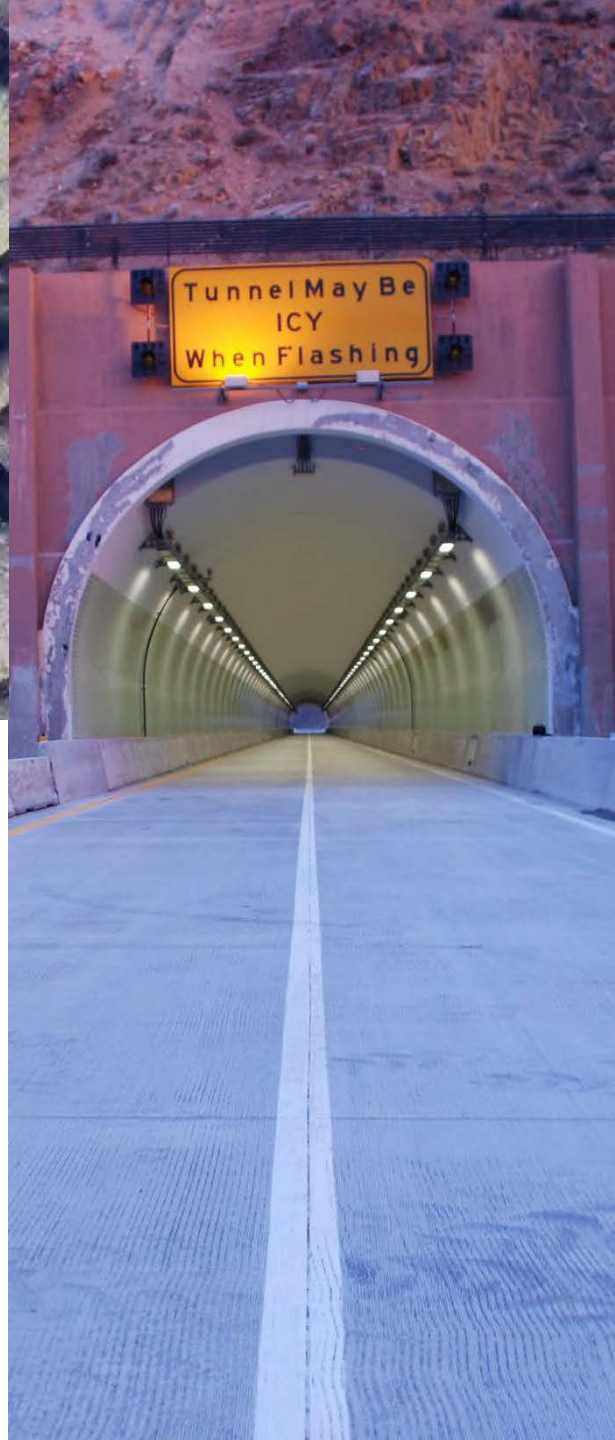




Let There Be Light

Tunnel Lighting Controls

NEVADA DOT
SAFE AND CONNECTED

05/07/2024

Eric MacGill
emacgill@dot.nv.gov, 775-888-7561

Frederick (Rick) Tydeman, PE
ftydeman@dot.nv.gov, 775-888-7556

NEVADA DOT
SAFE AND CONNECTED

Introduction

- Contract 4509, IR 80, Carlin Tunnel Lighting
- Tunnel Lighting System
  - Nyx Hemera Tunnel Lighting Addressable Control System – Energy Management (TLACS-EM)

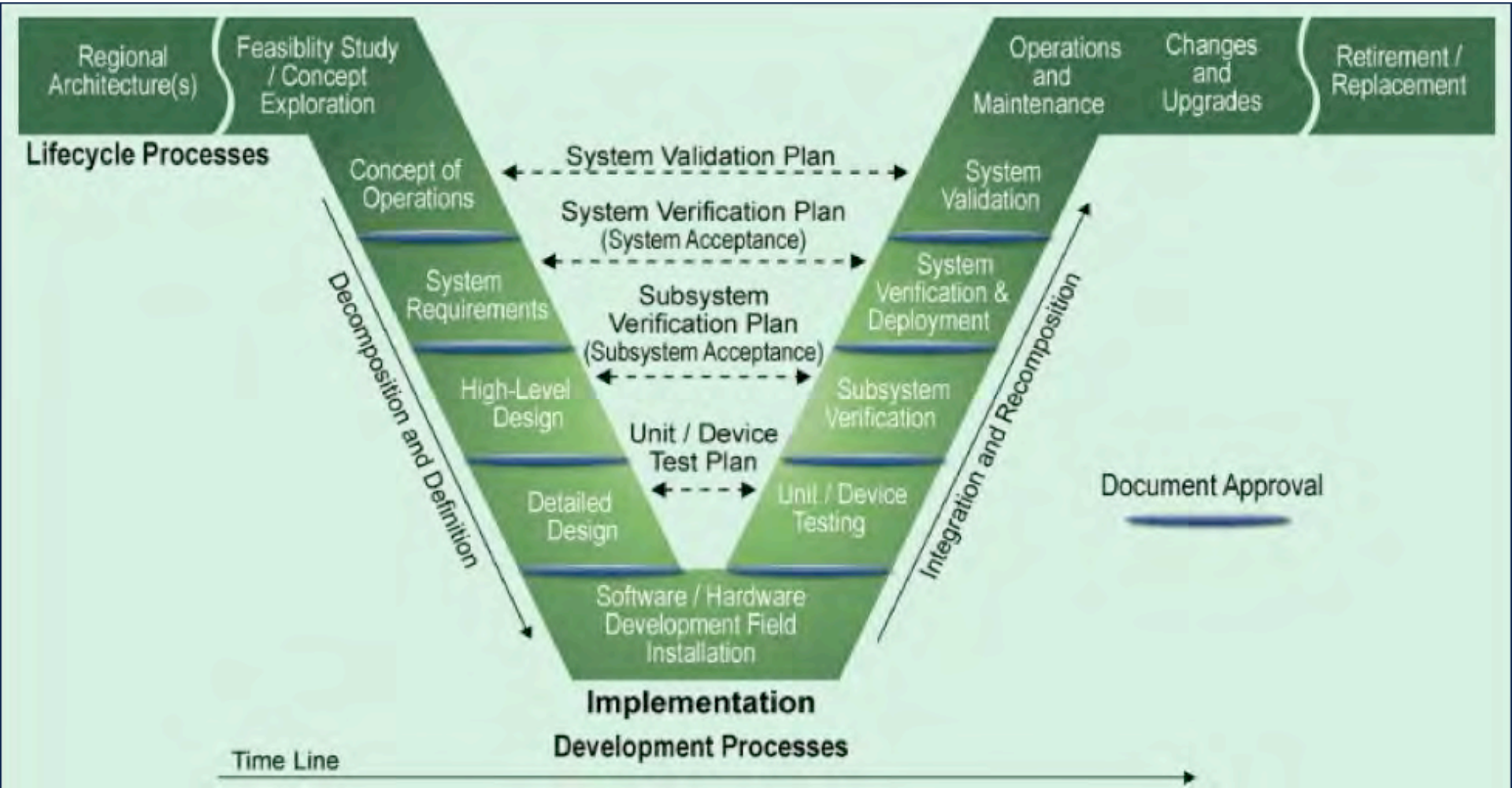
General Background

- Tunnel Lighting
  - Design Considerations

2013 Project Background

- Contract 3540, IR 80, Carlin Tunnel Lighting
  - Research
  - Systems Engineering
  - Selected System
  - Components
  - Operational Ability

2013 Project Systems Engineering



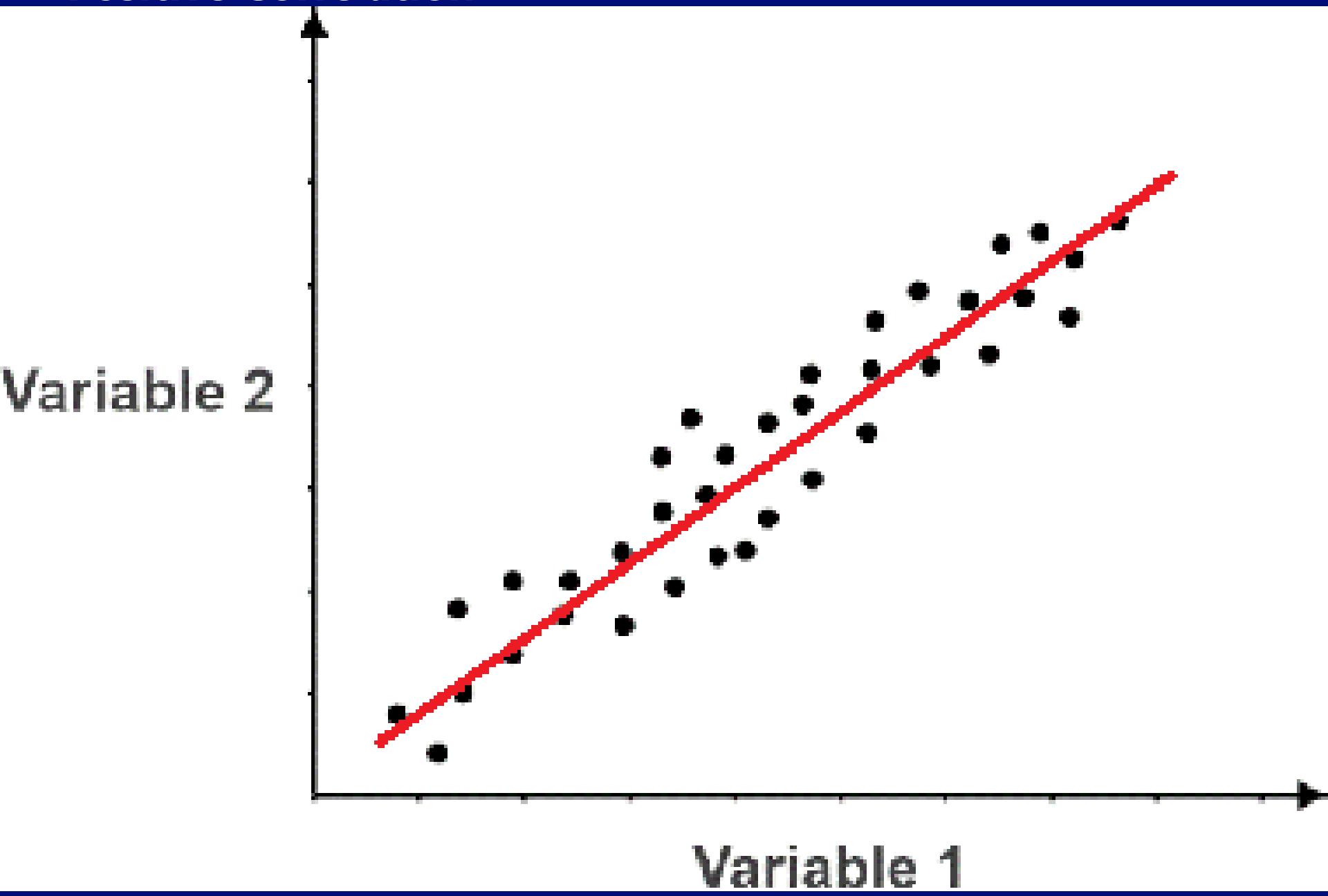
2013 Project Research

- Off-the-Shelf System
  - Controls
  - Lighting
- All Light Emitting Diodes (LED) Luminaires
- Hardwire Controls vs. Power-Line Carrier

2013 Project Operational Ability

- Internal light levels positively correlated to external light levels
  - Mitigate “driving in to a dark tunnel”
- Maximum and minimum light levels
  - Prevent threshold temporary eyesight blinding
  - Ensure enough light to see internal tunnel environment without significantly impacting nighttime driver vision

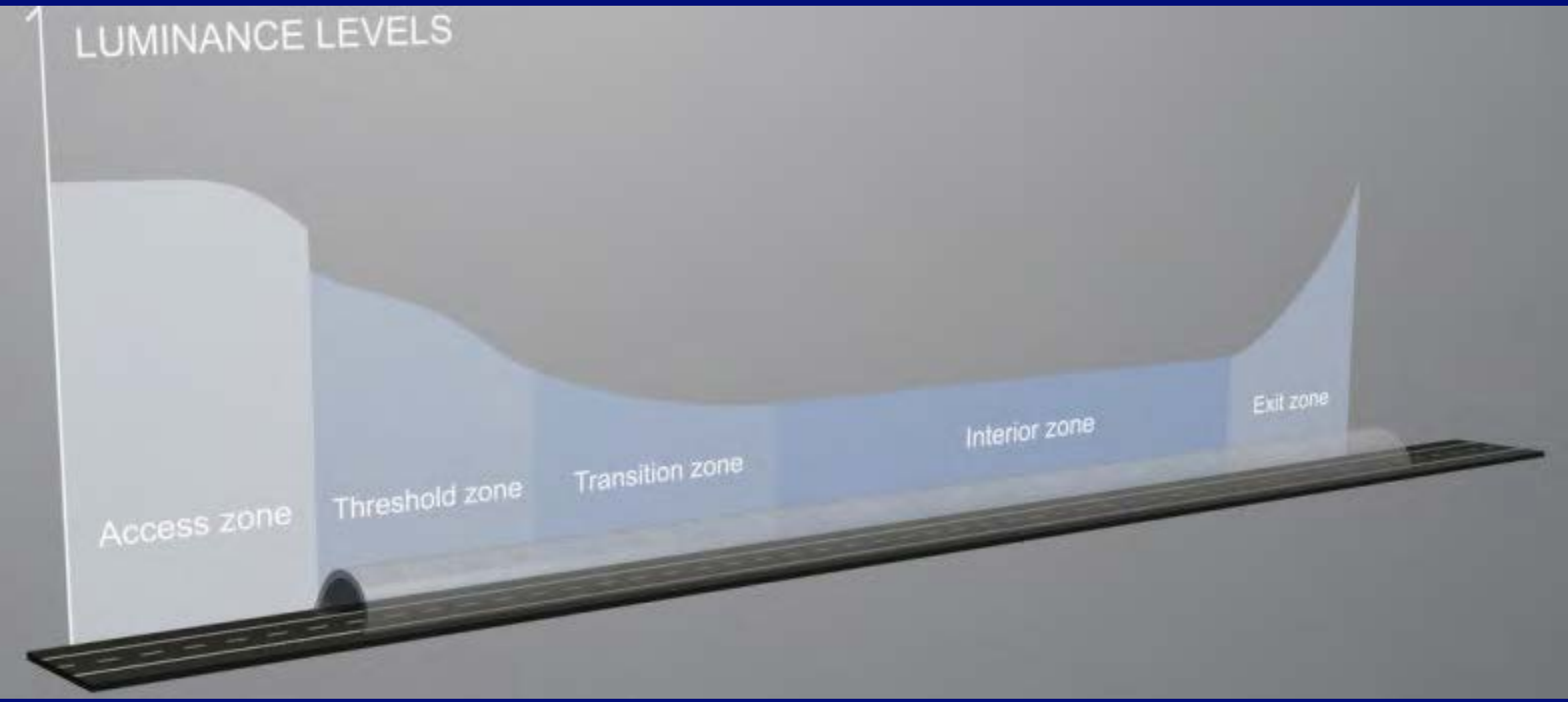
Positive Correlation



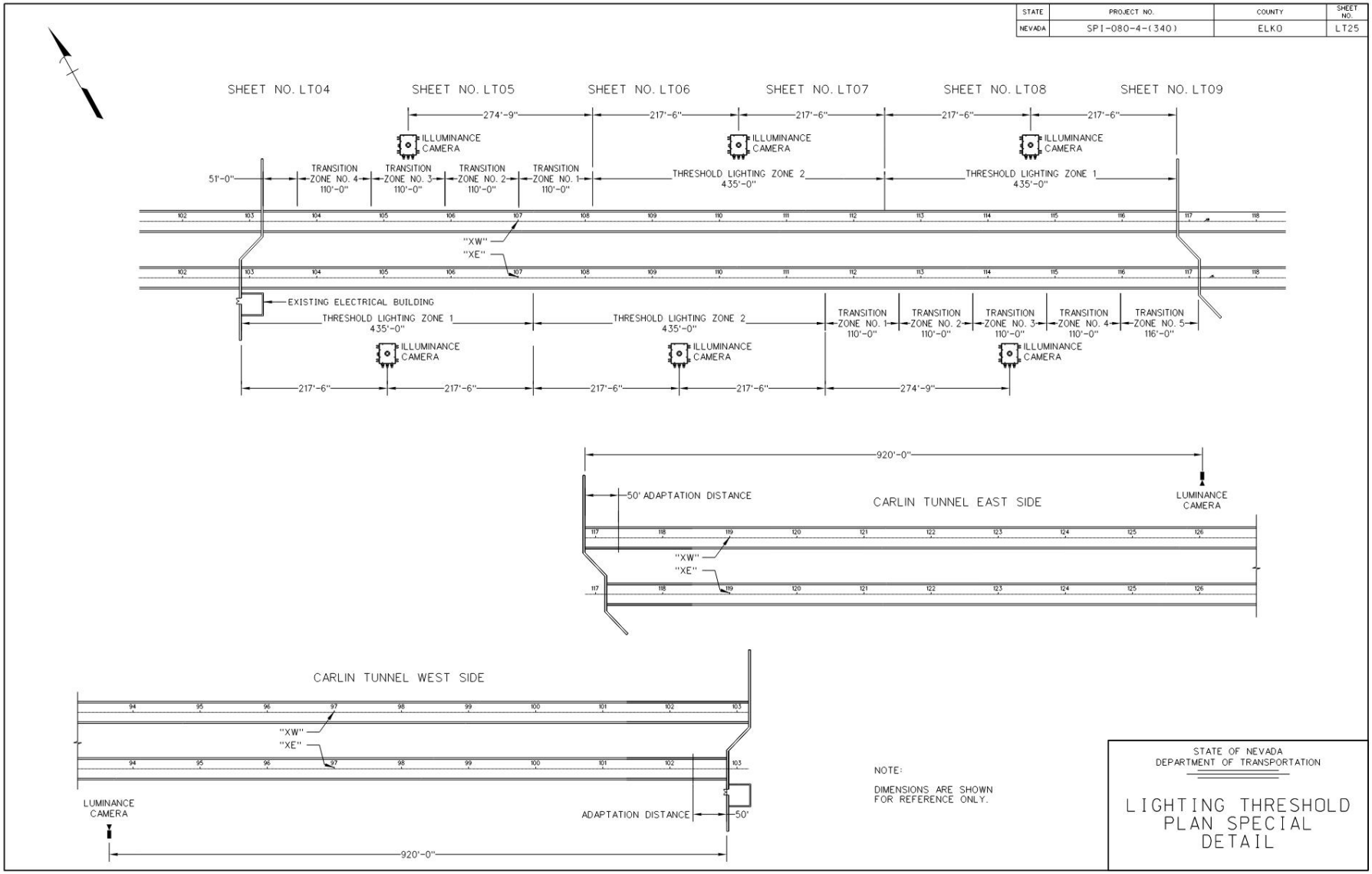
2013 Project Operational Ability

- Lighting zones
  - Access
  - Threshold
  - Transition
  - Interior
  - Exit

Threshold Lighting



Threshold Lighting



2013 Project Major Components

- Luminaires
  - Researched all tunnel lighting manufacturers
  - Obtained IES files and performed lighting analysis calculations to determine number of luminaires needed to meet lighting design specifications
  - Obtained samples of each luminaire
  - Created life-cycle cost model including capital outlay and operational costs (power, maintenance)
    - Component replacement timeline
  - Internal meeting with technical advisory committee (designers, maintainers) to evaluate maintainability and life-cycle cost of each luminaire for final selection

