



Case Study – Bridges

o Arsenal Bridge

Rock Island, IL, 2009-2010





- Constructed 1896, Steel Through Pratt Truss, 8 Spans
- Combined Two Lane Highway-Railway Structure
- Length: Rail (Spans 1-8) 1,848 ft, Vehicle (Spans 2-6) 1,556 ft
- 360° Swing Span 2: 336 ft, 2,000 Tons
- Swing Span Average Turn Time: 12 Min
- Traffic: Rail 1,881/yr, Vehicle 10,297/day, Barges/Boats 18,568/2,884/yr

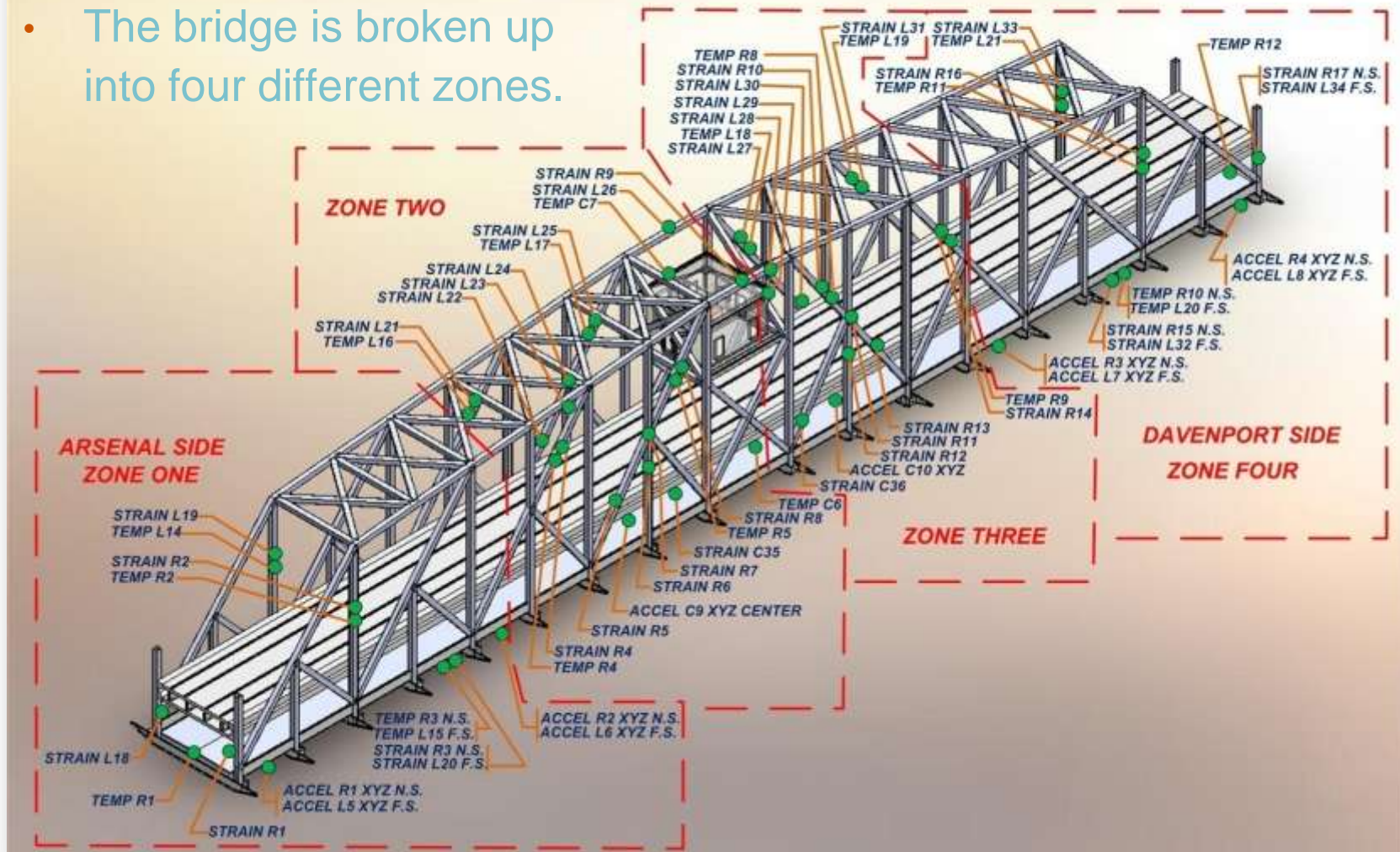


Aim	To monitor the integrity and behavior of the bridge structure, and effects due to high traffic and heavy truck loads that could cause possible damage & fatigue.
Location	Rock Island, IL
System Integrator	Chandler Monitoring Systems, Inc. http://www.chandlermonitoring.net
Customer	Concurrent Technologies Corporations
Date	November 2009
Instrumentation	(1) Micron Optics sm130-500 Optical Sensing Interrogator (1) Micron Optics sm041-416 Optical Channel Switch Extension
Sensors	(36) Micron Optics os3100 Strain Sensors (21) Micron Optics os4300 Temperature Sensors (10) Micron Optics os7100 3D Accelerometers (1) Fiber Optic Tilt Meter Conventional AE, weather and corrosion sensors
Project Scope	Employ system on the bridge to greatly reduce risk of catastrophic failure by providing advance warning of growing structural problems caused by corrosion/materials degradation. Demonstrate and validate state-of-the-art and emerging innovative technology approaches for remote structural health and corrosion degradation monitoring of steel bridges.



