University of New Hampshire

The "Living" Bridge: The Future of Smart, Sustainable, User-Centered Transportation Infrastructure

Adapting to Climate Change using ITS

May 10th 2016

Civil & Environmental Engineering

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Tat Fu

Sociology

Lawrence Hamilton

Mechanical/Ocean Engineering

Ken Baldwin

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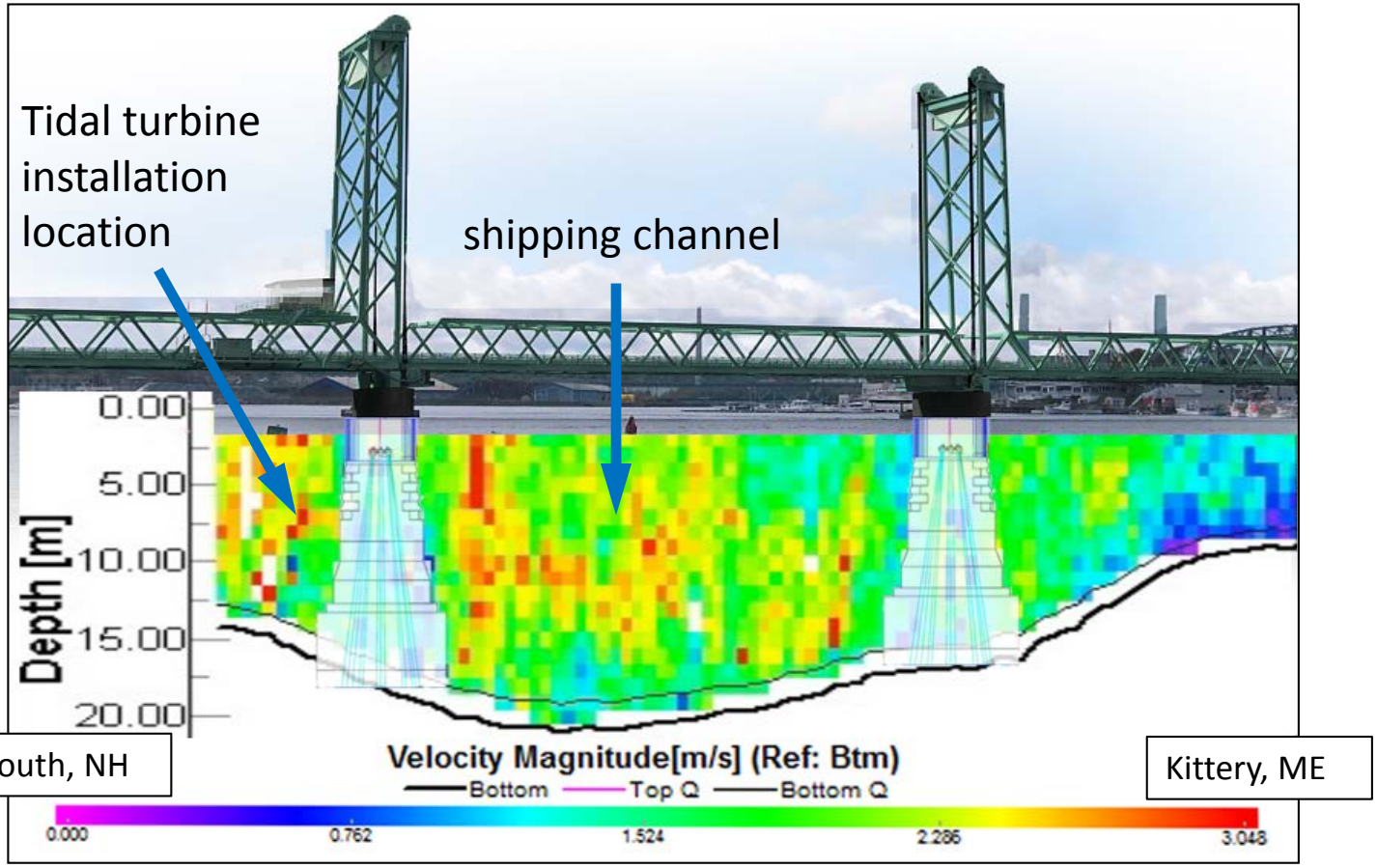
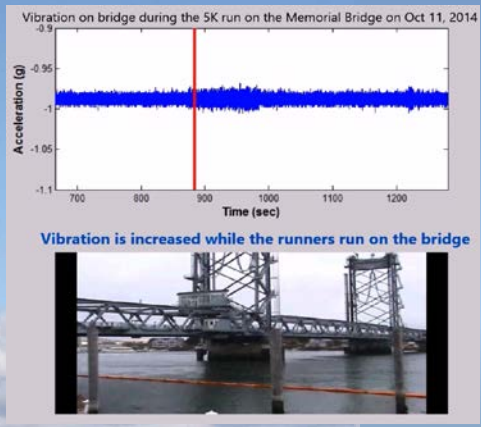
Sustainable Infrastructure