2013 Project Major Components

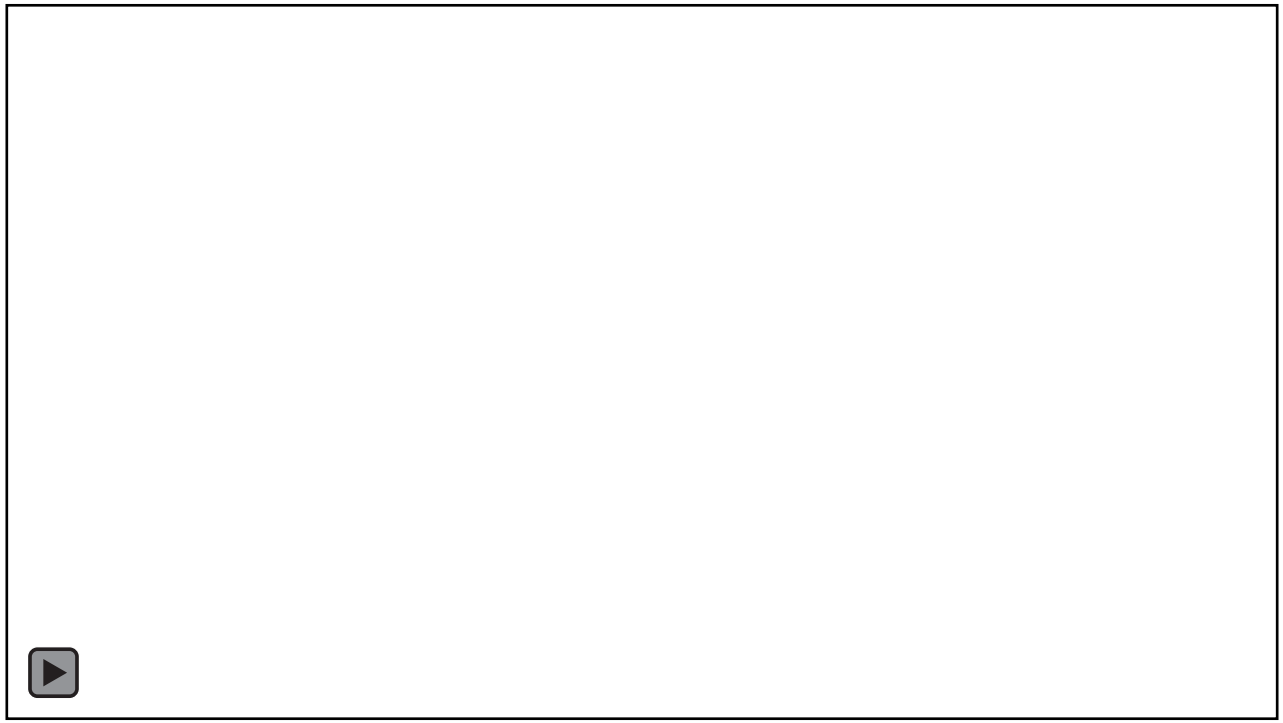
- Power System
  - Overview of power circuit feeding tunnel
  - Required filtering
    - Power/Harmonic filtering

2013 Project Major Components

- Lighting Control System
  - How [hardwire; power and communications]
    - Individual control of each luminaire
  - What
    - Separate wiring vs. powerline carrier
  - Why
    - Testimonials from US clients
      - Established powerline carrier (less expensive long-term maintenance and reduced capital outlay)

2013 Project

- Discovery Channel Video



2013 Project Comparison

Current Tunnel Lighting vs. Previous Tunnel Lighting



Current Project Background

- Challenges Leading To Project Need
  - Discontinued Manufacturer Components
    - LED Boards
    - LED Drivers
  - NDOT Maintenance
    - Stockpile Depletion
    - Troubleshooting

Maintenance Issues

- Mean time between component failure
  - System design based on manufacturer provided information
    - System installed and spare components should last for 20 years
    - Components would be available for 20-year period for replacements

Current Project

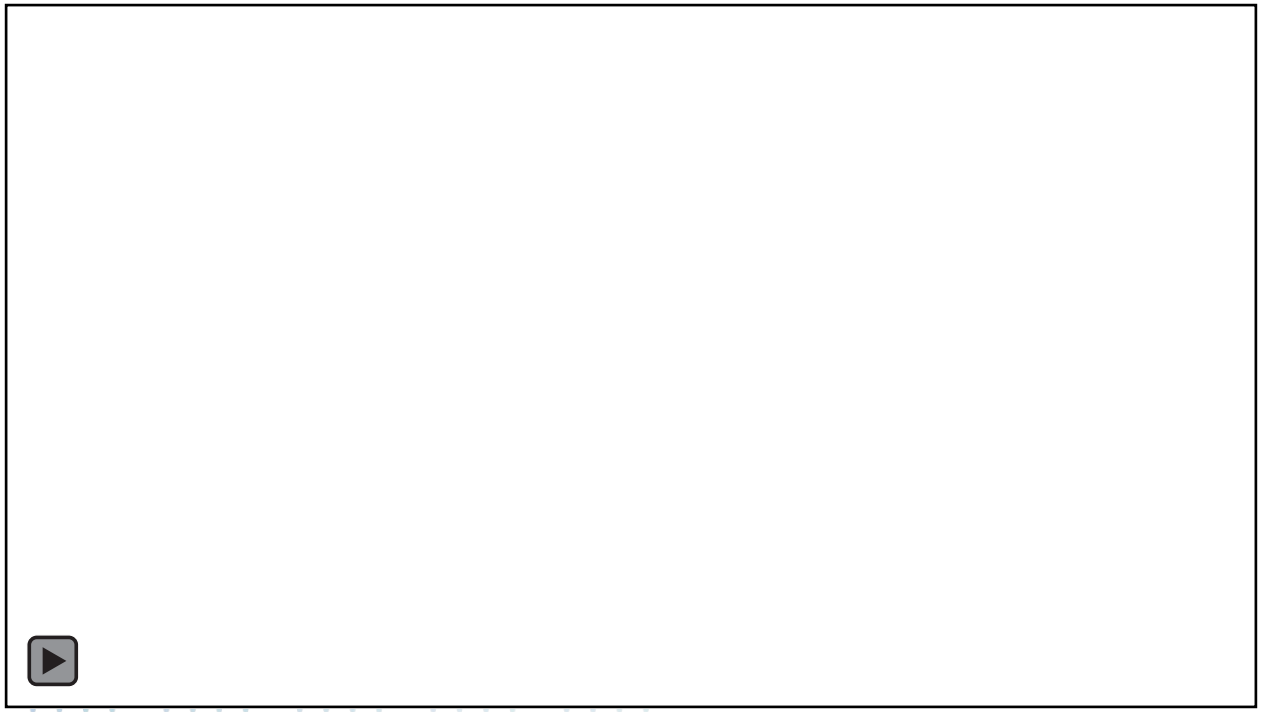
- Contract 4509 – IR 80, Carlin Tunnel Lighting
  - Scope
    - Location
  - Schedule
  - Budget

Lighting Control System

- Nyx Hemera Tunnel Lighting Addressable Control System – Energy Management (TLACS-EM)
- Major TLACS-EM Systems Components
  - Power-Line Carrier Communications (PLCC)
  - Lighting Control Cabinet (LCC)
  - Lighting Controller (LC)
  - Local Product Controller (LPC)
  - Lighting Control Sensors
    - Illuminance Camera - ILCAM
    - Luminance Camera - LCAM