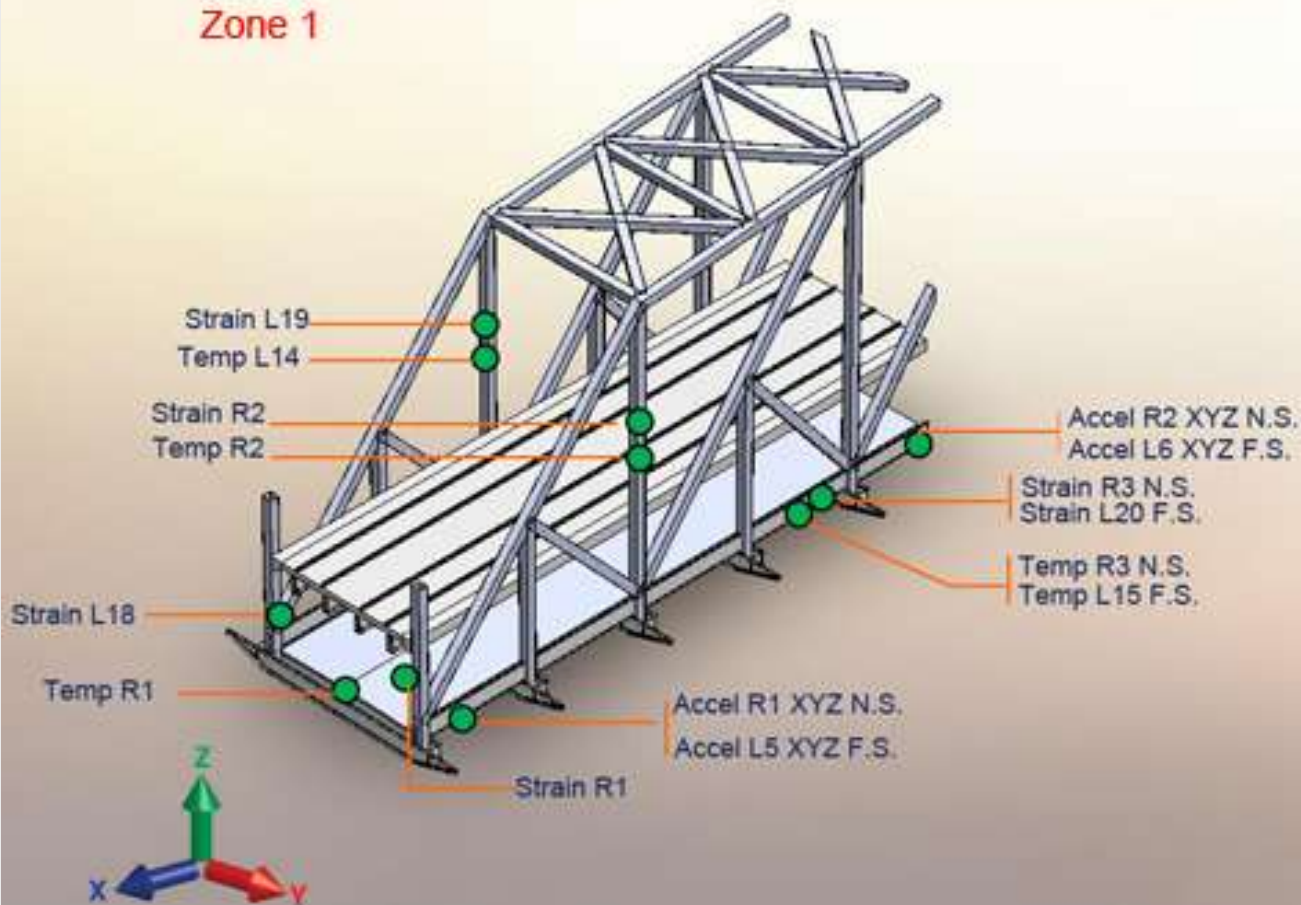


- Sensors were installed along the length of the entire structure, including the rail deck above and the road deck below.
- The bridge is broken up into four different zones.



Arsenal Side

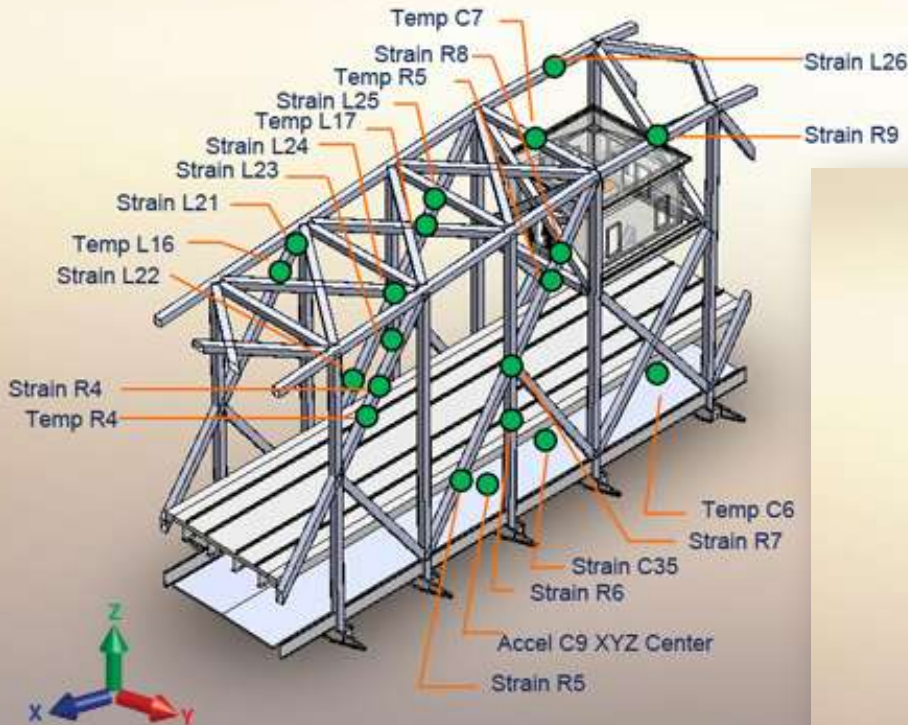
Zone 1



- A total of 15 sensors cover the upper and lower deck.
- Sensors consist of :
 - (6) Strain
 - (5) Temperature
 - (4) 3D Accel

