Western States Forum
Managed Lighting Control Systems

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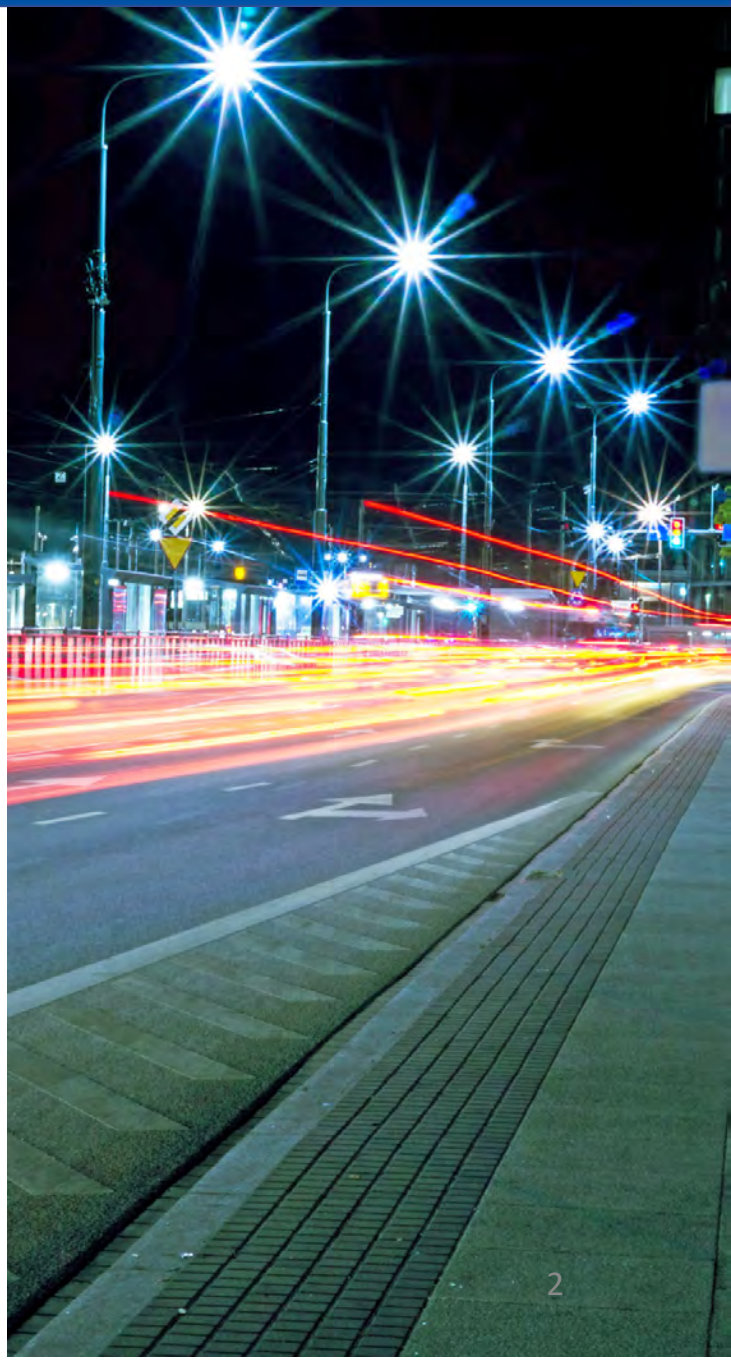
What is a Managed Lighting Control System?

- Enables remote **management** & **monitoring** of roadway lights

- A full system contains:
  1. Control Node (Circuit or Fixture)
  2. Base Station (Vendor Dependent)
  3. Central Control Software (Cloud or Local)

- Benefits may include:
  - Streamlining Maintenance
  - Improved Asset Management
  - Reduction in Energy Consumption
  - Increased Fixture Lifespan
  - Fewer public complaints related to lighting outages



What is a Control Node?

- Enables:
  1. Remote lighting control (on/off/dimming/schedule)
  2. Lighting asset management functionality
- Connects to each fixture using the seven-pin receptacle on each fixture
  - Same receptacle as “dumb” photocell
- Communicates through either on-board cellular radio or low power mesh networking with a base station
  - NDOT's pilot project includes vendors using both communication methods
  - Mesh nodes usually use ISM 908 MHz to 928 MHz bands or 2.4 GHz RF for communication

