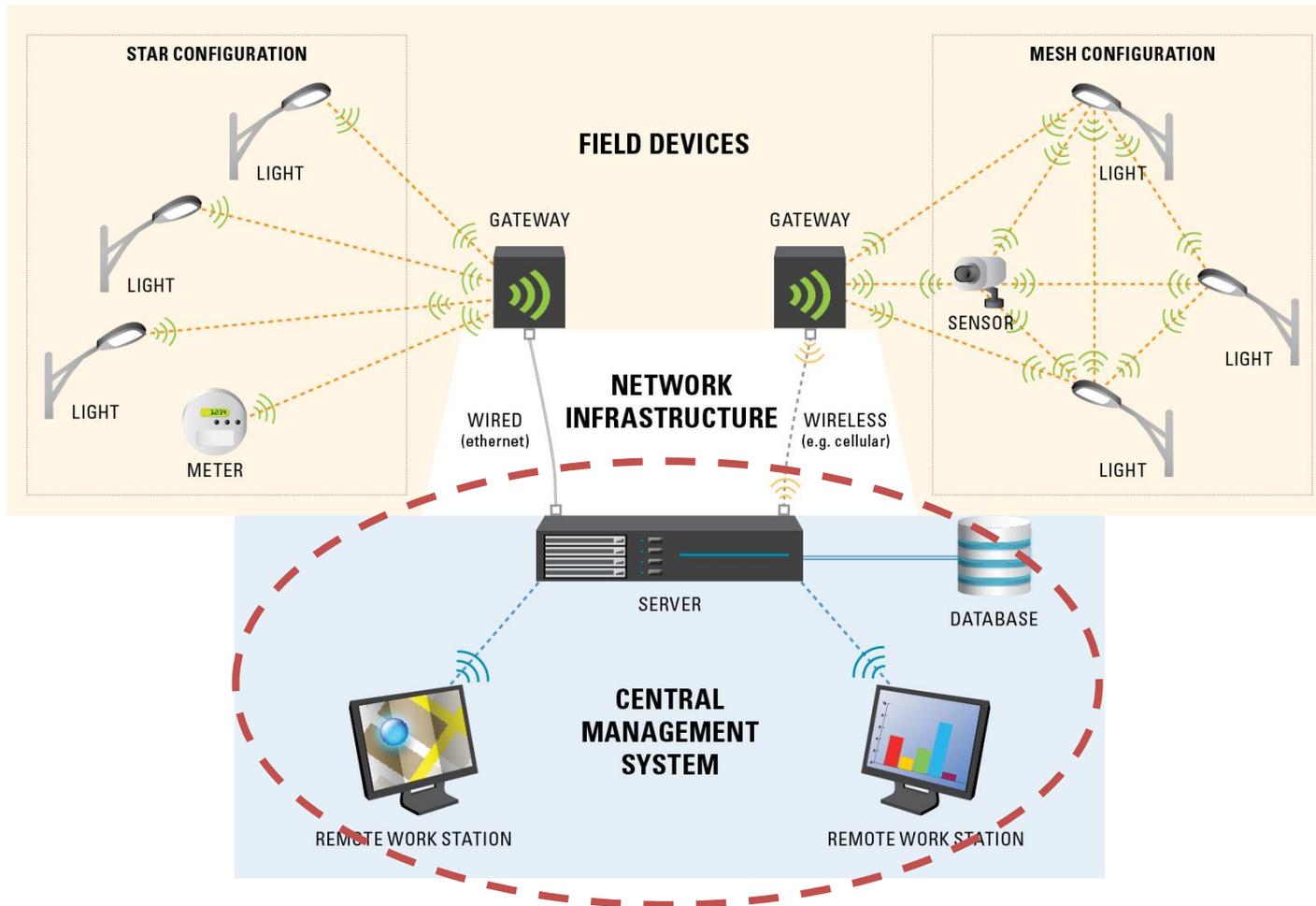
- To prevent unauthorized people or devices from controlling or disrupting the system

Secure software updates

- To prevent hackers from uploading non-functional or malicious software to the system

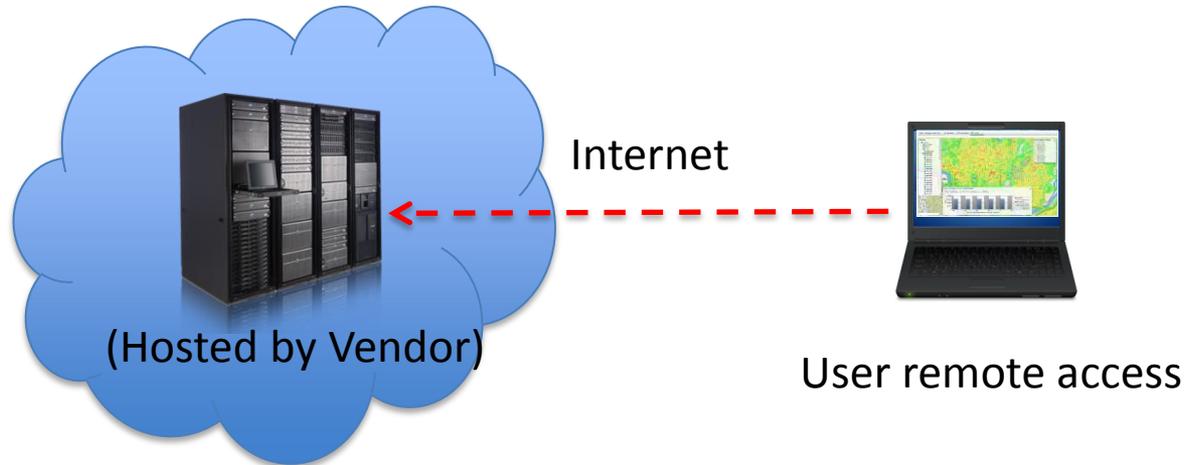
# CENTRAL MANAGEMENT SYSTEMS

Computer environments that function as the core of a System by providing all shared System services, and consolidating and storing (or managing the storage of) all System data



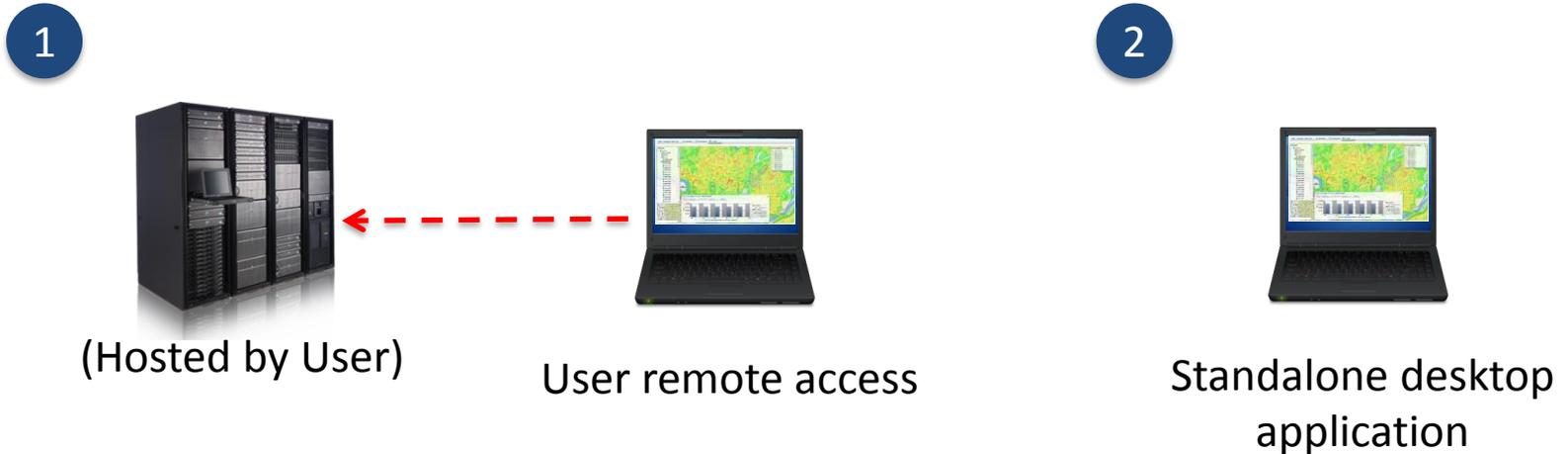
# CLOUD-BASED HOSTING

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- Complexity (application management, software upgrades, security management) handled by Vendor
- Access through encrypted user sessions (https) – technology similar to online banking
- Reliable infrastructure with multitenant software and automated backups
- Cost effective (leverage the cloud scale)
- Typically involves a service fee (per-light-point-per-year fee)

# USER SITE BASED HOSTING



- End user and vendor coordinates application management and software upgrades
- All data stays within the user's premises
- End user responsible for data backup and security management
- Typically, one time software cost + support services (helpdesk/upgrades)

# CENTRAL MANAGEMENT SYSTEM CORE CAPABILITIES

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- Graphic User Interface (GUI)
- Commissioning
  - Control strategies
  - Fault thresholds
- Asset management
- Reporting
  - Remote monitoring
  - Energy consumption
  - Fault detection, tracking, alarm generation
- Diagnostics and manual control

**DELETE?**



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## Q & A

Technology Fundamentals

Mark Wilbur



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# **OUTDOOR LIGHTING CONTROL SYSTEM FUNDAMENTALS**

Basic System Capabilities & Value Propositions

Michael Poplawski



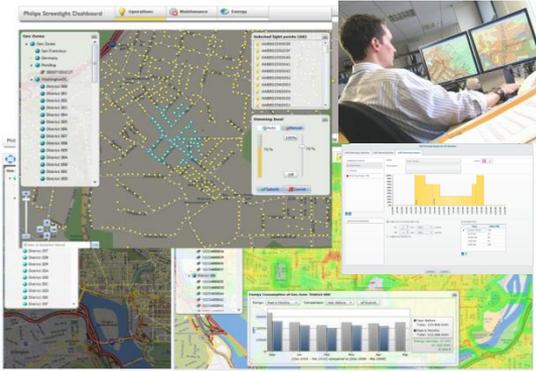


# BASIC SYSTEM CAPABILITIES

## High performance sources



## Remote monitoring & control metering, status, energy reports



## Connected Wireless, scalability, security



## Adaptive schedules, presence, weather, traffic



## Sensing cars, pedestrians, bicycles, environment...

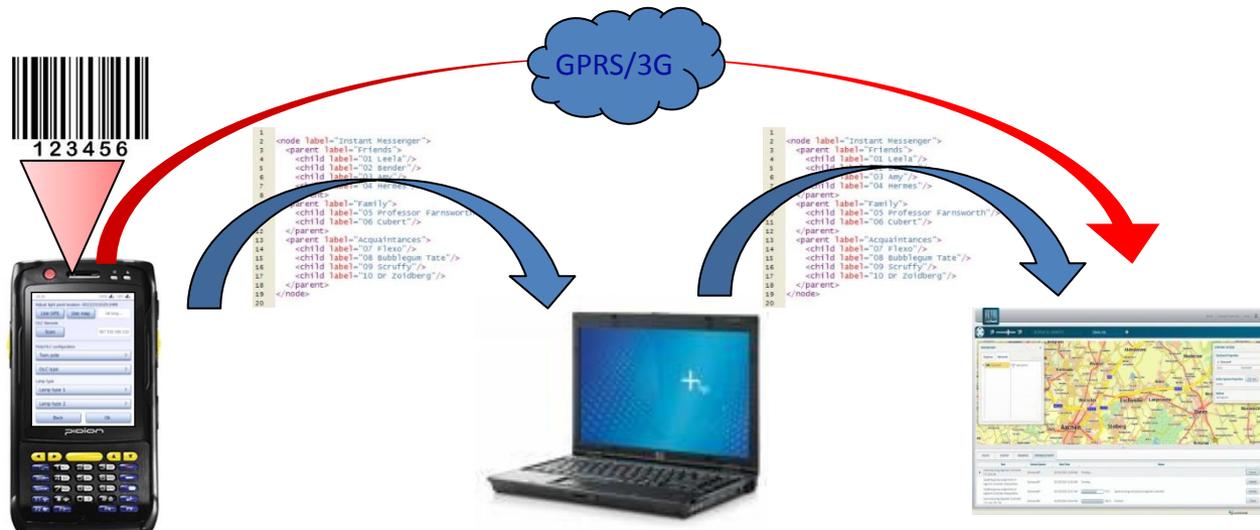


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# LOCAL START-UP

- Upload light plan (if available)
- Scan barcodes
- Collect GPS coordinates (with handheld GPS)
- Send handheld data file to PC or directly to CMS
- Configure devices from CMS



# REMOTE START-UP

- Plug in twist-lock module
- Watch Indicator lights
- Input Fixture information (Lamp, Driver, etc.) - Proceed to next Fixture
- Behind the scenes
  - GPS Coordinates acquisition & storage
  - Sync clock with GPS time
  - Auto Join mesh network & register
  - Sync schedule and settings info from CMS
  - Run initial diagnostics
  - Register collected information with CMS
  - Blink indicator lights for success/fail code



# ASSET TYPES

- Street light
  - Pole
  - Controller
  - Luminaire
- Cabinets
  - Gateway
  - Traffic management equipment

Endpoint: lightD828C9140917001D

State: Light State | link-excellent | fault endpoint

Manual positioning: disabled change

Device | GPS | Light Control | Network | Firmware | NanoService | Assets

Component	Attributes			Actions
	Name	Value	Actions	
Pole	Material	Wood		
	Height	30 Feet		
	Age	20 Yrs		
	Condition	Fair		
Liminaire	Manufature	GE		
	Model	GE ERS1-0-F2 E1-7-40-9-GRAY-D-G-L		
	Installation Date	01/25/2010		
	Purchase Order	01252010ABC		
Utility	Meter Number	456789221144-7894-1		
	Account Number	45668799988		
	Per KWH rate	0.12		

Close

# ASSET MANAGEMENT

**STREET LIGHT**

**General**

ID	3
Name	SL-SpeedStar_Right
Type	Street Light
Longitude	6.081442° E
Latitude	50.757508° N
Region	/CityTouch Aachen
Street	Weisshausstrasse
Street Reference	
Location Comment	

**Attachments (1)**

910503883618_EU-RTP-global-001_highres.jpg	Name: 910503883618_EU-RTP-global-001_highres.jpg	
	Uploaded by: stefan.bohrer@philips.com	
	Uploaded on: 8/31/2012 9:19:47 AM	
	Description: Philips Speedstar luminaire BGB322	

Download

Close

# ASSET LOCATION

The screenshot displays a smart lighting management software interface. At the top, a navigation bar shows coordinates (38.931681° N, 77.018031° W) and a search field for 'Street, City'. The main map area shows a city street grid with numerous yellow circular markers representing streetlights. Several streetlights are highlighted with purple square outlines. Three data panels are overlaid on the map:

- ACTIVE SYSTEM PROPERTIES (Luminaire 521019):** Shows system status from 22:20. Includes sections for Basics (Reachable: Yes, Manual Override: Off), Measured Electric Parameters (Mains Voltage: 236.0 V, Current: 503.0 mA), Constant Light Output (CLO) (Adjustment Period: 0 h, Initial Max Output: 100%), Virtual Power Output (VPO) (Required Power: 169.0 W), and Configured Lamp Characteristics (Power: 169.0 W).
- CitySoc Properties (Component ID: 32):** Shows general information (Name: 521023, Type: Luminaire) and lamp characteristics (Min Dimming Level: 30%, Warm-up Time: 6 min, Max Control Voltage: 10.0 V, Max Burning Hours: 20,000 h).
- CitySoc Properties (General):** Shows location (City: Washington, District: Hospital Center) and installation details (Installation Date: 4/13/2011 2:00:00 AM, Commissioning Date: 4/13/2011 2:00:00 AM).

On the right side, a 'CABINET' panel shows the hierarchy for 'Asset: CAB-Philips\_SC\_13', including 'Simulator' and 'Router\_13'. Below this, an 'Actions' menu lists options like 'Select Cabinet', 'Highlight Connected Assets', and 'Refresh Realtime Properties'.

# COORDINATED ASSETS

**STREET LIGHT**

**General**

ID 4717

Name SL-93211

Longitude -74.846406 °

Latitude 40.15293 °

Street Robin Hill Ln (Bristol PA)

Location Comment

Installation Date Unspecified 15

Commissioning Date 3/20/2014

Is Remotely Managed True

Unit Identity

Street Arrangement One Row

Roadway Class Local

Pavement Class R2 and R3

Pedestrian Conflict Area Medium

100 % Segment controller is fully synchronized.