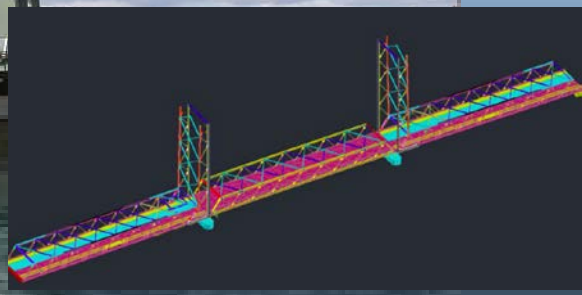


Utilize locally available renewable, sustainable, tidal energy at Memorial Bridge.

Memorial Bridge
in Portsmouth, NH

Structural Model & Response

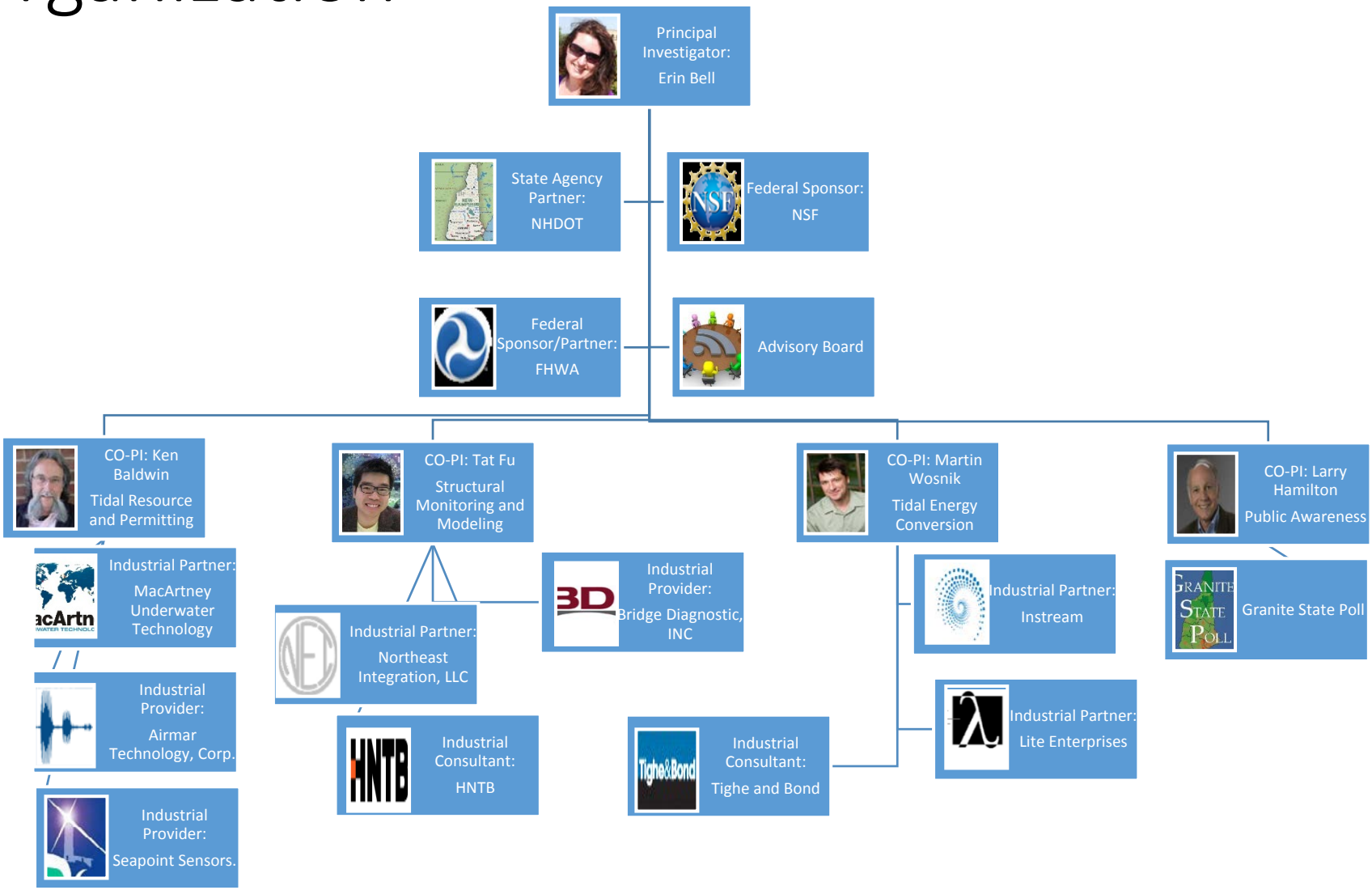