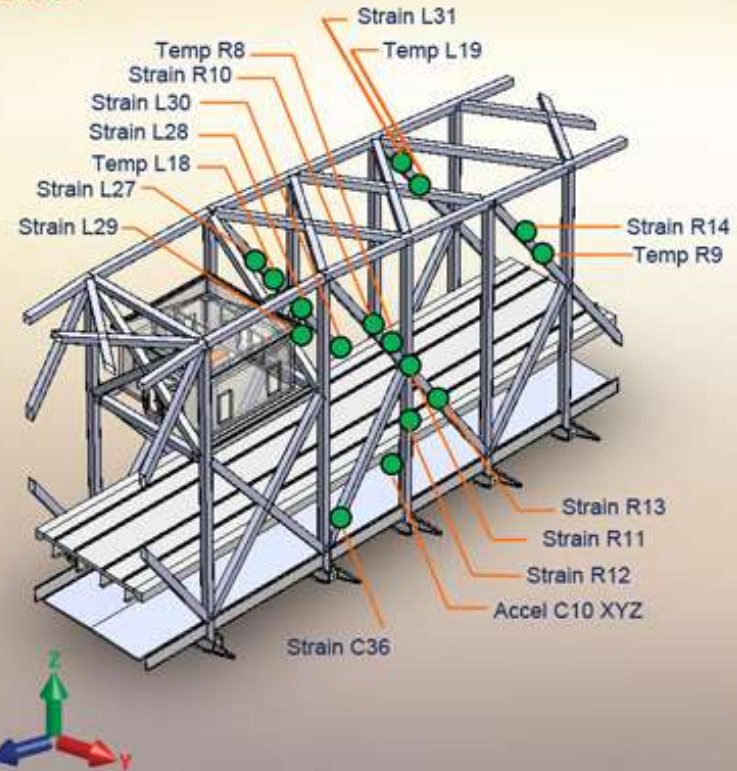


Zone 2

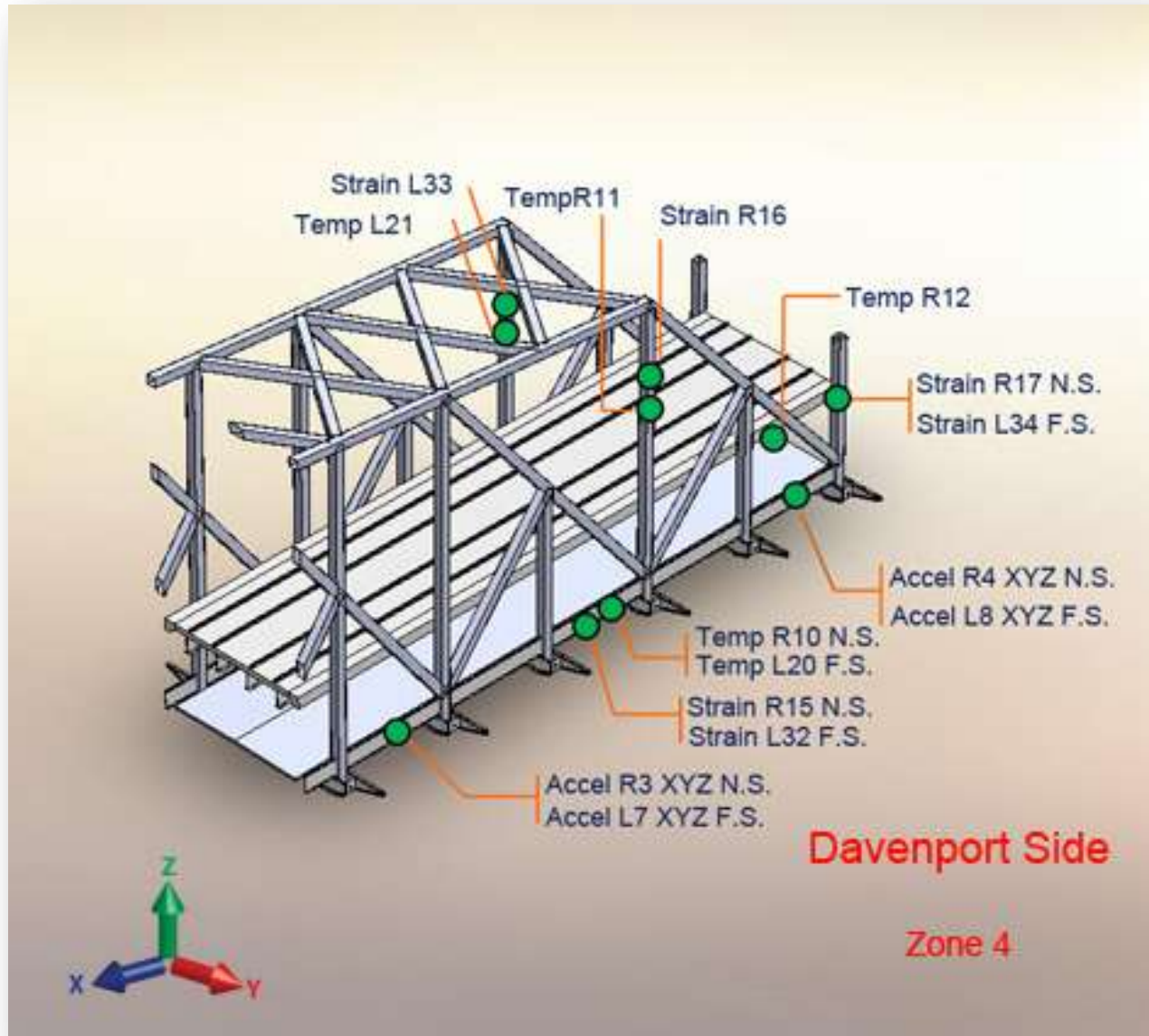


- Zone 2 - Arsenal side of the swing span.
- (13) Strain Sensors
- (6) Temperature Sensors
- (1) 3D Accelerometer
- (1) Tilt Meter

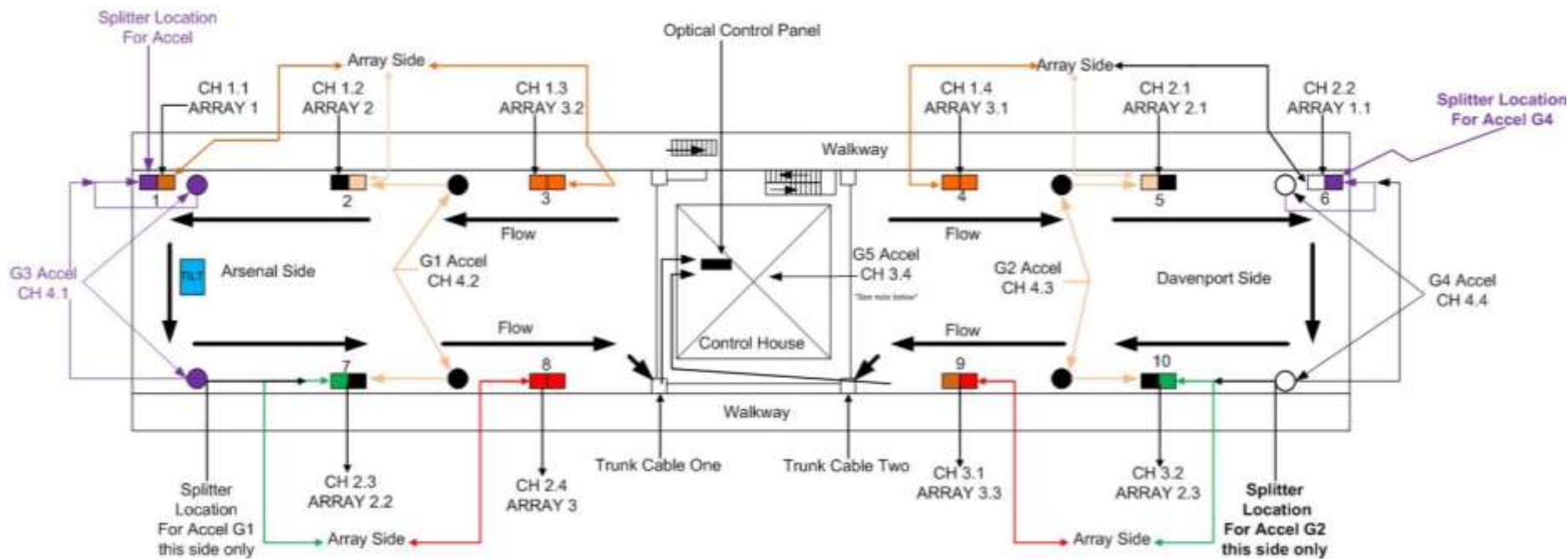
Zone 3



- Zone 3 – Davenport side of the swing span.
- (11) Strain Sensors
- (4) Temperature Sensors
- (1) 3D Accelerometer