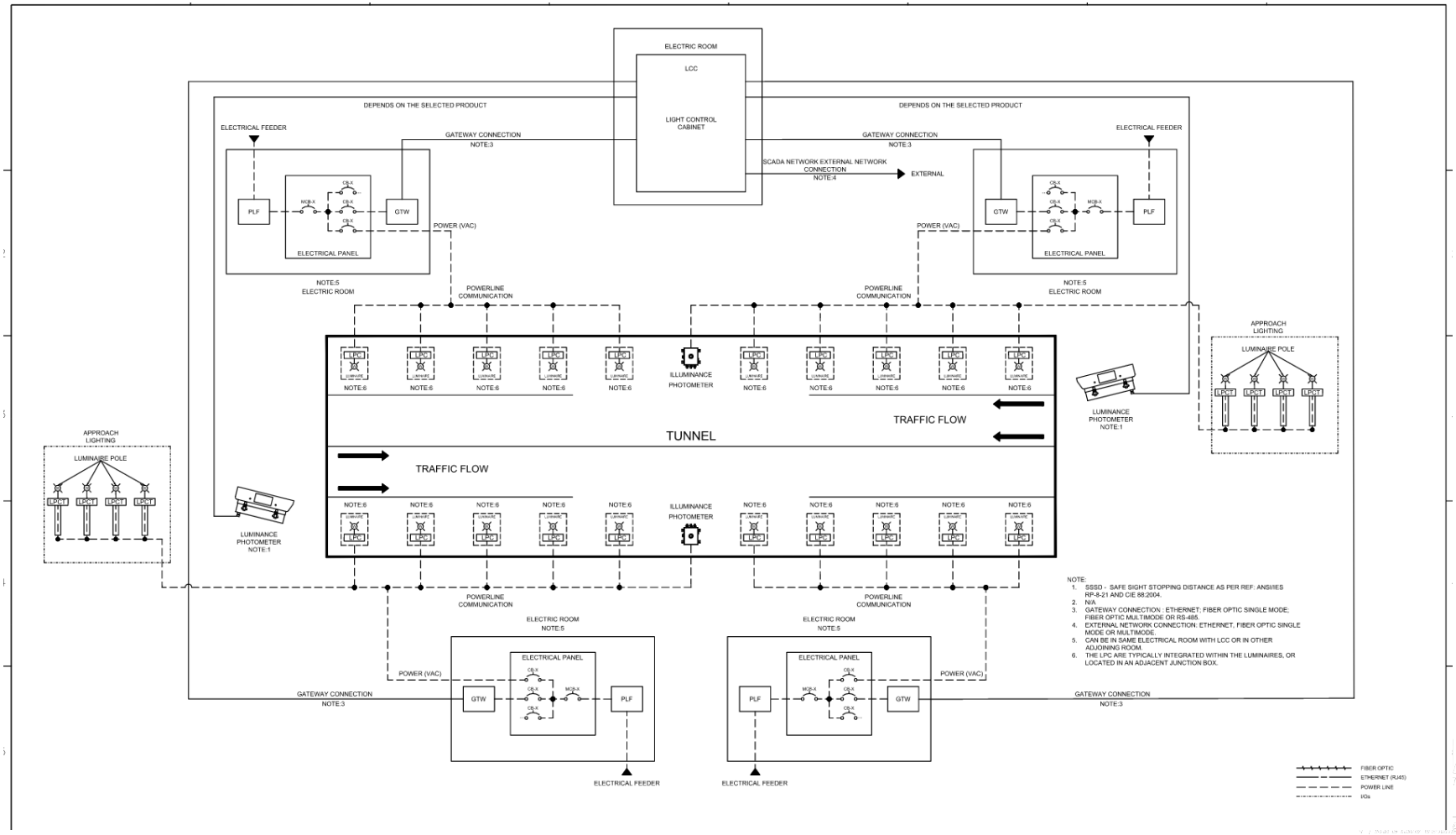
Lighting Control System

- TLACS-EM



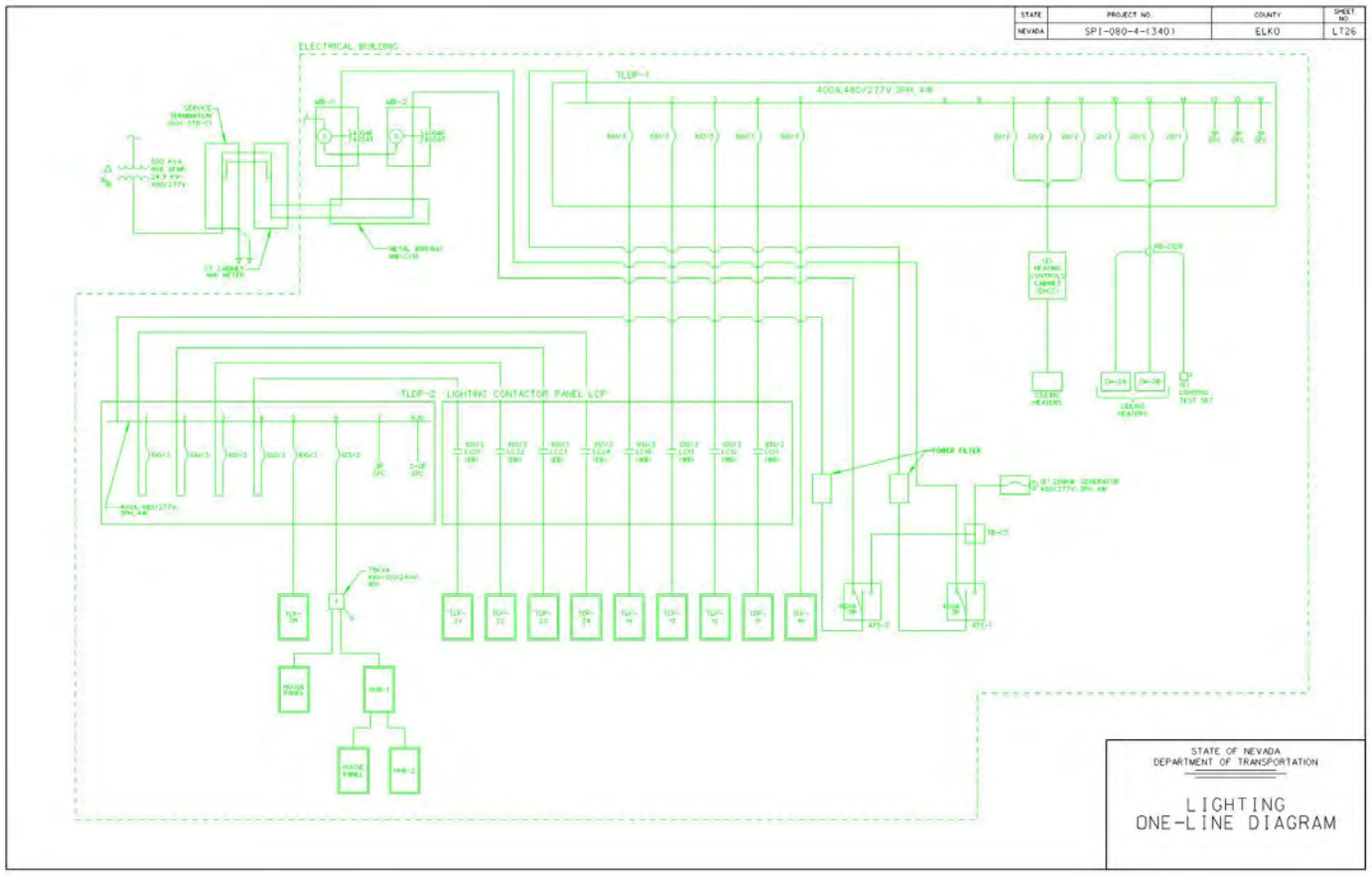
Lighting Control System

- System Diagram



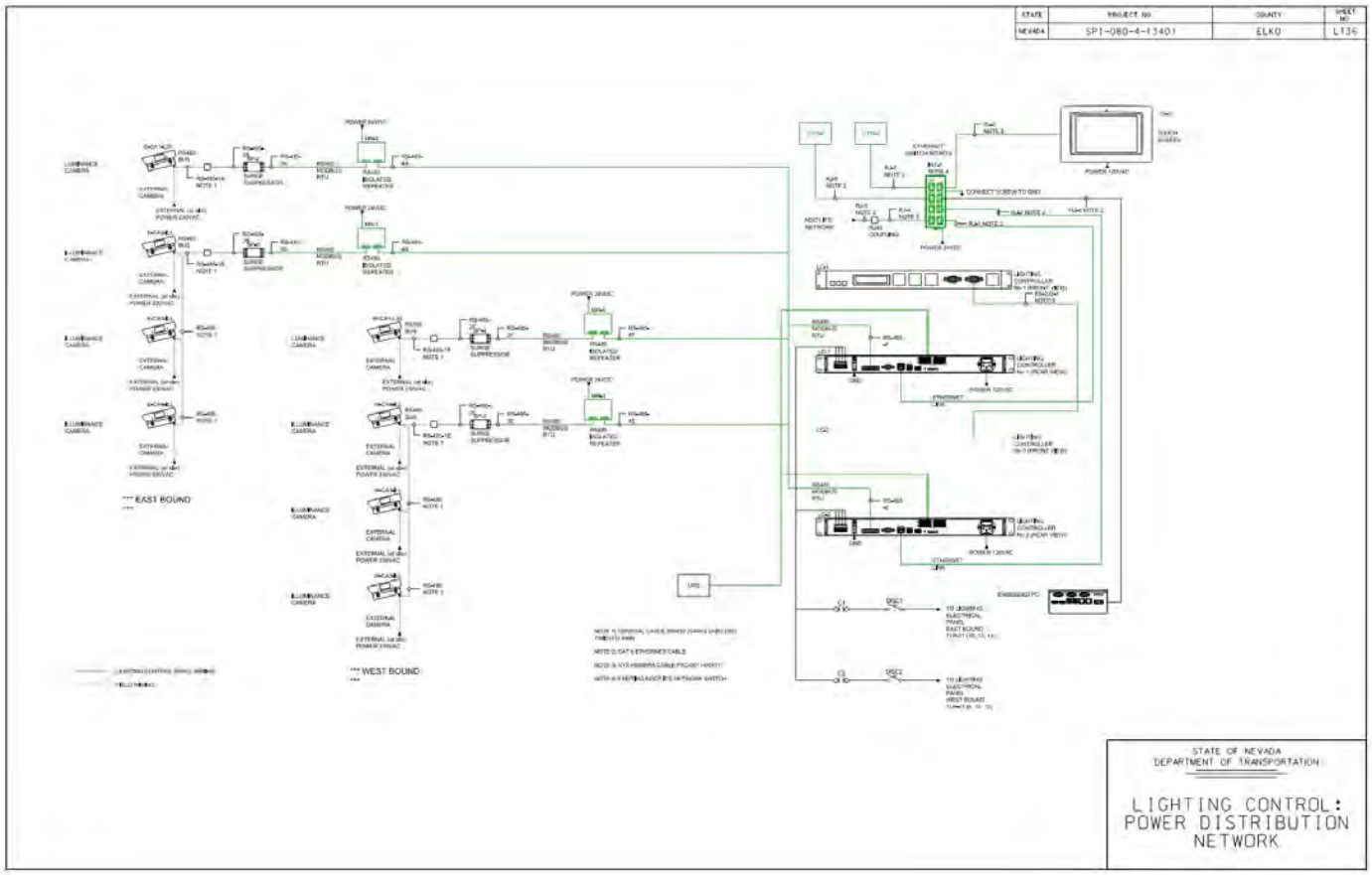
Lighting Control System

- Lighting One-Line Diagram



Lighting Control System

- Communications Distribution Network Diagram

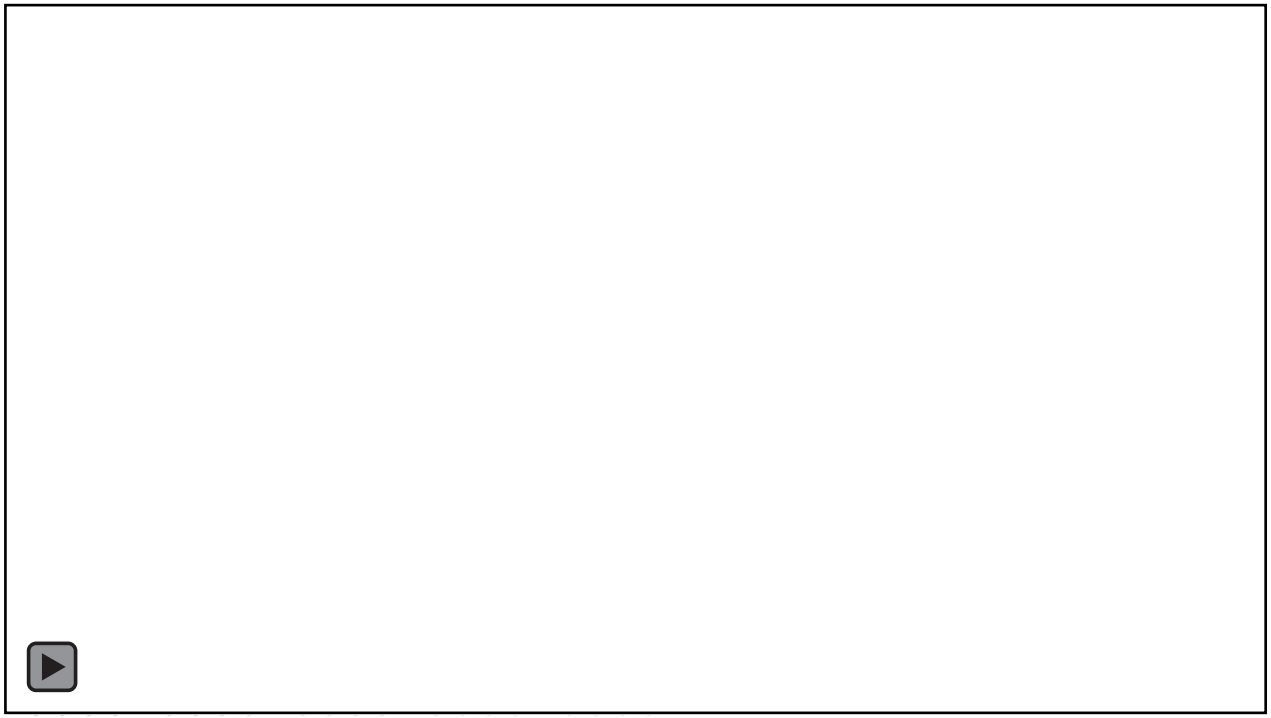


Power Supply

- Harmonic Filtering

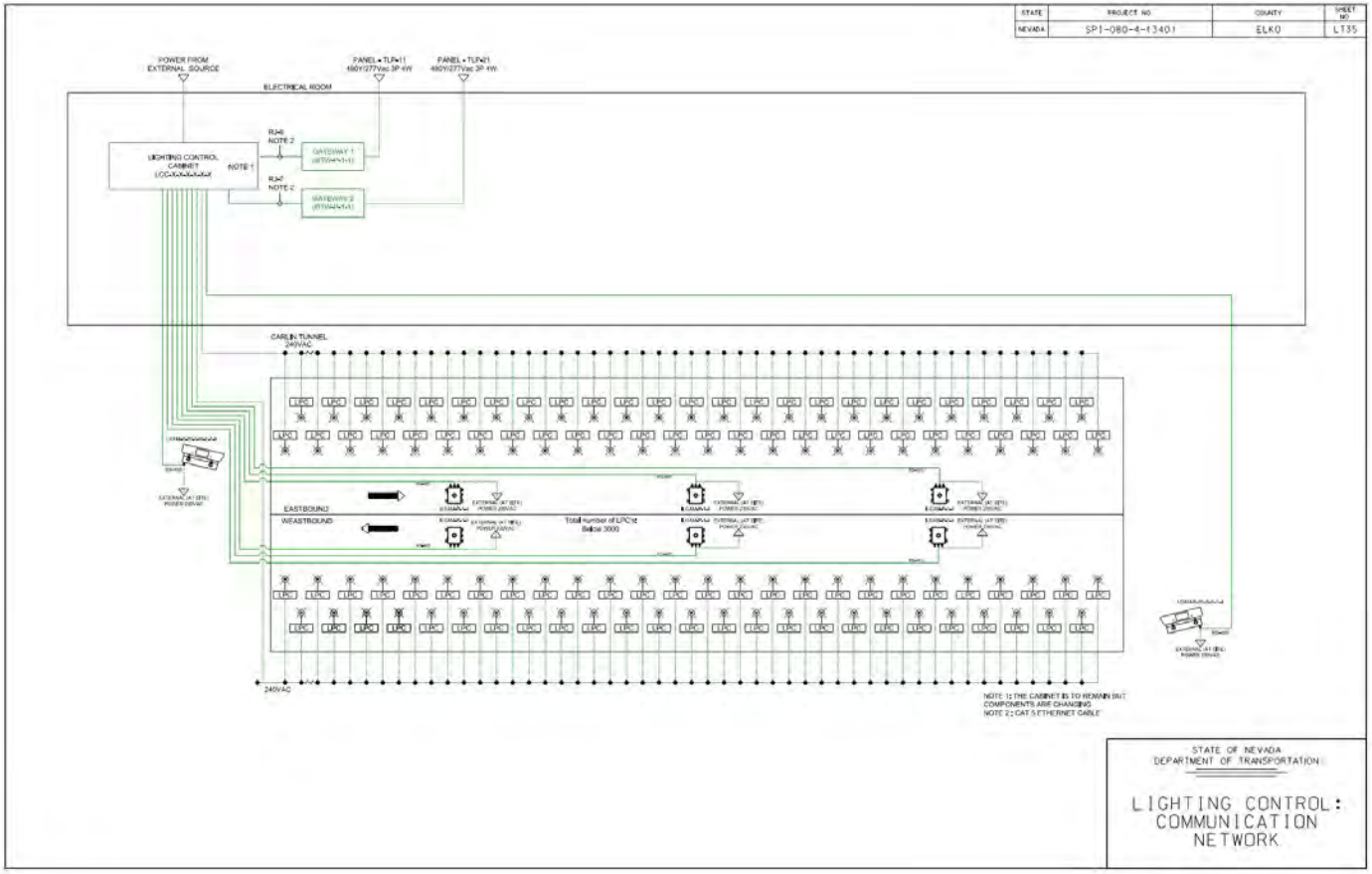
Power-Line Carrier Communications (PLCC)