OK

Undo Edits

# POLE ASSET FIELDS

Endpoint: lightD828C9140917001D

State: Light State | link-excellent | fault endpoint

Manual positioning: disabled

Device | GPS | Light Control | Network | Firmware | NanoService | Assets

Component	Attributes			Actions
	Name	Value	Actions	
Pole	Material	Wood	<input type="button" value="edit"/>	<input type="button" value="delete"/>
	Height	30 Feet	<input type="button" value="edit"/>	
	Age	20 Yrs	<input type="button" value="edit"/>	
	Condition	Fair	<input type="button" value="edit"/>	
Liminaire	Manufacture	GE	<input type="button" value="edit"/>	<input type="button" value="delete"/>
	Model	GE ERS1-0-F2 E1-7-40-9-GRAY-D-G-L	<input type="button" value="edit"/>	
	Installation Date	01/25/2010	<input type="button" value="edit"/>	
	Purchase Order	01252010ABC	<input type="button" value="edit"/>	
Utility	Meter Number	456789221144-7894-1	<input type="button" value="edit"/>	<input type="button" value="delete"/>
	Account Number	45668799988	<input type="button" value="edit"/>	
	Per KWH rate	0.12	<input type="button" value="edit"/>	

1

**Pole**

Name

Component ID 14170

Mounting Height  m

Model

Type Pole

Installation Date Unspecified

Material

Last Painted On Unspecified

Arm Length

Condition

Base Plate Thickness

Bolt Circle Diameter

Size

Height

# CONTROLLER ASSET FIELDS

Endpoint: lightD828C9140917001D

State: Light State | link-excellent | fault endpoint

Manual positioning: disabled

Device | GPS | Light Control | Network | Firmware | NanoService | Assets

Component	Attributes			Actions
	Name	Value		Actions
Pole	Material	Wood		
	Height	30 Feet		
	Age	20 Yrs		
	Condition	Fair		
Liminaire	Manufacture	GE		
	Model	GE ERS1-0-F2 E1-7-40-9-GRAY-D-G-L		
	Installation Date	01/25/2010		
	Purchase Order	01252010ABC		
Utility	Meter Number	456789221144-7894-1		
	Account Number	45668799988		
	Per KWH rate	0.12		

### Control Gear

Component ID 14195

Name

Type Communications Node

Dimming Calendar Default Calendar

Is Remotely Managed True

Control System Philips Starsense Wireless

PhotoCell

Is Meter True

Number of Metering Channels 1

Model LLC7310

Hardware Address 00:17:88:01:00:81:EC:31

Firmware Version

### Philips Starsense Wireless

Commissioning Status Done

Node ID on Message Interface olc-369

Installation Date 3/20/2014 3:29:35 PM

Last Configuration Change 3/20/2014 3:29:35 PM

# LUMINAIRE ASSET FIELDS

Endpoint: lightD828C9140917001D

State: Light State | link-excellent | fault endpoint

Manual positioning: disabled change

Device | GPS | Light Control | Network | Firmware | NanoService | Assets

Component	Attributes			Actions
	Name	Value	Actions	
Pole	Material	Wood		⊞
	Height	30 Feet		⊞
	Age	20 Yrs		⊞
	Condition	Fair		⊞
Luminaire	Manufacture	GE		⊞
	Model	GE ERS1-0-F2 E1-7-40-9-GRAY-D-G-L		⊞
	Installation Date	01/25/2010		⊞
	Purchase Order	01252010ABC		⊞
Utility	Meter Number	456789221144-7894-1		⊞
	Account Number	45668799988		⊞
	Per KWH rate	0.12		⊞

⊞ Close

### Luminaire

Component ID 14145

Name

Type Luminaire

Control System Philips Starsense Wireless

Lamp Burning Hours 1,439.0 h

Lamp Lifetime 1.44 %

Installation Date Unspecified 15

Lamp Switch On Count 136

Lamp Last Replaced On Unspecified 15

Lamp Last Cleaned On Unspecified 15

Starsense Configuration Hadco 37W 240V >

OLC Port 1

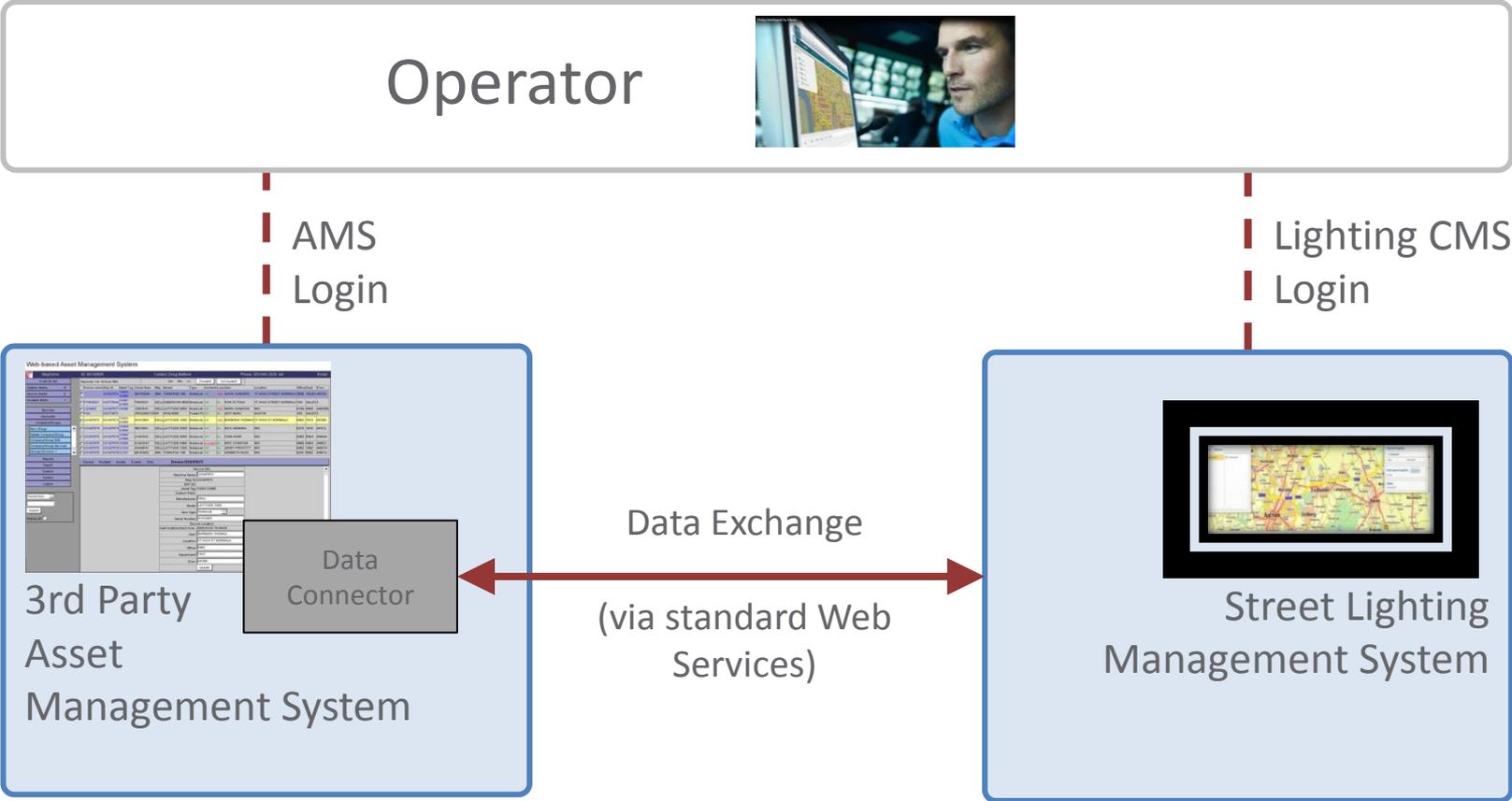
Model

ID

Style

Arrangement

# IMPORTING LEGACY OR EXISTING ASSET DATA



# USER MANAGEMENT

- Configure user roles and access rights
- Use roles
- Administrator (full access)
- User (standard/normal operational access)
- Report (view only access)

+ New User

List of Users										
Userid	First Name	Last Name	UserRole	Active	Locked	Added On	Modified On	Modified By	Edit	Delete
Lorie	Lorie	Azar	ADMIN	Yes	No	Thu Jul 18 00:00:00 PDT 2013	Thu Jul 18 00:00:00 PDT 2013	mwilbur	✓ ✕	🗑
Tester1	Tester1	Tester1	ADMIN	Yes	No	Tue Jul 23 00:00:00 PDT 2013	Tue Jul 23 00:00:00 PDT 2013	mwilbur	✍	🗑
Tester2	Tester2	Tester2	USER	Yes	No	Fri Jul 26 00:00:00 PDT 2013	Fri Jul 26 00:00:00 PDT 2013	Tester1	✍	🗑
Tester3	Tester3	Tester3	REPORT	Yes	No	Fri Jul 26 00:00:00 PDT 2013	Fri Jul 26 00:00:00 PDT 2013	Tester1	✍	🗑

1

# DEVICE CONFIGURATION

Control Gear	
Component ID	14195
Name	<input type="text" value="OLC-93211"/>
Type	Communications Node
Dimming Calendar	Default Calendar
Is Remotely Managed	True
Control System	Philips Starsense Wireless
PhotoCell	<input type="text" value="Yes"/>
Is Meter	True
Number of Metering Channels	1
Model	LLC7310
Hardware Address	00:17:88:01:00:81:EC:31
Firmware Version	

Philips Starsense Wireless	
Commissioning Status	Done
Node ID on Message Interface	olc-369
Installation Date	3/20/2014 3:29:35 PM
Last Configuration Change	3/20/2014 3:29:35 PM

Endpoint: lightD828C914101702DC

State: Light State

Manual positioning: disabled [change](#)

- Device
- GPS
- Light Control
- Network
- Firmware
- Assets

Time	Icon	Property	Value	Actions
12:45	🔊	Light control:	Off	<a href="#">Read All</a> <a href="#">Actions</a> Off On
06:33	🔊	Percent of Power:	<input type="text" value="100"/>	<a href="#">Edit</a>
06:33	🔊	Light On time:	461 h	
00:14	🔊	Next schedule element:	At 00:00 on days of the weekend the light will be at 100% power	
12:59	🔊	Schedule:	Name: CLEAR; conditions: 2	<a href="#">Actions</a>

[Close](#)



# OVER-THE-AIR FIRMWARE UPDATES

+ Add firmware update

Name	Firmware server	Status	Time	
OTA for GPSNanoLightingApplication_OTA.hex new/NanoLightingApplication/5358 - 23.253.90.121	AccessPoint-0a0800040000	READY waiting: 0	16.05.2014 01:09	<input type="button" value="Cancel"/>

### Firmware update

Upload firmware

(empty)

Update target

Firmware Server:

Firmware Type:

**Naming**

Firmware version:

Process name:

# GROUPING

Map
Reports
Admin

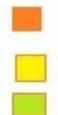
Lights (normal): **6456**  
 Lights (stale): **120**

Mwlbur LightGrid CMS-1.0.0.27 Logout

+ New Group
+ Add selected to group
✗ Remove selected groups
Actions..

<input type="checkbox"/>	Name	Domain	Type	Status	Action
<input checked="" type="checkbox"/>	LSBU2		Group	9 endpoints	show on map
<input checked="" type="checkbox"/>	LSBUtucker		Group	5 endpoints	show on map
<input checked="" type="checkbox"/>	altec		Group	56 endpoints	show on map

Legend



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# TIME AND CALENDAR SCHEDULING

The screenshot displays a software interface for lighting control and scheduling. At the top, there is a navigation bar with a compass icon, a search bar containing coordinates (38.855405° N, 76.980023° W), and a dropdown menu for "Street, City". Below this is a map showing a street grid with yellow traffic cones and speed limit signs (30 mph). A "NAVIGATION" sidebar on the left lists regions: Washington, North East, North West, South East, South West, and Unknown Region. On the right, a "CONTROL SYSTEMS" panel includes a "Simulator" button and an "Actions" section with the text "No available actions".

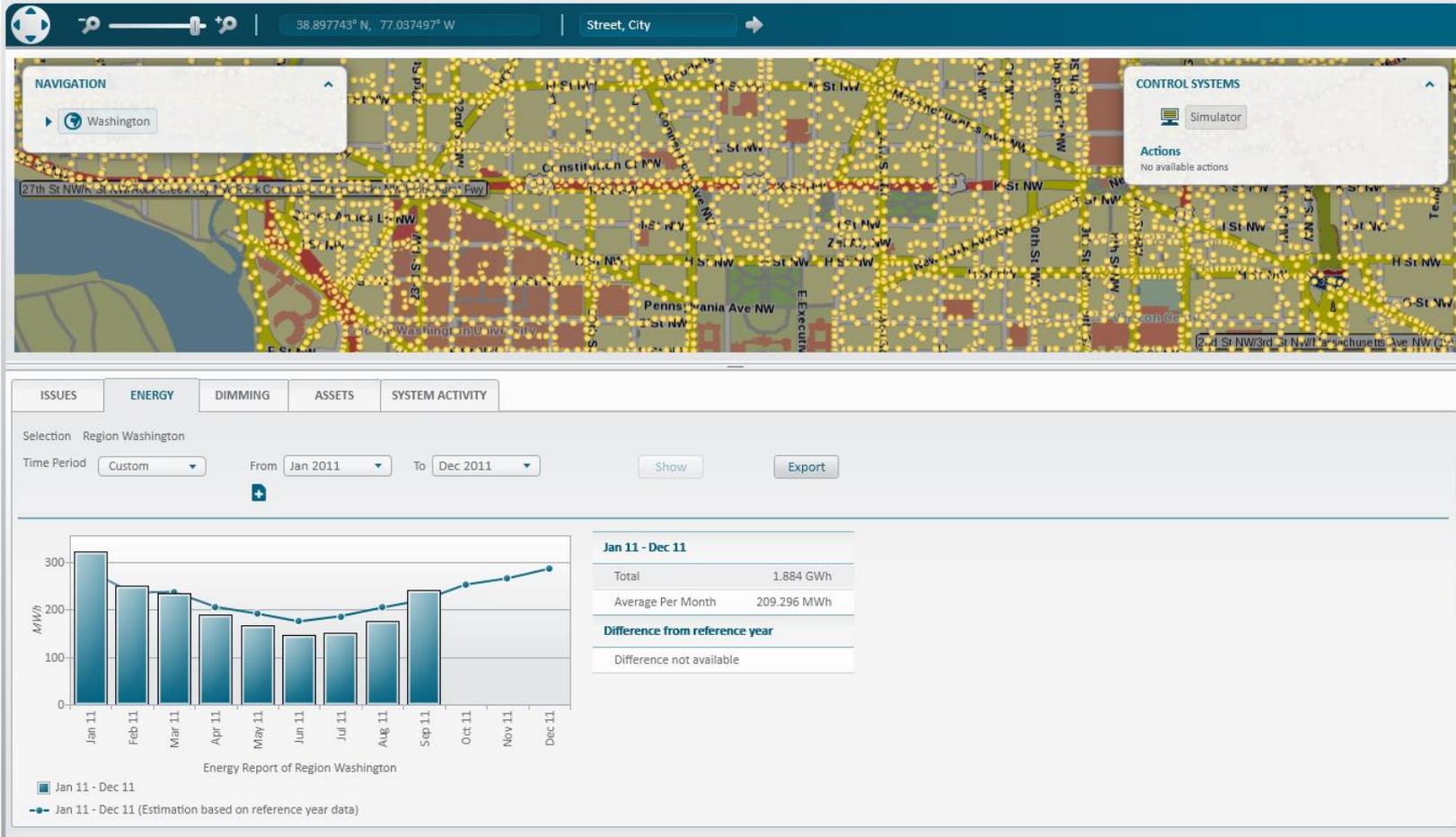
Two overlapping windows are shown in the foreground. The larger window, titled "Overview for Energy Saving Calendar", has three tabs: "Edit Dimming Calendar", "Edit Dimming Rules", and "Edit Dimming Shapes". It displays a calendar for the year 2011, with months from May to October. Each month's calendar shows days with colored squares representing different dimming rules. A legend at the bottom identifies the colors: blue for "Weekend to Weekday", green for "Weekday to Weekday", dark green for "Weekday to Weekend", and light blue for "Weekend to Weekend". A "Weekday to Weekday" rule is highlighted, and a small inset window shows a bar chart for this rule. The main window also includes a "Name" field (Energy Saving Calendar), a "Color" dropdown (green), and a "Comment" field (Saves energy by nightly dimming). "Submit" and "Cancel" buttons are at the bottom.

The smaller window, also titled "Overview for Energy Saving Calendar", is in the "Edit Dimming Shapes" tab. It shows a list of "DIMMING SHAPES" on the left, including "Weekday to Weekday", "Weekday to Weekend", "Weekend to Weekday", and "Default". The main area features a line graph showing light levels over a 24-hour period. Below the graph, there are controls for "Lights are on during the night only" (checked) and "Lights are always on" (unchecked). A "Switching Point" table is visible:

Time	Value (%)
06:00	100
21:00	75
23:00	50
06:00	100

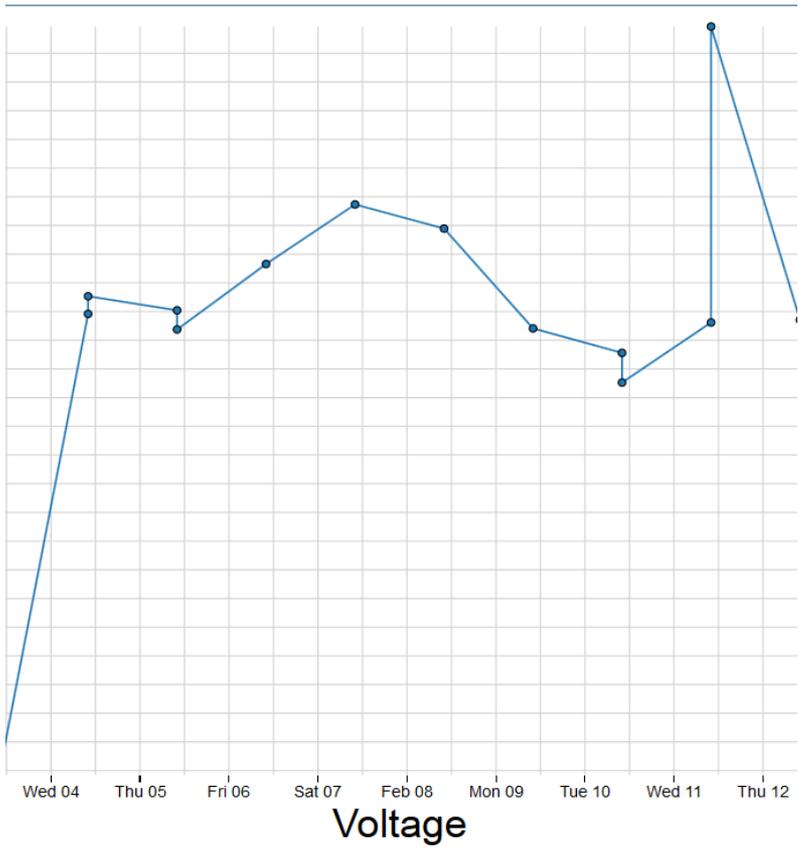
"Submit" and "Cancel" buttons are at the bottom of this window.