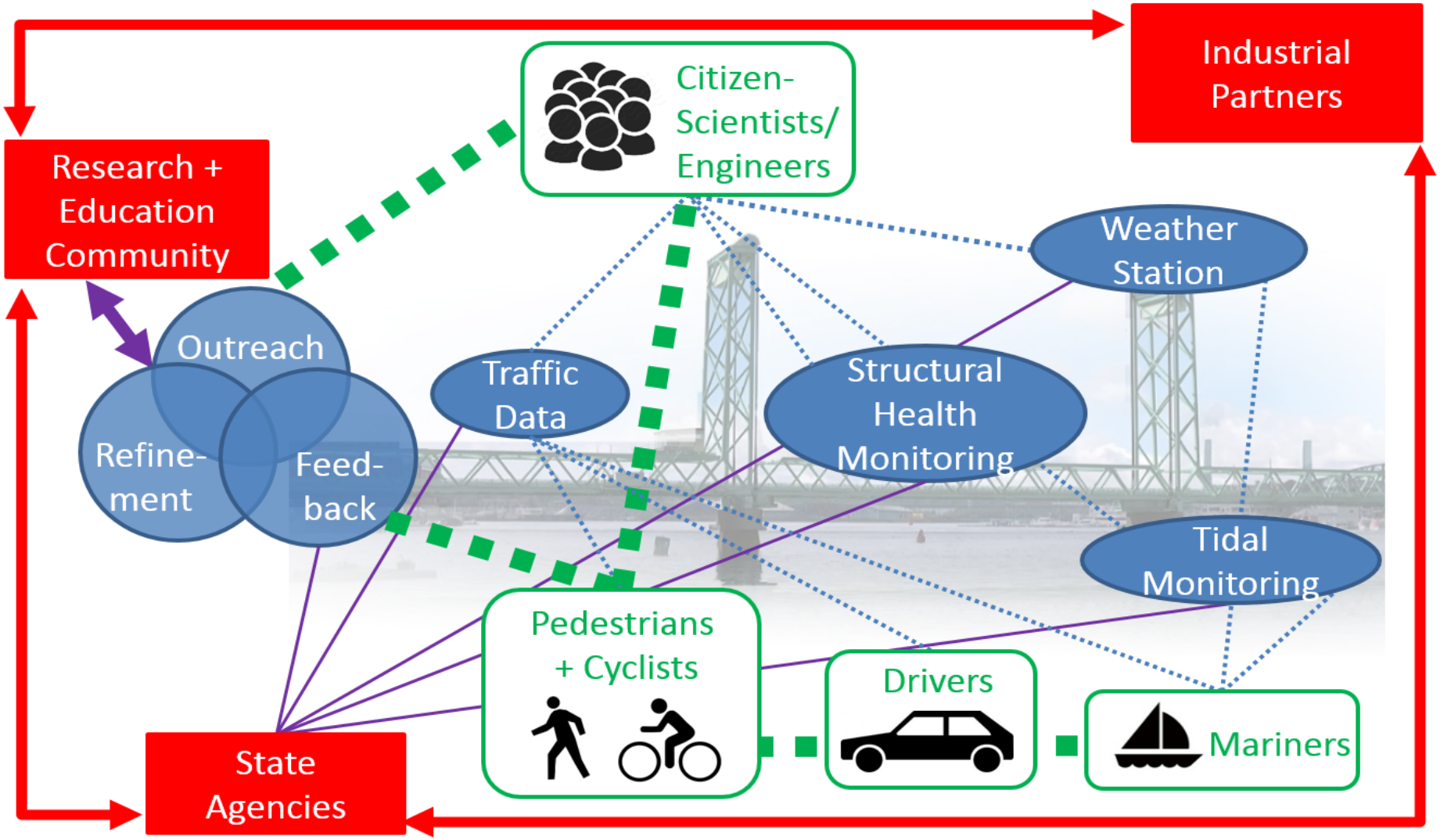
Structural and marine sensors

Tidal turbine powers sensors

Project Organization



User-Centered Smart Infrastructure



Instrumentation Team

Traffic

Vehicle type, speed and

Environmental

AIRMAR TECHNOLOGY CORPORATION