- Power-Line Communication



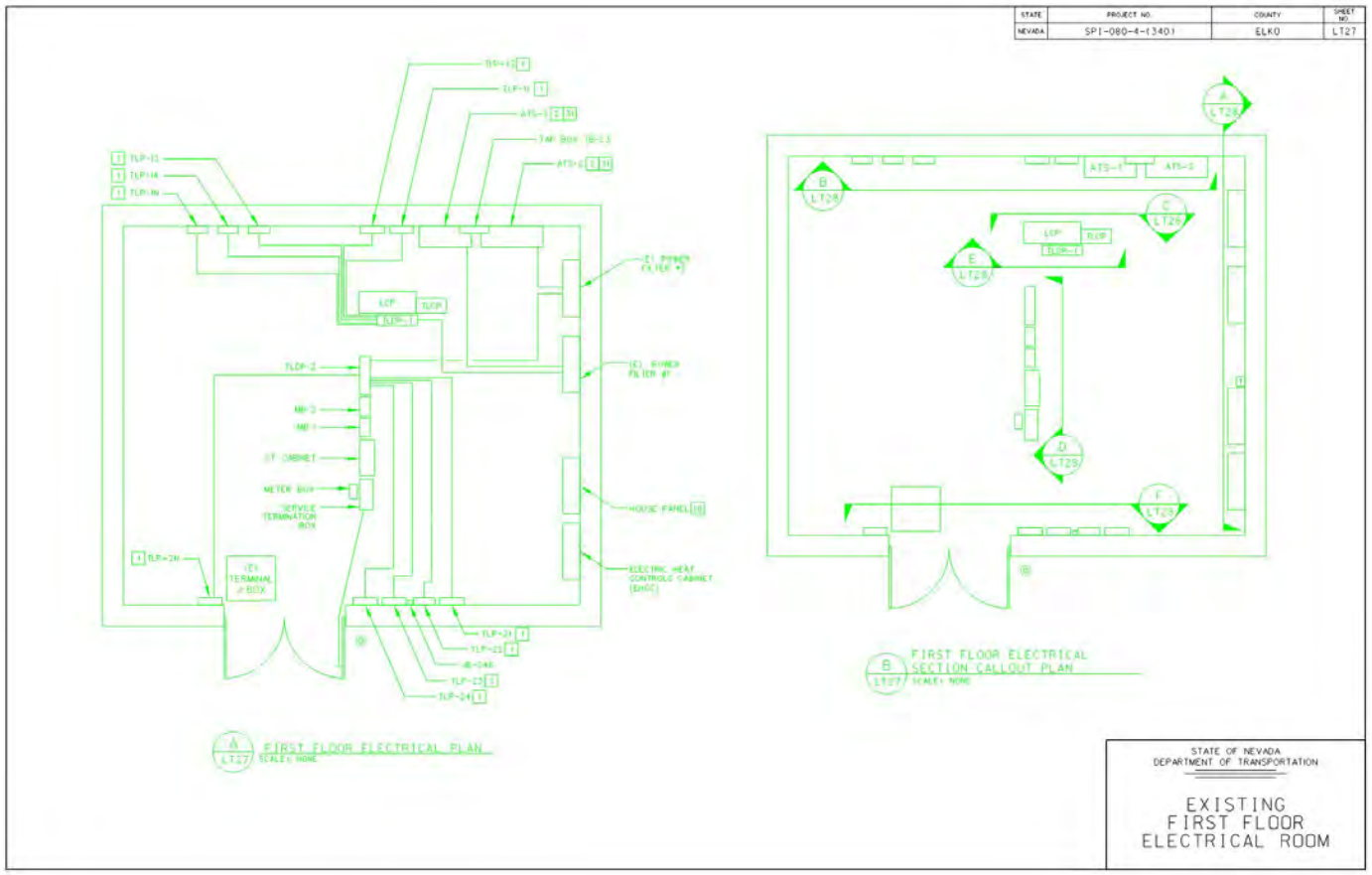
Lighting Control System

Communications Network Diagram



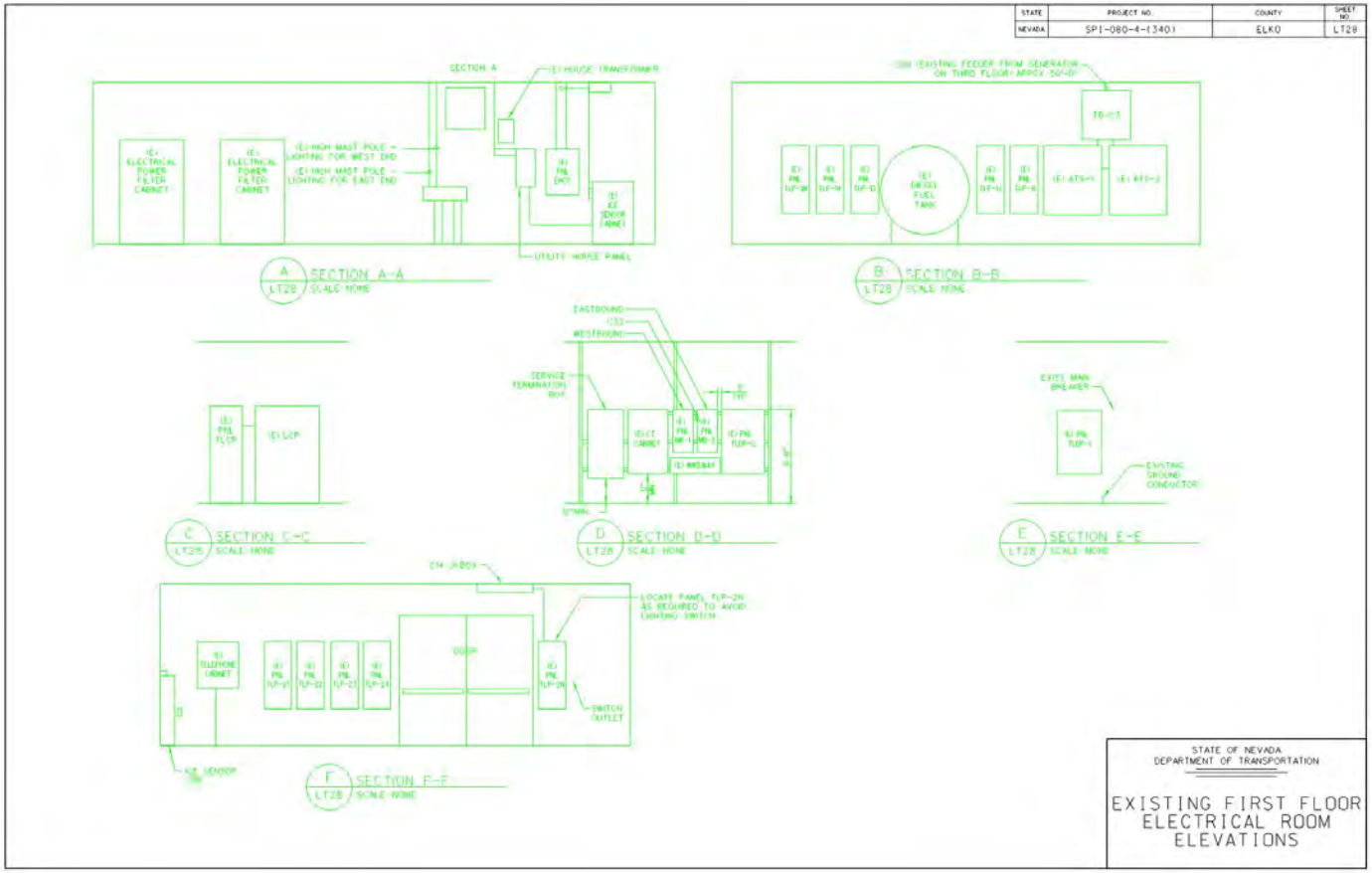
Lighting Control Cabinet

LCC Room – First Floor Plan View



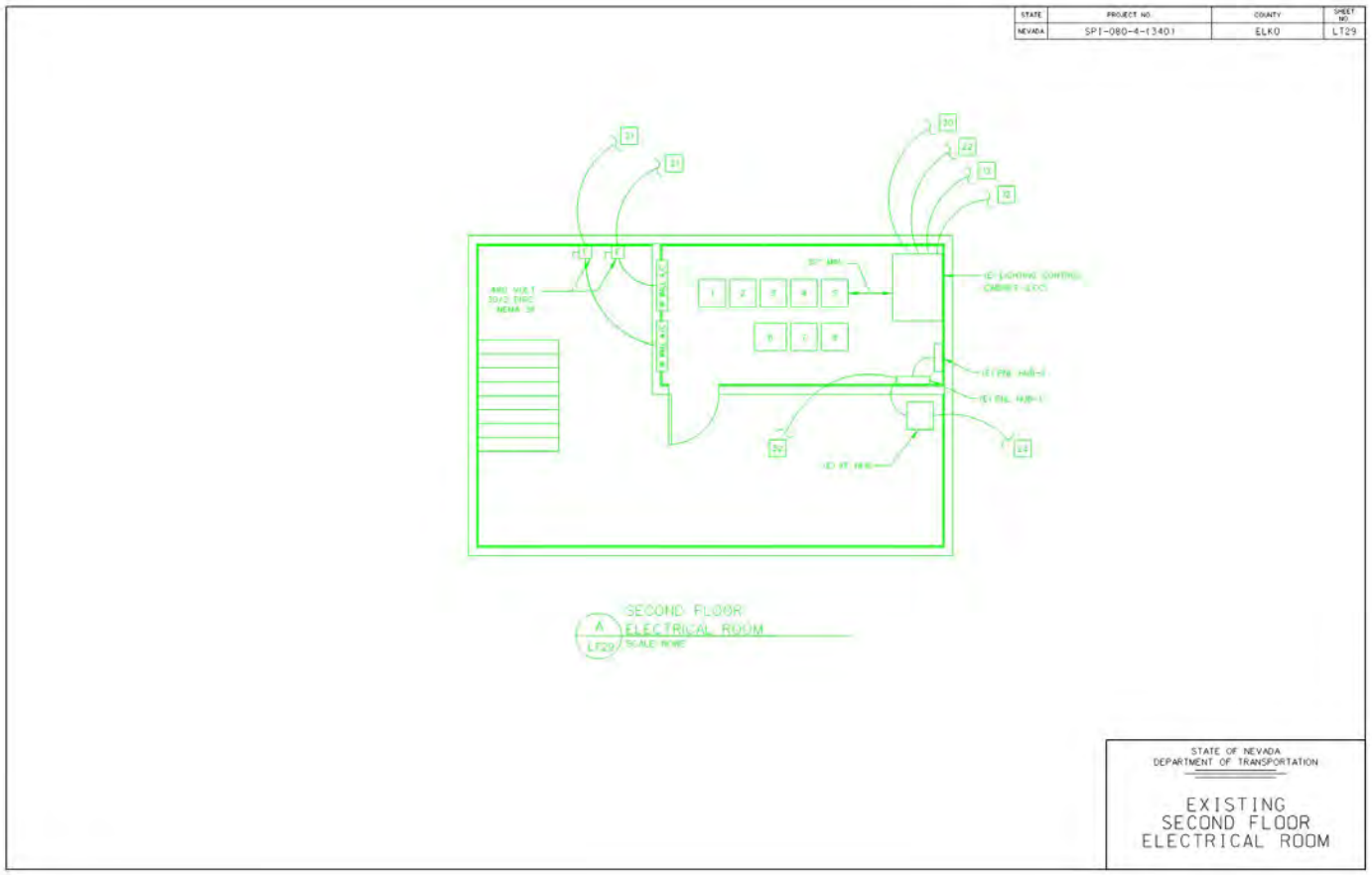
Lighting Control Cabinet

LCC Room – First Floor Profile View



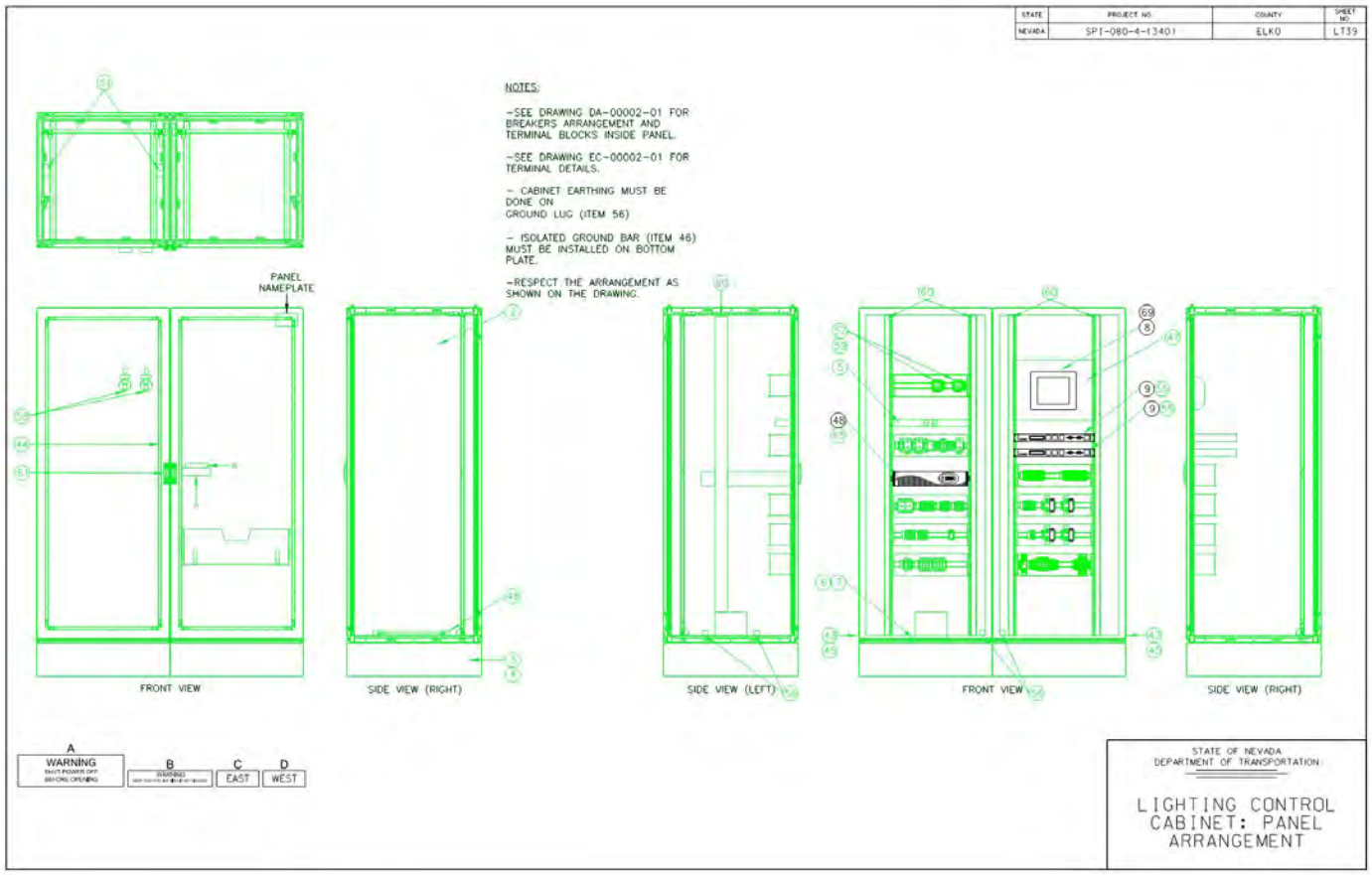
Lighting Control Cabinet

LCC Room – Second Floor – Plan View



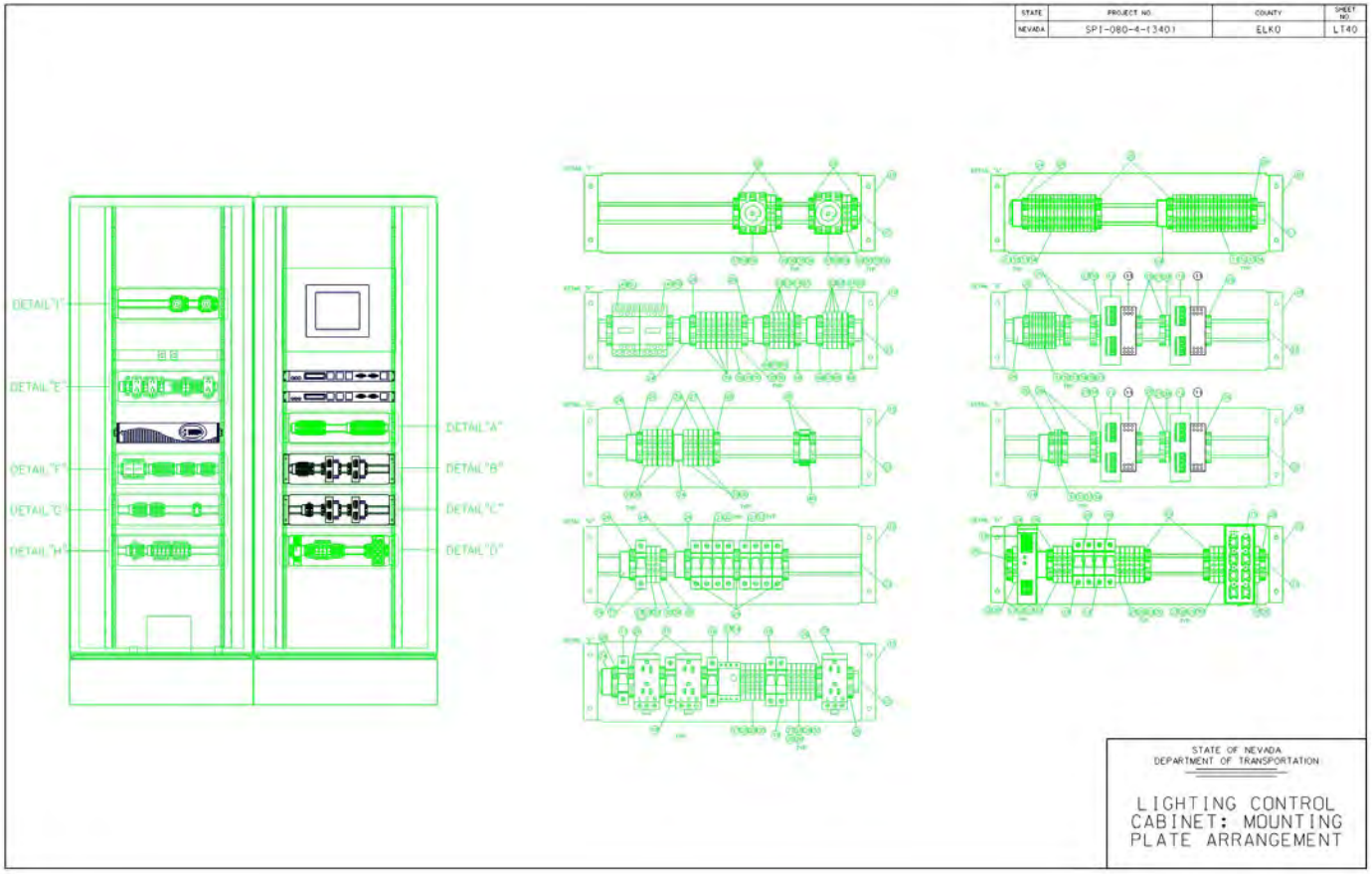
Lighting Control Cabinet

LCC Panel Arrangement



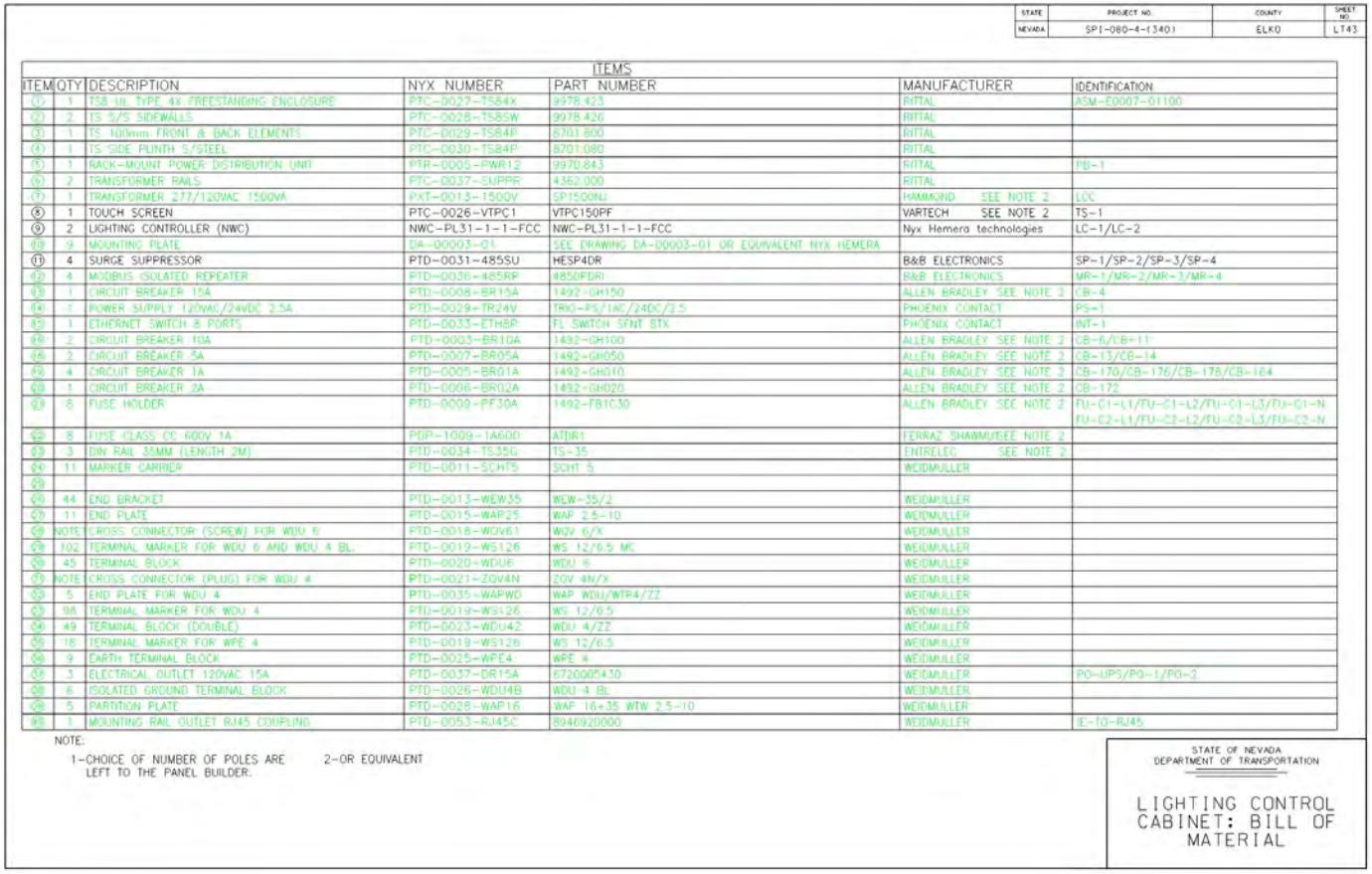
Lighting Control Cabinet

LCC Mounting Plate Arrangement



Lighting Control Cabinet

LCC Bill of Material (1)



STATE	PROJECT NO.	COUNTY	SHEET NO.
NEVADA	SPI-080-4-(340)	ELKO	LT43

ITEMS

ITEM	QTY	DESCRIPTION	NYX NUMBER	PART NUMBER	MANUFACTURER	IDENTIFICATION
①	1	TS8 UL TYPE 4X FREESTANDING ENCLOSURE	PTC-0027-TS84X	9378.423	RITTAL	ASM-E0007-01100
②	2	TS S/S SIDEWALLS	PTC-0028-TS8SW	9378.426	RITTAL	
③	1	TS 100mm FRONT & BACK ELEMENTS	PTC-0029-TS84P	8701.800	RITTAL	
④	1	TS SIDE PLINTH S/STEEL	PTC-0030-TS84P	8701.080	RITTAL	
⑤	1	RACK-MOUNT POWER DISTRIBUTION UNIT	PTR-0005-PWR12	9370.843	RITTAL	PD-1
⑥	2	TRANSFORMER RAILS	PTC-0037-SUPPR	4362.000	RITTAL	
⑦	1	TRANSFORMER 277/120VAC 1500VA	PXT-0013-1500V	SP1500NU	HAMMOND SEE NOTE 2	LCC
⑧	1	TOUCH SCREEN	PTC-0026-VTPC1	VTPC150PF	VARTECH SEE NOTE 2	TS-1
⑨	2	LIGHTING CONTROLLER (NWC)	NWC-PL31-1-1-FCC	NWC-PL31-1-1-FCC	Nyx Hemera technologies	LC-1/LC-2
⑩	9	MOUNTING PLATE	DA-00003-01	SEE DRAWING DA-00003-01 OR EQUIVALENT NYX HEMERA		
⑪	4	SURGE SUPPRESSOR	PTD-0031-485SU	HESP4DR	B&B ELECTRONICS	SP-1/SP-2/SP-3/SP-4
⑫	4	MODBUS ISOLATED REPEATER	PTD-0036-485RP	485OPDRI	B&B ELECTRONICS	MR-1/MR-2/MR-3/MR-4
⑬	1	CIRCUIT BREAKER 15A	PTD-0008-BR15A	1492-GH150	ALLEN BRADLEY SEE NOTE 2	CB-4
⑭	1	POWER SUPPLY 120VAC/24VDC 2.5A	PTD-0029-TR24V	TRIO-PS/1AC/24DC/2.5	PHOENIX CONTACT	PS-1
⑮	1	ETHERNET SWITCH 8 PORTS	PTD-0033-ETH8P	FL SWITCH SFNT 8TX	PHOENIX CONTACT	INT-1
⑯	2	CIRCUIT BREAKER 10A	PTD-0003-BR10A	1492-GH100	ALLEN BRADLEY SEE NOTE 2	CB-6/CB-11
⑰	2	CIRCUIT BREAKER 5A	PTD-0007-BR05A	1492-GH050	ALLEN BRADLEY SEE NOTE 2	CB-13/CB-14
⑱	4	CIRCUIT BREAKER 1A	PTD-0005-BR01A	1492-GH010	ALLEN BRADLEY SEE NOTE 2	CB-170/CB-176/CB-178/CB-184
⑲	1	CIRCUIT BREAKER 2A	PTD-0006-BR02A	1492-GH020	ALLEN BRADLEY SEE NOTE 2	CB-172
⑳	8	FUSE HOLDER	PTD-0009-PF30A	1492-FB1C30	ALLEN BRADLEY SEE NOTE 2	FU-C1-L1/FU-C1-L2/FU-C1-L3/FU-C1-N FU-C2-L1/FU-C2-L2/FU-C2-L3/FU-C2-N
㉑	8	FUSE CLASS CC 600V 1A	PDP-1009-1A600	ATDR1	TERRAZ SHAWMUT SEE NOTE 2	
㉒	3	DIN RAIL 35MM (LENGTH 2M)	PTD-0034-TS35G	TS-35	ENTRELEC SEE NOTE 2	
㉓	11	MARKER CARRIER	PTD-0011-SCHT5	SCHT 5	WEIDMULLER	
㉔						
㉕	44	END BRACKET	PTD-0013-WEW35	WEW-35/2	WEIDMULLER	
㉖	11	END PLATE	PTD-0015-WAP25	WAP 2.5-10	WEIDMULLER	
㉗	NOTE	CROSS CONNECTOR (SCREW) FOR WDU 6	PTD-0018-WQV61	WQV 6/X	WEIDMULLER	
㉘	102	TERMINAL MARKER FOR WDU 6 AND WDU 4 BL	PTD-0019-WS126	WS 12/6.5 MC	WEIDMULLER	
㉙	45	TERMINAL BLOCK	PTD-0020-WDU6	WDU 6	WEIDMULLER	
㉚	NOTE	CROSS CONNECTOR (PLUG) FOR WDU 4	PTD-0021-ZQV4N	ZQV 4N/X	WEIDMULLER	
㉛	5	END PLATE FOR WDU 4	PTD-0035-WAPWD	WAP WDU/WTR4/ZZ	WEIDMULLER	
㉜	98	TERMINAL MARKER FOR WDU 4	PTD-0019-WS126	WS 12/6.5	WEIDMULLER	
㉝	49	TERMINAL BLOCK (DOUBLE)	PTD-0023-WDU42	WDU 4/ZZ	WEIDMULLER	
㉞	18	TERMINAL MARKER FOR WPE 4	PTD-0019-WS126	WS 12/6.5	WEIDMULLER	
㉟	9	EARTH TERMINAL BLOCK	PTD-0025-WPE4	WPE 4	WEIDMULLER	
㊱	3	ELECTRICAL OUTLET 120VAC 15A	PTD-0037-DR15A	6720005430	WEIDMULLER	PO-UPS/PO-1/PO-2
㊲	6	ISOLATED GROUND TERMINAL BLOCK	PTD-0026-WDU4B	WDU 4 BL	WEIDMULLER	
㊳	5	PARTITION PLATE	PTD-0028-WAP16	WAP 16+35 WTW 2.5-10	WEIDMULLER	
㊴	1	MOUNTING RAIL OUTLET RJ45 COUPLING	PTD-0053-RJ45C	8946920000	WEIDMULLER	IE-TG-RJ45