# ENERGY CONSUMPTION

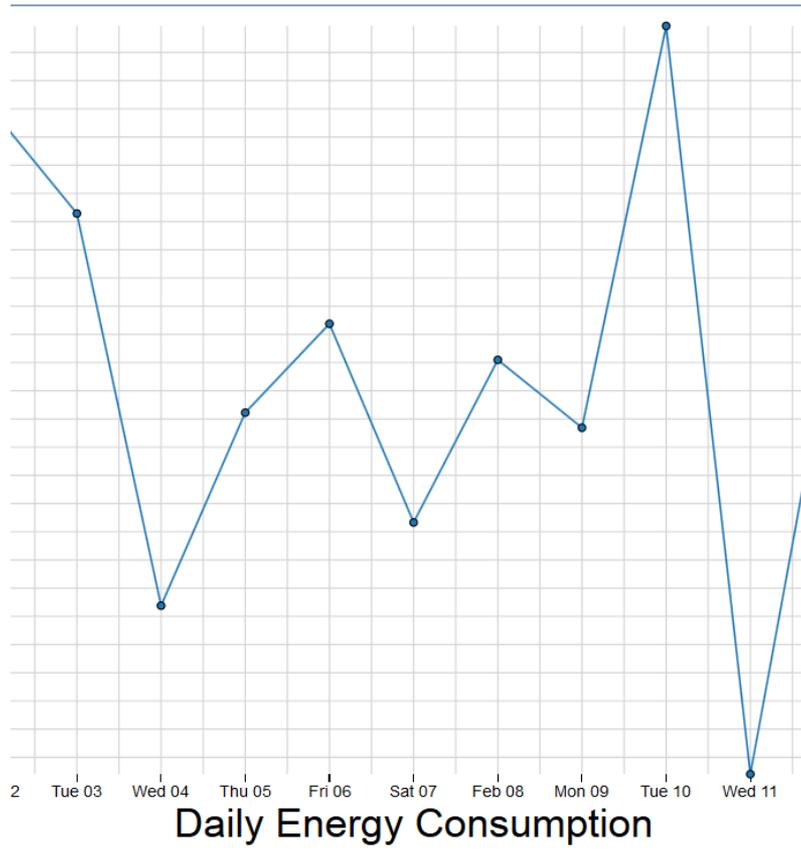


# ELECTRICAL PARAMETERS

Map Reports Admin



Map Reports Admin



# CONFIGURING FAULTS AND NOTIFICATIONS

Map Reports Admin Firmware

+ Add New Rule Edit

RuleId	Rule Desc	Notification Type	Endpoint Id	Rule Conditions	Retrigger Interval	Email Id
27	2E7Voltage	ALARM				

**Edit Rule**

Name:

Type: ALARM

Interval limit:

End Point: AccessPoint-0008e

Resource Path: Temperature

Add Conditions: Relation Value

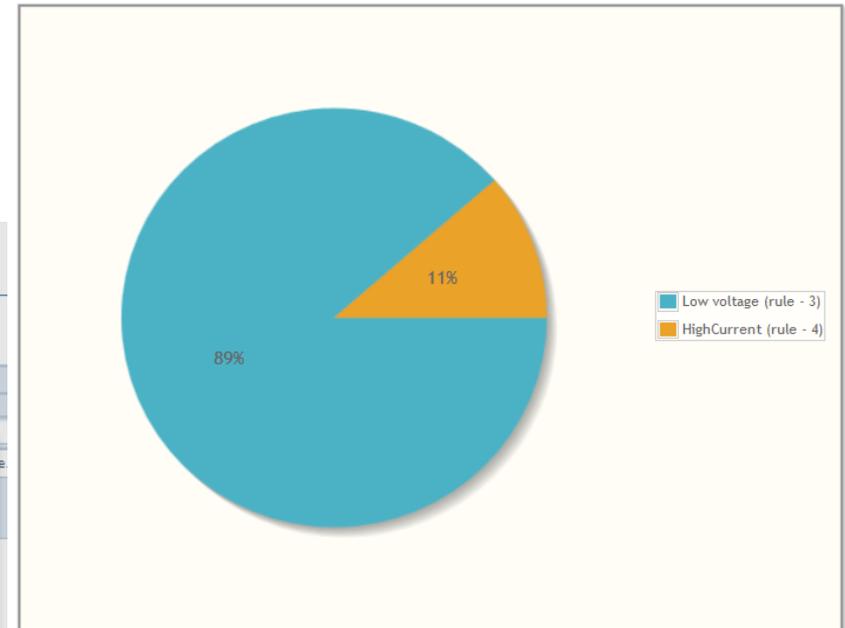
- Temperature
- Current
- Voltage
- Power factor
- sysUpTime
- On time
- Power
- Resource Update Interval
- Power
- Power Factor

Notifications

Add Email:

Save Close

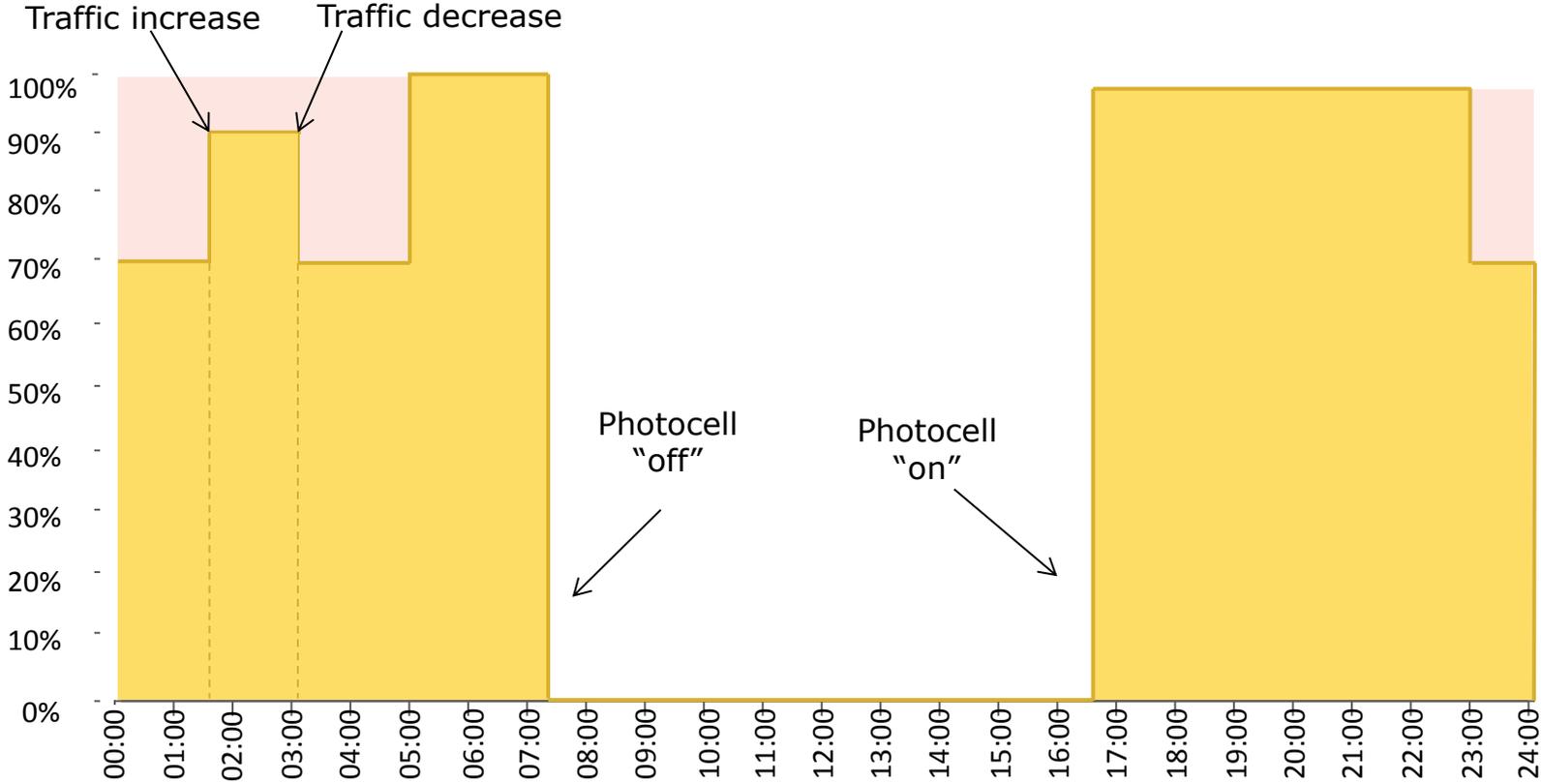
Faults for Last Month



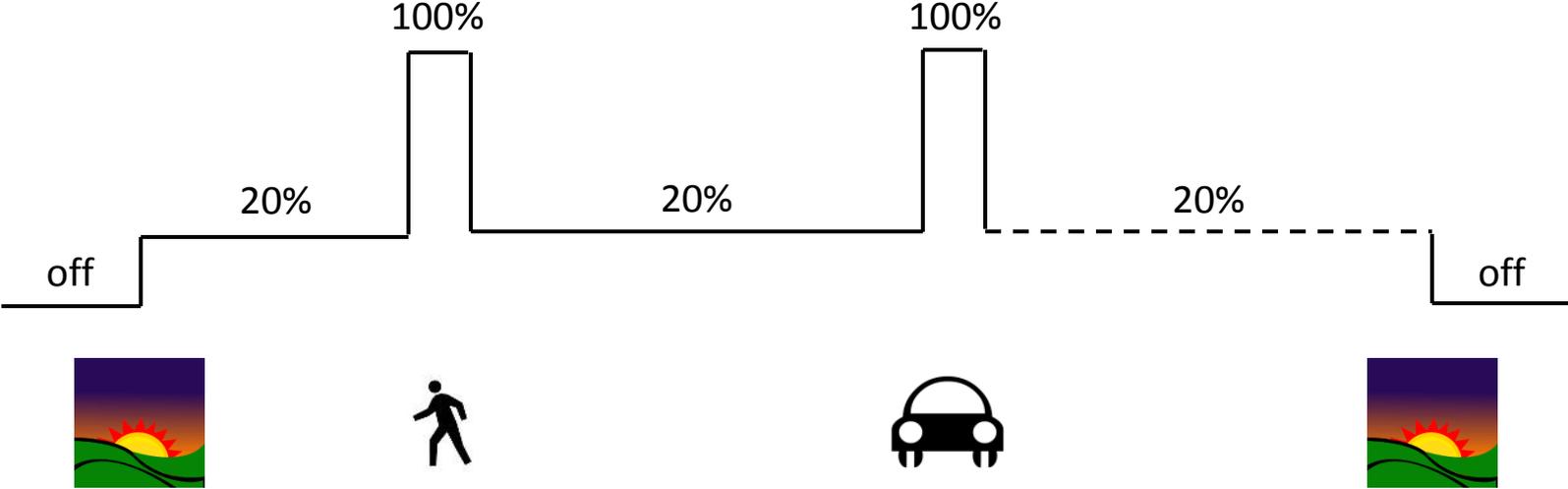
# ADAPTIVE CONTROL STRATEGIES

- Time based
  - Scheduled by time (and possibly calendar date)
  - Fixed, finite number of switching times and light levels
- Event based
  - Triggered by data from one or more sources
    - Sensors, networked data sources
    - Traffic, ambient light, motion, environmental conditions)
  - Dynamically varying switching times and light levels in response to event triggers

# TIME AND EVENT-BASED CONTROL (E.G. TRAFFIC SENSOR)



# TIME AND EVENT-BASED CONTROL (E.G. MOTION SENSOR)



# FAULT REPORTING

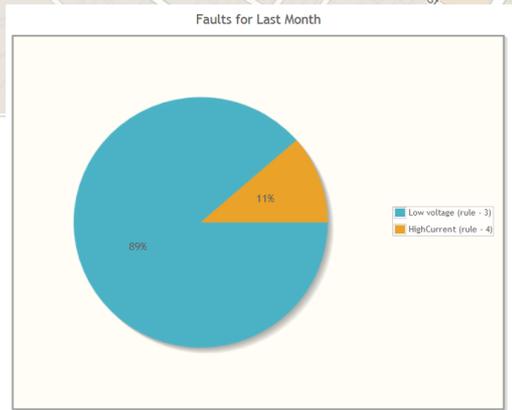
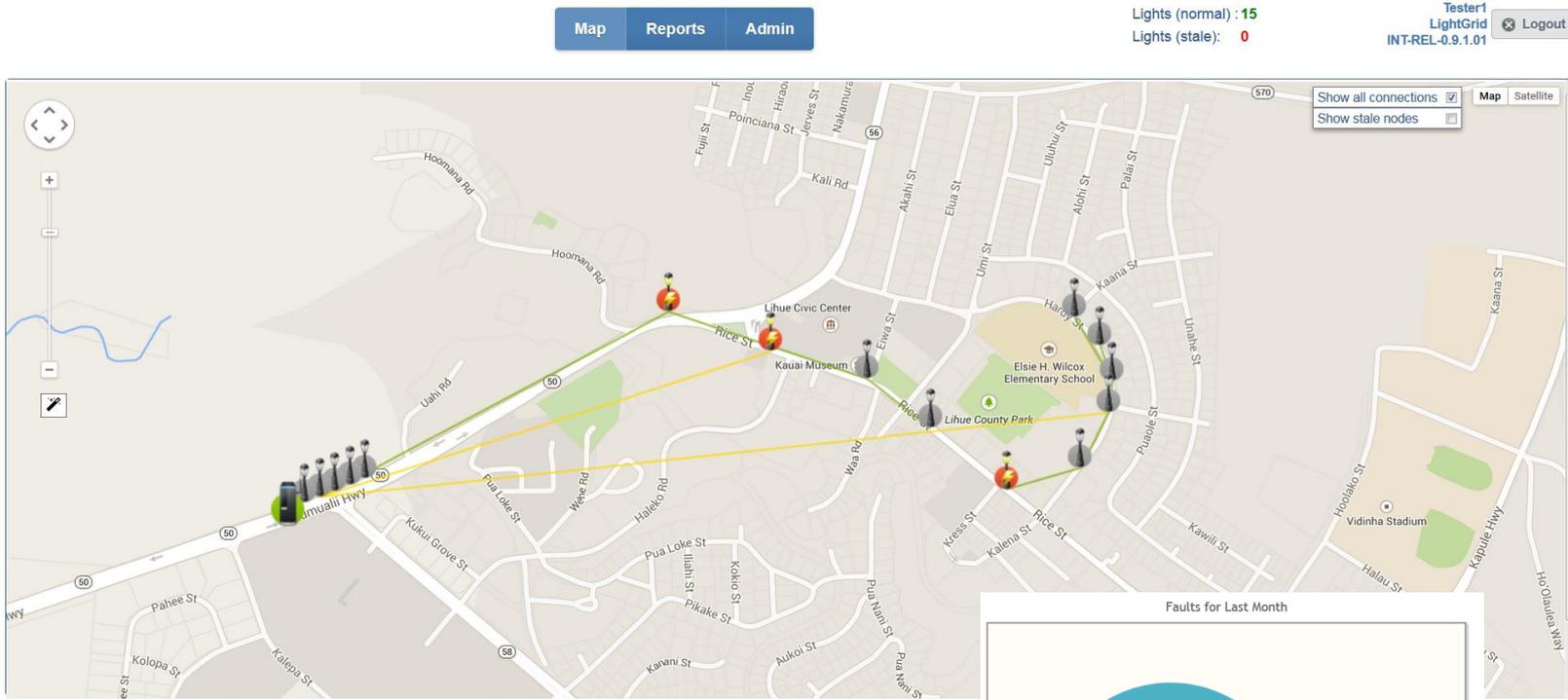
The screenshot displays a smart city management interface. At the top, there's a map showing a street grid with numerous yellow circular markers indicating fault locations. The interface includes a navigation sidebar on the left with a search bar and a list of locations: Salobre, CM-Cementerio, CM-García Lorca, CM-Huertos, and CM-Reolid. On the right, a 'CONTROL SYSTEMS' sidebar shows 'Philips Starsense Powerline' and an 'Actions' menu with 'Add Segment'. Below the map is a detailed fault report table with columns for ID, Asset Name, Component Name, Component Type, Model, Category, and First Reported. A search bar on the left of the table shows '3 results'.

ID	Asset Name	Component Name	Component Type	Model	Category	First Reported
248	SL-RF_078	RF_078	Luminaire		Failure	9/5/2012
187	CAB-CM_Salobre_Cem	CM_Salobre_Cem	Communications Node	Philips LFC7070	Unreachable	7/9/2012
171	SL-PL Ficticio		Communications Node	Philips LLC7040	Unreachable	1/18/2012

Status	Node Name	NodeType	Category	First Reported On	Last Reported On	Error Type	
7	Fixed	LC204	Lum	Broken	5-11-11 10:45	5-11-11 11:01	Lamp has failed.
8	Fixed	LC204	Lum	Broken	5-12-11 20:53	5-13-11 20:56	Lamp has failed.
9	Fixed	LC204	Lum	Broken	5-7-11 0:03	5-7-11 20:46	Lamp has failed.
10	Fixed	LC204	Lum	Broken	5-15-11 20:58	5-16-11 21:00	Lamp has failed.
11	Fixed	LC204	Lum	Broken	5-19-11 21:05	5-20-11 21:07	Lamp has failed.
12	Fixed	LC204	Lum	Broken	5-22-11 21:09	5-23-11 21:11	Lamp has failed.
13	Fixed	LC204	Lum	Broken	5-16-11 21:00	5-17-11 21:02	Lamp has failed.
14	Fixed	LC204	Lum	Broken	5-7-11 20:46	5-8-11 20:46	Lamp has failed.
15	Fixed	LC204	Lum	Broken	5-11-11 11:01	5-11-11 20:52	Lamp has failed.
16	Fixed	LC204	Lum	Broken	5-13-11 20:56	5-14-11 20:57	Lamp has failed.
17	Fixed	LC204	Lum	Broken	5-20-11 21:07	5-21-11 21:08	Lamp has failed.
18	Fixed	LC204	Lum	Broken	5-24-11 21:13	5-25-11 21:14	Lamp has failed.
19	Fixed	LC204	Lum	Broken	5-24-11 12:01	5-24-11 21:13	Lamp has failed.
20	Fixed	LC204	Lum	Broken	5-23-11 21:11	5-24-11 12:01	Lamp has failed.
21	Fixed	LC204	Lum	Broken	5-25-11 21:14	5-27-11 21:16	Lamp has failed.
22	Fixed	LC204	Lum	Broken	5-27-11 21:16	5-28-11 21:18	Lamp has failed.
23	Fixed	LC204	Lum	Broken	4-30-11 20:32	5-1-11 20:34	Lamp has failed.
24	Fixed	LC204	Lum	Broken	5-3-11 20:39	5-4-11 20:39	Lamp has failed.
25	Fixed	LC204	Lum	Broken	5-1-11 20:34	5-2-11 15:01	Lamp has failed.
26	Fixed	LC204	Lum	Broken	5-2-11 20:38	5-3-11 20:39	Lamp has failed.
27	Fixed	LC204	Lum	Broken	5-4-11 20:39	5-7-11 0:03	Lamp has failed.
28	Fixed	LC204	Lum	Broken	5-10-11 20:52	5-11-11 10:43	Lamp has failed.
29	Fixed	LC204	Lum	Broken	5-11-11 20:52	5-12-11 10:04	Lamp has failed.
30	Fixed	LC204	Lum	Broken	5-14-11 20:57	5-15-11 20:58	Lamp has failed.
31	Fixed	LC204	Lum	Broken	5-17-11 21:02	5-18-11 21:03	Lamp has failed.
32	Fixed	LC204	Lum	Broken	5-18-11 21:03	5-19-11 21:05	Lamp has failed.
33	Fixed	LC204	Lum	Broken	5-21-11 21:08	5-22-11 21:09	Lamp has failed.
34	Fixed	LC204	Lum	Broken	5-28-11 21:18	5-29-11 21:19	Lamp has failed.
35	Active	LC204	Lum	Broken	5-29-11 21:19	5-29-11 21:19	Lamp has failed.
36	Fixed	OLC_C174	OLC	Unreachable	5-9-11 11:43	5-9-11 11:45	OLC is not reachable.