Dark To Light Node

Ubicquia Ubicell Node

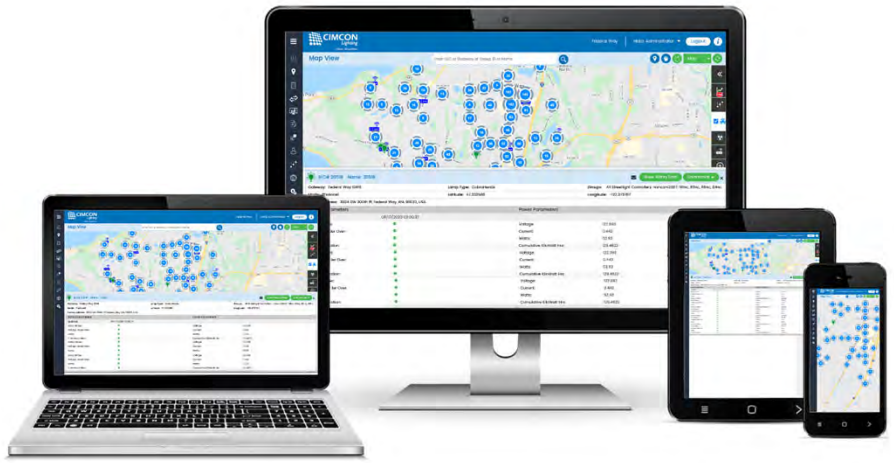
What is a Base Station?

- The Base Station serves as a gateway between the Control Nodes and the Central Control Software
- It aggregates multiple Control Nodes to enable centralized control and monitoring of the lighting system
- Typically, the Base Station uses cellular radio for backhaul, although some vendors offer Ethernet connection options
- Some systems do not use a base station. Each control node connects directly to the Central Control Software through a SIM card or eSIM in each node

GE Current LightGrid Base Station

What is Central Control Software?

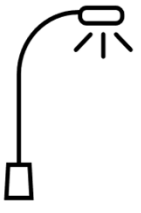
- A cloud-based graphical interface accessed via web browser
- Enables users to configure features such as scheduling or photocell parameters for the Nodes
- Enables users to monitor real-time and historical status and power consumption data
- The system can integrate with NDOT's existing ATMS platform via API or SMTP
- This integration enables immediate alerts for power outages or other events that may impact roadway lighting



Quantela Management Platform

Initial Goals of Adaptive Lighting Project

- Initial project goals ≠ Final project goals!
- Operations Goals:
  - Enable remote control of fixtures
  - Reduce energy consumption
  - Detect vehicular, motorcycle, bicycle, and pedestrian traffic
  - Internet Protocol (IP) communication for all nodes
- Maintenance Goals:
  - Detect conductor theft
  - Enable remote troubleshooting
  - Monitor fixture performance
  - Monitor environmental conditions
- Safety Goals:
  - Enable remote detection of fixture failure
  - Provide adjustable dimming depending on the traffic volume (including vehicles, pedestrians, etc.)
  - Evaluate “bells and whistles” (e.g. Gunshot detection)



Project Timeline

Q2 2019	• NDOT creates Initial Statement of Work
Q1 2020	• State of the Practice Report – Completed
Summer 2020	• Stakeholder Outreach – Completed (and continues as needed)
Q1 2021	• Managed Lighting Handbook – Draft Complete
Summer 2022	• Pilot Design Project Completed
Summer 2023	• Managed Lighting Handbook – Final, Approval Pending
Summer 2023	• Evaluation Criteria Memo – In Progress
TBD	• Pilot Construction Project – In Progress

Adaptive Lighting System – State of the Practice

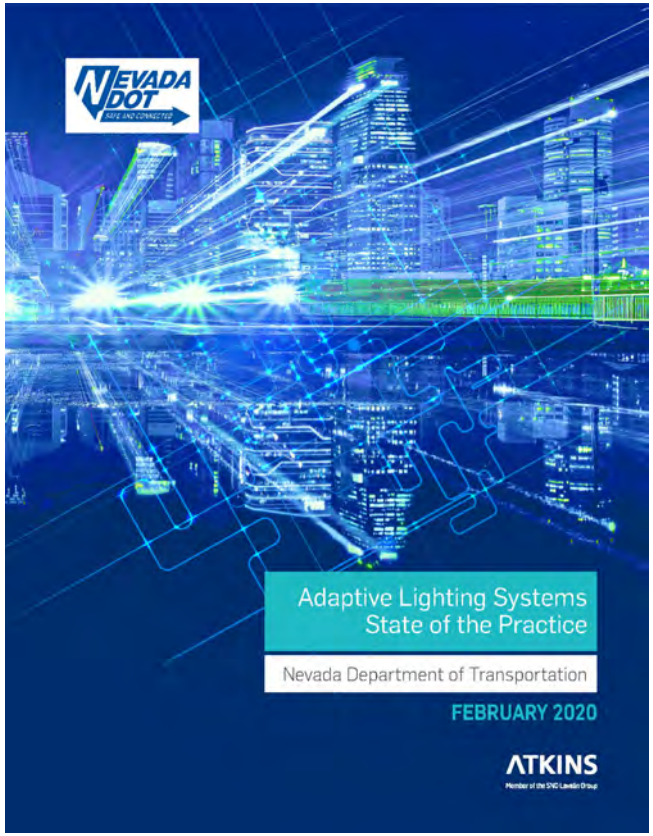
From June 2019-Feb 2020, Atkins developed a State of the Practice report to establish a better understanding of the available systems on the market.