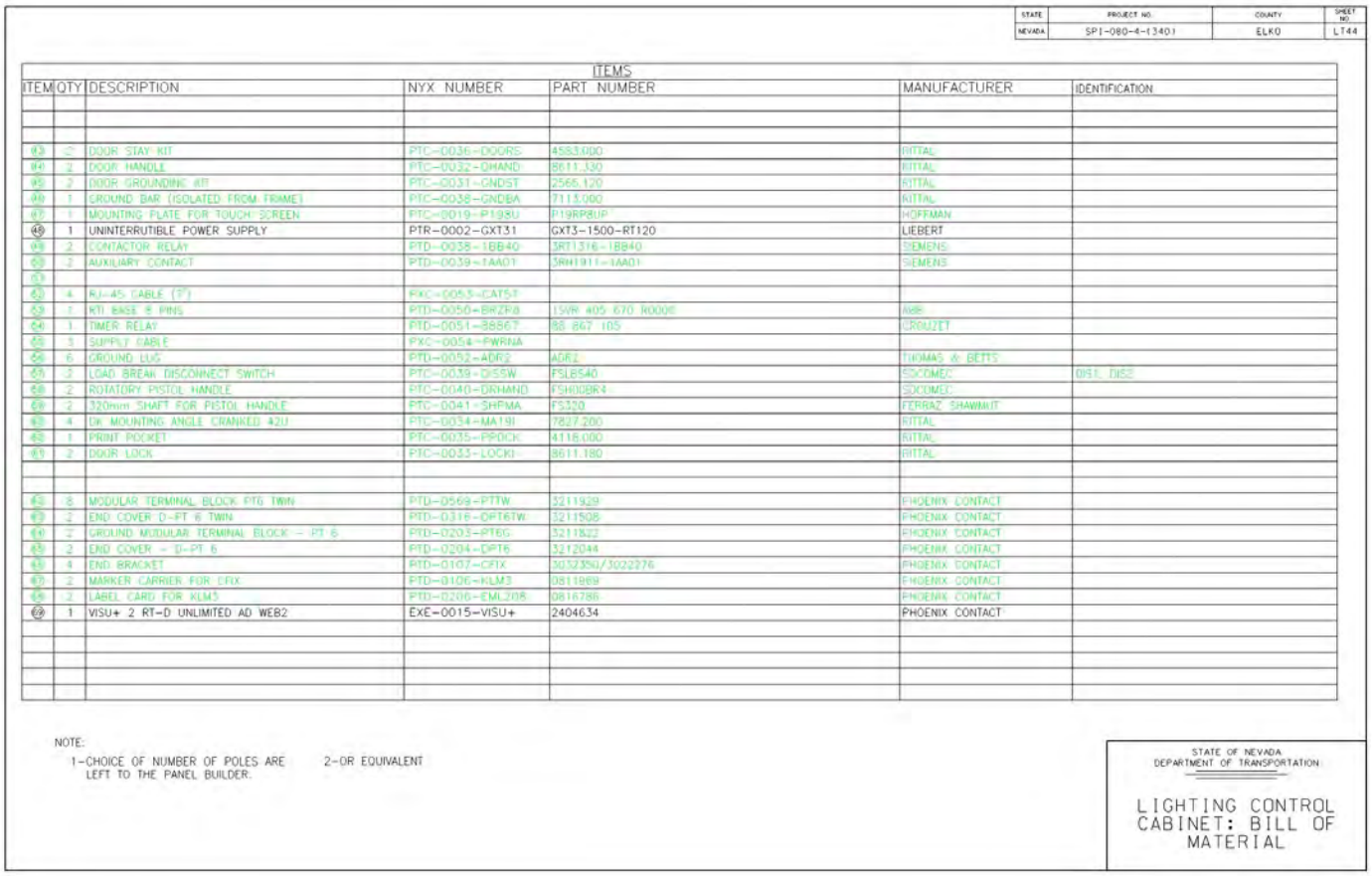
NOTE:
1-CHOICE OF NUMBER OF POLES ARE LEFT TO THE PANEL BUILDER.
2-OR EQUIVALENT

STATE OF NEVADA
DEPARTMENT OF TRANSPORTATION

LIGHTING CONTROL CABINET: BILL OF MATERIAL

Lighting Control Cabinet

LCC Bill of Material (2)



STATE	PROJECT NO.	COUNTY	SHEET NO.
NEVADA	SPI-080-4-(134O)	ELKO	LT44

ITEMS

ITEM	QTY	DESCRIPTION	NYX NUMBER	PART NUMBER	MANUFACTURER	IDENTIFICATION
03	2	DOOR STAY KIT	PTC-0036-DOORS	4583.000	RITTAL	
04	2	DOOR HANDLE	PTC-0032-DHAND	8611.330	RITTAL	
05	2	DOOR GROUNDING KIT	PTC-0031-GNDST	2565.120	RITTAL	
06	1	GROUND BAR (ISOLATED FROM FRAME)	PTC-0038-GNDBA	7113.000	RITTAL	
07	1	MOUNTING PLATE FOR TOUCH SCREEN	PTC-0019-P19RU	P19RP8UP	HOFFMAN	
45	1	UNINTERRUTIBLE POWER SUPPLY	PTR-0002-GXT31	GXT3-1500-RT120	LIEBERT	
01	2	CONTACTOR RELAY	PTD-0038-18B40	3RT1316-1BB40	SIEMENS	
02	2	AUXILIARY CONTACT	PTD-0039-1AA01	3RH1911-1AA01	SIEMENS	
03						
42	4	RJ-45 CABLE (7')	PXC-0053-CAT5T			
53	1	RTI BASE 8 PINS	PTD-0050-BRZR8	15WR 405 670 R0005	AMP	
54	1	TIMER RELAY	PTD-0051-88867	88 867 105	CROUZET	
55	5	SUPPLY CABLE	PXC-0054-PWRNA			
56	6	GROUND LUG	PTD-0052-ADR2	ADR2	THOMAS & BETTS	
57	3	LOAD BREAK DISCONNECT SWITCH	PTC-0039-DISSW	FSLB540	SOCOMEC	DISC DISS
58	2	ROTATORY PISTOL HANDLE	PTC-0040-DRHAND	FSH100BR4	SOCOMEC	
59	2	320mm SHAFT FOR PISTOL HANDLE	PTC-0041-SHFMA	FS320	FERRAZ SHAWMUT	
60	4	DIN MOUNTING ANGLE CRANKED 42U	PTC-0034-MA191	7827.200	RITTAL	
48	1	PRINT POCKET	PTC-0035-PPOCK	4116.000	RITTAL	
61	2	DOOR LOCK	PTC-0033-LOCKI	8611.180	RITTAL	
62	8	MODULAR TERMINAL BLOCK PT6 TWIN	PTD-0568-PTTW	3211929	PHOENIX CONTACT	
63	2	END COVER D-PT 6 TWIN	PTD-0316-DPT6TW	3211508	PHOENIX CONTACT	
64	2	GROUND MODULAR TERMINAL BLOCK - PT 6	PTD-0203-PT6G	3211822	PHOENIX CONTACT	
65	2	END COVER - D-PT 6	PTD-0204-DPT6	3212044	PHOENIX CONTACT	
66	4	END BRACKET	PTD-0107-CFIX	3032350/3022276	PHOENIX CONTACT	
67	2	MARKER CARRIER FOR CFIX	PTD-0106-KLM3	0811989	PHOENIX CONTACT	
68	2	LABEL CARD FOR KLM3	PTD-0206-EML208	0816786	PHOENIX CONTACT	
69	1	VISU+ 2 RT-D UNLIMITED AD WEB2	EXE-0015-VISU+	2404634	PHOENIX CONTACT	

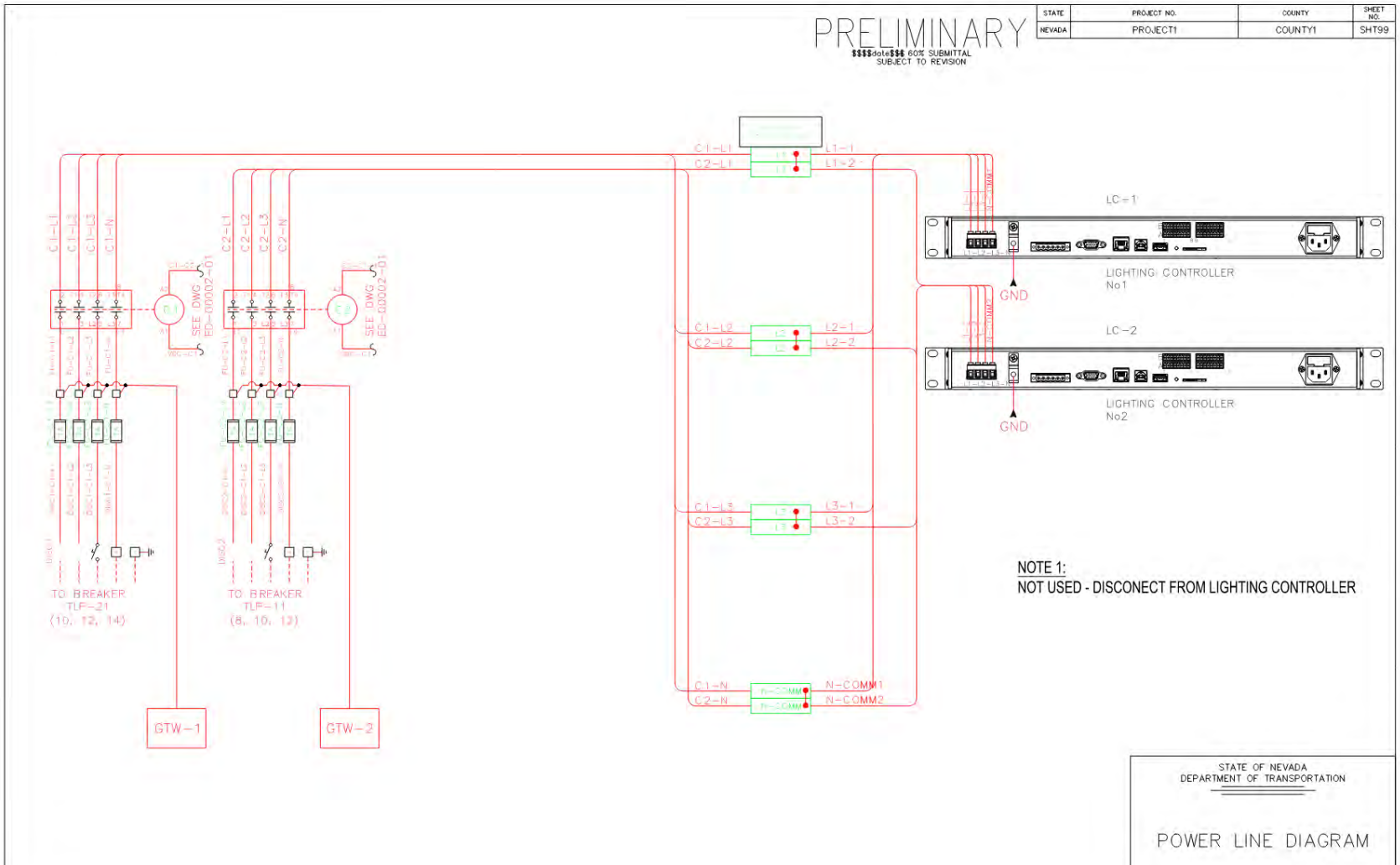
NOTE:
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STATE OF NEVADA
DEPARTMENT OF TRANSPORTATION