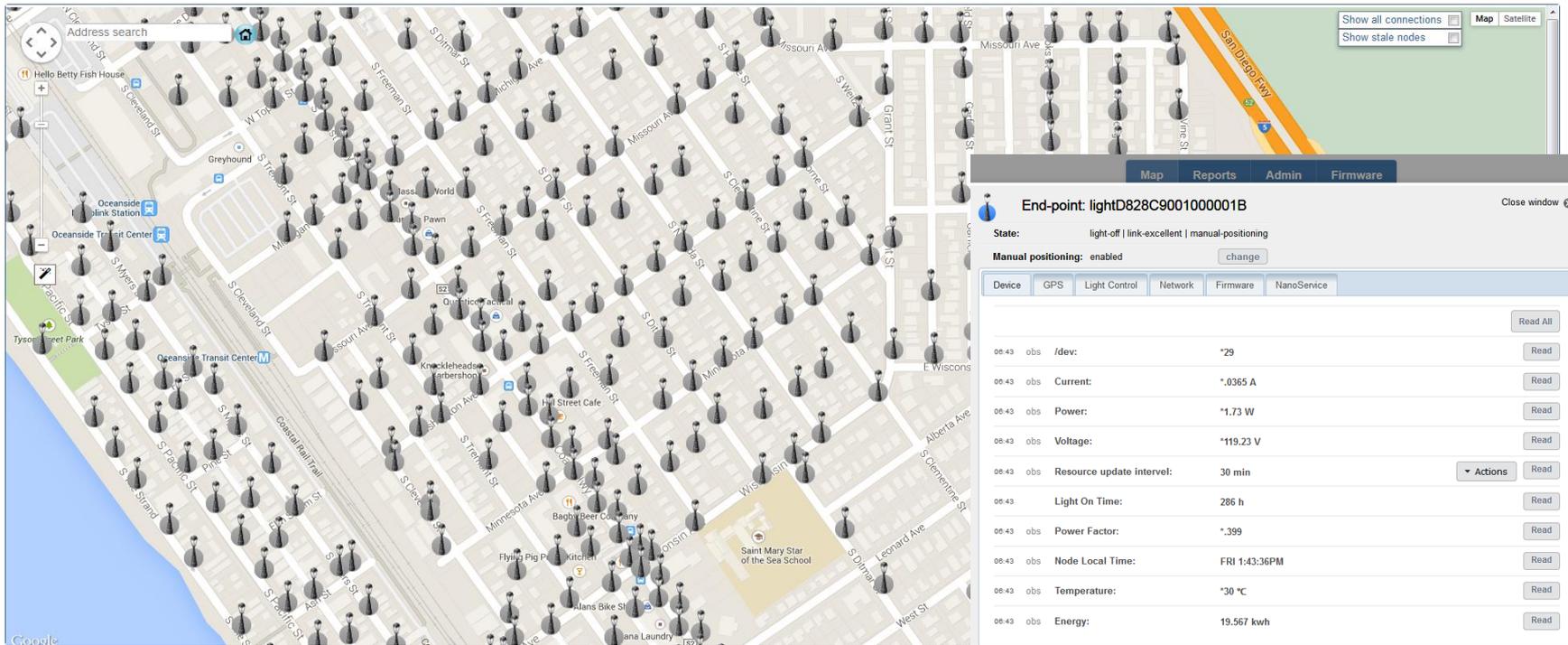
# SYSTEM STATUS



Map Reports Admin

Lights (normal): 6456  
Lights (stale): 120

Mwilbur  
LightGrid  
CMS-1.0.0.27  
Logout



FAIR

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## Q & A

Basic System Capabilities & Value Propositions

Michael Poplawski



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# **OUTDOOR LIGHTING CONTROL SYSTEM FUNDAMENTALS**

Demonstration Part 1

Mark Wilbur



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# **OUTDOOR LIGHTING CONTROL SYSTEM FUNDAMENTALS**

Lunch (90 minutes)



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# OUTDOOR LIGHTING CONTROL SYSTEM FUNDAMENTALS

Demonstration Part 2

Mark Wilbur



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**2015**

# OUTDOOR LIGHTING CONTROL SYSTEM FUNDAMENTALS

Market Adoption Status

Michael Poplawski

# KEY MARKET ADOPTION ISSUES

- Market and user maturity
- Upfront cost and/or payback time
- Quantifiable value propositions
- Game changers
  - Managing modularity vs. integration
  - Interoperability
  - Future city visions, interdepartmental or municipal-utility collaboration models, business models
  - New value propositions, revenue opportunities

# USER AND MARKET MATURITY

- Utilities and municipalities and have different vested interests
- Different utilities/municipalities see value propositions differently
- Size matters
- User learning curve
  - Networks, communication
  - New/additional devices to maintain
- Young market
  - Mature core technology
  - Start-up and commissioning processes viewed as complex and time-consuming
  - Rapid product evolution
- One size does not fit all
  - Match desirable feature set(s) to user type(s)
  - MSSLC Model Specification

# UPFRONT COST AND PAYBACK TIME

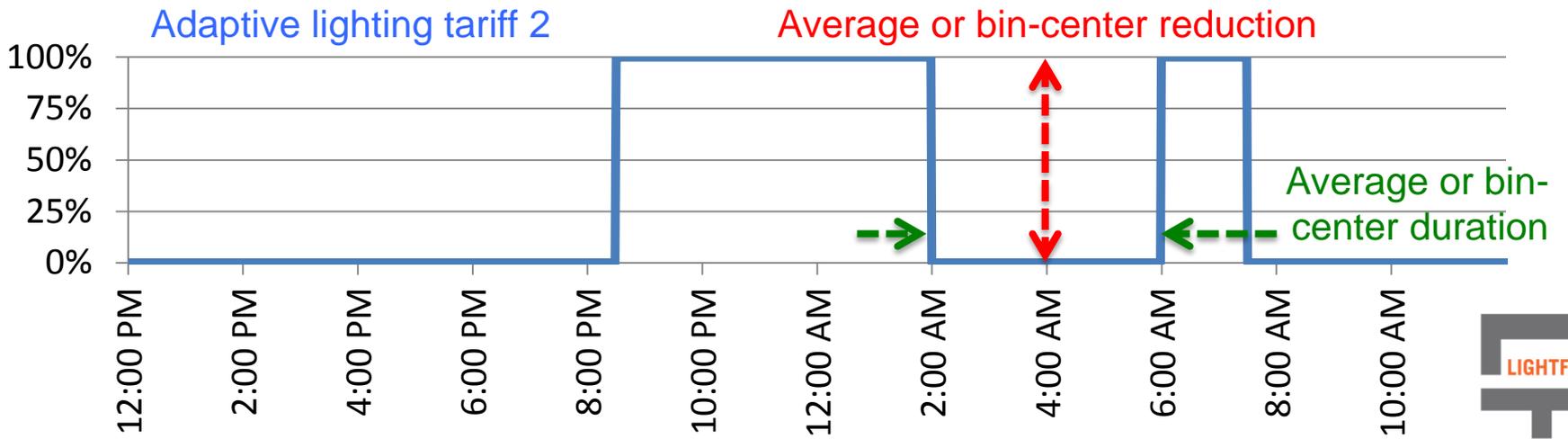
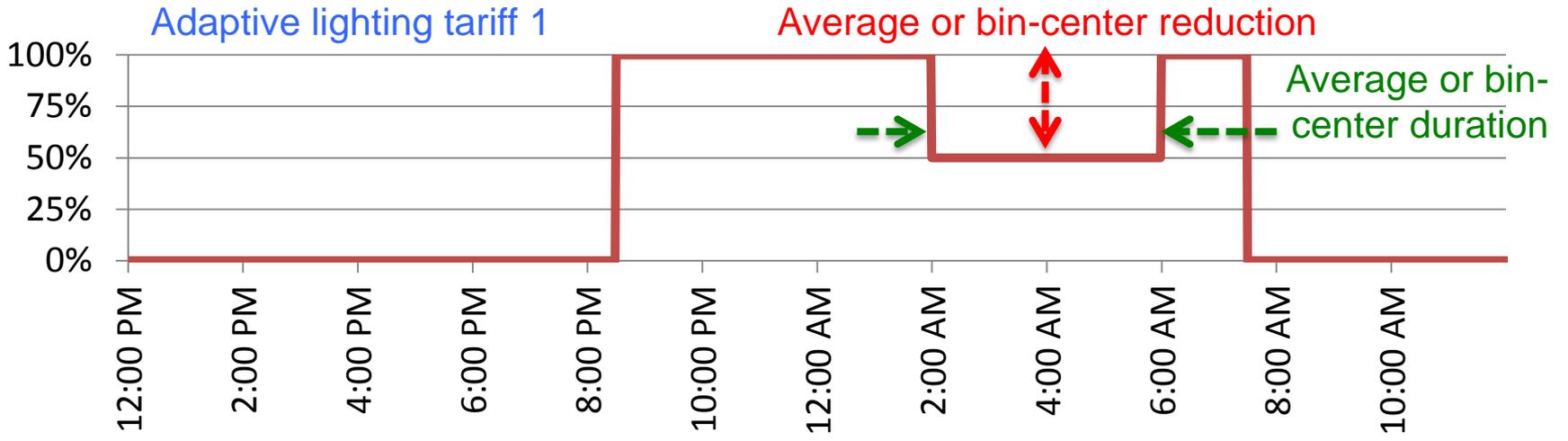
117

- Controls cost on par with LED luminaire
- Focus on simple value propositions may not lead to acceptable payback
  - Maintenance and energy cost savings from remote monitoring are straightforward, but vary by user
  - Energy savings from adaptive lighting are difficult to monetize due to lack of metered tariffs and regulatory guidance

# MONETIZING ENERGY SAVINGS

- Requires new utility tariff(s)
- Existing utility infrastructure does not support accepting metering data
- Existing metering standards not (directly) applicable
  - ANSI C12.1, 12.20
  - Meter accuracy
  - Data security for billing purposes
- New ANSI C136.50 “revenue grade energy measurement device” standard (specific for lighting) under development

# ALTERNATIVES TO ENERGY METERING



# MUNICIPALITIES VS. UTILITIES

- New fixed tariff vs. metered tariff
- Responsibility, liability
  - Meter ownership, accuracy requirements
  - Network infrastructure ownership
  - Data security
- Future opportunities
  - Integration with other systems
  - Revenue stream

# ADAPTIVE LIGHTING IMPLEMENTATION STRUGGLES

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- Adjust light levels according to what? How? Based on what data?
  - Pedestrian traffic
  - Automobile traffic
  - Mass transit schedules
  - Lighting zones, condition
  - Weather
- Liability concerns
- IES RP-8-14
  - Some adaptable recommended light levels
  - Limited specific guidance

# MODULARITY

- Easy incorporation of new or exchange of existing component, typically facilitated by plug/receptacle or some other connector
- May better facilitate gradual adoption of new/upgraded component
- Separation of components with different expected lifetime/reliability may lead to lower life-cycle cost
- Typically leads to higher up-front (material) cost
- Modularity + standardization (leading to high volume) may limit increase in up-front cost

# INTEGRATION

- Co-design of single system previously comprised of two or more sub-systems, typically resulting in fewer components, circuit boards, connectors, manufacturing steps
- Typically leads to lower up-front (material) cost, and higher reliability
- Need to get the feature set right
  - Compromised ability to incorporate new or exchange existing component later
  - Typically driven by clear feature demand, standards

# TERMINOLOGY

- **Compatibility:** The capability of two or more devices, applications, networks, or systems to coexist in the same physical environment – that is, operate without corrupting, interfering with, or hindering the operation of the other entity.
- **Interoperability:** The capability of two or more devices, applications, networks, or systems to reliably and securely exchange and readily use data with a commonly shared meaning.
- **Interchangeability:** The capability of two or more devices, applications, networks, or systems to be physically exchanged for each other and provide a defined level of identical operation without additional configuration.

# THE IMPACT OF GREATER INTEROPERABILITY

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- Facilitates the incorporation of best-of-breed devices, deployment of an energy-saving platform (i.e. multi-phase, not limited to initial install choices)
- Reduces incremental cost of system enhancement (e.g. software vs. hardware)
- Facilitates crowd-sourced development (software, use cases)
- Reduces user risk (e.g. device, manufacturer obsolescence), increase user satisfaction and adoption
- Facilitates greater data exchange
  - Use data from, share data with non-lighting systems
  - Improved performance of lighting and non-lighting systems
  - Non-energy benefits
  - Communicate measured performance (hours-of-use, energy)

# INTEROPERABILITY QUESTIONS

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- Where?
  - Physical/MAC layers?
  - Network stack?
  - Application layer?
- When?
  - Market adoption bottleneck
  - Mature feature definition, technology
- How?
  - Requires understanding of industry standards and specifications
  - Careful, comprehensive specification, certification and compliance testing

## City of San José Public Streetlight Design Guide

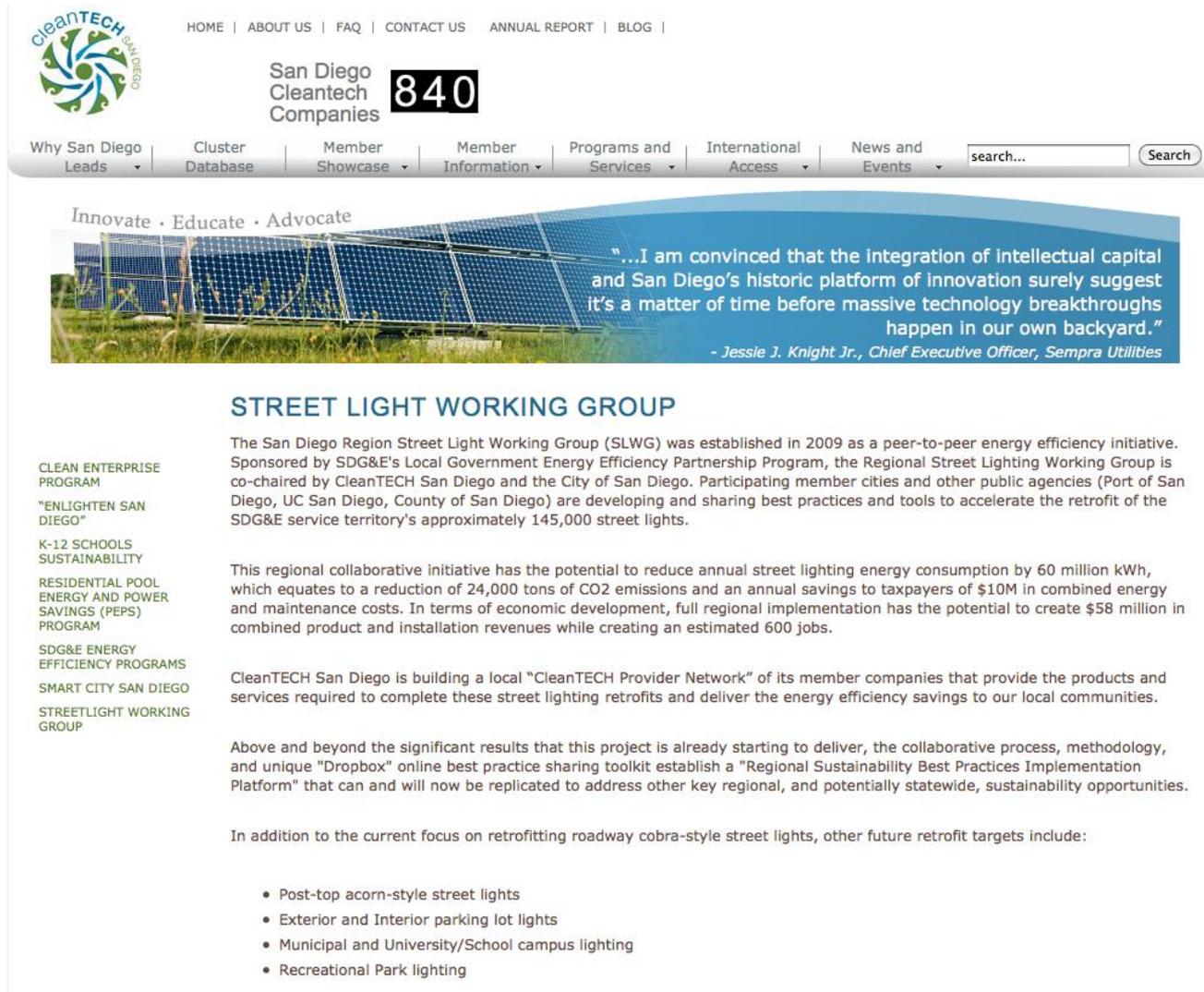


February 2011



<http://ca-sanjose.civicplus.com/DocumentCenter/Home/View/242>

<http://www.nyc.gov/html/dot/downloads/pdf/2013-dot-sustainable-streets.pdf>



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Innovate · Educate · Advocate

“...I am convinced that the integration of intellectual capital and San Diego’s historic platform of innovation surely suggest it’s a matter of time before massive technology breakthroughs happen in our own backyard.”  
- Jessie J. Knight Jr., Chief Executive Officer, Sempra Utilities

## STREET LIGHT WORKING GROUP

The San Diego Region Street Light Working Group (SLWG) was established in 2009 as a peer-to-peer energy efficiency initiative. Sponsored by SDG&E’s Local Government Energy Efficiency Partnership Program, the Regional Street Lighting Working Group is co-chaired by CleanTECH San Diego and the City of San Diego. Participating member cities and other public agencies (Port of San Diego, UC San Diego, County of San Diego) are developing and sharing best practices and tools to accelerate the retrofit of the SDG&E service territory’s approximately 145,000 street lights.

This regional collaborative initiative has the potential to reduce annual street lighting energy consumption by 60 million kWh, which equates to a reduction of 24,000 tons of CO2 emissions and an annual savings to taxpayers of \$10M in combined energy and maintenance costs. In terms of economic development, full regional implementation has the potential to create \$58 million in combined product and installation revenues while creating an estimated 600 jobs.

CleanTECH San Diego is building a local “CleanTECH Provider Network” of its member companies that provide the products and services required to complete these street lighting retrofits and deliver the energy efficiency savings to our local communities.