The report included:

- Review of available lighting control systems
- Assessment of NDOT's required capabilities
- Analysis of deployments by others
- Rating of available solutions in early 2020

The report also outlined two additional steps that NDOT should complete to move forward:

- Clearly define standards and specifications to achieve the required capabilities
- Complete a pilot project (currently in progress)

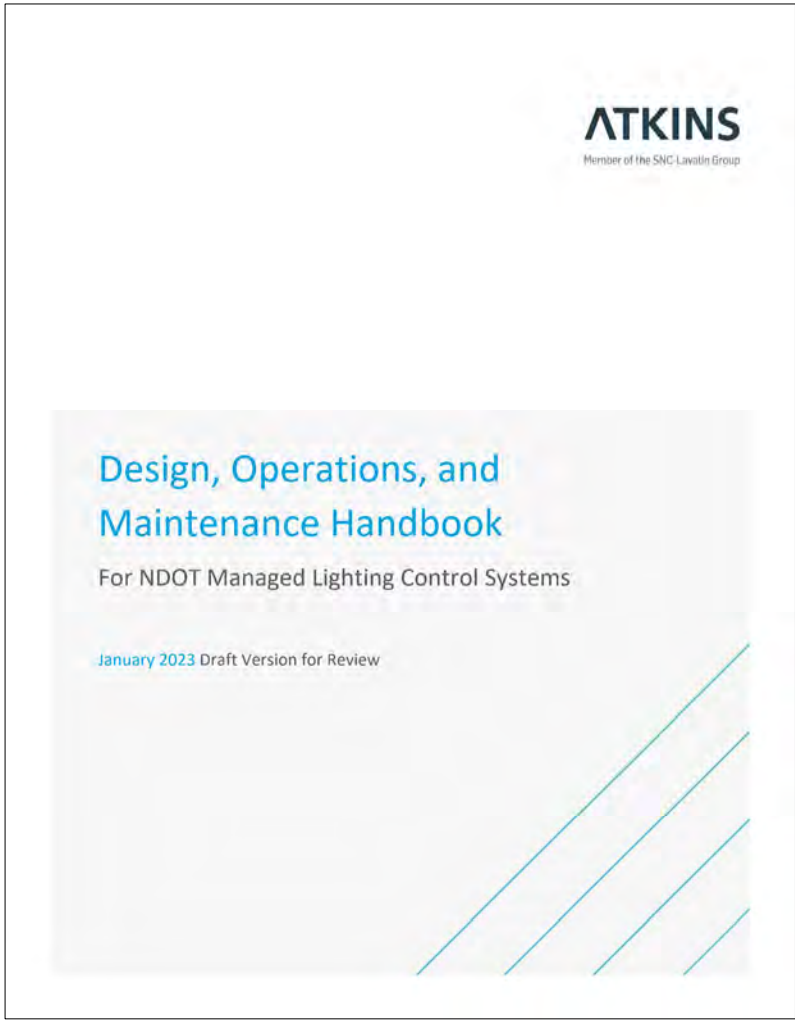


Stakeholder Engagement

- Atkins conducted stakeholder engagement with NDOT districts and RTC FAST.
- Aimed to capture the concerns and feedback of the stakeholders regarding the proposed adaptive lighting system.
- Identified several concerns, including aging infrastructure, limited maintenance resources, and theft/vandalism of lighting infrastructure.
- Based on the stakeholder feedback, it became clear that asset management capabilities would provide the most benefits and should be prioritized.
- The conclusion of the stakeholder engagement campaign led to revising the terminology from adaptive lighting to managed lighting.
- This adjustment demonstrates the importance of engaging with stakeholders to understand their concerns and perspectives, which can ultimately lead to better project outcomes.