LIGHTING CONTROL CABINET: BILL OF MATERIAL

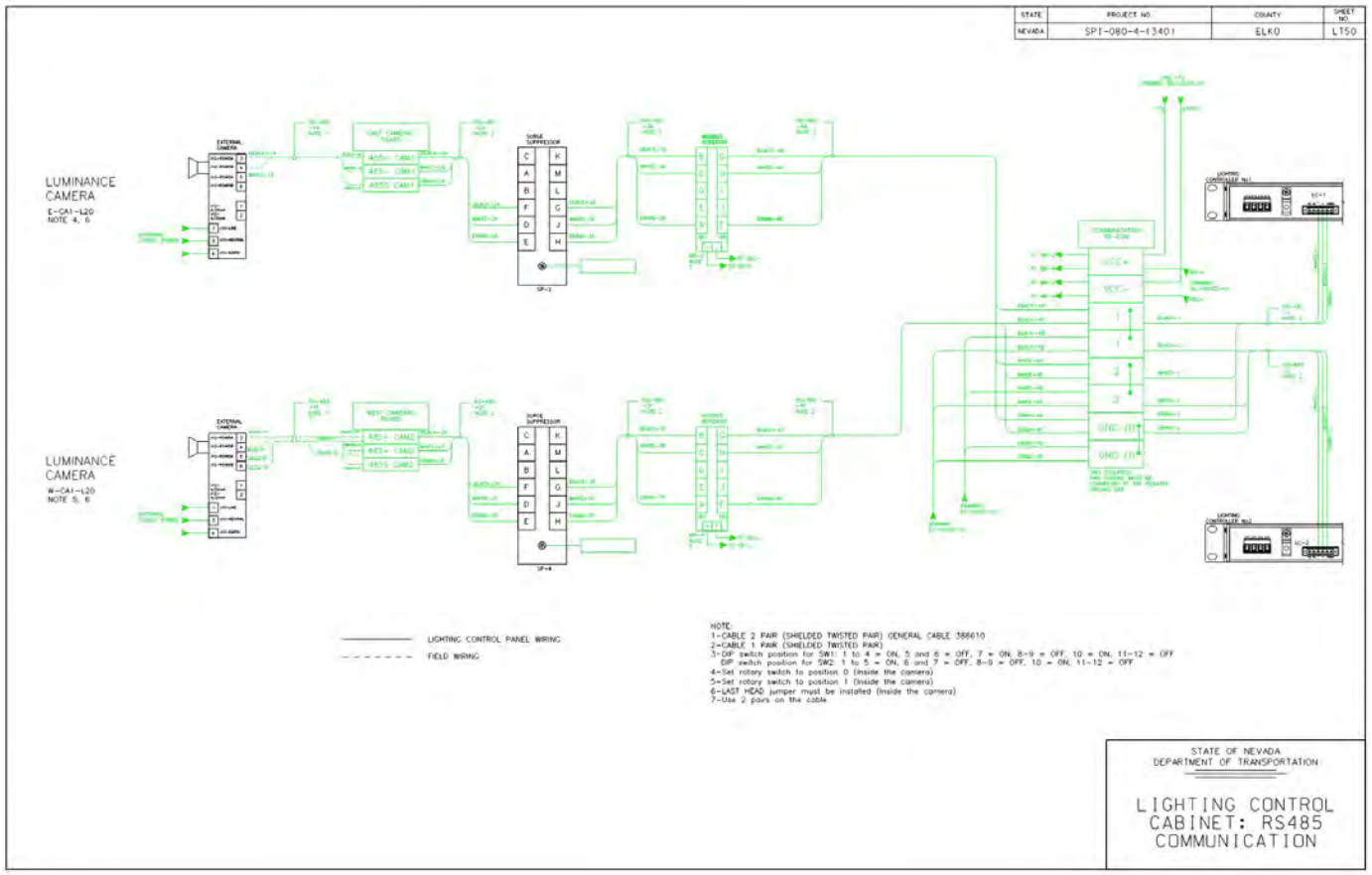
Lighting Control Cabinet

LCC Power Line Diagram



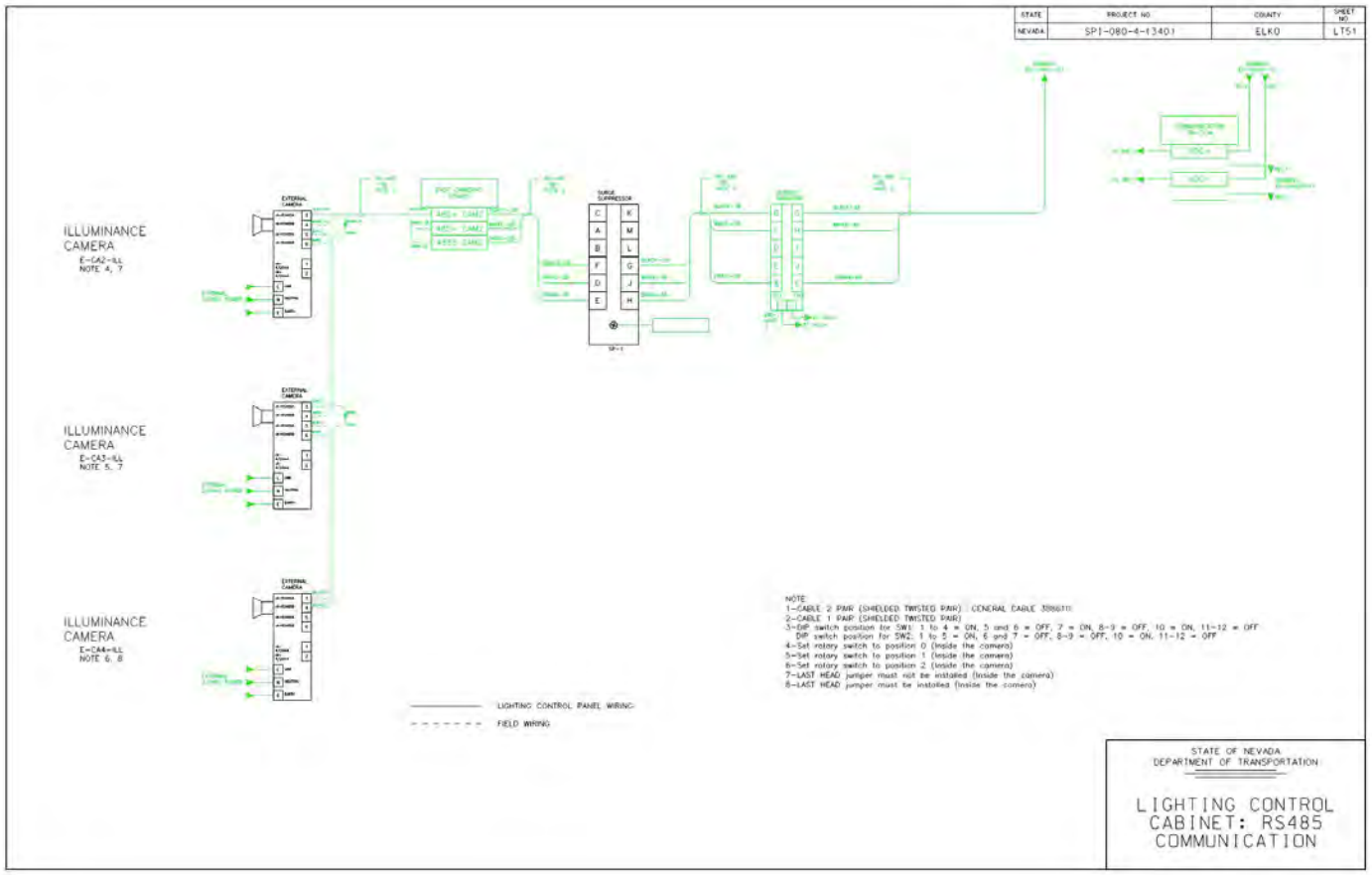
Lighting Control Cabinet

LCC RS485 Communications Diagram - LCAM



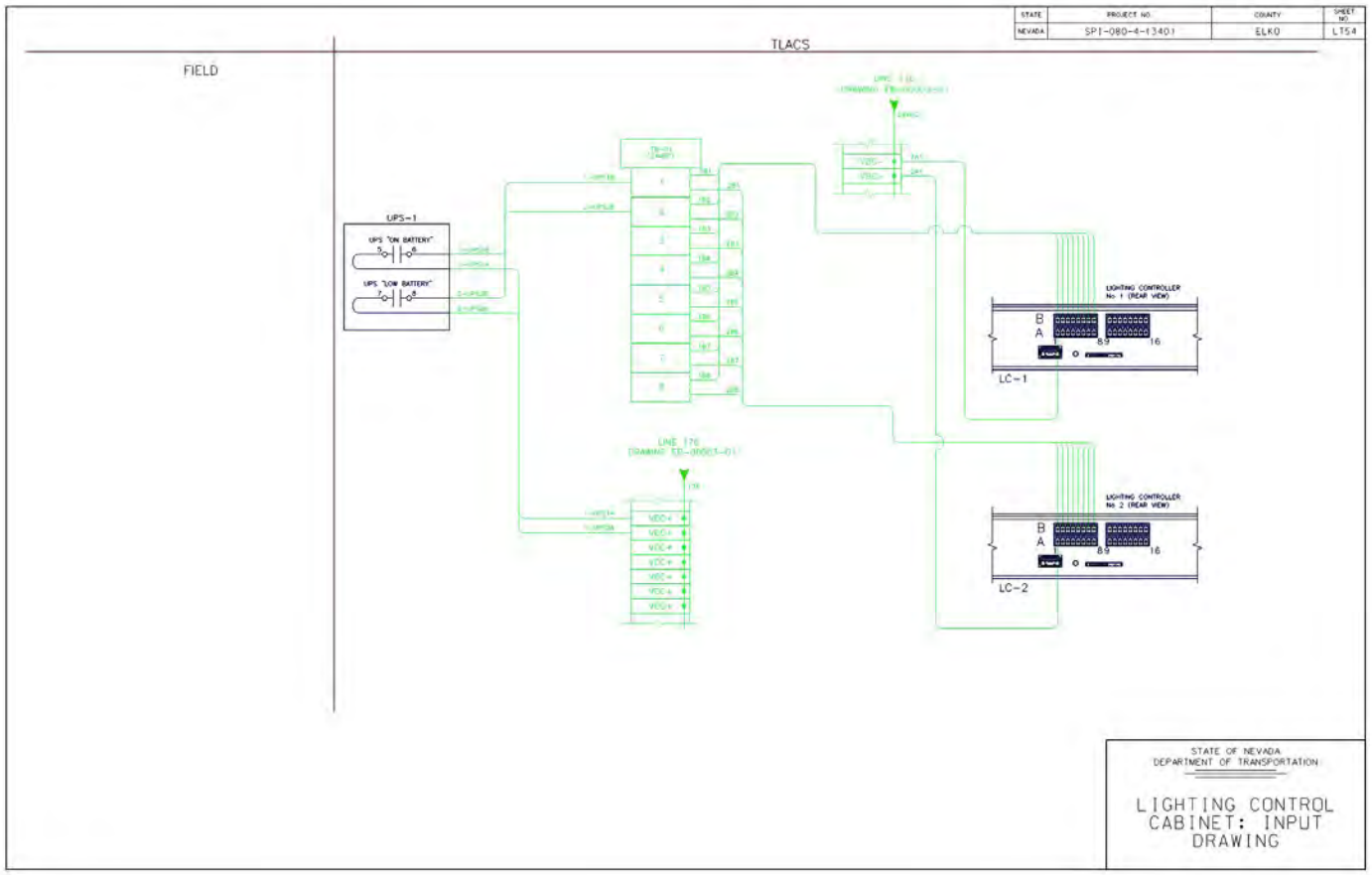
Lighting Control Cabinet

LCC RS85 Communications Diagram - ILCAM



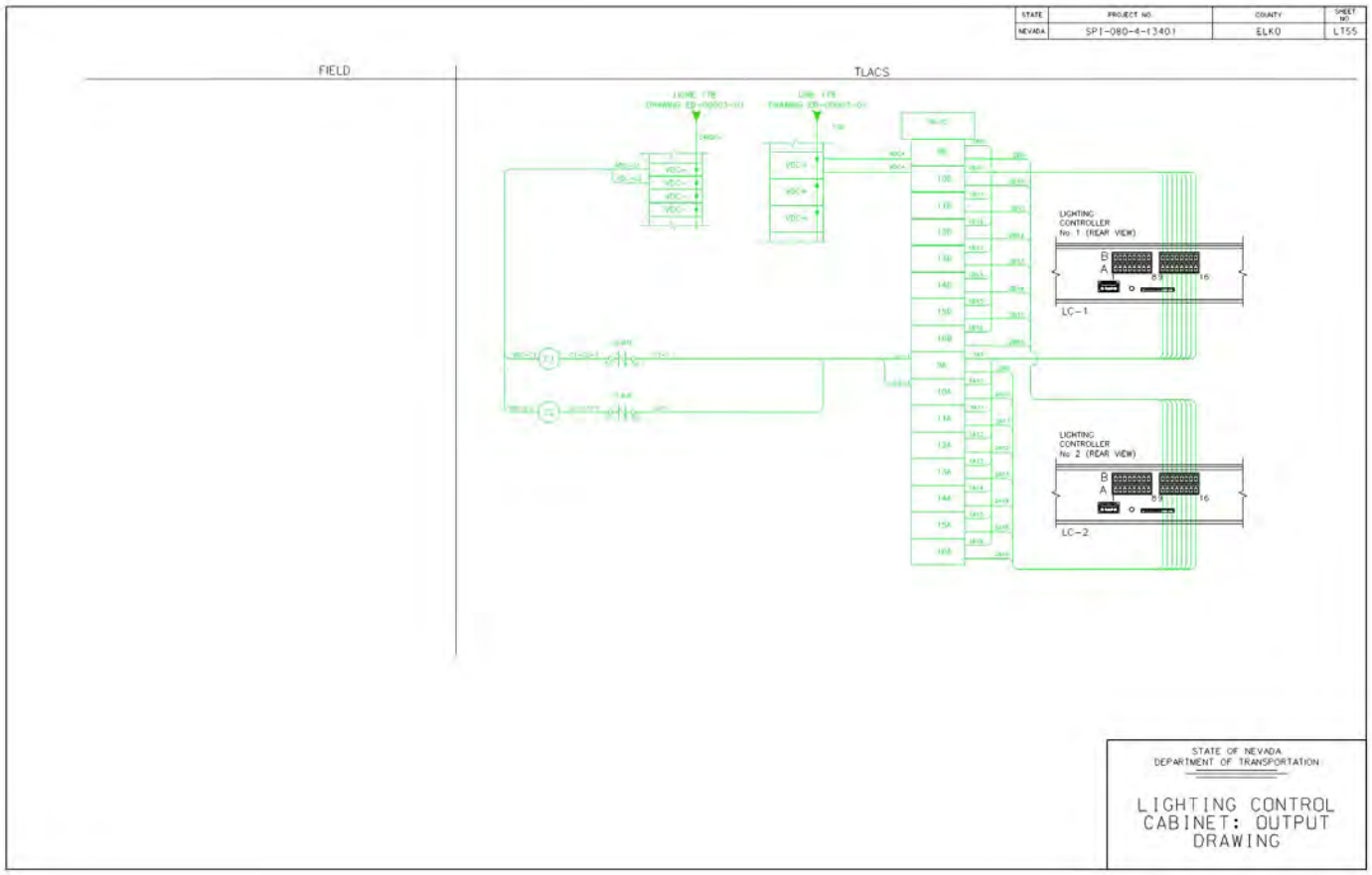
Lighting Control Cabinet

LCC Input Diagram



Lighting Control Cabinet

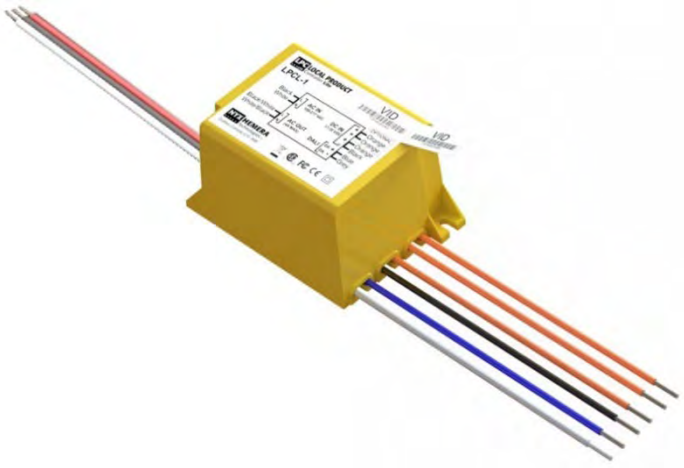
LCC Output Diagram



Local Product Controller

- Tunnel Specific LPC
- Luminaire Driver
  - Dim levels

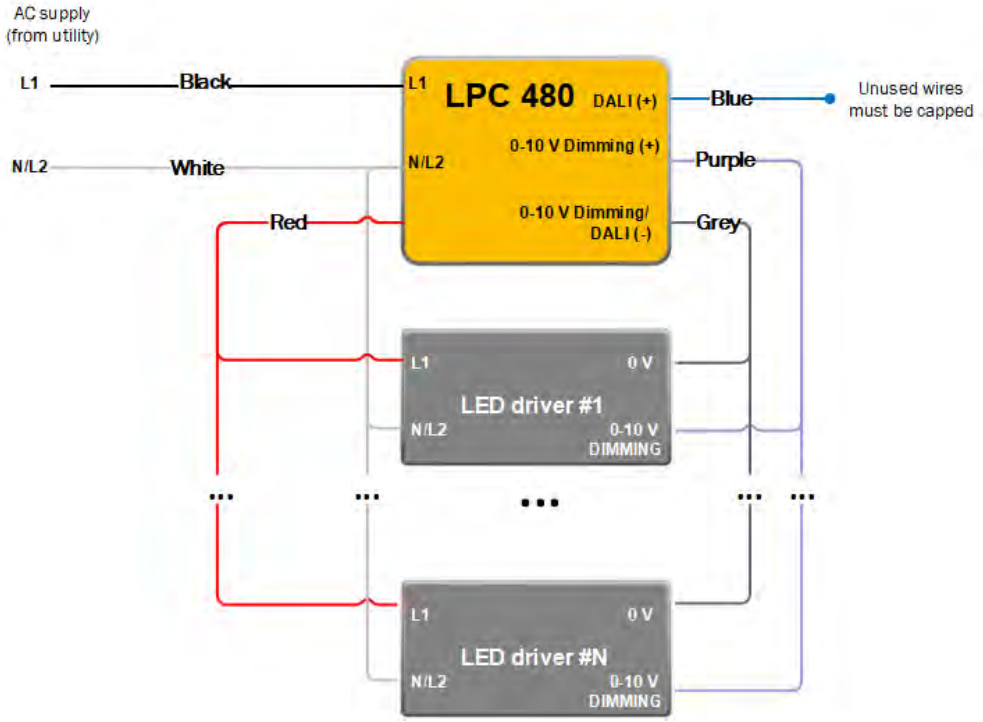






Local Product Controller

- Block Diagram



Lighting Control Sensors

- Luminance
  - External Tunnel Threshold Illumination
- Illuminance
  - Internal Tunnel Roadway Lighting





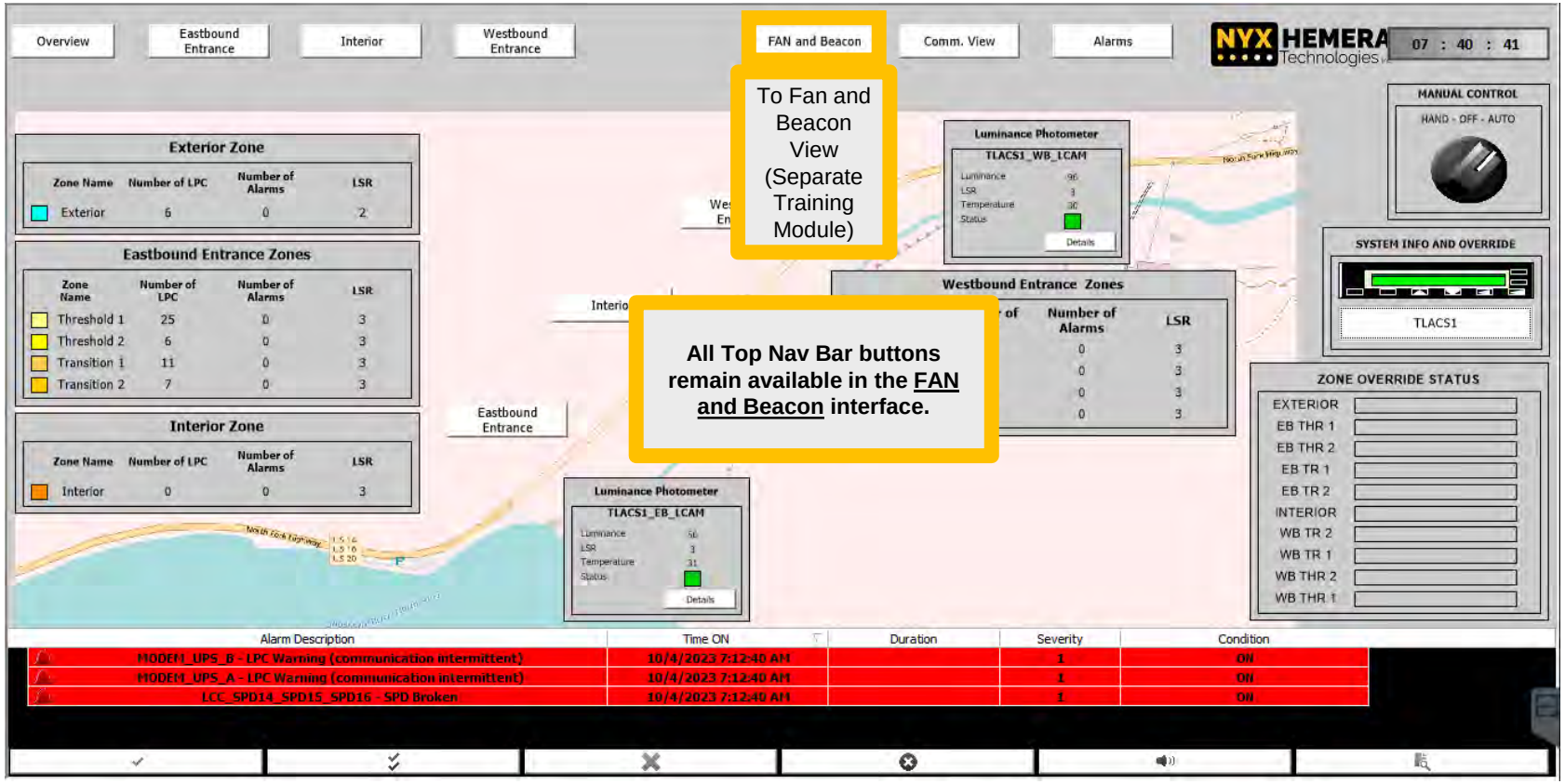
Communications Integration

- Network integrated
- Remote access
  - Monitoring purposes

Lighting Control System

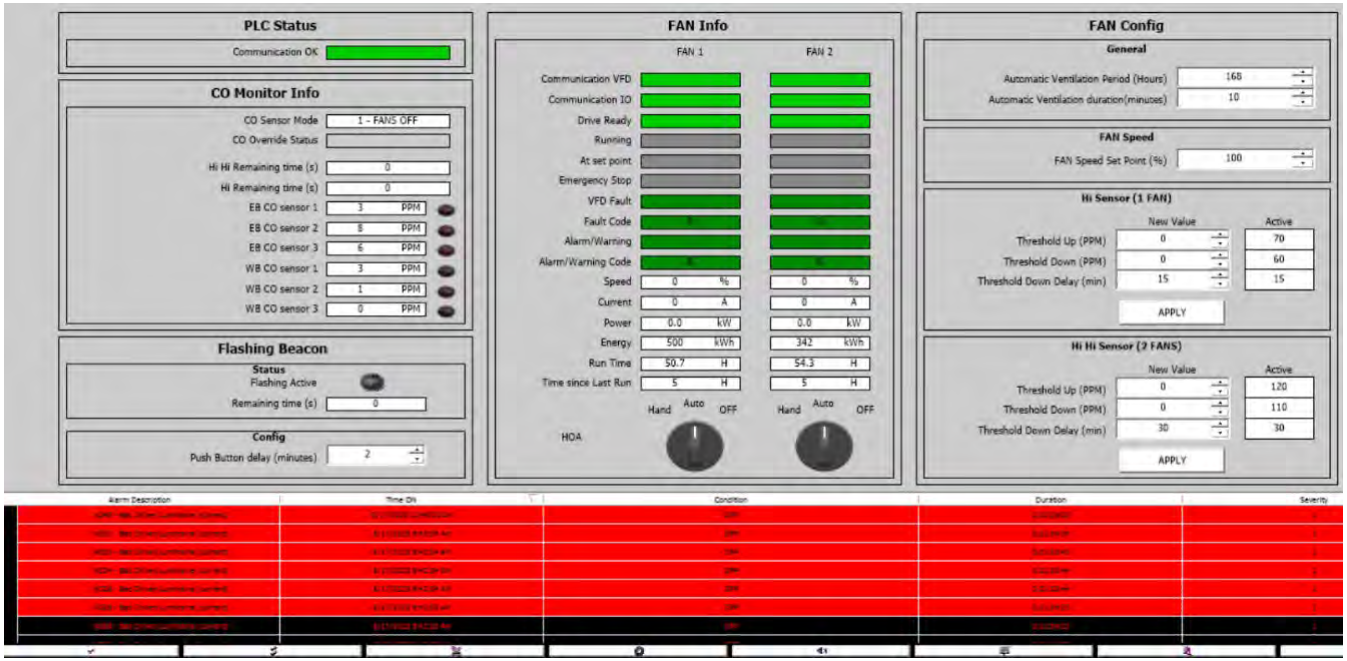
- TLACS-SCADA
  - The following **Interfaces** slides were provided by Nyx Hemera.