Above and beyond the significant results that this project is already starting to deliver, the collaborative process, methodology, and unique “Dropbox” online best practice sharing toolkit establish a “Regional Sustainability Best Practices Implementation Platform” that can and will now be replicated to address other key regional, and potentially statewide, sustainability opportunities.

In addition to the current focus on retrofitting roadway cobra-style street lights, other future retrofit targets include:

- Post-top acorn-style street lights
- Exterior and Interior parking lot lights
- Municipal and University/School campus lighting
- Recreational Park lighting

CLEAN ENTERPRISE PROGRAM  
“ENLIGHTEN SAN DIEGO”  
K-12 SCHOOLS SUSTAINABILITY  
RESIDENTIAL POOL ENERGY AND POWER SAVINGS (PEPS) PROGRAM  
SDG&E ENERGY EFFICIENCY PROGRAMS  
SMART CITY SAN DIEGO  
STREETLIGHT WORKING GROUP

<http://www.cleantechsandiego.org/streetlight-working-group.html>

- Many implementations
  - Energy service contract (ESCO)
  - Lease-to-own
  - Pay for performance
- Many financing benefits
  - Capital vs. Operating cost flexibility, optimization
  - Reduced risk
- Many owner and operator benefits
  - Reduced or eliminated system management, re-commissioning
  - Improved system optimization, performance

[http://www.wmata.com/about\\_metro/news/PressReleaseDetail.cfm?ReleaseID=5613](http://www.wmata.com/about_metro/news/PressReleaseDetail.cfm?ReleaseID=5613)

<http://greatergreaterwashington.org/post/21636/wmata-gets-turned-on-to-public-private-partnerships/>

## Metro to overhaul parking garage lighting for safety, efficiency

Brighter garages to benefit 66,000 parking customers while reducing expenses for Metro

Metro has awarded a zero-cost, performance-based contract for the replacement of over 13,000 parking garage light fixtures in the next year—a key part of *Metro's Sustainability Agenda*.

Under the 10-year contract, outdated and inefficient lighting will be replaced with new high-efficiency LED lighting that will create a brighter environment for riders, use less electricity, and lower costs. The contract was awarded to Philips Electronics through a competitive, technology-neutral procurement process that will be funded entirely through the resulting \$2 million in energy and maintenance savings annually.

Metro has 25 parking facilities that will benefit from improved lighting as a result of the project.

"Today's contract award advances our commitment to improving the system's infrastructure for our customers for years to come," said Richard Sarles, Metro General Manager and CEO. "This high-efficiency LED lighting overhaul not only means increased safety and visibility for riders, but also a 68 percent reduction in energy consumption at these facilities."

The contract award will provide light quality that is far superior to Metro's existent yellowish, high-pressure sodium lighting. Designed to each garage's unique characteristics, the new LED lighting will direct light when and where it is needed. Each fixture will respond to its environment by automatically dimming in response to motion and ambient light from the sun or other sources. As a secondary benefit, the performance of existing security cameras will improve as a result of the higher quality light. The project is expected to save Metro more than 15 million KWh in energy per year, reducing carbon emissions by the equivalent of 140 tanker trucks of gasoline — or the electricity used by 1,456 homes — annually. Each garage will be individually metered to allow real-time performance tracking and automated reporting.

In addition to the energy savings, the contract also includes the maintenance of the lighting system for the life of the contract. This will allow resources to be redeployed to other operational and maintenance needs throughout the system, redirecting approximately \$600,000 annually in labor and material resources to other system maintenance tasks.

The *Metro Sustainability Agenda* sets an Authority-wide commitment to modernize Metro's infrastructure with sustainable, resource-efficient operations.

News release issued at 3:11 pm, November 12, 2013.

# LEGISLATED MANDATES AND FUNDING SUPPORT?



<http://www.its.dot.gov/>

<http://www.fhwa.dot.gov/everydaycounts/technology/adsc/intro.cfm>

<http://www.fhwa.dot.gov/federalaid/projects.pdf#its>



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## Q & A

Market Adoption Status

Michael Poplawski



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# OUTDOOR LIGHTING CONTROL SYSTEM FUNDAMENTALS

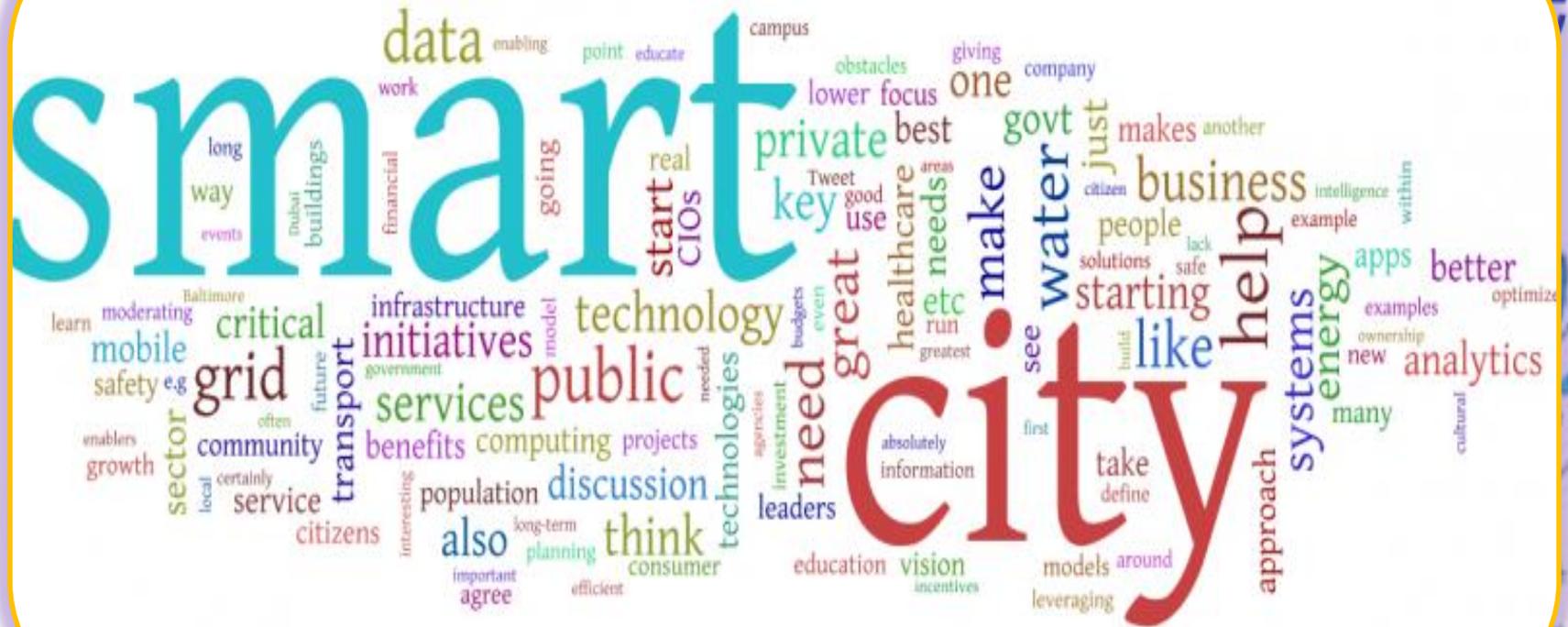
Future Possibilities

Mark Wilbur

Big City,



Bigger Infrastructure



# FUTURE OPPORTUNITIES FOR THE LIGHTING INFRASTRUCTURE

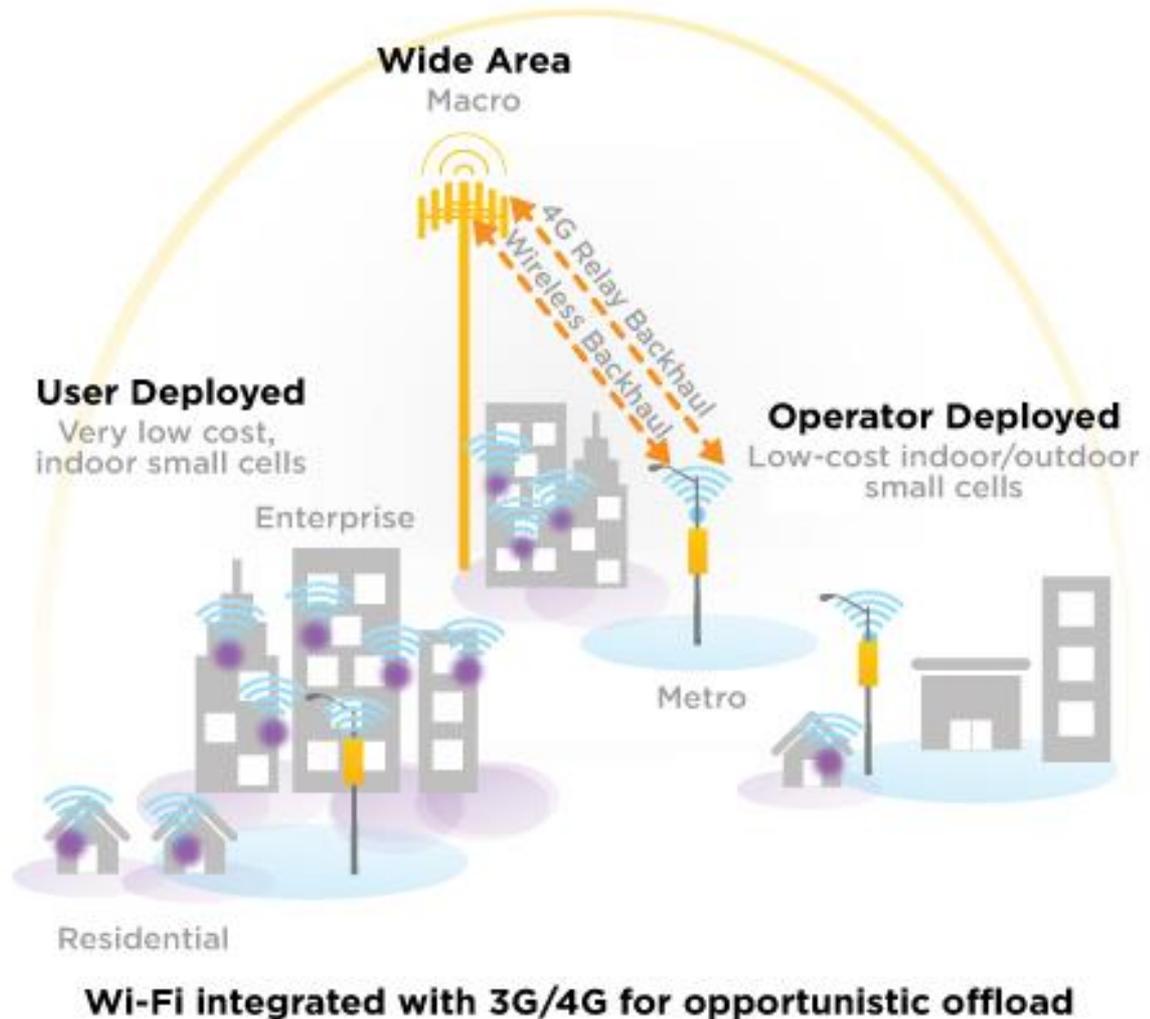
134

- Mini-Cell Tower Deployments: ATT / Verizon Leases
- Parking Availability: Parking Location Provider Fees
- Parking Metering: Parking Fines
- Interactive LCD Billboards: Retail Advertising Fees
- Weather Reporting: Weather Service Fees
- Air Quality Reporting: Industrial Offender Fines
- Illegal Dumping Detection: Dumping Fines

## Small Cells

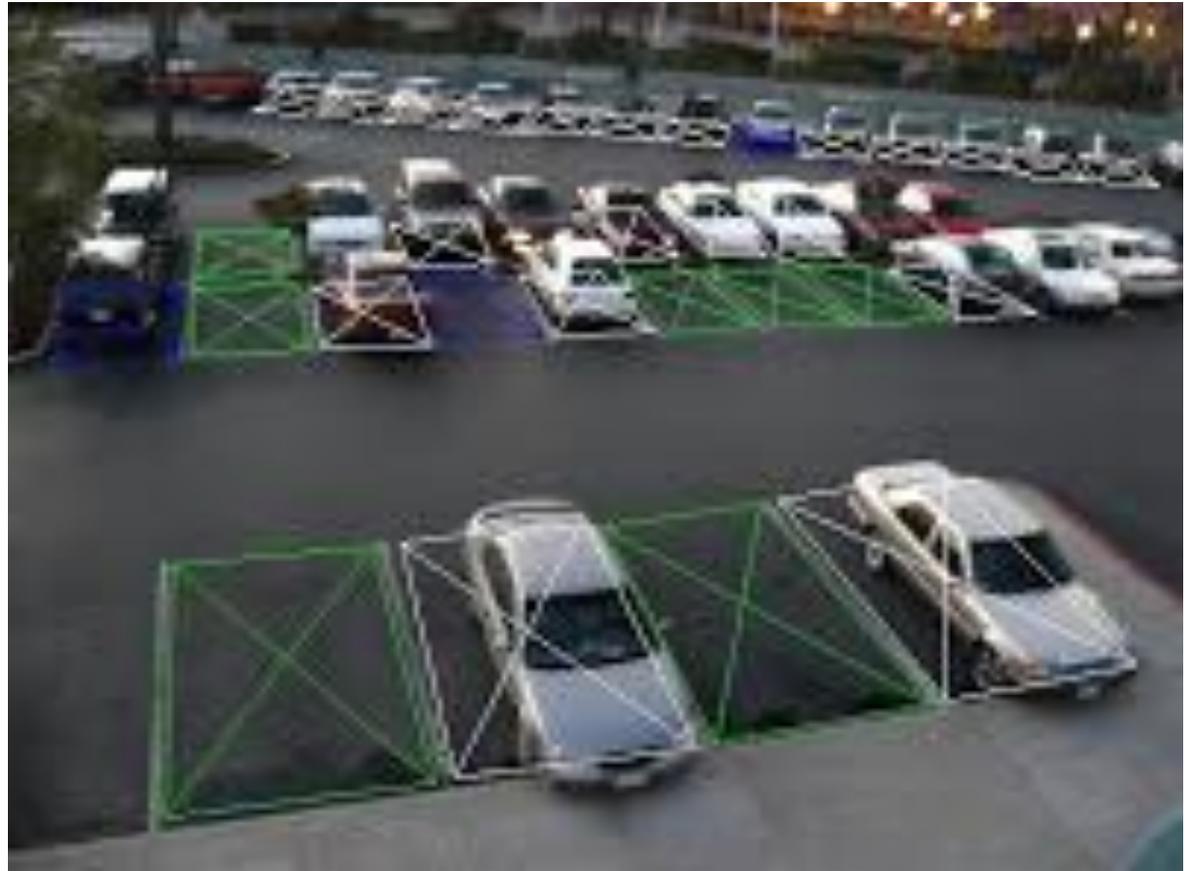
are low-powered radio access nodes that operate in licensed and unlicensed spectrum that have a range of 10 meters to 1 or 2 kilometers.

ARCchart estimates that by 2017 a total of 5 million small cells will ship annually



# AUTOMATED PARKING SPACES

Smart phone application developers charge a small fee to guide users to the nearest available parking space



The same communications network can interact with the local parking meters to notify the parking enforcement team of violations

# INTERACTIVE RETAIL / INFORMATIONAL DISPLAYS

- Interactive Directions
- Local Retailer Advertisements
- Tourist Information
- Interactive Sightseeing Challenges



# WEATHER MONITORING

- Temperature
- Barometric Pressure
- Wind Speed and Directions
- Humidity
- Rain Fall
- Snow Accumulations
- Roadway Surface Temperatures



## 3 Primary sensor technologies used in motion/occupancy detectors

### Passive Infrared

Radiation IR wavelength detection ideal indoors away from direct sunlight lowest cost and complexity

### Doppler

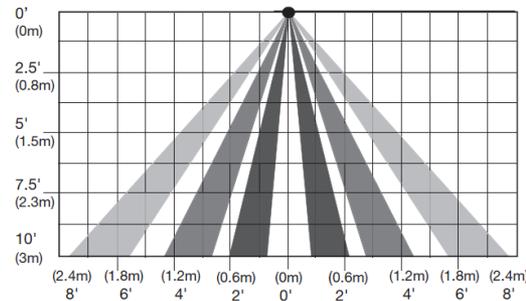
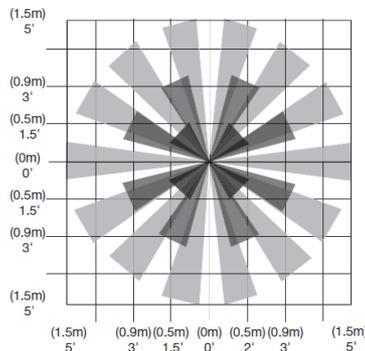
Audio Frequency Shift Ideal for outdoor applications Many manufactures offer hybrid PIR/Doppler sensors

### Microwave

RF pulse reflection strength delay Ideal for applications that report velocity and direct detection

## Lighting Network Uses:

- Adaptive lighting during of peak activity
- Security Lighting
- Energy Conservation

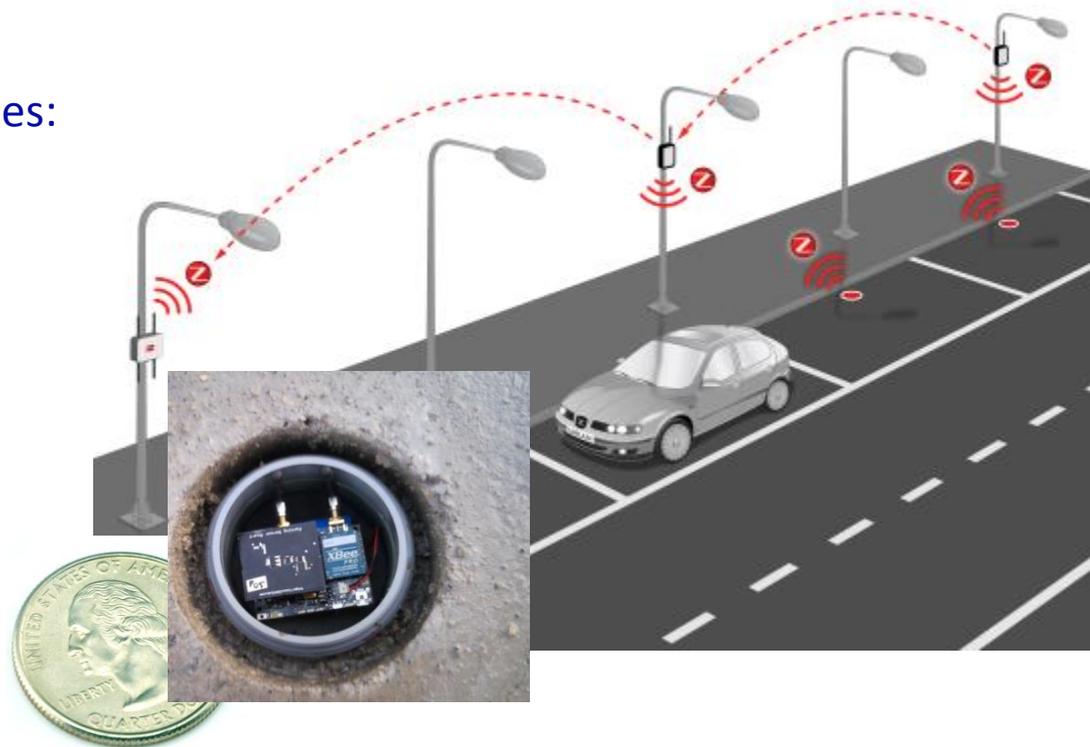


# MAGNETOMETERS

The outstanding performance of in-roadway sensors such as inductive loops, magnetic detectors, and magnetometers is due partly to their close proximity to the vehicles passing over them. Another advantage is that they are insensitive to inclement weather such as rain, fog, and snow.