Managed Lighting Handbook

- Written for multiple audiences:
  - Design engineers
  - NDOT district staff
  - NDOT SLI staff
- To be used throughout the lifecycle of a deployment:
  1. Design
  2. Operation
  3. Asset Management/Maintenance



Pilot Project – Design Scope

Pilot Design in Washoe Valley & Reno:

- 184 control nodes from five vendors
- Locations:
  - 3 rural interchanges on I-580
  - Approx. 1 mile of urban freeway on I-580
- Mix of existing and proposed luminaires
- Adaptive lighting capabilities:
  - Vehicle detection triggers an increase in light levels for one minute downstream of detected vehicle
  - Originally designed for three rural interchanges, but is now not supported by the other vendors; final design will include functionality at one rural interchange
- Pilot project will evaluate system performance and inform future deployment decisions

Pilot Project Selected Vendors

COOPER Lighting Solutions

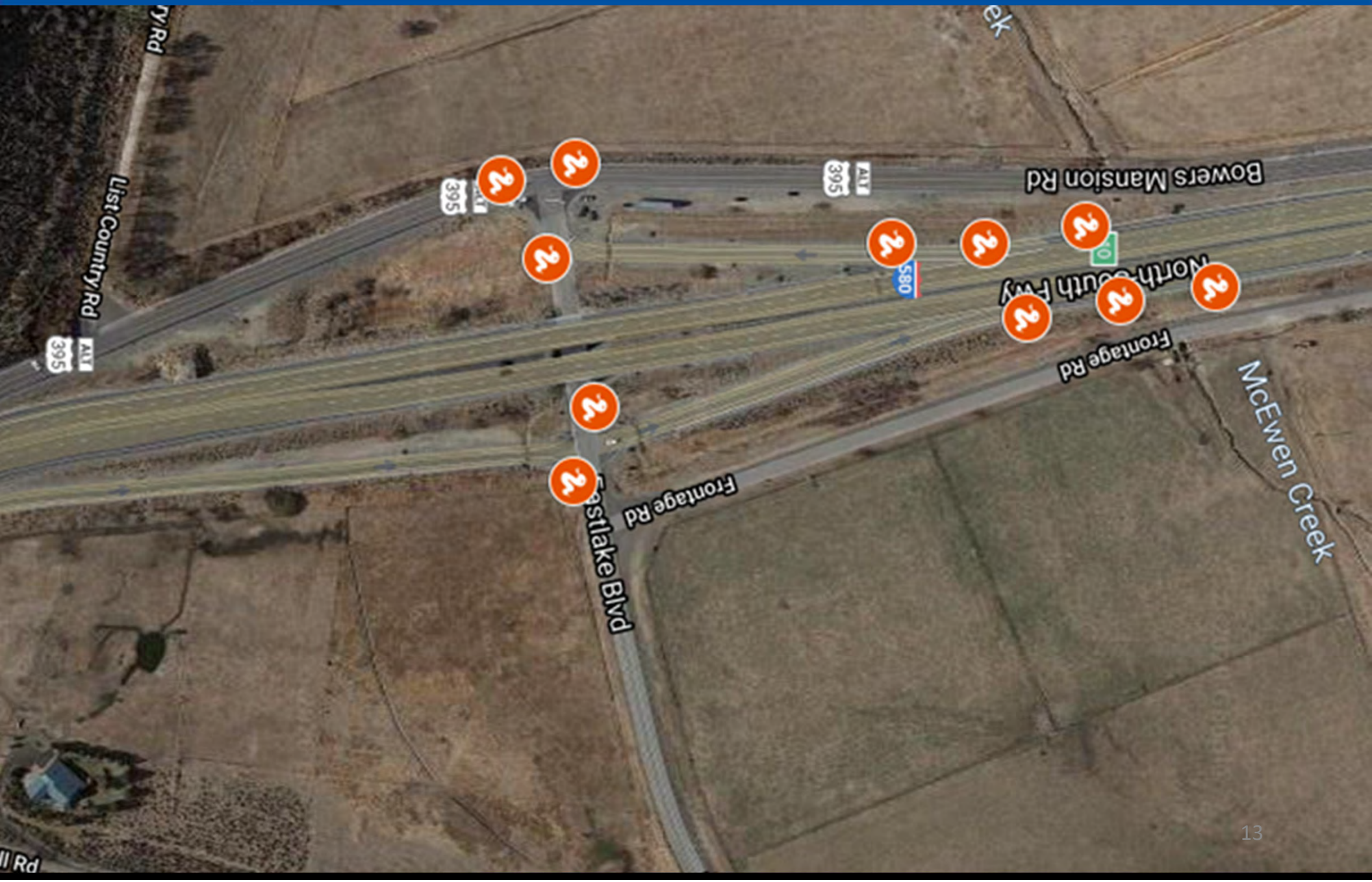
DTL Dark To Light

GE current a Daintree company

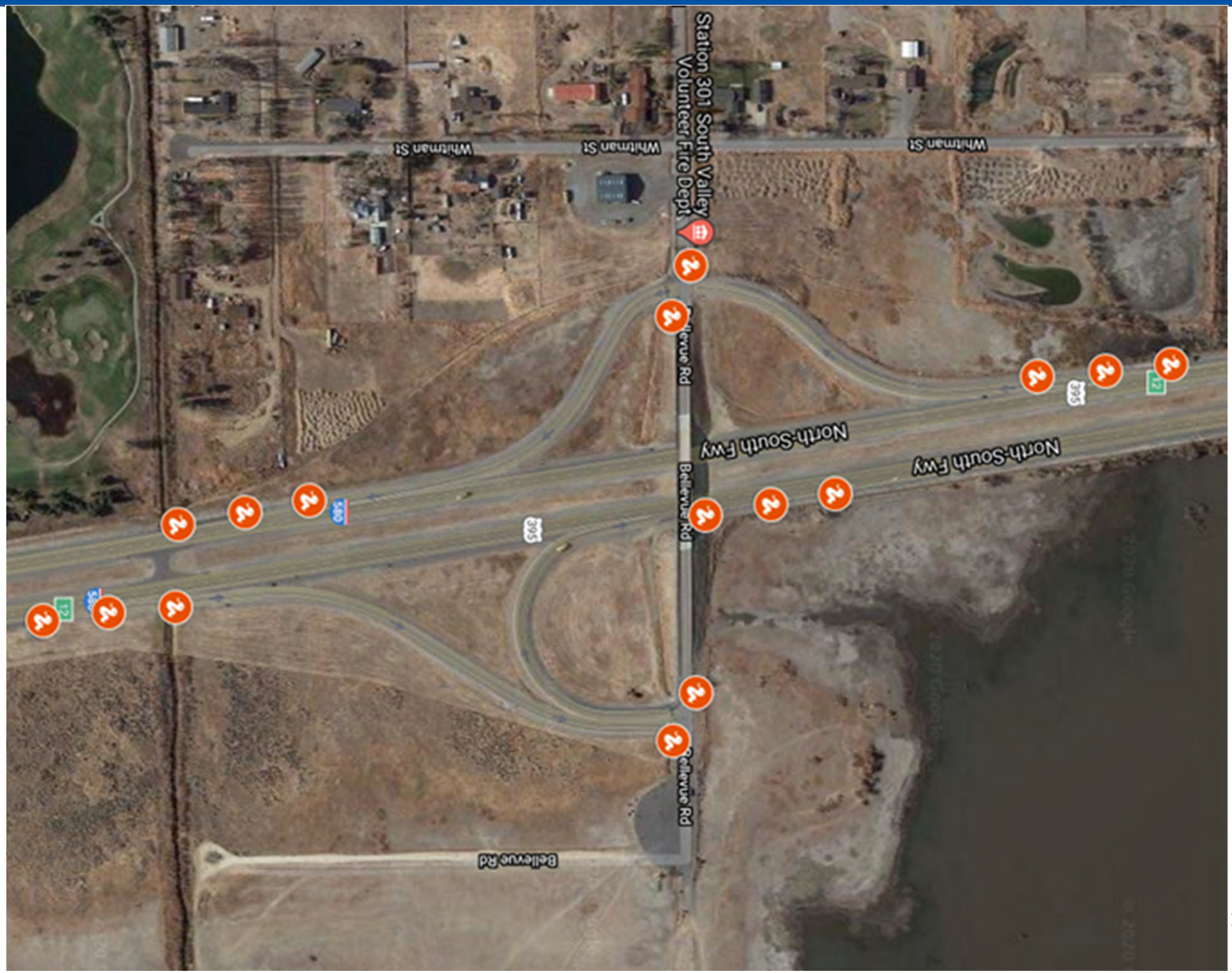
ubicquia

Quantela

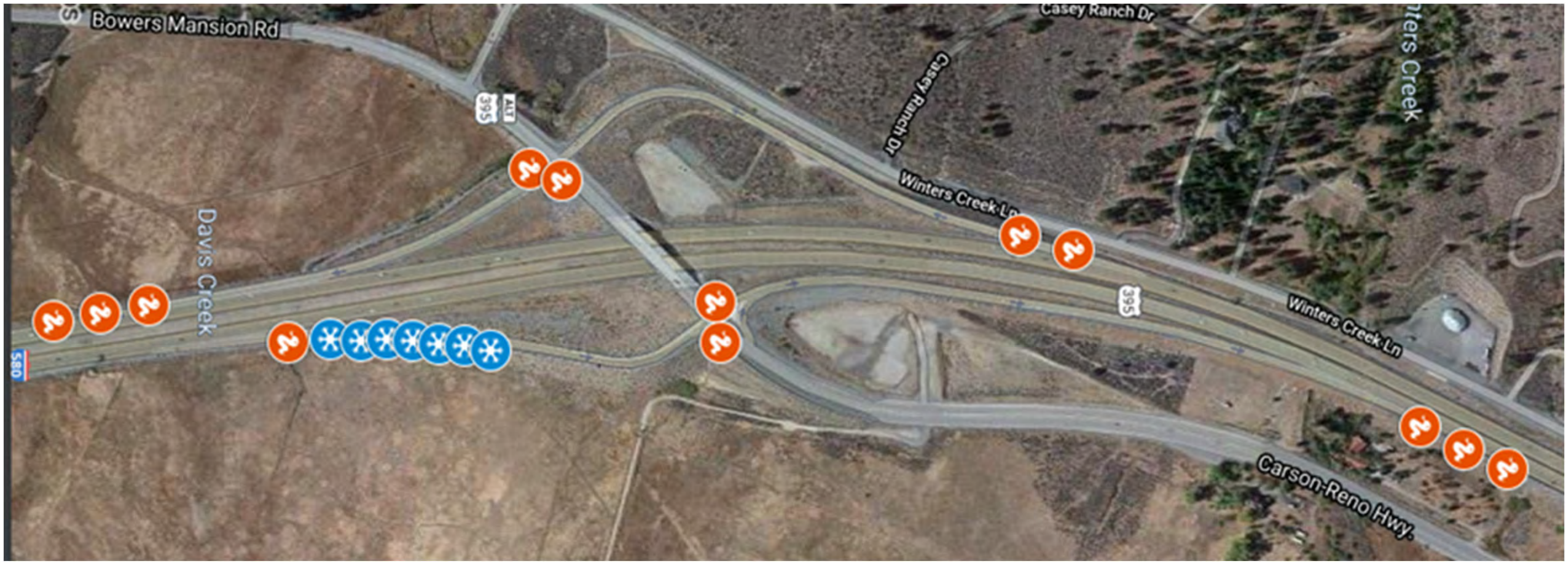
Pilot Project Location: Eastlake Blvd & I-580



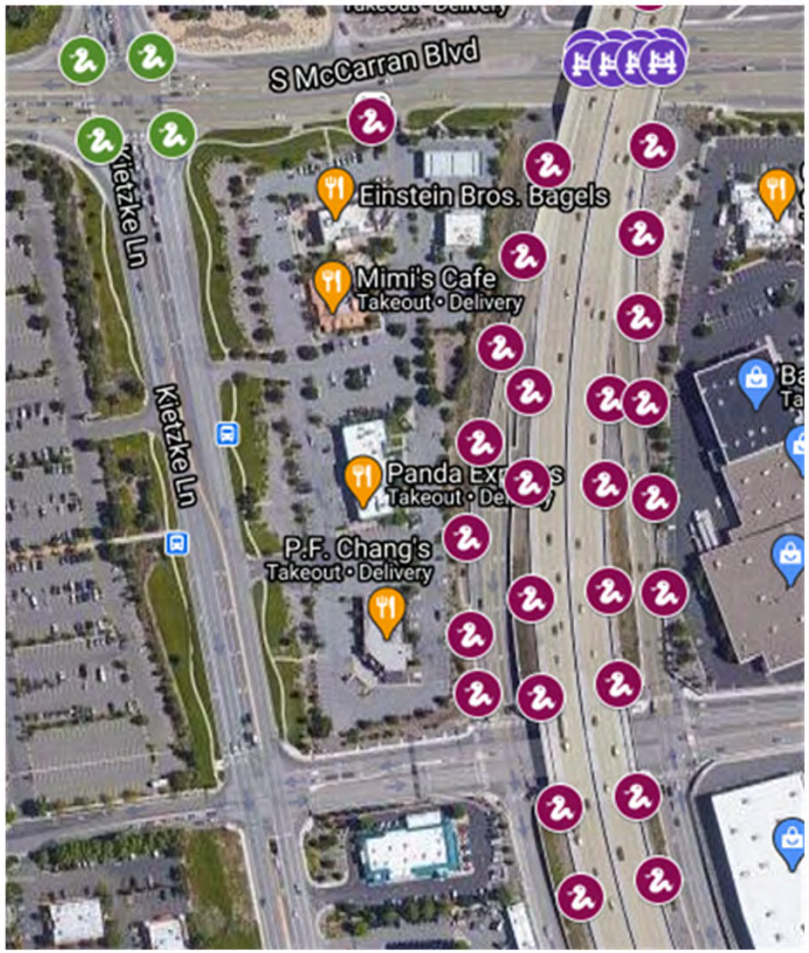
Pilot Project Location: Bellevue Rd & I-580