- A total of 15 sensors cover the upper and lower deck.
- Sensors consist of :
 - (6) Strain
 - (5) Temperature
 - (4) 3D Accel



Splice Tray Cable Color Guide

The monitoring system instrumentation is composed of:

- Single optical interrogator (model sm130-500), 1Khz, 4 channels
- 4x16 channel sensor multiplexer (model sm041-416)
- sp130 controller and data acquisition module

Controller & Data Storage sp130



Sensor Interrogator sm130-500



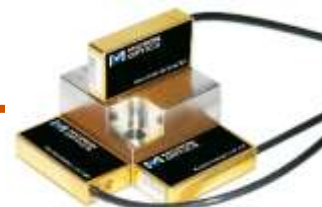
Sensor Multiplexer sm041-416



Strain



Temp



Acceleration



Temp



Tilt



FBG sensor arrays were pre-assembled to length for each bridge segment.



Once on-site, sensors are unpacked and prepared for installation.

Access via man-lift and scaffolding



3D Accelerometer being installed on the swing span



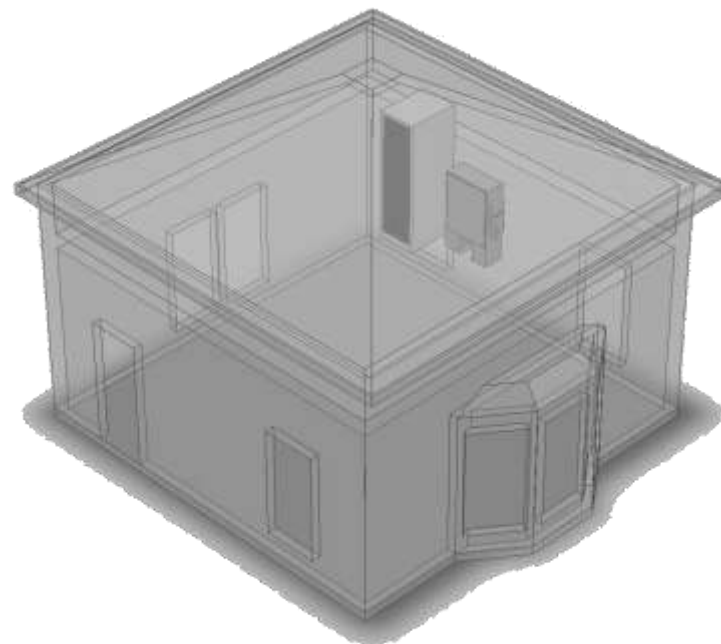
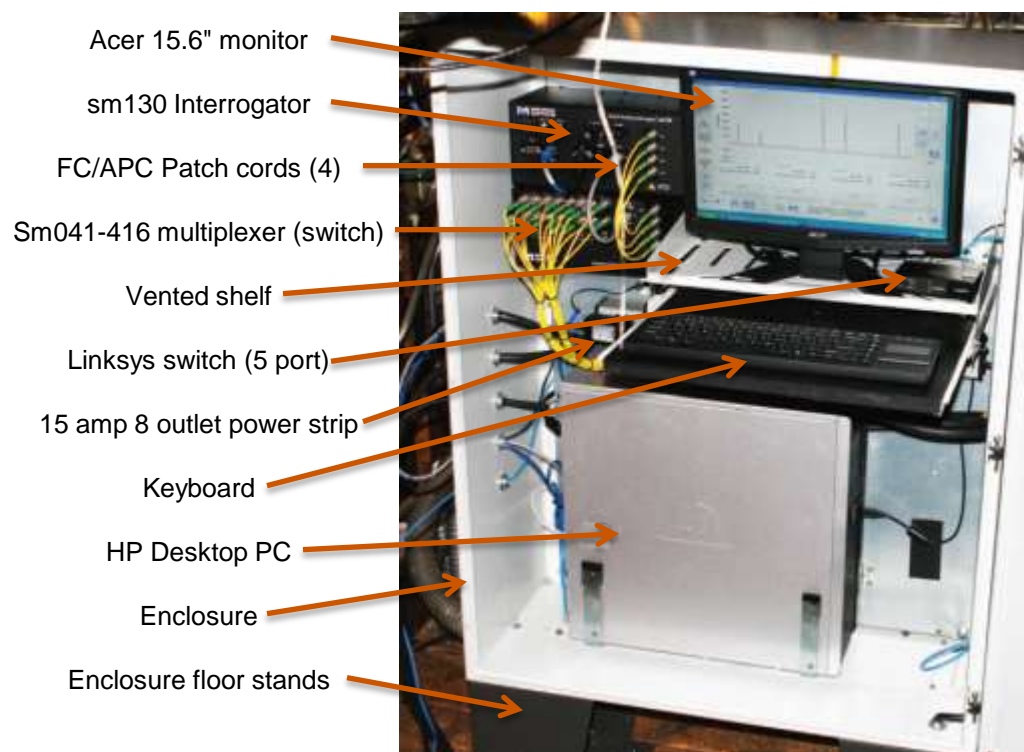


Main cable feed tapping point and industrial grade IP69 splice tray. *(below)*

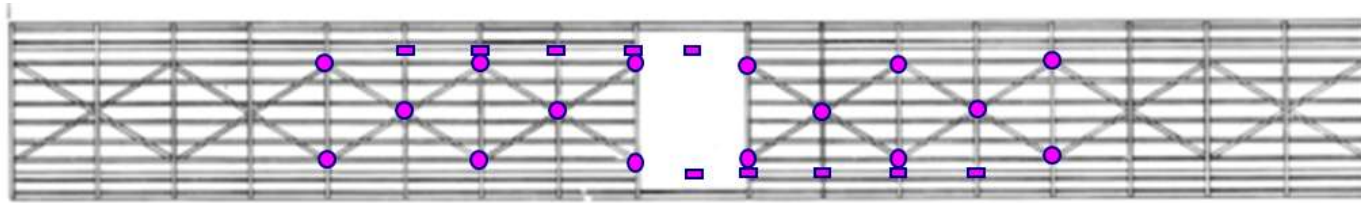
Tapping into the main cable feed at various locations along the bridge. *(above)*



The optical system is housed inside a NEMA rated box with controlled temperature and humidity.