Interfaces
TLACS-SCADA: Overview Page

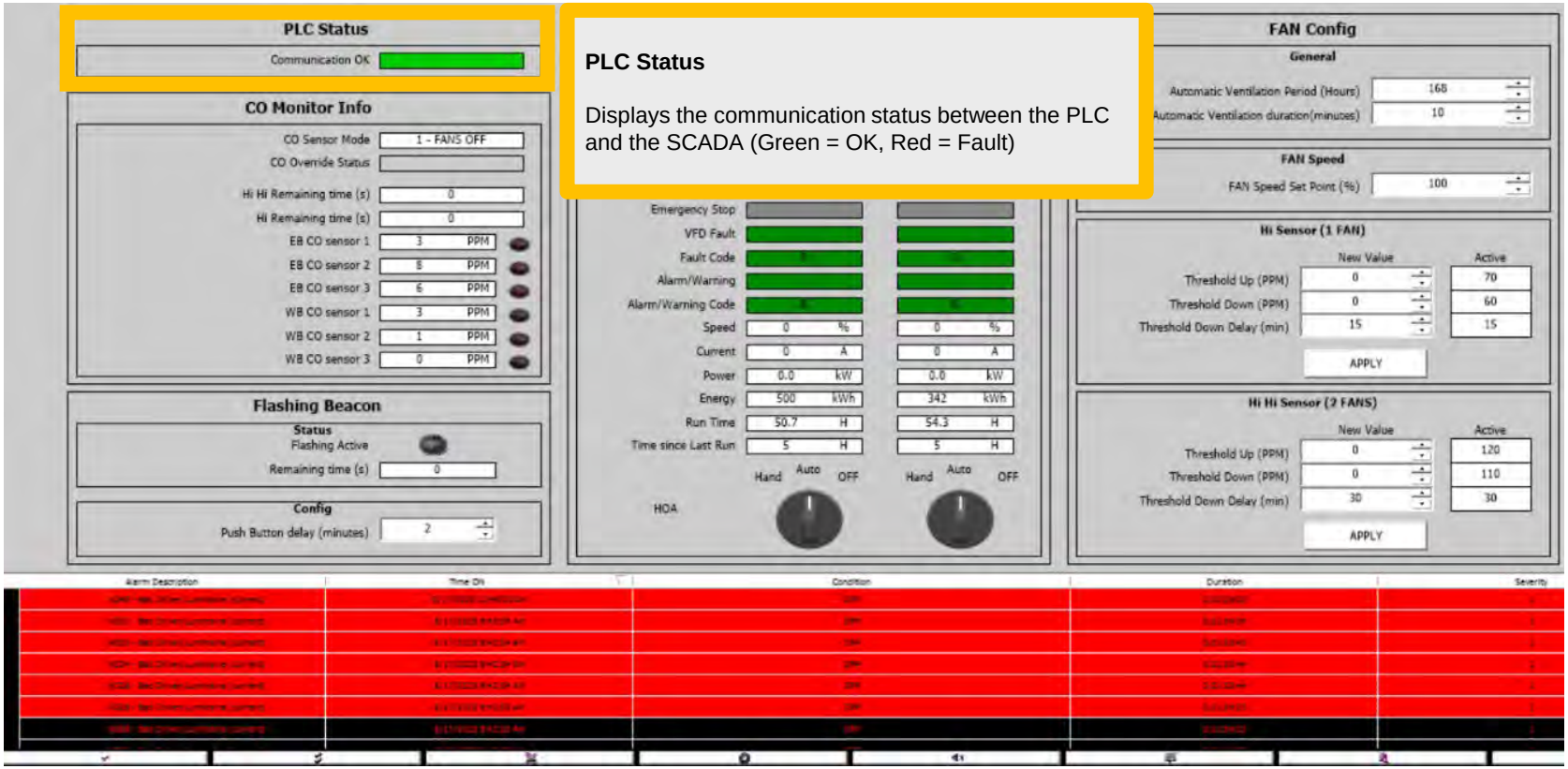


Interfaces
TLACS-SCADA: Fan and Beacon

- VFD status and monitoring through PLC
- Accessible via computer of Tunnel Control Cabinet (TCC)



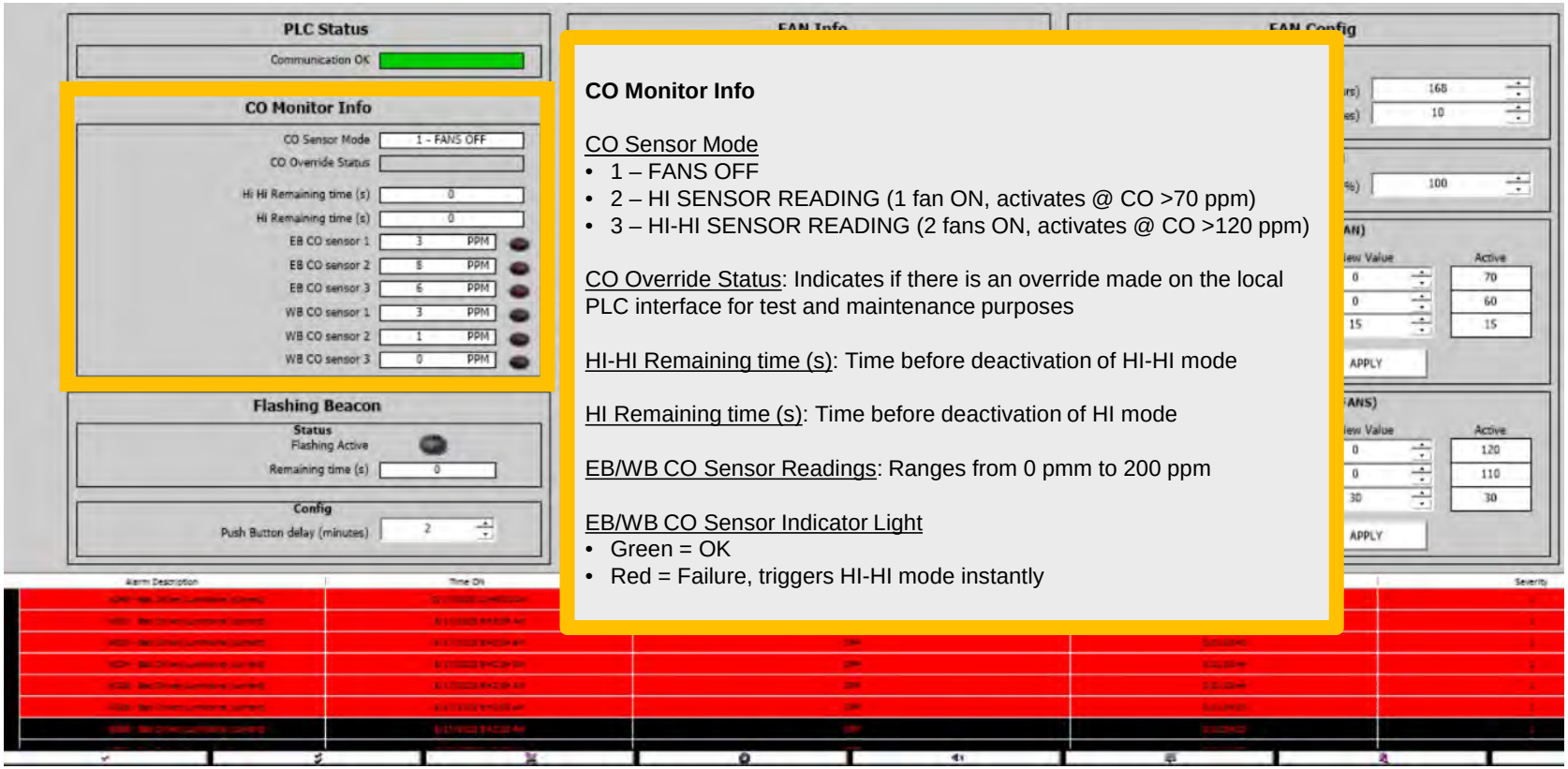
Interfaces
TLACS-SCADA: Fan and Beacon



PLC Status

Displays the communication status between the PLC and the SCADA (Green = OK, Red = Fault)

Interfaces
TLACS-SCADA: Fan and Beacon



CO Monitor Info

CO Sensor Mode
- 1 – FANS OFF
- 2 – HI SENSOR READING (1 fan ON, activates @ CO >70 ppm)
- 3 – HI-HI SENSOR READING (2 fans ON, activates @ CO >120 ppm)

CO Override Status: Indicates if there is an override made on the local PLC interface for test and maintenance purposes

HI-HI Remaining time (s): Time before deactivation of HI-HI mode

HI Remaining time (s): Time before deactivation of HI mode

EB/WB CO Sensor Readings: Ranges from 0 pmm to 200 ppm

EB/WB CO Sensor Indicator Light
- Green = OK
- Red = Failure, triggers HI-HI mode instantly

Interfaces
TLACS-SCADA: Fan and Beacon

FAN Info

Communication VFD: Communication status between the VFD and the SCADA (Green = OK, Red = Fault)

Communication IO: Communication status between the remote I/Os of the VFDs and the SCADA (Green = OK, Red = Fault)

Drive Ready: Ready-to-run status reported by VFD

Running: Running status reported by VFD

At set point: At-set-point status reported by VFD

Emergency Stop: Emergency stop status reported by VFD

VFD Fault: Fault status reported by VFD (refer to Fault Code)

Fault Code: Displays fault code returned by VFD (refer to project manual and/or manufacturer's literature; use for troubleshooting)

Alarm/Warning: Alarm or warning status reported by VFD (refer to Alarm/Warning Code)

Alarm/Warning Code: Displays alarm or warning code returned by VFD (refer to project manual and/or manufacturer's literature; use for troubleshooting)



Interfaces
TLACS-SCADA: Fan and Beacon

FAN Info (Continued)

Speed: Real-time speed value (%) reported by VFD

Current: Real-time current value (A) reported by VFD

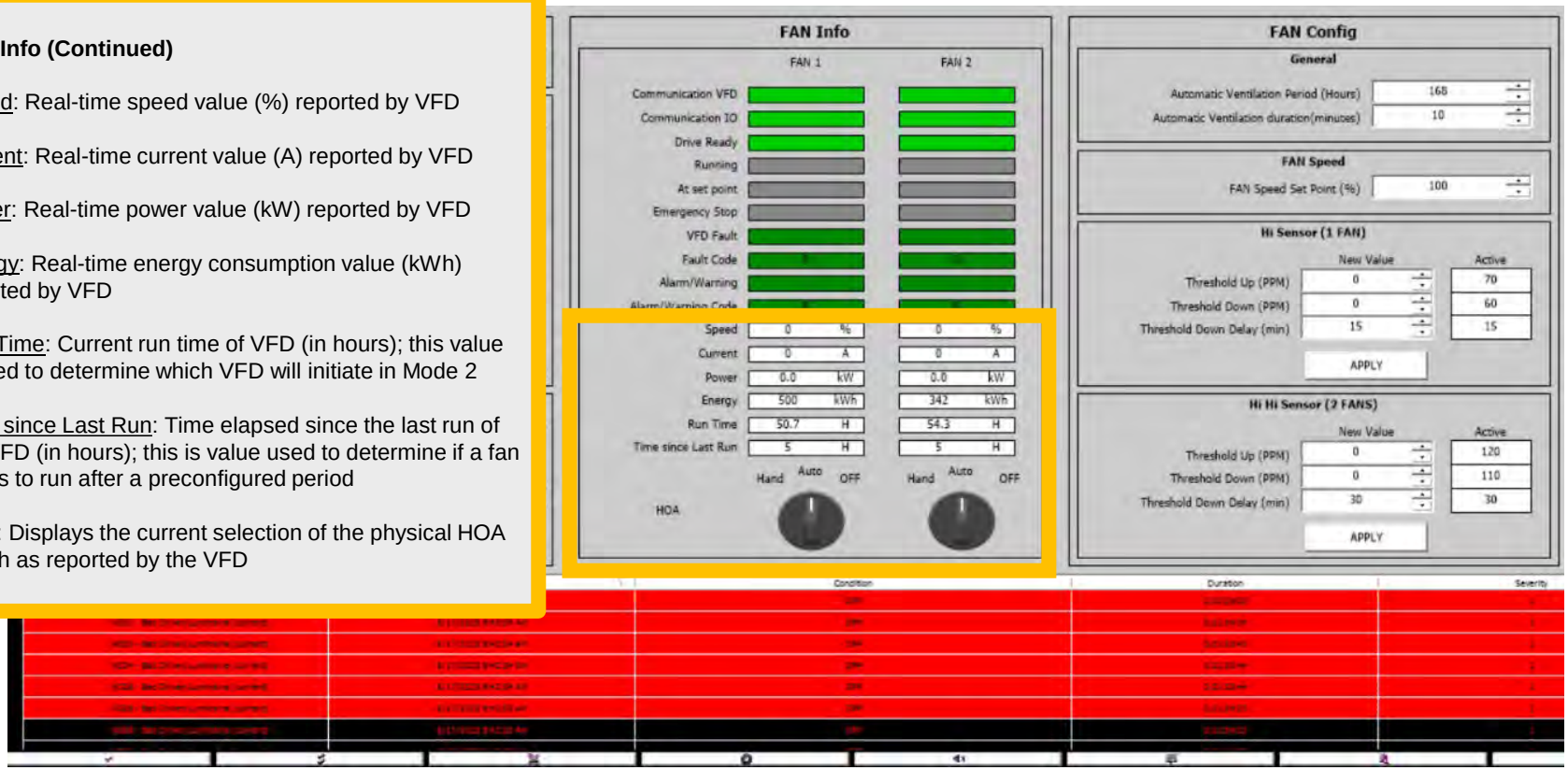
Power: Real-time power value (kW) reported by VFD

Energy: Real-time energy consumption value (kWh) reported by VFD

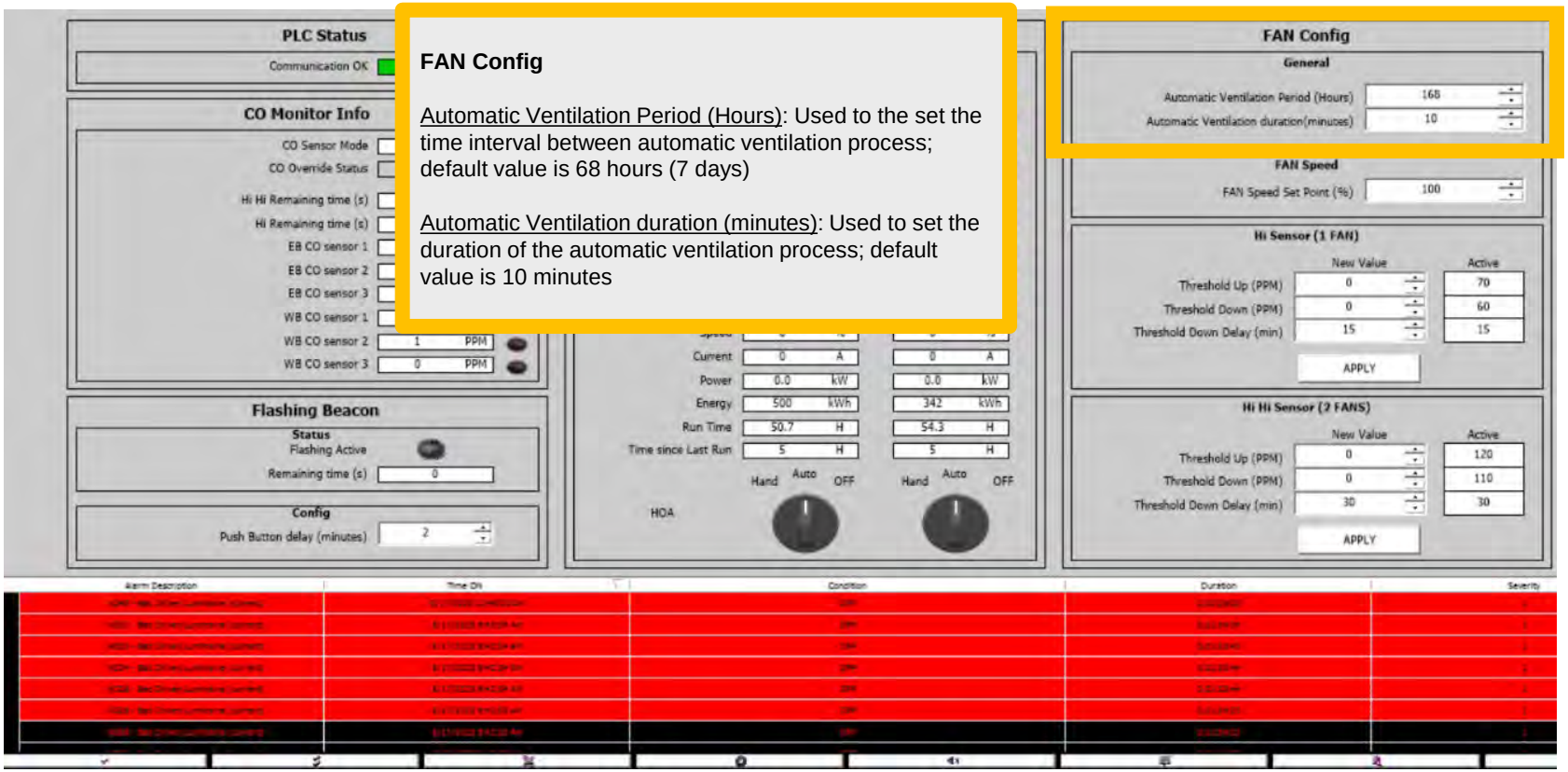
Run Time: Current run time of VFD (in hours); this value is used to determine which VFD will initiate in Mode 2

Time since Last Run: Time elapsed since the last run of the VFD (in hours); this is value used to determine if a fan needs to run after a preconfigured period

HOA: Displays the current selection of the physical HOA switch as reported by the VFD



Interfaces
TLACS-SCADA: Fan and Beacon

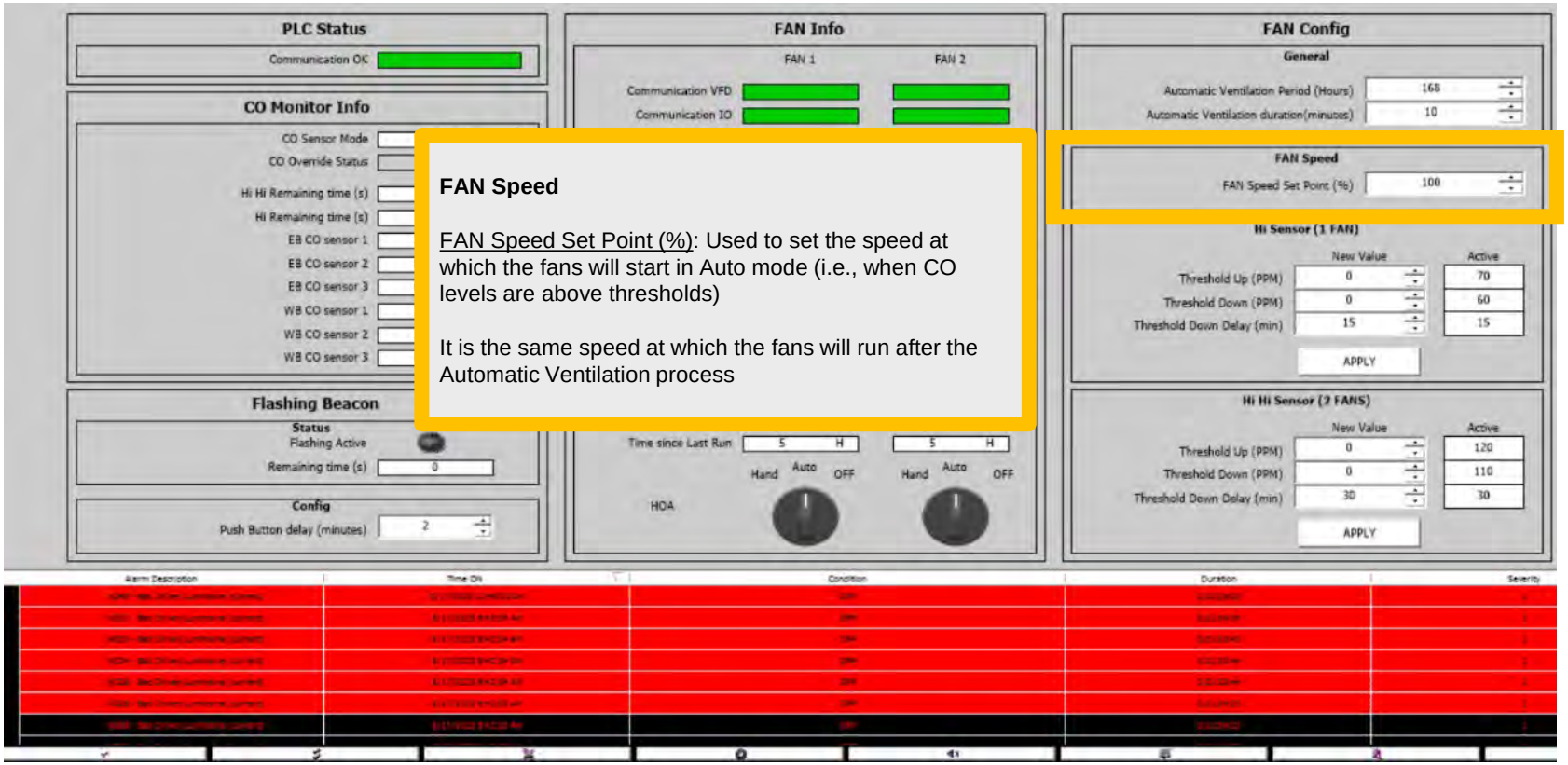


FAN Config

Automatic Ventilation Period (Hours): Used to the set the time interval between automatic ventilation process; default value is 68 hours (7 days)