Pilot Project Location: Bowers Mansion Rd & I-580



Pilot Project Location: I-580 (Meadowood Mall Way to Moana Lane)



Design of Minimum Lighting Levels

- Atkins created AGI32 model to evaluate existing lighting levels
- Compared to minimum levels per NDOT SLI Design Guide
- Rural areas = brighter than required
- Urban areas = at or close to required
- Atkins developed an Excel tool to calculate the percentage of full brightness that each light may be set to achieve the minimum required lighting levels.

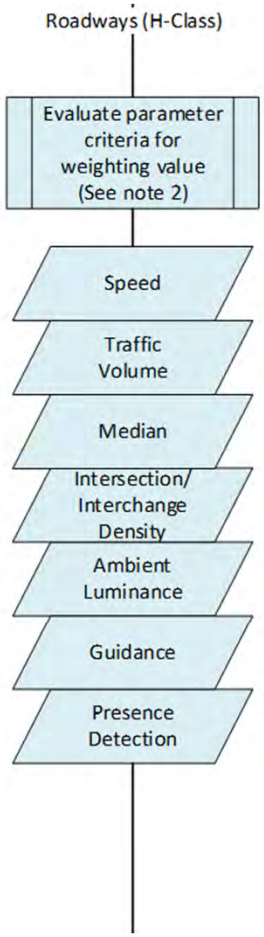
Minimum % light level = required avg luminance ÷ modeled avg luminance

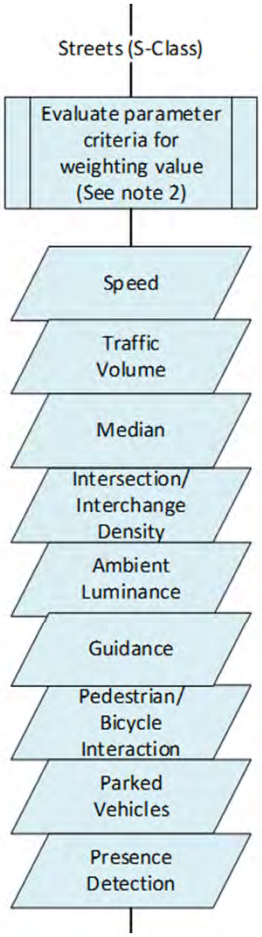
- Operators may set the light levels higher than the minimum percentage but setting any lower would require further engineering evaluation.

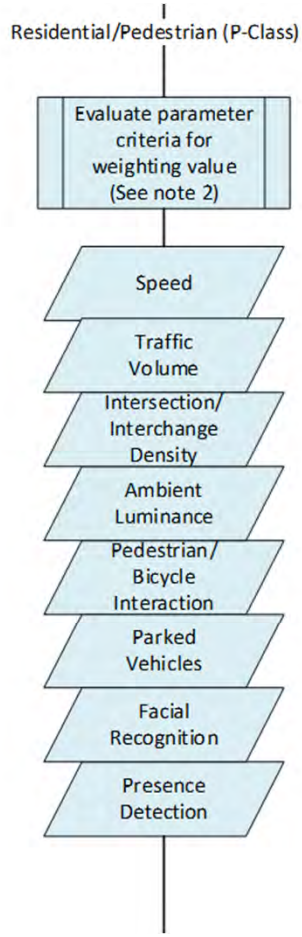
Calculation of Minimum Lighting Levels

- Parameters per FHWA-HRT-14-050 publication, June 2014
- Weighting formula determines lighting class.