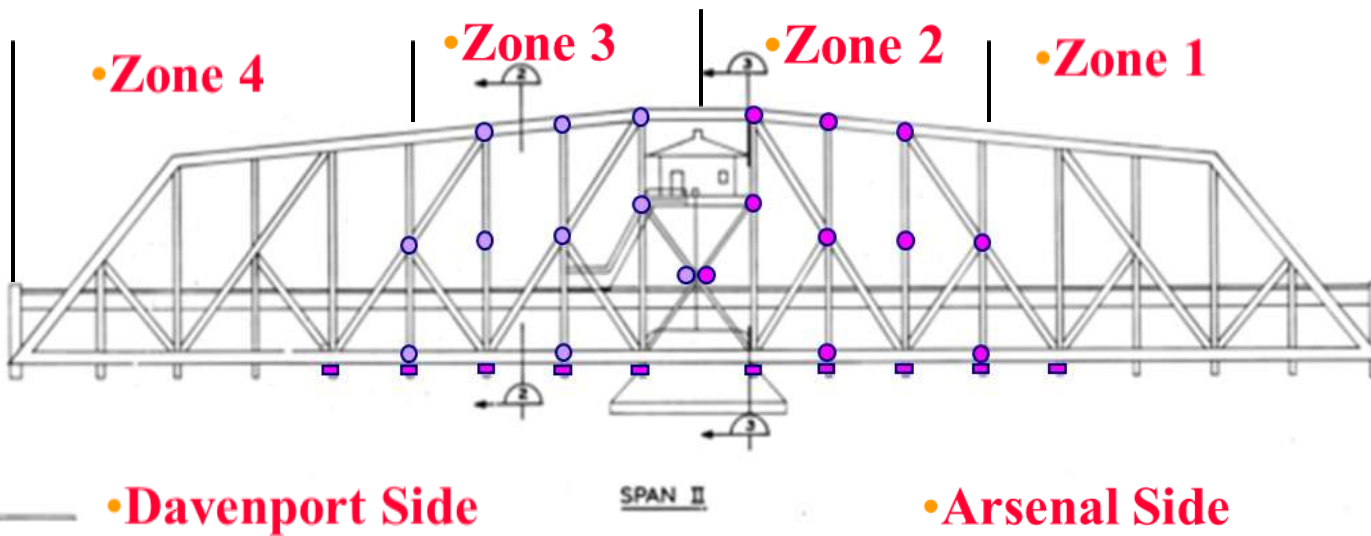


Control House with optical panel in attic.



HIGHWAY DECK – UNDERSIDE PLAN

- 16 AE sensors on underside of road deck (8 per side)



- 20 AE sensors on vertical trusses (10 per side)