## Lighting Networks Uses:

- Vehicle Detection
- Vehicle Velocity
- Vehicle Direction
- Parking Availability



# VIDEO CAMERAS

Video cameras are the fastest growing sensor technology with an estimated 10,000 new cameras being deployed every day

Lighting Networks Uses:

Pole Mounted Imaging opportunities including...

- Pedestrian Congestion
- Vehicle Congestion
- Parking Availability
- Parking Violations
- Illegal Dumping Detection
- Vandalism Detection

Real progress being made with distributed pattern matching VS real time video transmission and external image evaluations



# DRONES ARE ON THEIR WAY TO A COMMUNITY NEAR YOU

142

Light fixtures are the ideal charging and staging locations

Life saving opportunities include:

**Police:** Saving lives by providing advance video surveillance of active crime scenes

**Fire:** Saving lives by advanced surveillance of active fires and rescues, optimization of asset deployments to minimize risks

**Home Land Security:** Video Surveillance of reported national security treats

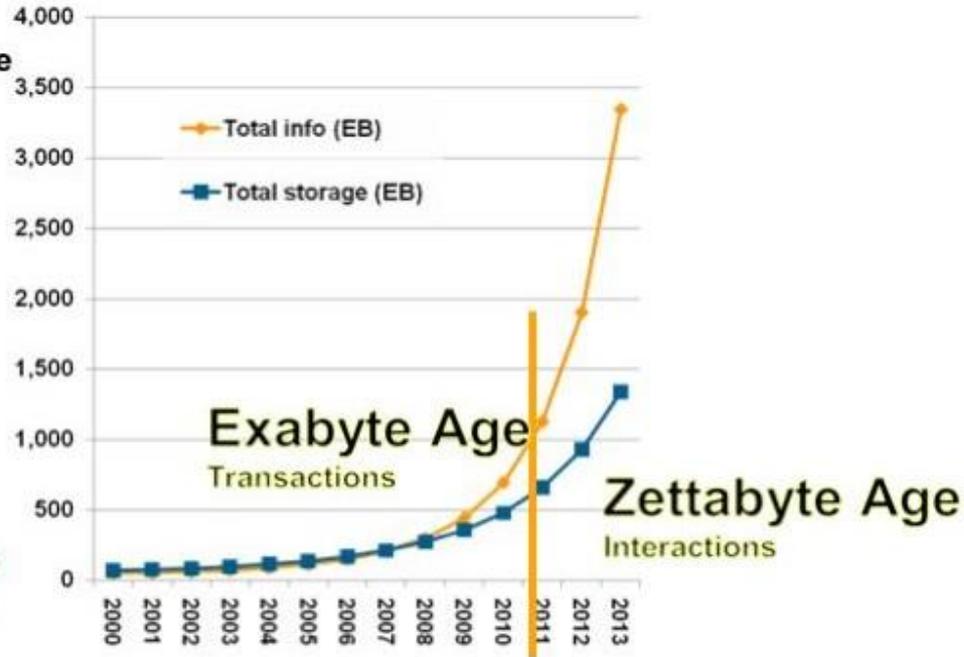
**Emergency Medical:** Delivery of portable defibrillators and other self administered aid prior to the arrival of EMS personnel



# DATA COLLECTION GROWTH CONTINUES TO EXCEED ALL PREDICTIONS

- More data has been created in the last three years than in all past 40,000 years.
- Almost all of this data has a location
- Business and government decision-makers must have a strategy for dealing with location based data

**Technology Trend:** (1) Sensor data and mobility apps are creating more data tagged with location. (2) Increasing number of apps are location-aware, so queries involve spatial dimension. High confidence that analytic apps will include who-what-when-where dimensions.



One Zettabyte (ZB) = 1,000,000,000,000,000,000 bytes =  $10^{21}$  bytes.  
Based on IDC and UC Berkeley data growth estimates.



# THE MACHINES HAVE TAKEN OVER MACHINES HAVE SILENTLY TAKEN OVER THE INTERNET GENERATING MORE TRAFFIC THAN ALL OF THE PEOPLE ON THE PLANET COMBINED

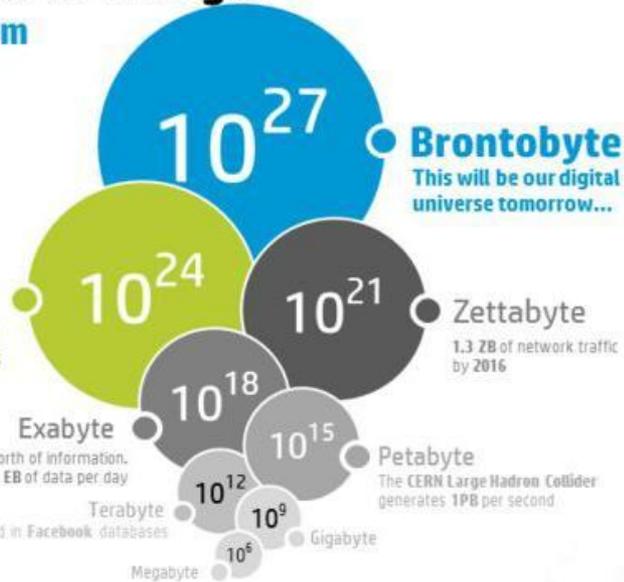
## Information from the Internet of Things:

We have gone beyond the decimal system

Today data scientist uses **Yottabytes** to describe how much government data the NSA or FBI have on people altogether.

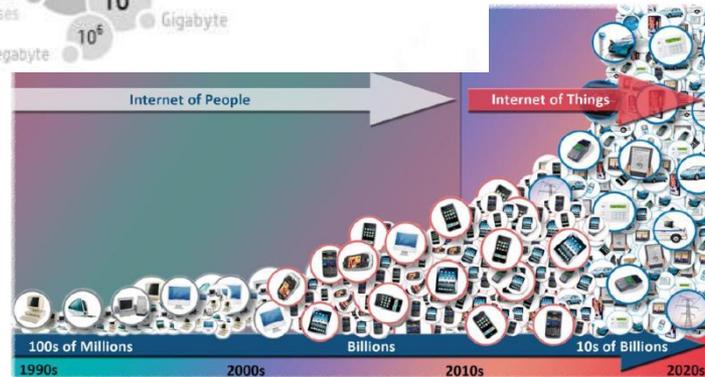
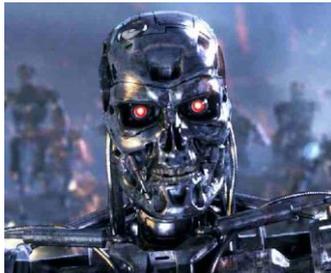
In the near future, **Brontobyte** will be the measurement to describe the type of sensor data that will be generated from the IoT (Internet of Things)

**Yottabyte**  
This is our digital universe today  
= 250 trillion of DVDs



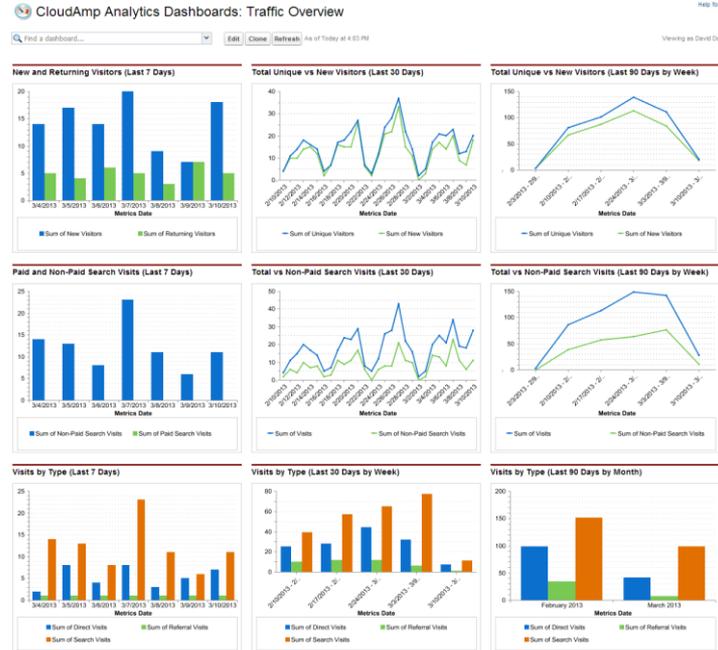
1 EB of data is created on the internet each day = 250 million DVDs worth of information. The proposed Square Kilometer Array telescope will generate an EB of data per day

500TB of new data per day are ingested in Facebook databases



# DATA ANALYTICS APPLICATIONS USE AVAILABLE SENSOR DATA TO PROVIDE REAL WORLD ACTIONABLE DATA YOU AND YOUR CUSTOMERS CAN USE

Interaction Between the Three Components of the Internet of Things



- Where has increased lighting levels reduced crime ?
- Where has additional lighting levels increased retail sales ?
- Where has increased lighting levels increased property values ?
- Where has roadway temperature reporting reduced salt usage and slow plow cost ?
- Where has reducing time looking for a parking space increase retail sales ?



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## Q & A

Future Possibilities,  
Mark Wilbur



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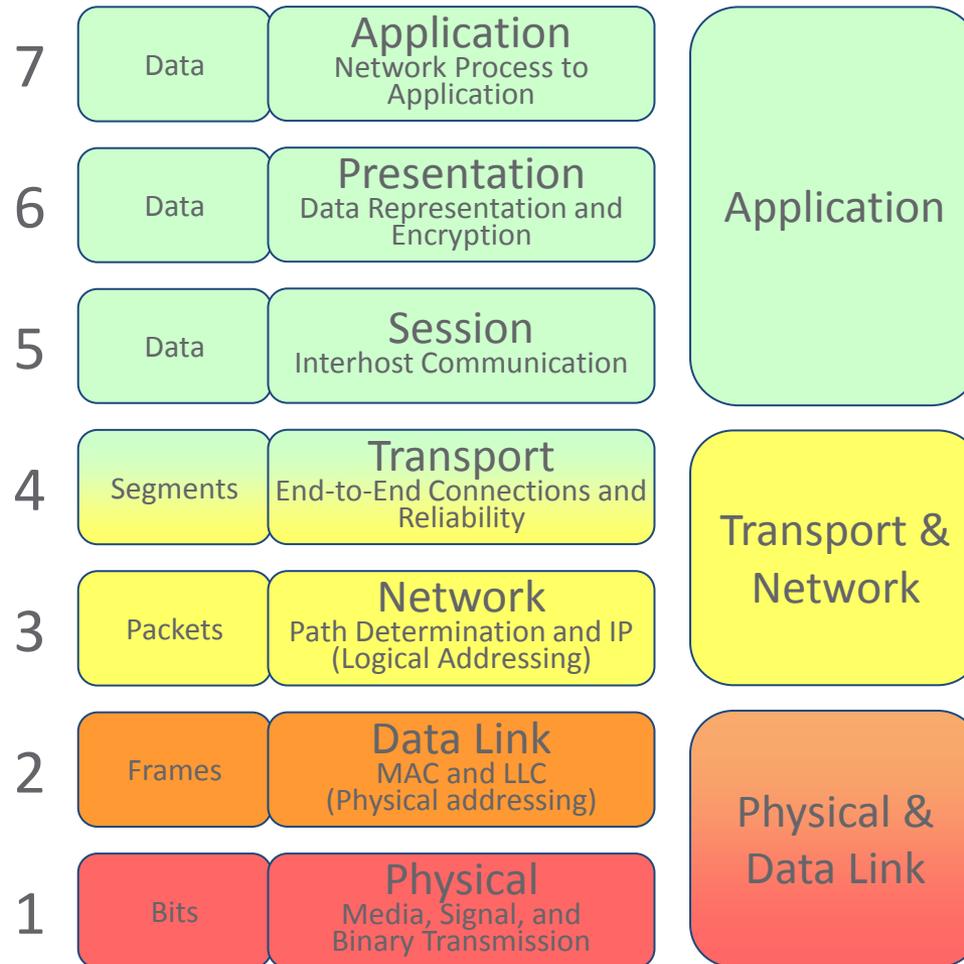
**2015**

# **OUTDOOR LIGHTING CONTROL SYSTEM FUNDAMENTALS**

Interoperability, Standards & Specifications

Michael Poplawski

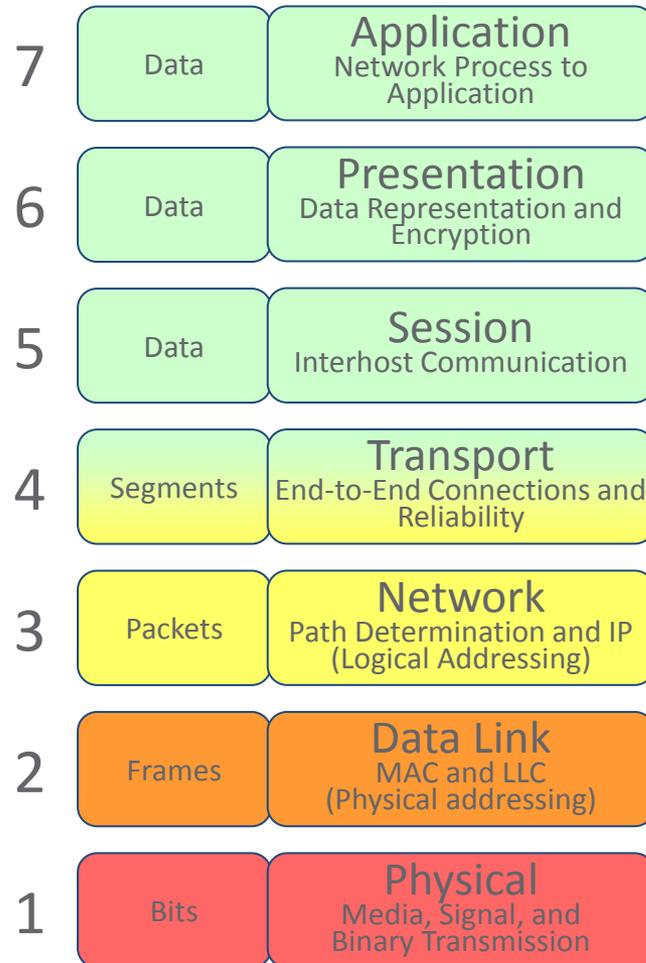
# THERE ARE MANY POSSIBLE LEVELS OF INTEROPERABILITY



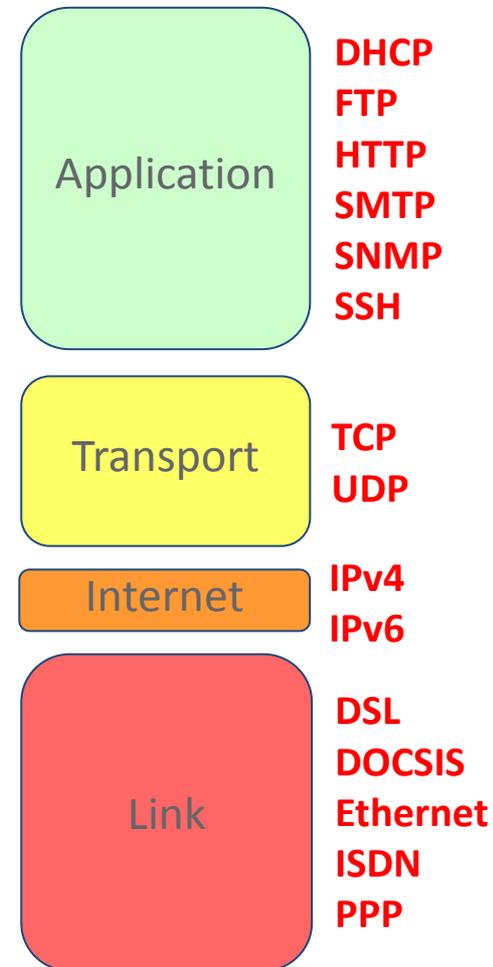
[http://en.wikipedia.org/wiki/OSI\\_model](http://en.wikipedia.org/wiki/OSI_model)