Automatic Ventilation duration (minutes): Used to set the duration of the automatic ventilation process; default value is 10 minutes

Interfaces
TLACS-SCADA: Fan and Beacon

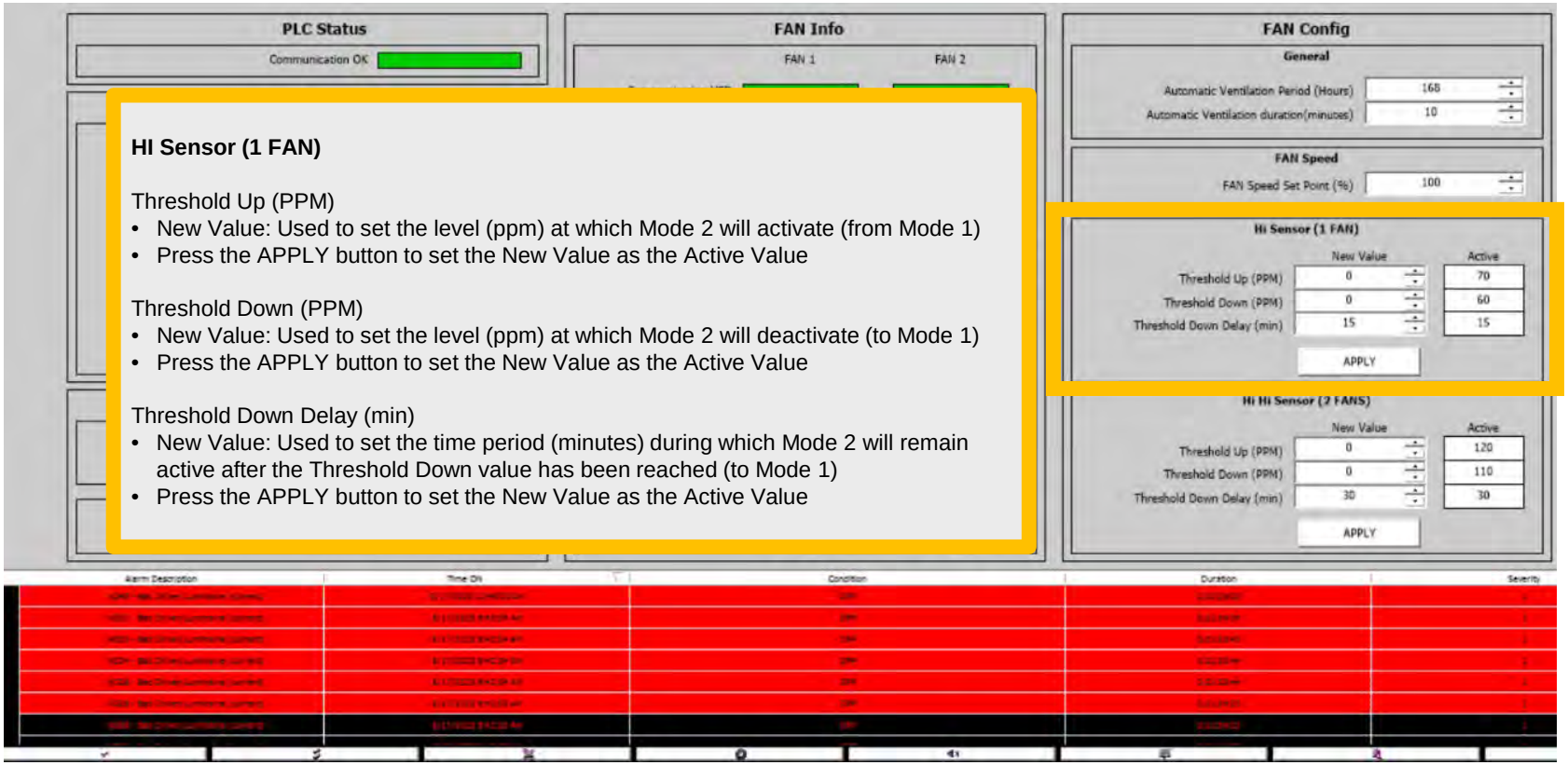


FAN Speed

FAN Speed Set Point (%): Used to set the speed at which the fans will start in Auto mode (i.e., when CO levels are above thresholds)

It is the same speed at which the fans will run after the Automatic Ventilation process

Interfaces
TLACS-SCADA: Fan and Beacon



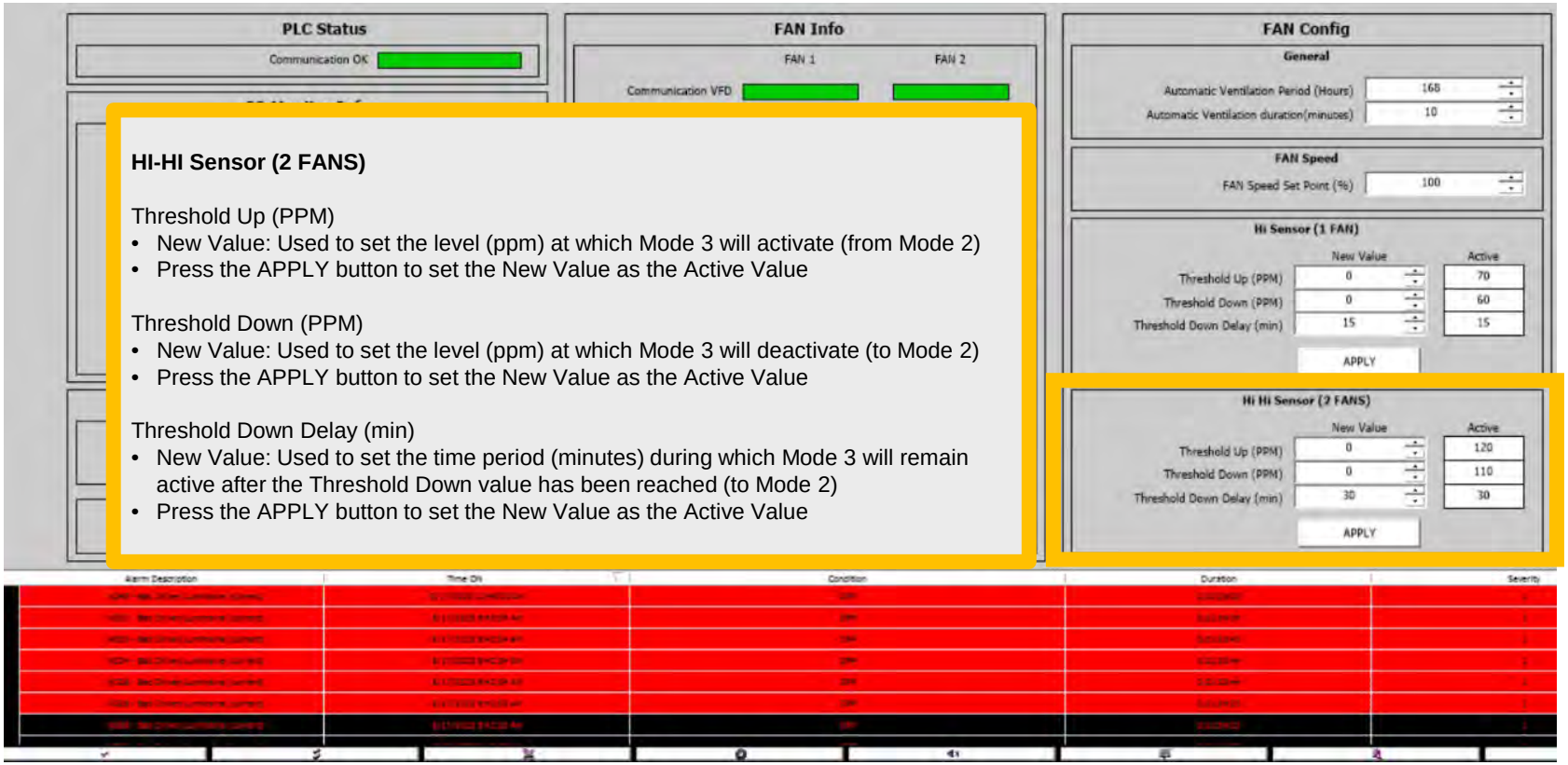
HI Sensor (1 FAN)

Threshold Up (PPM)
- New Value: Used to set the level (ppm) at which Mode 2 will activate (from Mode 1)
- Press the APPLY button to set the New Value as the Active Value

Threshold Down (PPM)
- New Value: Used to set the level (ppm) at which Mode 2 will deactivate (to Mode 1)
- Press the APPLY button to set the New Value as the Active Value

Threshold Down Delay (min)
- New Value: Used to set the time period (minutes) during which Mode 2 will remain active after the Threshold Down value has been reached (to Mode 1)
- Press the APPLY button to set the New Value as the Active Value

Interfaces
TLACS-SCADA: Fan and Beacon



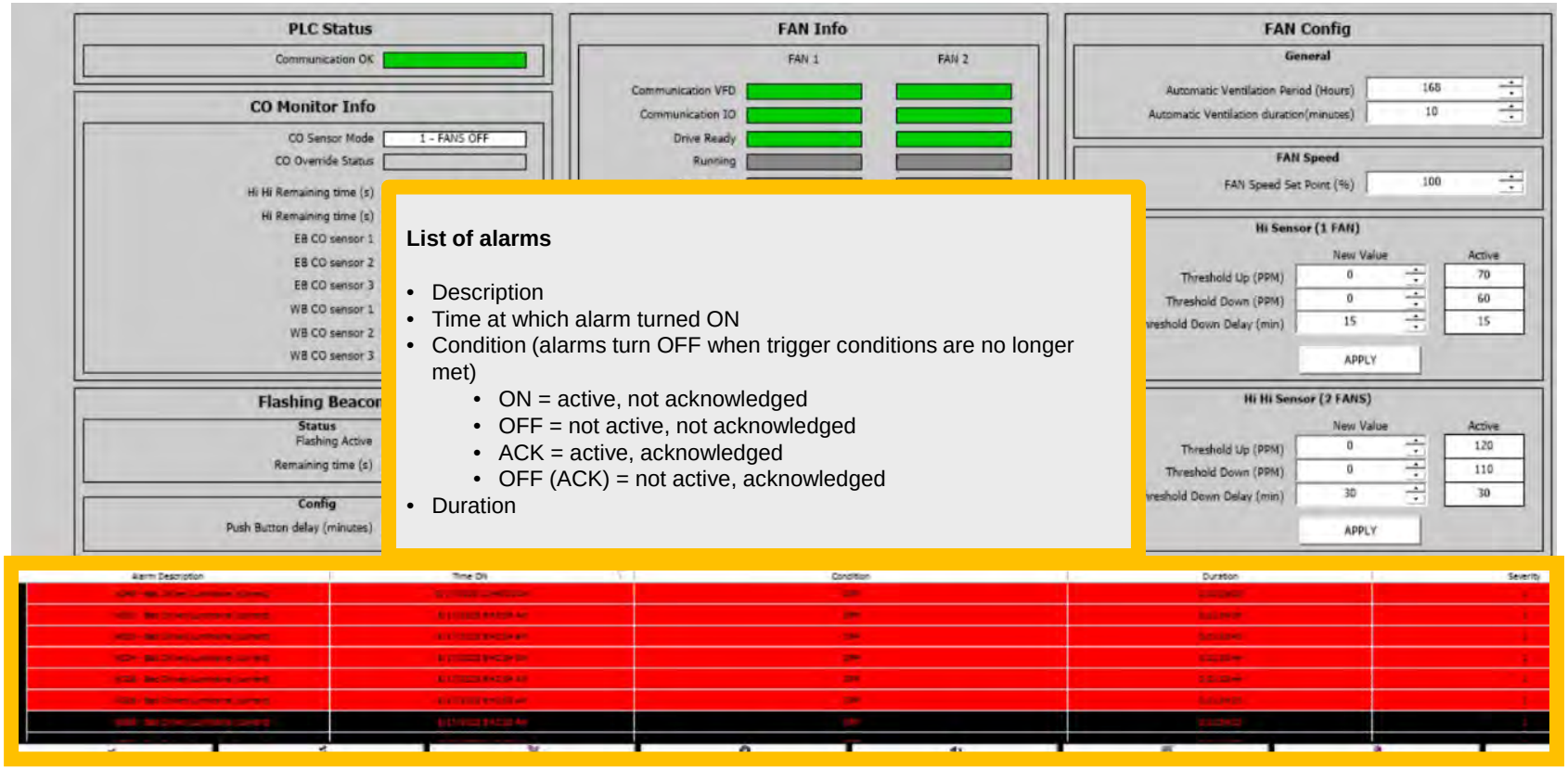
HI-HI Sensor (2 FANS)

Threshold Up (PPM)
- New Value: Used to set the level (ppm) at which Mode 3 will activate (from Mode 2)
- Press the APPLY button to set the New Value as the Active Value

Threshold Down (PPM)
- New Value: Used to set the level (ppm) at which Mode 3 will deactivate (to Mode 2)
- Press the APPLY button to set the New Value as the Active Value

Threshold Down Delay (min)
- New Value: Used to set the time period (minutes) during which Mode 3 will remain active after the Threshold Down value has been reached (to Mode 2)
- Press the APPLY button to set the New Value as the Active Value

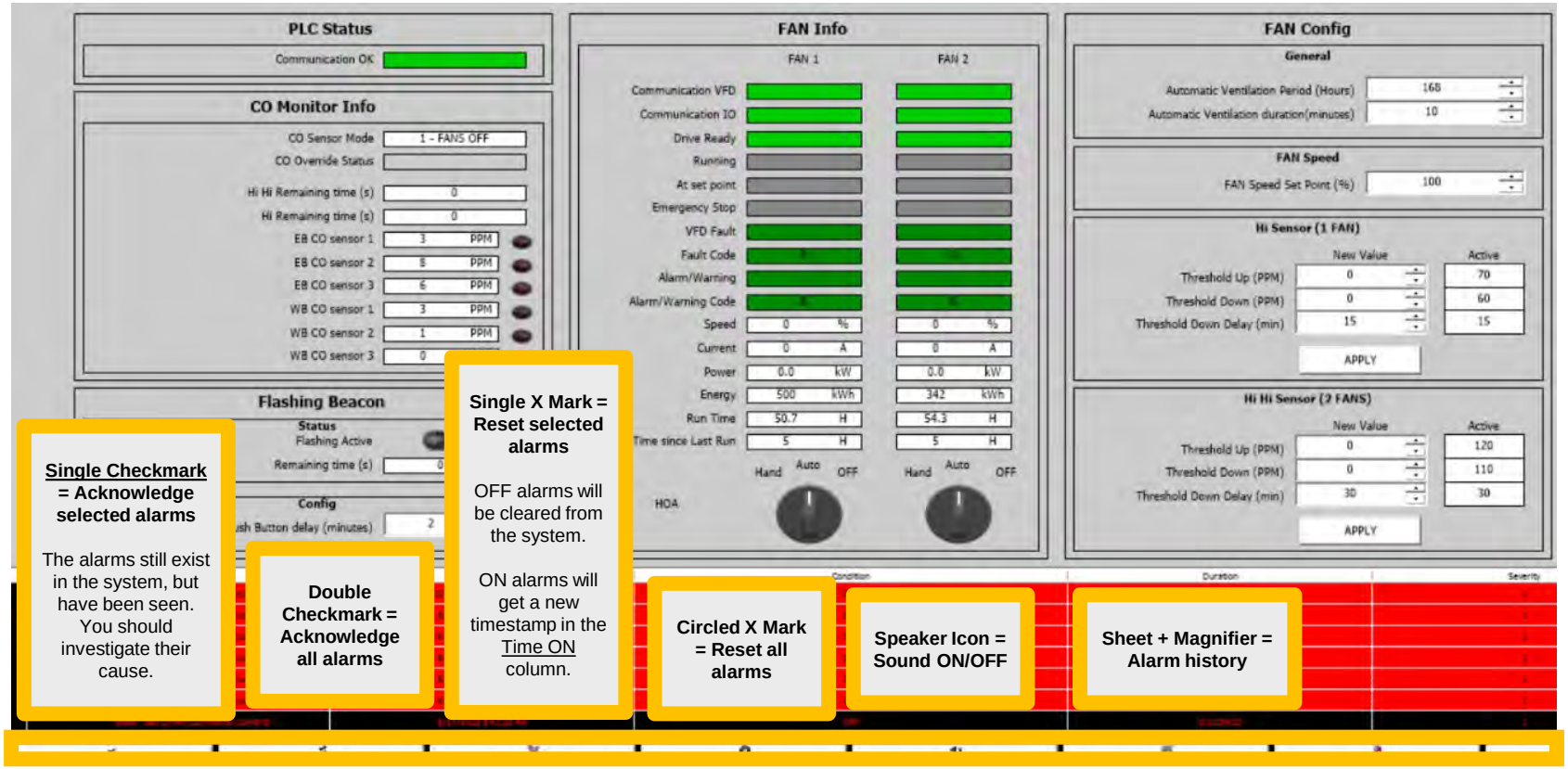
Interfaces
TLACS-SCADA: Fan and Beacon



List of alarms

- Description
- Time at which alarm turned ON
- Condition (alarms turn OFF when trigger conditions are no longer met)
  - ON = active, not acknowledged
  - OFF = not active, not acknowledged
  - ACK = active, acknowledged
  - OFF (ACK) = not active, acknowledged
- Duration

Interfaces
TLACS-SCADA: Fan and Beacon



Interfaces
TLACS-SCADA: Fan and Beacon

- VFD Operation Alarms reported in TLACS-SCADA
- Alarms that will be sent via email

Log Description	Email Alert
FAN1 - Fan 1 Running	
CO Sensor Mode - ONE FAN ON	
CO Sensor Mode - TWO FANS ON	
CO Sensor Mode - CO monitor Invalid Value	X
CO Override Status - Override Active	X
VFD PLC Com Fail - VFD PLC Communication failure	X
VFD1Alarm - Alarm <<AlarmWordFan1>>	X
VFD1ComFail - Communication Failure	X
VFD1Fault - Fault <<FaultWordFan1>>	X
VFD1HOA - HAND Mode	X
VFD1HOA - OFF Mode	X

Interfaces
TLACS-SCADA: Fan and Beacon

- CO monitor alarms reported in TLACS-SCADA
- Alarms that will be sent via email

Log Description	Email Alert
EB_CO_Sensor1 - Calibration	X
EB_CO_Sensor1 - Cleaning mode	X
EB_CO_Sensor1 - Fault	X
EB_CO_Sensor1 - Maintenance	X
EB_CO_Sensor1 - Overange	X
EB_CO_Sensor1 - Unknown Error	X

Conclusion

- Contract 4509, IR 80, Carlin Tunnel Lighting
- Tunnel Lighting System
  - Nyx Hemera Tunnel Lighting Addressable Control System – Energy Management (TLACS-EM)

Questions?


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