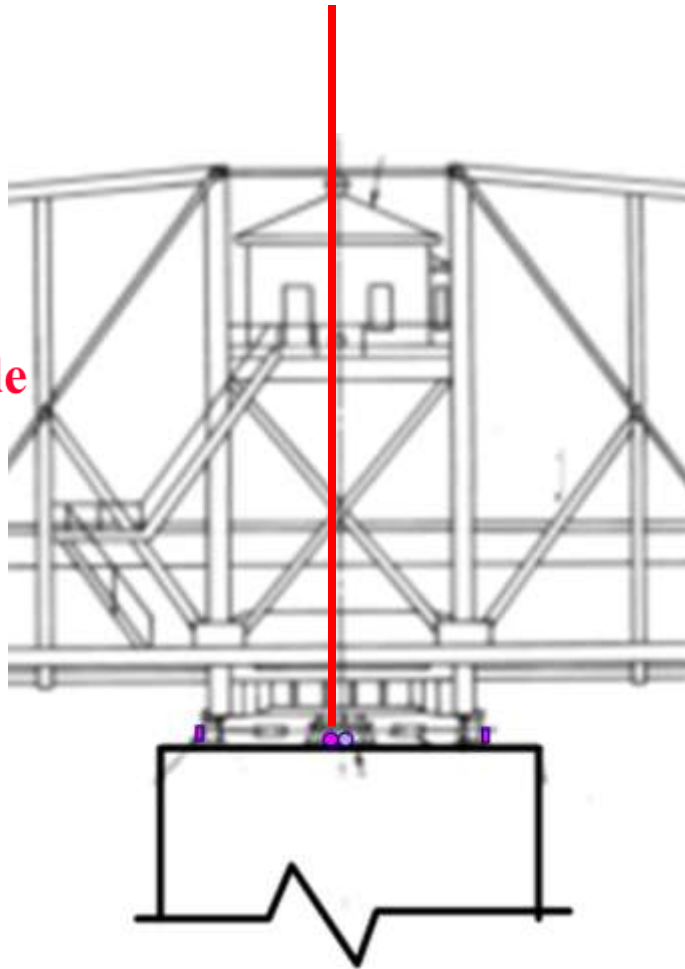
● Sensor on front side

○ Sensor on back side

■ Side view of sensor

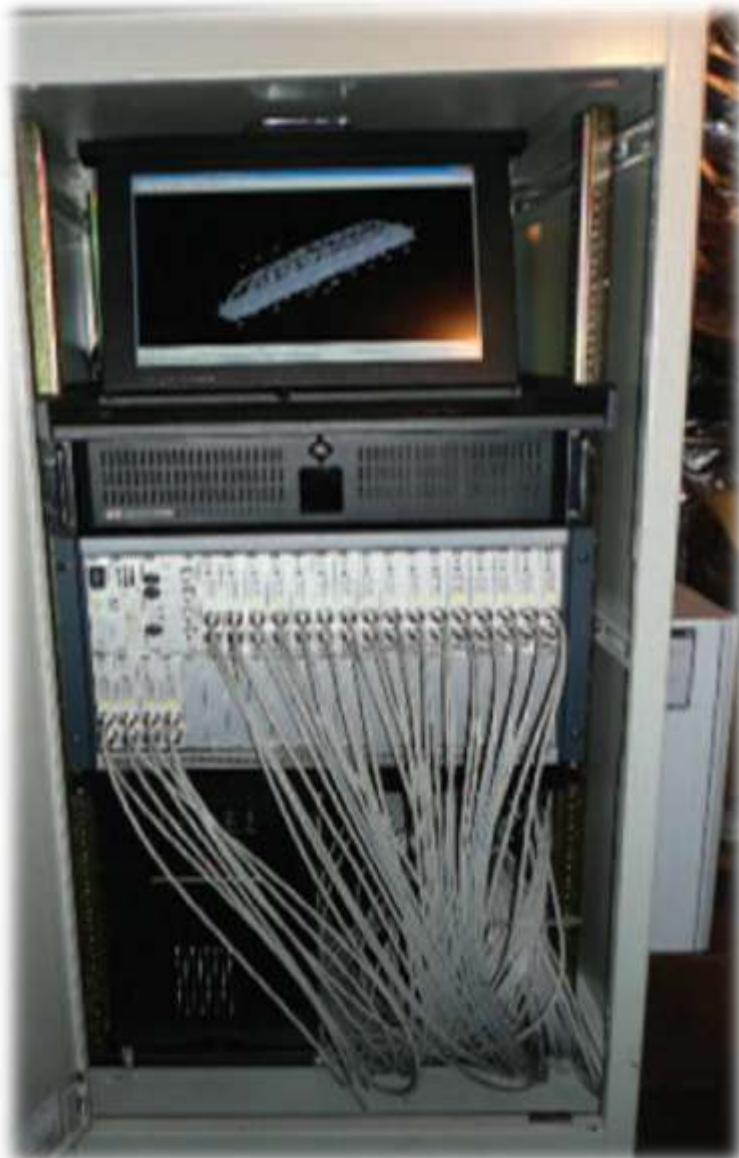


- **Davenport Side**
- **Zone 3**



- 4 AE sensors staggered around turntable structure
- **Arsenal Side**
- **Zone 2**

- Sensor on front side
- Sensor on back side
- Side view of sensor



Acoustical Emission Sensors are installed and tied into the IntelOptics Software Program.



- Chandler Monitoring Systems' customized GUI software
 - Monitors, gathers data and provides alerts and analysis when various sensing systems approach or exceed established limits.
 - Communicates with numerous sensing systems to display status and provide information in one centralized user program which can be accessed remotely.
 - Electrical Resistance Corrosion Sensors, Weight in Motion Sensors, Weather Stations, Security sensors, and Water depth sensors are some sensors that may be fully integrated into the IntelOptics™ software.
- Micron Optics ENLIGHT application software is used for FBG sensor setup and to stream sensor data to IntelOptics™.



Overall Status Indicator Zone Status Indicator Button To Zone 2 page Bridge Image with Zone Indications

The screenshot shows the IntelOptics software interface. At the top is a navigation menu with tabs: OPTICAL SENSORS, SUMMARY, ZONES, ADVANCED, SETTINGS, REPORTS, REPORT OUTPUT, CORROSION, AE SYSTEM, and Discussion Board (Chat). Below the menu are logos for IntelOptics, CMS, CTC, and the US Army Corps of Engineers. The main area features an 'Overall Status' section with three colored circles (green, yellow, red) and a red warning box. To the right is a 3D model of a bridge structure with four zones labeled 'Zone 1' through 'Zone 4', 'Arsenal End', and 'Davenport End'. A red dot on Zone 2 indicates an active alert. Below the model is a 'System Last Updated' timestamp and a 'Most Recent Notification' table.

Alert Date/Time	Sensor Name (s)	System	Location
1/22/2010 1:00 PM	STRAIN R4 (Red)	Optical Sensors	Zone 2
1/22/2010 1:00 PM	STRAIN R4 (Red)	Optical Sensors	Zone 2