# THERE ARE MANY POSSIBLE LEVELS OF INTEROPERABILITY

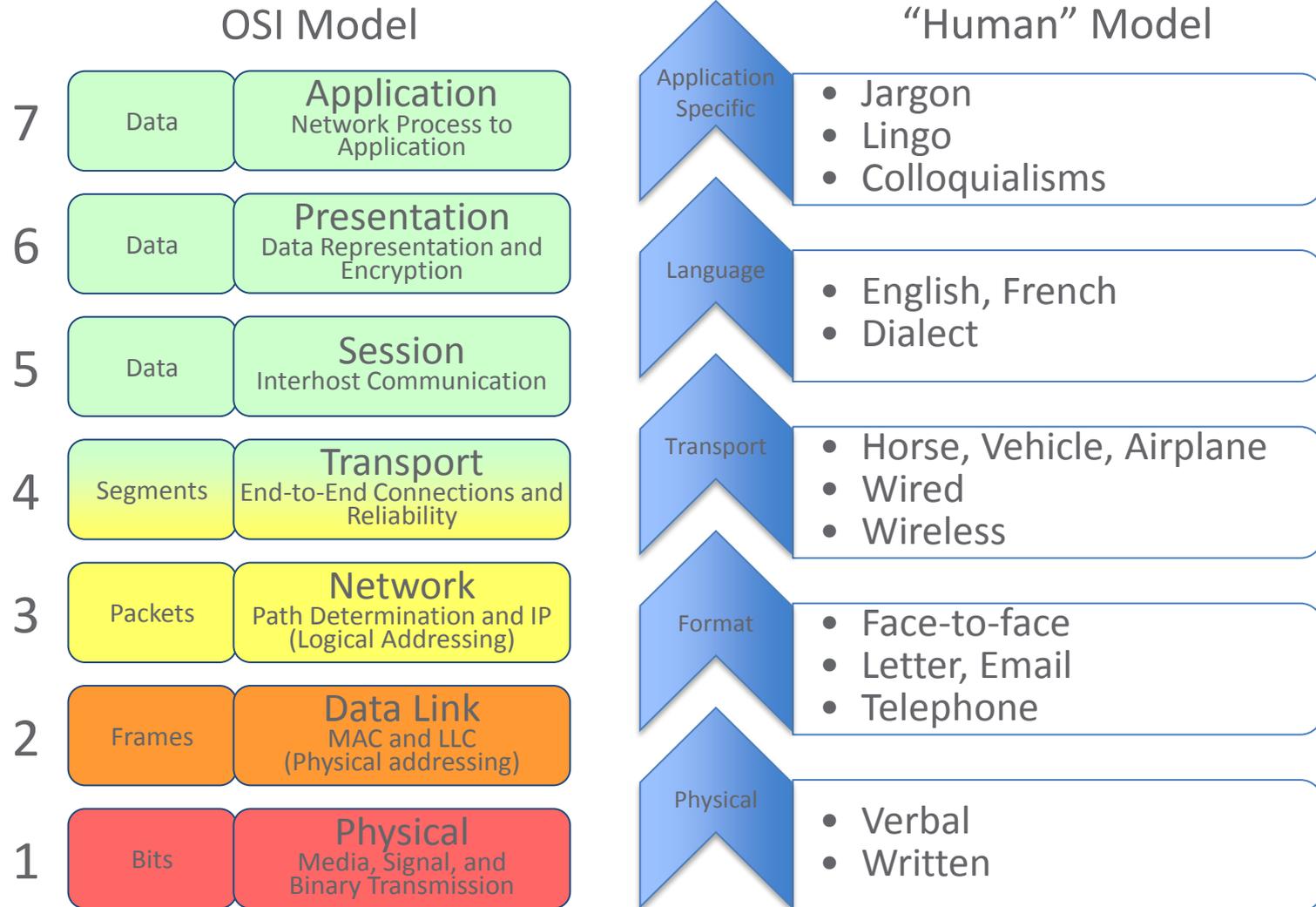
OSI Model



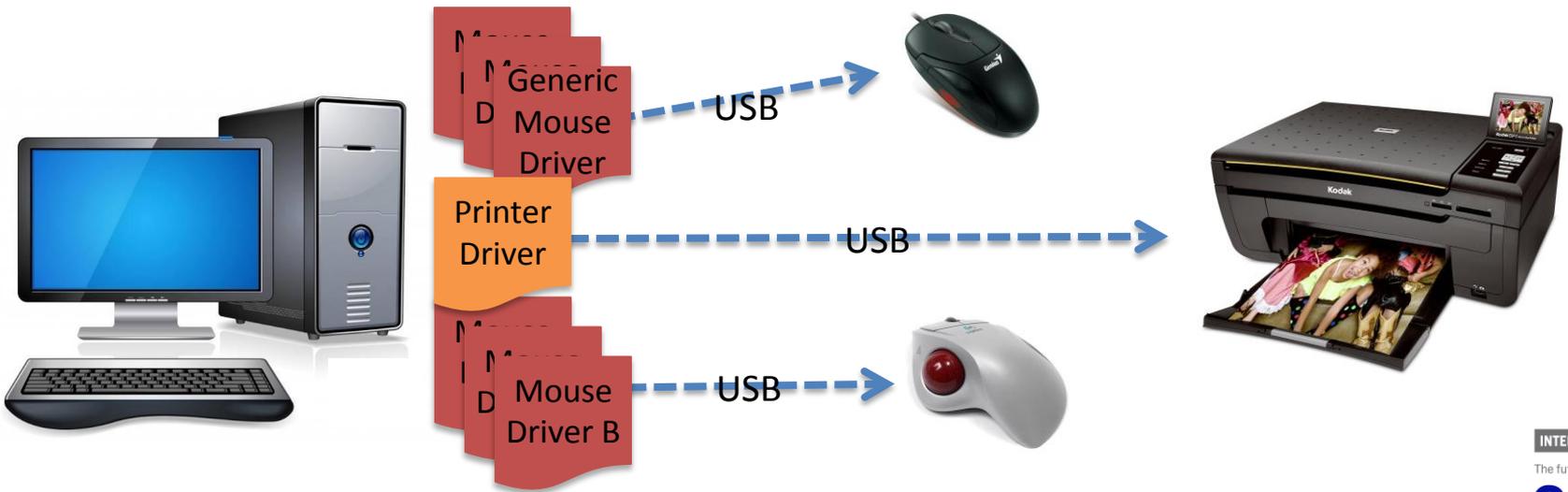
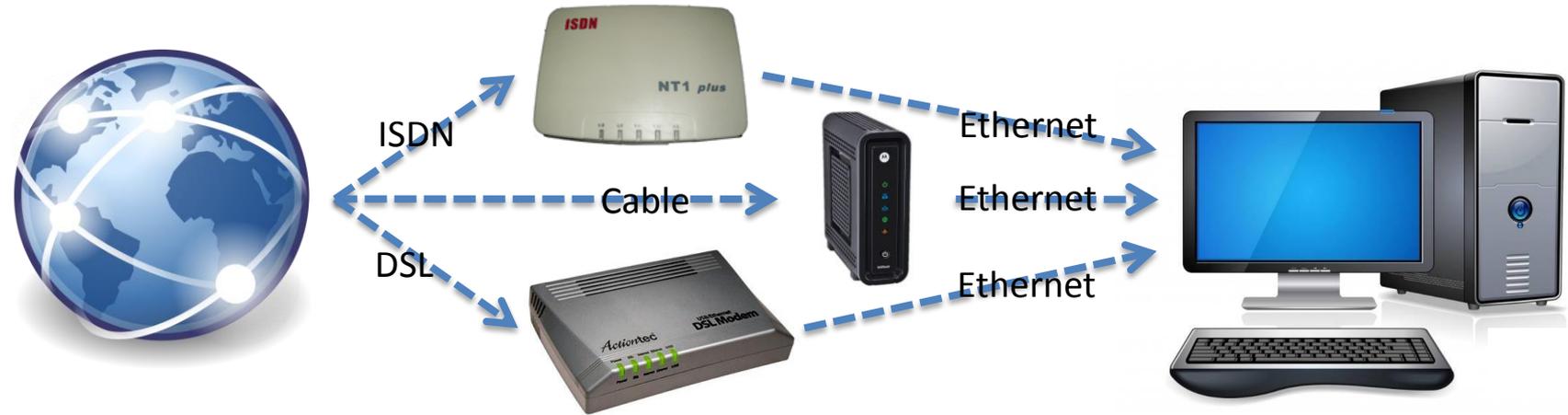
“Internet” Model



# THERE ARE MANY POSSIBLE LEVELS OF INTEROPERABILITY



# THERE ARE MANY POSSIBLE LEVELS OF INTEROPERABILITY



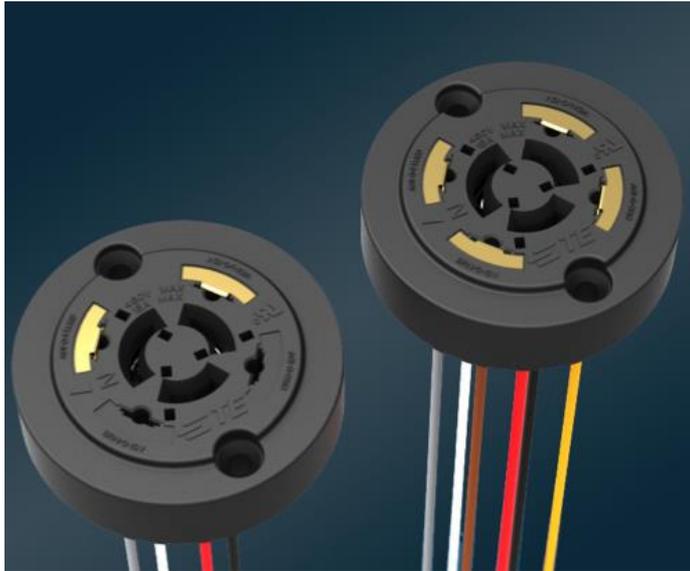
# ANSI C136.10-2010

“Locking-Type Photocontrol Devices and Mating Receptacles—  
Physical and Electrical Interchangeability and Testing”



# ANSI C136.41-2013

“Dimming Control Between an External Locking Type Photocontrol and Ballast or Driver”



<https://www.nema.org/Standards/Pages/For-Roadway-and-Area-Lighting-Equipment-Dimming-Control-Between-an-External-Locking-Type-Photocontrol-and-Ballast-or-Driver.aspx>

# ANSI C136.41-2013 COMPLIANT COMPONENTS

Buy Selected		Compare Selected		Compare up to 20 parts.																
Select	Image	Mouser Part #	Mfr. Part #	Mfr.	Description	Availability	Pricing (USD)	Quantity	RoHS	Product	Type	Termination Style	Contact Plating	Contact Material	Housing Material	Current Rating	Voltage Rating			
<input type="checkbox"/>	 <a href="#">Enlarge</a>	571-2213362-1	2213362-1	TE Connectivity / AMP	Lighting Connectors Dimming PhotoCell Recept Assy 3/2 150 C <a href="#">Learn More</a>	Page 1,682 Data Sheet	128 In Stock	1: \$8.03 10: \$7.65 50: \$6.88 100: \$6.49 200: View	<input type="text"/> Buy Min.: 1 Mult.: 1	 Details	Connectors	Receptacle	Crimp	Tin	Copper Alloy	Polybutylene Terephthalate (PBT)	15 A	600 V		
<input type="checkbox"/>	 <a href="#">Enlarge</a>	571-2213365-1	2213365-1	TE Connectivity / AMP	Lighting Connectors Dimming PhotoCell Brush Contact <a href="#">Learn More</a>	Page 1,682 Data Sheet	1,460 In Stock	Cut Tape 1: \$0.52 10: \$0.47 100: \$0.43 500: \$0.40 Reel 2,000: \$0.40	<input type="text"/> Buy Min.: 1 Mult.: 1 Reel: 2,000	 Details	Contacts		Through Hole	Gold	Copper Alloy		0.1 A	10 V		
<input type="checkbox"/>	 <a href="#">Enlarge</a>	571-2213362-3	2213362-3	TE Connectivity / AMP	Lighting Connectors Dimming PhotoCell Recept Assy 3/2 105 C <a href="#">Learn More</a>	Page 1,682 Data Sheet	70 In Stock	1: \$7.54 10: \$6.90 50: \$6.39 100: \$6.04	<input type="text"/> Buy Min.: 1 Mult.: 1	 Details	Connectors	Receptacle	Crimp	Tin	Copper Alloy	Polybutylene Terephthalate (PBT)	15 A	600 V		
<input type="checkbox"/>	 <a href="#">Enlarge</a>	571-2213362-4	2213362-4	TE Connectivity / AMP	Lighting Connectors Dimming PhotoCell Recept Assy 3/4 105 C <a href="#">Learn More</a>	Page 1,682 Data Sheet	59 In Stock More Info Available	1: \$9.75 10: \$8.83 20: \$8.07 50: \$7.54	<input type="text"/> Buy Min.: 1 Mult.: 1	 Details	Connectors	Receptacle	Crimp	Tin	Copper Alloy	Polybutylene Terephthalate (PBT)	15 A	600 V		
<input type="checkbox"/>	 <a href="#">Enlarge</a>	571-2213362-2	2213362-2	TE Connectivity / AMP	Lighting Connectors Dimming PhotoCell Recept Assy 3/4 150 C <a href="#">Learn More</a>	Page 1,682 Data Sheet	52 In Stock	1: \$10.02 10: \$9.36 20: \$8.93 50: \$8.42	<input type="text"/> Buy Min.: 1 Mult.: 1	 Details	Connectors	Receptacle	Crimp	Tin	Copper Alloy	Polybutylene Terephthalate (PBT)	15 A	600 V		



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# ANSI C136.41-2013 COMPLIANT PRODUCTS

**Dimming and Monitoring are Now in ONE control!**



## ANSI C136.41 Dimming Control

The DIM-3 is a Dusk-to-Dawn Twistlock Photocontrol that sends an LED dimming signal through an ANSI C136.41 compliant receptacle at MidNight. The DIM-3 is a Long Life Photocontrol.



**FEATURES:**

- Uses the ANSI C136.41 receptacle developed for 0-10V dimming driver connectivity

Product	No. & Type of LEDs	Voltage	Nominal Color Temperature <sup>1</sup>	Distribution	Finish <sup>2</sup>	Drive Current <sup>3</sup>	Options
AR18	6M	MV 120-277V	NW 4000K	2 Type 2	BK Black	350 350mA	BSK Bird Spider Kit
	10M	HV 347-480V		3 Type 3	DB Dark	530 530mA	RPA Round Pole Adaptor
	15M			4 Type 4	BR Bronze	700 700mA	HSS <sup>4</sup> House Side Shield
	18M			5 Type 5	WH White		FDC <sup>5</sup> Fixed Drive Current
	20M						PCR NEMA Photocontrol Receptacle
	24M						PCR5 ANSI 5-wire Photocontrol Receptacle
	30M						PCR7 ANSI 7-wire Photocontrol Receptacle
							SC PCR Shorting Cap
							MSL7 <sup>6</sup> Motion Sensor with Photocontrol, L7 Lens
							PPS <sup>7</sup> Programmable Power Supply
							ORR Optics Rotated Right
							ORL Optics Rotated Left

# “CONTROL-READY” LUMINAIRES

- What?
  - Dimmable LED driver
  - Low additional up-front material cost
  - Low future upgrade labor cost
- Why?
  - Growing adoption of controllable (e.g. LED) luminaires
  - Minimize cost to add control later
- How?
  - Exterior plug/receptacle 
  - Power-door replacement
  - LED driver replacement
  - Interior plug/receptacle
  - Firmware upgrade



# ANSI C136 STANDARDS IN DEVELOPMENT

- ANSI C136.48 – “Remote Monitoring and Control for Roadway and Area Lighting Equipment”
  - Defines the minimal requirements for remote control and monitoring systems used for roadway and area lighting
- ANSI C136.50 – “Revenue Grade Energy Measurement”
  - Defines the minimal requirements for energy metering devices in a roadway and area lighting control system

# LONMARK INTERNATIONAL

161

- Industry consortium
  - Many applications
  - 15 street lighting members
- Based on the ISO/IEC 14908 series of standards for networked control
- Full interoperability (including application layer), primarily for wired physical implementations
- Design specification(s) + compliance testing and certification

<http://www.lonmark.org/connection/solutions/lighting/streetlighting>



# THE TALQ CONSORTIUM

- Industry consortium
  - 13 regular members
  - 15 associate members
- Defines a standardized interface (including application layers) between central management systems and outdoor lighting networks
- Does not specify Physical or Data Link layers
- Design specification(s) + compliance testing and certification

<http://www.talq-consortium.org/>

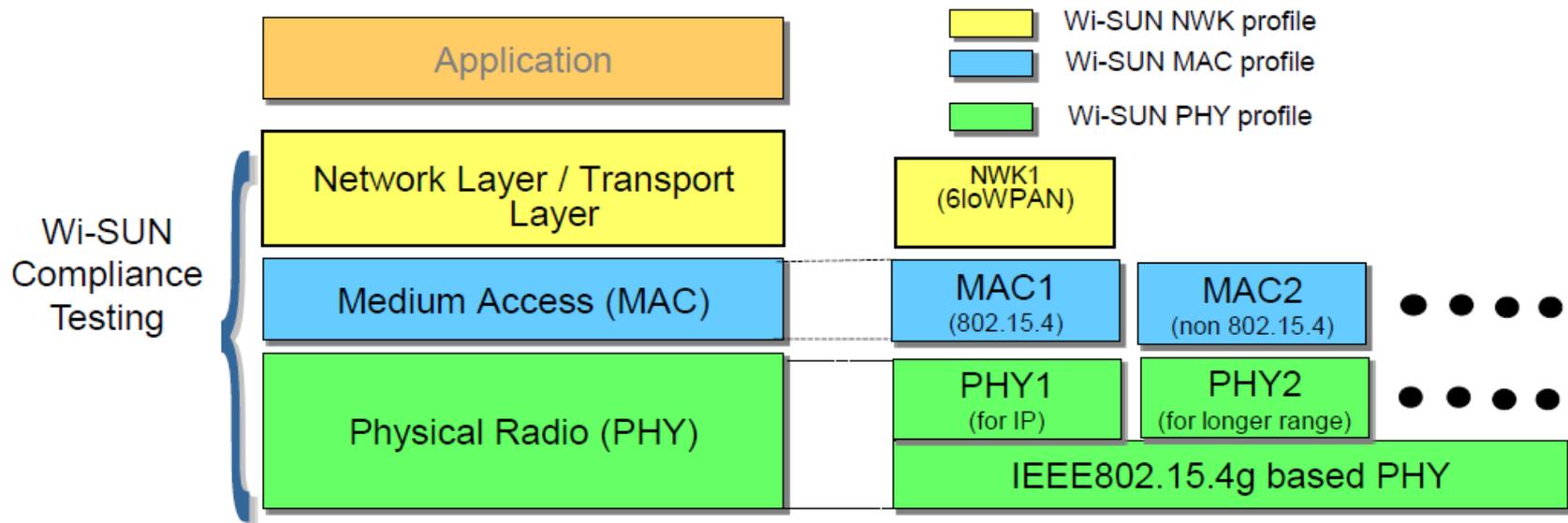
# WI-SUN ALLIANCE

- Industry Consortium
  - 9 Promoter Members
  - 49 Contributor Members
  - 5 Observer Members
- IEEE 802.15.4g Physical and Data Link
- IPv6, 6LoWPAN Network and Transport protocols
- Does not specify Application layer
- Design specification(s) + compliance testing and certification

<http://www.wi-sun.org>

# WI-SUN ALLIANCE

- Primarily focused on Physical & Data Link Layers, with Network layers as required
- Does not specify Application layer