Weather Station

lity, etc.)

Structural

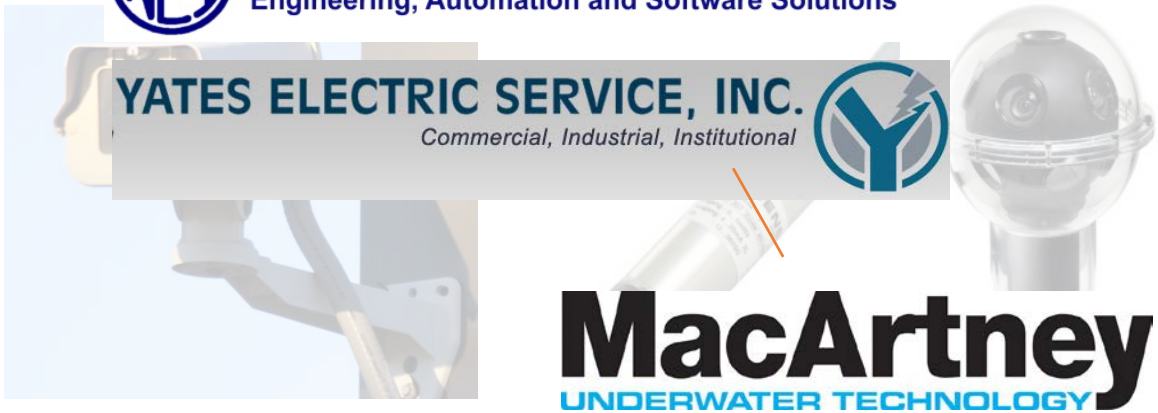
Accelerometers

Installation & System Integration

Northeast Integration, LLC
Engineering, Automation and Software Solutions

BDI Bridge Diagnostics Inc.