System Last Updated Indication

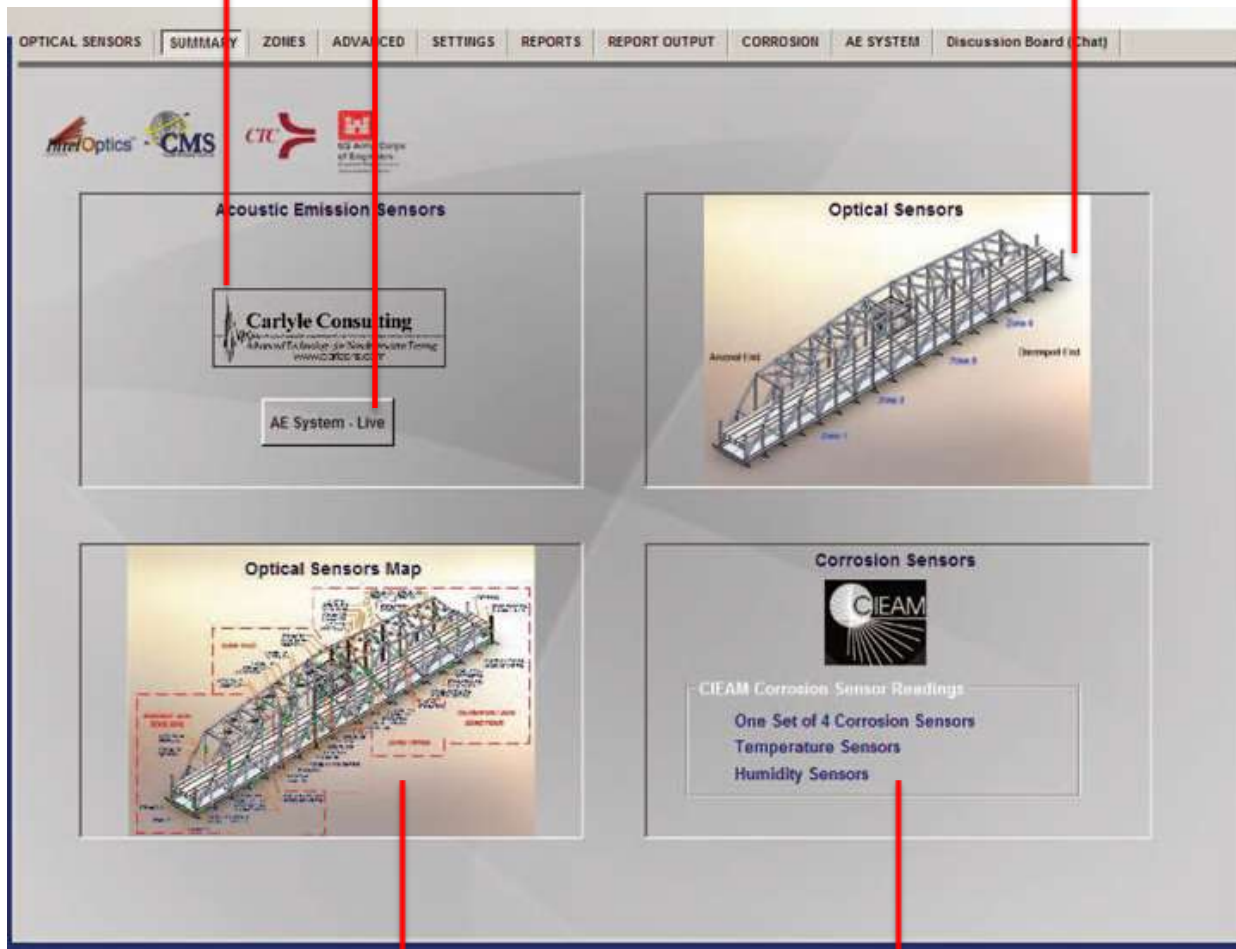
List of Previous Alarm Status



Button linked to AE System Page

Button linked to AE System Computer located at the bridge

Button linked to Optical Systems Page



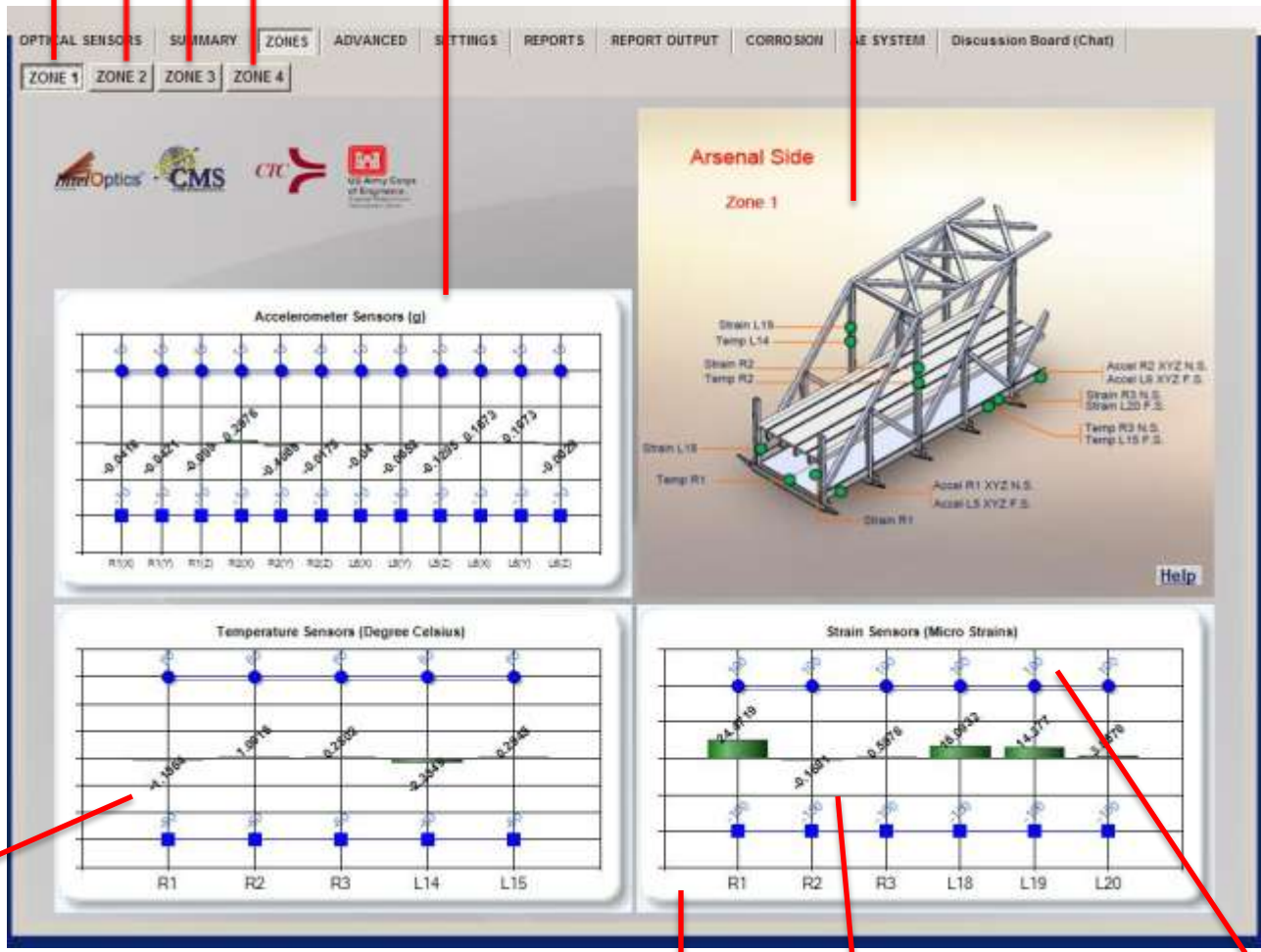
Button to zoom in on the sensor map

Button linked to Corrosion Systems Page

Zone 1 Button Zone 2 Button Zone 3 Button Zone 4 Button

Accelerometer Sensor Graph

Optical System Zone 1 Sensor Map



Temperature Sensor Graph

Strain Sensor Graph

Minimum Sensor Limit (when exceeded status will turn)

Maximum Sensor Limit (when passed status will turn red)



Data saving options. Choose to save on peak events or continuously.

Data saving interval (in seconds)

Start connection to server

Server IP address indication

Stop connection to server

ENLIGHT connection status

Database server connection status

Optical graph connection status

The screenshot shows the 'SETTINGS' tab of the IntelOptics software. At the top, there is a navigation bar with tabs: OPTICAL SENSORS, SUMMARY, ZONES, ADVANCED, SETTINGS (selected), REPORTS, REPORT OUTPUT, CORROSION, AE SYSTEM, and Discussion Board (Chat). Below the navigation bar are logos for IntelOptics, CMS, CTC, and US Army Corps of Engineers. The main content area is divided into several sections:

- Data Save Options:** Contains two sections. The first section has an unchecked checkbox 'Save Optical Sensor Readings Continuously' and a text input 'Yellow/Red Status - Save Data Time Interval (Seconds)' with the value '1'. The second section has a checked checkbox 'Save Optical Sensor Readings During Peak Events Only' and a text input 'Green Status - Save Data Time Interval (Seconds)' with the value '1'.
- Communication (Admin Use Only):** Contains an 'IP Address' field with '10.1.1.26', 'Start' and 'Stop' buttons, an 'Exit' button, and an 'Open SM130 Controls' button.
- Status Panels:** Three panels showing connection statuses: 'Enlight Communication Status: Working Normal', 'SQL Server Data Save Operation: Working Normal', and an error message: 'Index was out of range. Must be non-negative and less than the size of the collection. Parameter name: index'.
- Report Server Name:** A text input field containing 'CMSSERVER:80'.
- Enable Alarm Sound:** A checkbox that is currently unchecked.