# ZIGBEE NEIGHBORHOOD AREA NETWORK

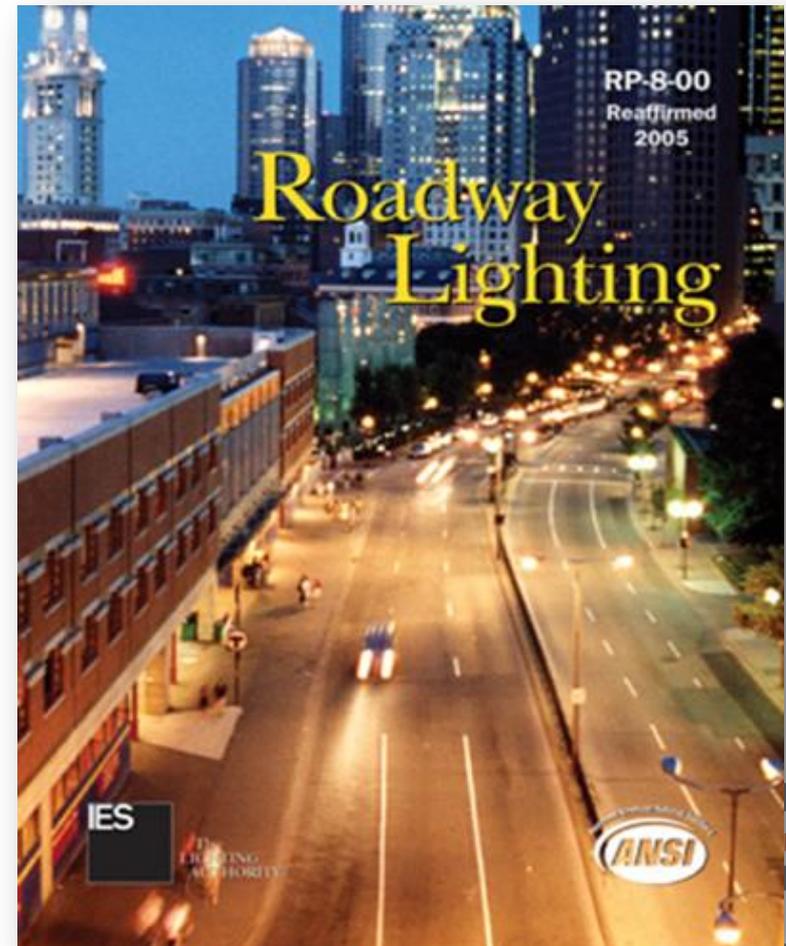
- Industry consortium
  - Many applications
  - NAN members currently not specified
- Intended to be the last-mile, outdoor access network that connects smart meters and distribution automation devices to Wide Area Network (WAN) gateways
- IEEE 802.15.4g Physical and Data Link
- IETF Network and Transport protocols, including IPv6, RPL, UDP and TCP
- Does not specify Application layer
- Design specification(s) + compliance testing and certification

<http://www.zigbee.org/what-is-zigbee/utility-industry/>

# LIGHTING STANDARDS AND RECOMMENDED PRACTICES

170

- Have focused on illumination requirements to meet visual task requirements and ensure safety
- Based on legacy technology; largely do not take into account newer technologies, connected lighting, and adaptive strategies
- Need to evolve in sync with LED source and networked lighting control adoption



LIGHTFAIR

INTERNATIONAL

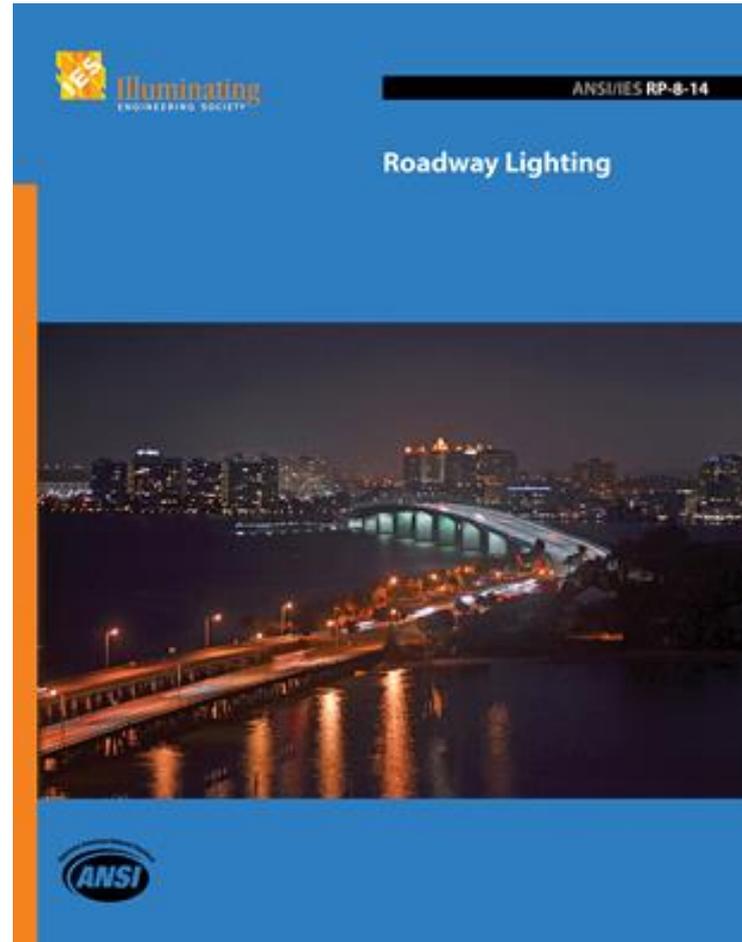
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# IES RP-8-14 – ROADWAY LIGHTING

171

- Includes adaptive lighting recommendations
- Light levels based on road classification
- Suggests that road classification may be adapted based on actual traffic conditions
- Refers to emerging international guidelines on adaptive lighting (CIE – 115-2010)



# CIE 115:2010 – LIGHTING OF ROADS FOR MOTOR AND PEDESTRIAN TRAFFIC

- Takes improved performance of luminaires and lamps and introduction of controls into account
- Provides a structured model for the selection of the appropriate lighting classifications, taking into account parameters relevant to visual tasks requirements
- By taking into account time dependent variables like traffic volume or weather conditions, the model offers the possibility to use adaptive lighting systems

# CIE 115:2010 – LIGHTING OF ROADS FOR MOTOR AND PEDESTRIAN TRAFFIC

- Six Illuminance Classes
- $M = 6 - Vws$
- $Vws = \text{Sum of } Vw$
- Higher Speed, Higher Volume, Higher Density, More Parked Vehicles
  - → Lower M
  - → Higher illuminance

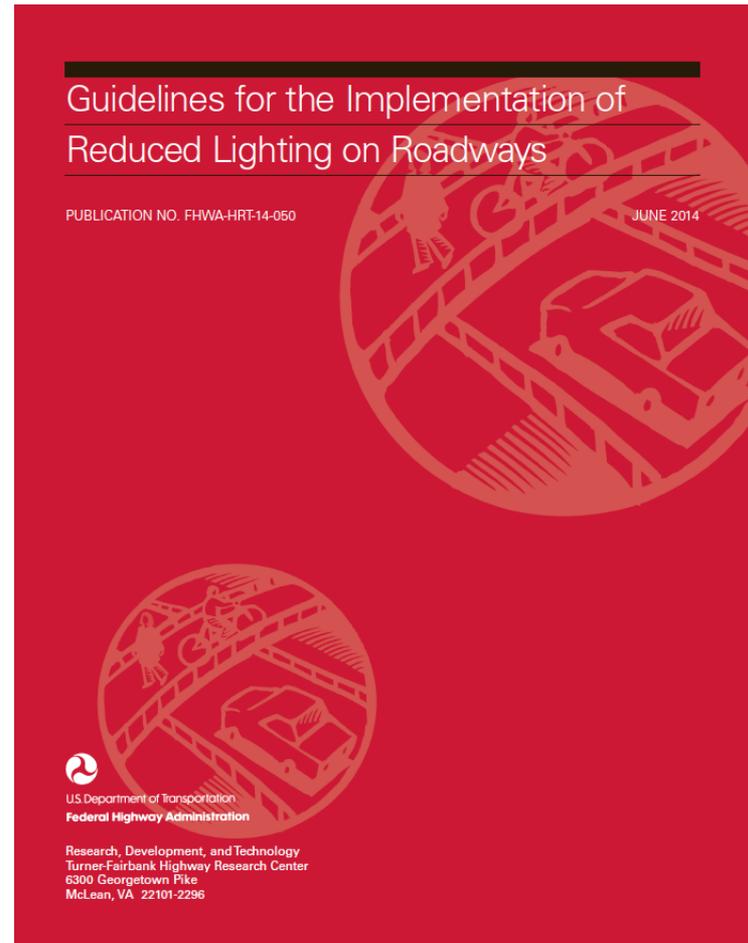
Class	M1	M2	M3	M4	M5	M6
Avg. Luminance	2.0	1.5	1.0	0.75	0.5	0.3
Avg. Illuminance	50	30	20	15	10	7.5

Parameter	Weighting Values (Vw)
Speed	1, 0.5, 0
Traffic Volume	1, 0.5, 0, -0.5, -1
Traffic Composition	2, 1, 0
Separation of Carriageways	1, 0
Intersection Density	1, 0
Parked Vehicles	0.5, 0
Ambient Luminance	1, 0, -1
Visual Guidance, Traffic Control	0.5, 0

# FHWA GUIDELINES

## Criteria for Luminance Selection

- Speed
- Traffic Volume
- Median
- Intersection/Interchange Density
- Ambient Luminance
- Guidance
- Pedestrians and Bicycles
- Parked Vehicles
- Facial Recognition



<http://www.fhwa.dot.gov/publications/research/safety/14050/14050.pdf>

# DOE MODEL SPECIFICATION FOR NETWORKED OUTDOOR LIGHTING CONTROL SYSTEMS

- A tool designed to help cities, utilities, and other local agencies accelerate their adoption of systems that can further reduce the energy and maintenance costs of operating their streetlights.
- A major update to the original “Model Specification for Adaptive Control and Remote Monitoring of LED Roadway Luminaires”
  - Renamed to better reflect its evolving scope
  - A work-in-progress, a living document that reflects user experiences and the changing commercial market

<http://www1.eere.energy.gov/buildings/ssl/control-specification.html>

# VERSION 2.0

- Released April, 2014
- Introduction of a Backhaul Communication Network section with associated requirements
- Separation of the Start-Up and Commissioning sections with updated or enhanced requirements for both
- Further refinement focused on facilitating independent bids for Central Management System(s), Backhaul Communication Network(s), and Field Devices.
- More user notes, new and updated references to industry standards activities, and continued clarification of specifications recommended for all users vs. those deemed optional and likely to be only required by some users.

# INTENDED USE

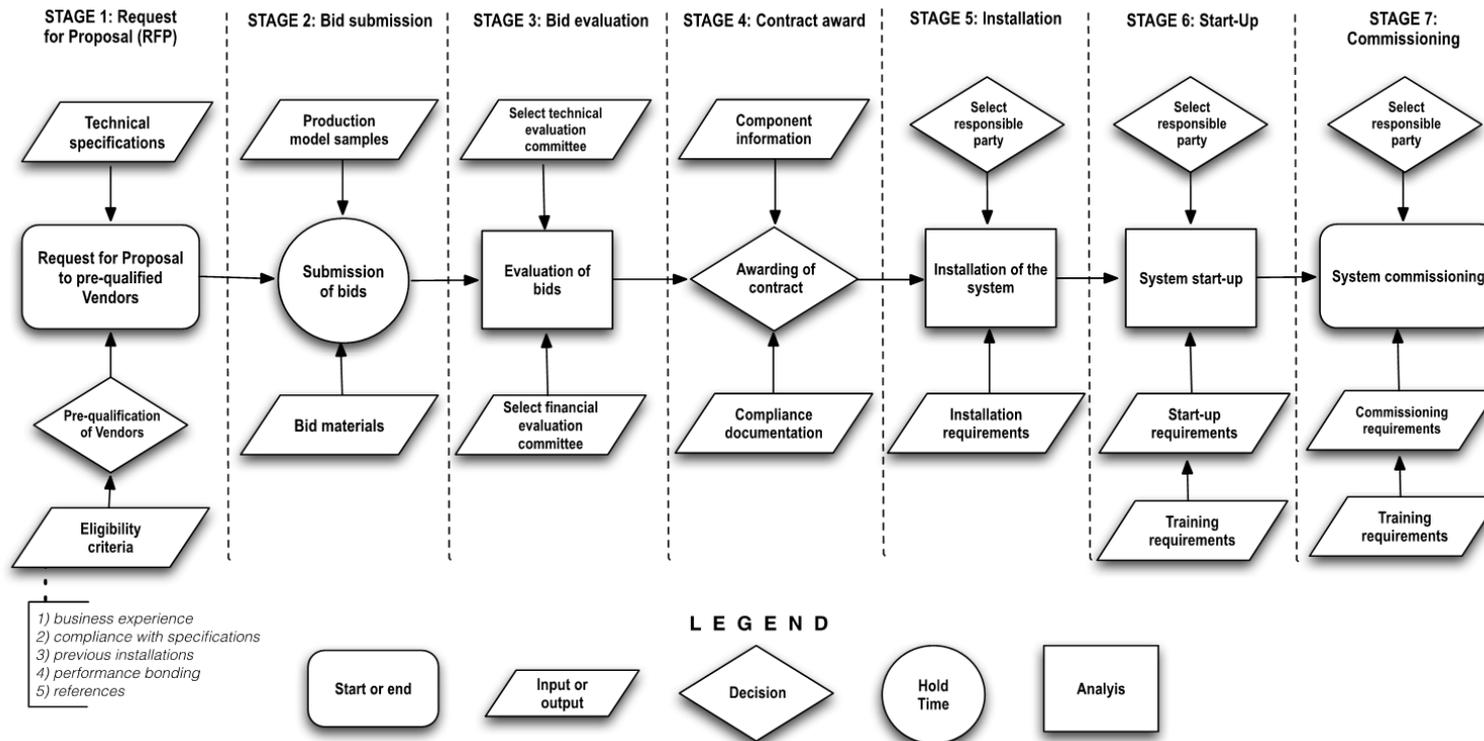
- Intended to serve as a modular reference for drafting Requests for Qualifications (RFQ's), Requests for Information (RFI's), Requests for Proposals (RFP's) or similar documents
- Not intended to serve as a standard specification, and therefore should not (and in unedited form, can not) be used to create a list of qualified products
- Intended to be customized as needed to meet the needs of a specific User

# CONTENT

- A template for translating unique user needs into clear and consistent specification language
- Some suggested content is considered suitable for all Users, and therefore presented as mandatory requirements.
- Other suggested content is considered suitable for only some Users, and is therefore presented as Optional requirements.

# ORGANIZED TO SUPPORT TYPICAL PROJECT STAGES

## NETWORKED LIGHTING CONTROL SYSTEM PROJECT STAGING



- PART 1 – INTRODUCTION
  - Lists of normative and informative standardized references
  - A structure for incorporating user-specific references
  - A set of definitions
- PART 2 – SUBMITTED MATERIALS
  - Suggested non-technical content that might be included in a RFQ, presented at the announcement of an RFP, included in a RFP, presented prior to signing a Contract, or included in Contract terms
- PART 3 – SYSTEM DESCRIPTION
  - Suggested content for describing the scope of a new project in terms of what Components are being procured as well as what Components comprise an existing System

# ORGANIZATION

- Parts 4-7 focused on Component types and warranty terms
  - PART 4 – CENTRAL MANAGEMENT SYSTEM
  - PART 5 – BACKHAUL COMMUNICATION NETWORK
  - PART 6 – FIELD DEVICES
  - PART 7 – COMPONENT WARRANTY

# ORGANIZATION

- Parts 8-11 focused on post-procurement project stages and maintenance terms
- PART 8 – COMPONENT INSTALLATION
- PART 9 – SYSTEM START-UP
- PART 10 – SYSTEM COMMISSIONING
- PART 11 – SYSTEM MAINTENANCE

# ORGANIZATION

- Appendices A-G contain suggested structure and examples for describing existing equipment that comprise an existing System, or will be integrated separately into the System
  - Appendix A: Existing Central Management System
  - Appendix B: Existing Backhaul Communication Network(s)
  - Appendix C: Existing Field Devices
  - Appendix D: Existing Luminaires
  - Appendix E: Existing Sensor(s)
  - Appendix F: Existing Asset Management System(s)
  - Appendix G: Existing Intelligent Traffic System(s)

# SPECIFYING INTEROPERABILITY

## 6.5 INTERCHANGEABILITY AND INTEROPERABILITY

- A.  Optional: Field Devices or Field Device networks shall be certified as compliant with the TALQ v\_\_\_\_ standard, and Interoperable with TALQ certified Central Management Systems.
- B.  Optional: Field Devices or Field Device networks shall be certified as compliant with the LonMark v\_\_\_\_ Outdoor Luminaire Controller standard.
- C.  Optional: Field Devices or Field Device networks shall be certified as compliant with the LonMark v\_\_\_\_ Smart Luminaire Controller standard.
- D.  Optional: Field Devices shall be Interoperable with the Central Management System specified in Appendix A.
- E.  Optional: The Vendor shall demonstrate Field Device Interoperability with the existing Central Management System described in Appendix A prior to INSTALLATION.
- F.  Optional: The Vendor shall provide standard production model samples of all Field Device Components required for User verification of Interoperability with the existing Central Management System described in Appendix A prior to INSTALLATION.
- G.  Optional: Field Devices shall be Interoperable with the Backhaul Communication Network(s) specified in Appendix B.
- H.  Optional: The Vendor shall demonstrate Field Device Interoperability with the existing Backhaul Communication Network(s) described in Appendix B prior to INSTALLATION.
- I.  Optional: The Vendor shall provide standard production model samples of all Field Device Components required for User verification of Interoperability with the existing Backhaul Communication Network(s) described in Appendix B prior to INSTALLATION.
- J.  Optional: Field Devices shall be Interchangeable with the Field Devices specified in Appendix C.
- K.  Optional: The Vendor shall demonstrate Field Device Interchangeability with the existing Field Devices described in Appendix C prior to INSTALLATION.
- L.  Optional: The Vendor shall provide standard production model samples of all Field Device Components required for User verification of Interchangeability with the existing Field Devices described in Appendix C prior to INSTALLATION.



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## Q & A

Interoperability, Standards & Specifications

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## Q & A

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**PLEASE REMEMBER TO COMPLETE THE  
COURSE EVALUATIONS.**

Thank you!