$$Lighting\ Class = Base\ Value - \sum Weighting\ Values$$







Selection Criteria for Roadways

Roadway Design Level Selection Criteria. Table 10 From FHWA Guidelines for the Implementation of Reduced Lighting on Roadways (Publication No. FHWA-HRT-14-050, June 2014)						
Parameter	**Selection Option**	**Options**	**Criteria**	**Weighting Value**	**Selection Weight**	**Description**
Speed		Very High	> 60 mph	1		Use 85th percentile speed, or other meaured speed of vehicles.
		High	45-60 mph	0.5		
		Moderate	< 45 mph	0		
Traffic Volume		High	> 2,000 vphpl	1		Use the highest volumes for the time period when adaptive lighting will be used.
		Moderate	1,000-2,000 vphpl	0		
		Low	< 1,000 vphpl	-1		
Median		No	No Median Present	1		Median must be wider than 49.2 ft or have a barrier/designed such that the light from opposing headlamps is limited and not visible to drivers approaching each other. If median is between 32.8 to 49.2 ft, engineering judgment may be used.
		Yes	Glare blocking or wider than 49.2 ft	0		
Intersection/Interchange Density		High	< 1.5 mi between intersections	1		Includes roadways, driveways, and other entrance areas.
		Moderate	1.5-4 mi between intersections	0		
		Low	> 4 mi between intersections	-1		
Ambient Luminance		High	LZ3 and LZ4	1		LZ1: Low Ambient Lighting LZ2: Moderate Ambient Lighting LZ3: Moderately High Ambient Lighting LZ4: High Ambient Lighting
		Moderate	LZ2	0		
		Low	LZ1	-1		
Guidance		Good	> 100 mcd/m^{2}lx (measured values)	0		If pavement marking retroreflectivity measurements are not obtained, evaluate condition pavement markings as good or poor.
		Poor	< 100 mcd/m^{2}lx (measured values)	0.5		
Presence Detection		Pedestrian	Pedestrian presence detection actuates full brightness	-1		Select Pedestrian if both pedestrian and vehicle detection are utilized.
		Vehicle	Vehicle presence detection actuates full brightness	-0.5		
		None	No detection utilized	0		
						Total
						Class

Design of Minimum Lighting Levels

- Lighting Class determined from formula corresponds to minimum design lighting levels.

H-Class Lighting Design Levels. From Table 11, FHWA Guidelines for the Implementation of Reduced Lighting on Roadways (Publication No. FHWA-HRT-14-050, June 2014)				
Class	**Average Luminance (cd/m^2)**	**Maximum Uniformity Ratio (avg/min)**	**Maximum Uniformity Ratio (max/min)**	**Veilling Luminance Ratio**
H1	1.0	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

- Enter the full luminosity of area which is determined by:
  1. Modeling the existing or proposed conditions in AGi32
  2. Use a luxmeter to measure existing lighting conditions

Full Luminosity Selection	
Manual or Calculated Measurement (Candelas per Square Meter)	

Design of Minimum Lighting Levels

Minimum Percent Dim Allowed	
Light Full Luminosity (Candelas per Square Meter)	1.03
Light Minimum Dimmed Luminosity (Candelas per Square Meter)	0.4
Minimum Percent Dim Allowed	**39%**

Remember to check the dimming curve (non-linear) of the fixture LED driver to ensure it is accurately set to the minimum dim level

- Required if you will use the 0V to 10V dimming method (NDOT method)
- Not required if a DALI (Digital Addressable Lighting Interface) driver is used

Live Exercise

Live demonstration of the reduced lighting levels calculator

Two scenarios

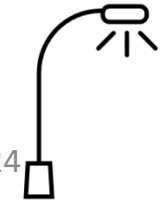
1. Rural Highspeed Roadway
   - The goal is to show how, when following the NDOT Signals, Lighting, & ITS Design Guide for safety lighting, energy consumption can be saved by reducing illumination levels
2. Urban Intersection
   - The goal is to show how using the calculator can show that reducing illumination levels may not be feasible in some scenarios

Pilot Project Construction

- Construction contract awarded to PAR West
- Product material submittals, January 2023
- Submitted models differed from design plan models available just 6 months earlier.
  - Product evolution
  - Only one still supports vehicle detection
- Due to market realities, change order revisions made to the project plans.

Adjusted, Final Goals of NDOT's Managed Lighting Project

- Operations Goals:
  - Enable remote control of fixtures
  - Reduce light levels where applicable
  - Track energy consumption
  - Provide adaptive dimming depending on vehicle traffic (1 location)
- Maintenance Goals:
  - Conductor theft detection
  - Enable remote troubleshooting of fixture failure
  - Fixture lifecycle performance monitoring
- Safety Goals:
  - Increased uptime of light fixtures with early alert of failures
  - Enable early alert of utility power outage



Lessons Learned

- Be Agile
  - The fast-evolving product category requires flexibility and adaptability to achieve success.
  - Examples:
    1. Switching from NDOT fiber to cellular for backhaul
    2. Reducing the number of vendors supporting presence-based dimming.
- Focus on required capabilities rather than specific means and methods.
- Further lessons will be learned as construction and commissioning are completed.

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