Exit system

Connect ENLIGHT at location on bridge



Prepared reports time frame

Select all Sensors

Zones 1 – 4 Optical Sensors

Clear all selections

Time frame selection for creating reports (days)

Time frame selection for creating reports (hours)

Reports for peak events only

View selected report

Zone 1 AE Sensors

Zone 1 Corrosion Sensors

Zone 2 AE Sensors

Zone 2 Corrosion Sensors

Zone 3 AE Sensors

Zone 3 Corrosion Sensors

Zone 4 AE Sensors

Zone 4 Corrosion Sensors

The screenshot shows the 'REPORTS' tab in the IntelOptics software. At the top, there are navigation tabs: OPTICAL SENSORS, SUMMARY, ZONES, ADVANCED, SETTINGS, REPORTS (selected), REPORT OUTPUT, CORROSION, AE SYSTEM, and Discussion Board (Chat). Below the navigation is a header area with logos for IntelOptics, CMS, CTC, and the US Army Corps of Engineers. The main interface is divided into several sections:

- Prepared Reports:** Includes radio buttons for 'Last 7 Days', 'Last 30 Days', 'Last 90 Days', and 'All Sensors Readings'. A 'Clear All' button is also present.
- Time Frame Selection (Days):** Two calendar pickers for 'From' and 'To' dates, both set to January 2010. The 'From' calendar has the 22nd selected.
- Time Frame Selection (Hours):** Two dropdown menus for 'From' and 'To' times, both set to 1:00AM.
- Peak Events Only:** A checkbox labeled 'Peak Events Only'.
- View Report:** A button to generate the report.
- Zones 1-4:** Four columns of sensor selection options. Each zone has sections for 'Strain Sensors', 'Temperature', and 'Accelerometer'. Each section contains checkboxes for specific sensor IDs (e.g., L18, R1, L12, R1, L5, R1). At the bottom of each zone column are checkboxes for 'AE System' and 'Corrosion Sys'.



Reports time frame selection (days/hours)

Sensor reading value selection

View report selection

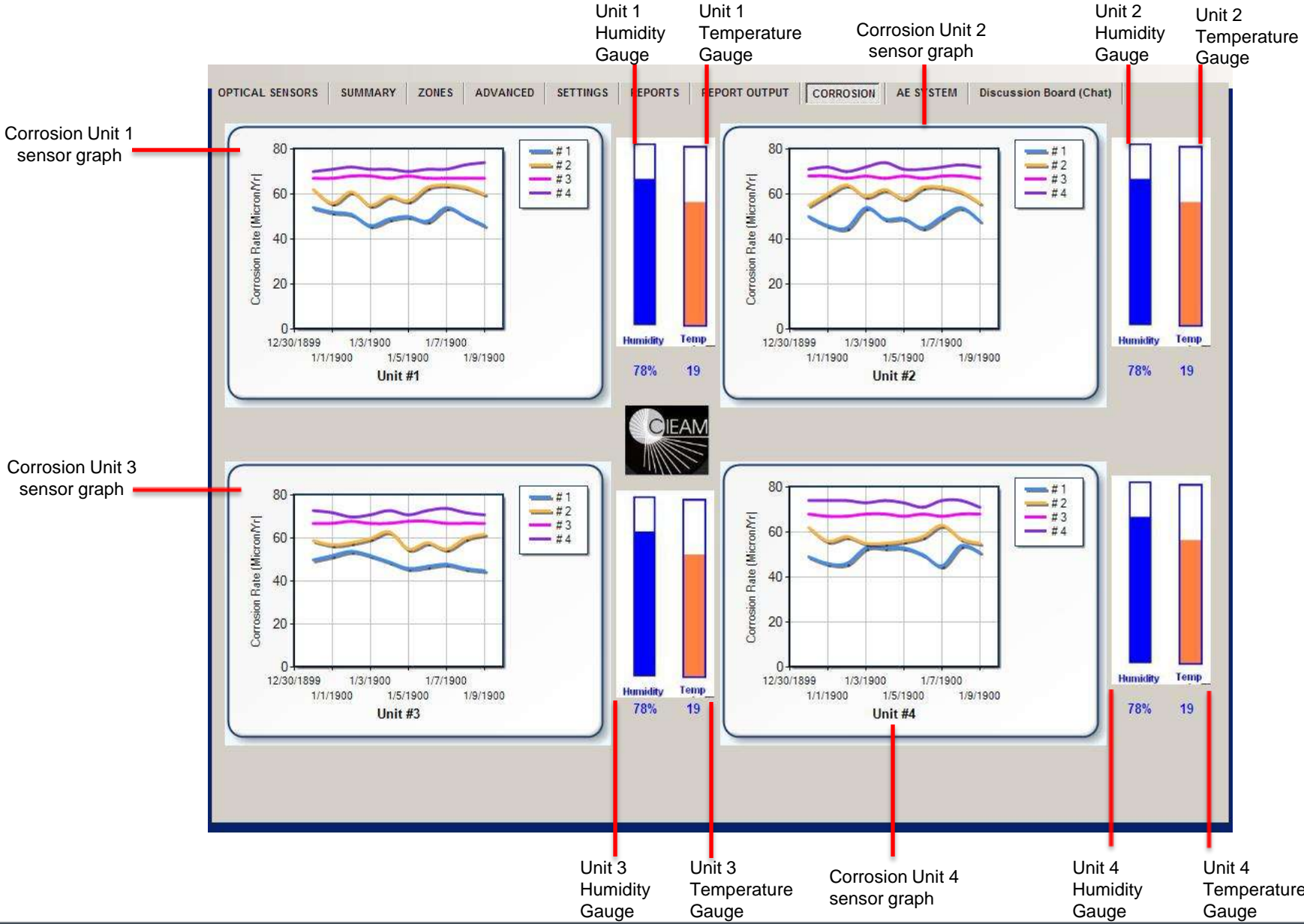
Reports page indication and selection

Reports export file type selections

Date Recorded	Strain Sensor L18
1/14/2010 8:06:00 AM	33.0125
1/14/2010 8:06:02 AM	33.0659
1/14/2010 8:06:04 AM	33.0042
1/14/2010 8:06:05 AM	33.1297
1/14/2010 8:06:08 AM	33.0798
1/14/2010 8:06:10 AM	33.0199
1/14/2010 8:06:11 AM	33.0629
1/14/2010 8:06:13 AM	32.9436
1/14/2010 8:06:15 AM	32.9195

Minimum Reading = -50.07 Average Reading = 32.79
Maximum Reading = 36.83 Total # of Readings = 1,587

IntelOptics Software : Corrosion Sensor Reporting



Corrosion Unit 1 sensor graph

Unit 1 Humidity Gauge

Unit 1 Temperature Gauge

Corrosion Unit 2 sensor graph

Unit 2 Humidity Gauge

Unit 2 Temperature Gauge

Corrosion Unit 3 sensor graph

Unit 3 Humidity Gauge

Unit 3 Temperature Gauge

Corrosion Unit 4 sensor graph

Unit 4 Humidity Gauge

Unit 4 Temperature Gauge



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