YATES ELECTRIC SERVICE, INC.
Commercial, Industrial, Institutional



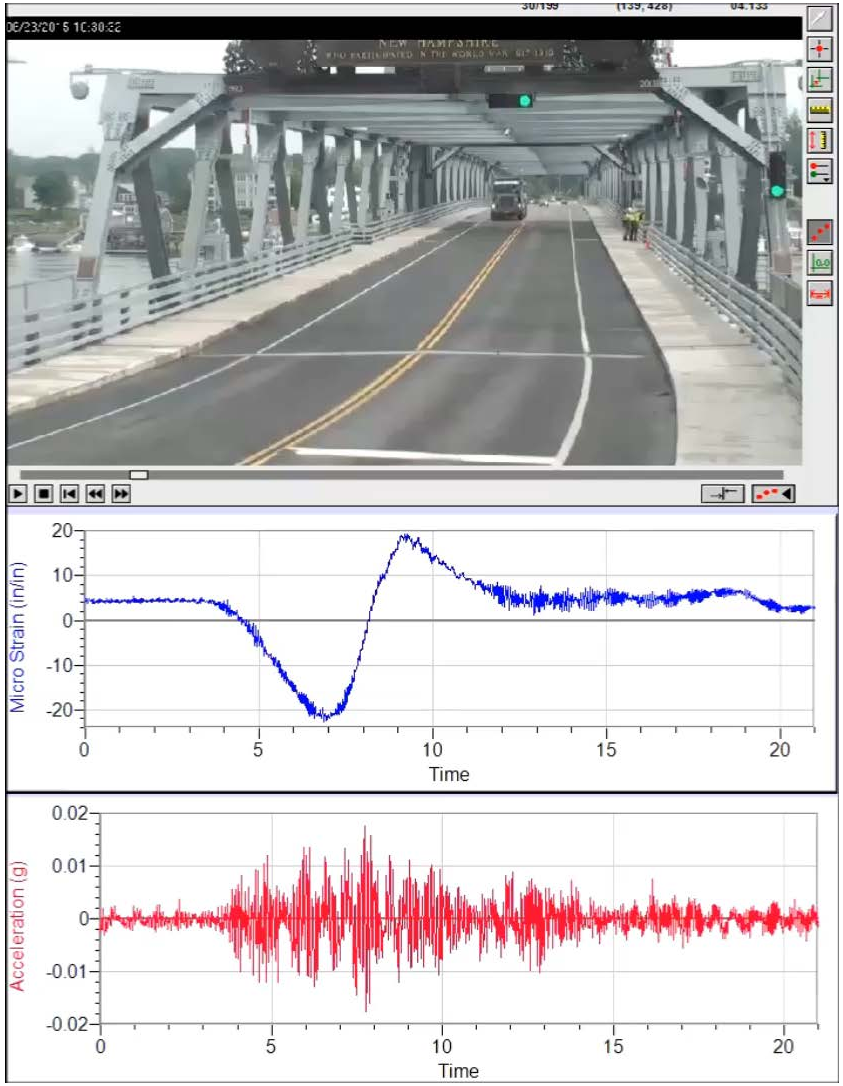
MacArtney UNDERWATER TECHNOLOGY

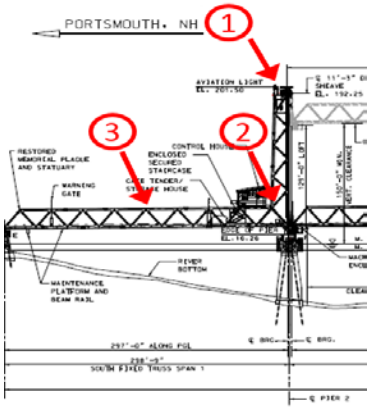
Video (security and pedestrian/bicycle traffic)

Underwater sensors (camera, water temperature, pH level, turbidity, salinity, etc.)

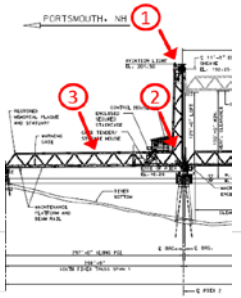
Strain gauges

Effect of Truck Traffic on Bridge at Location 3

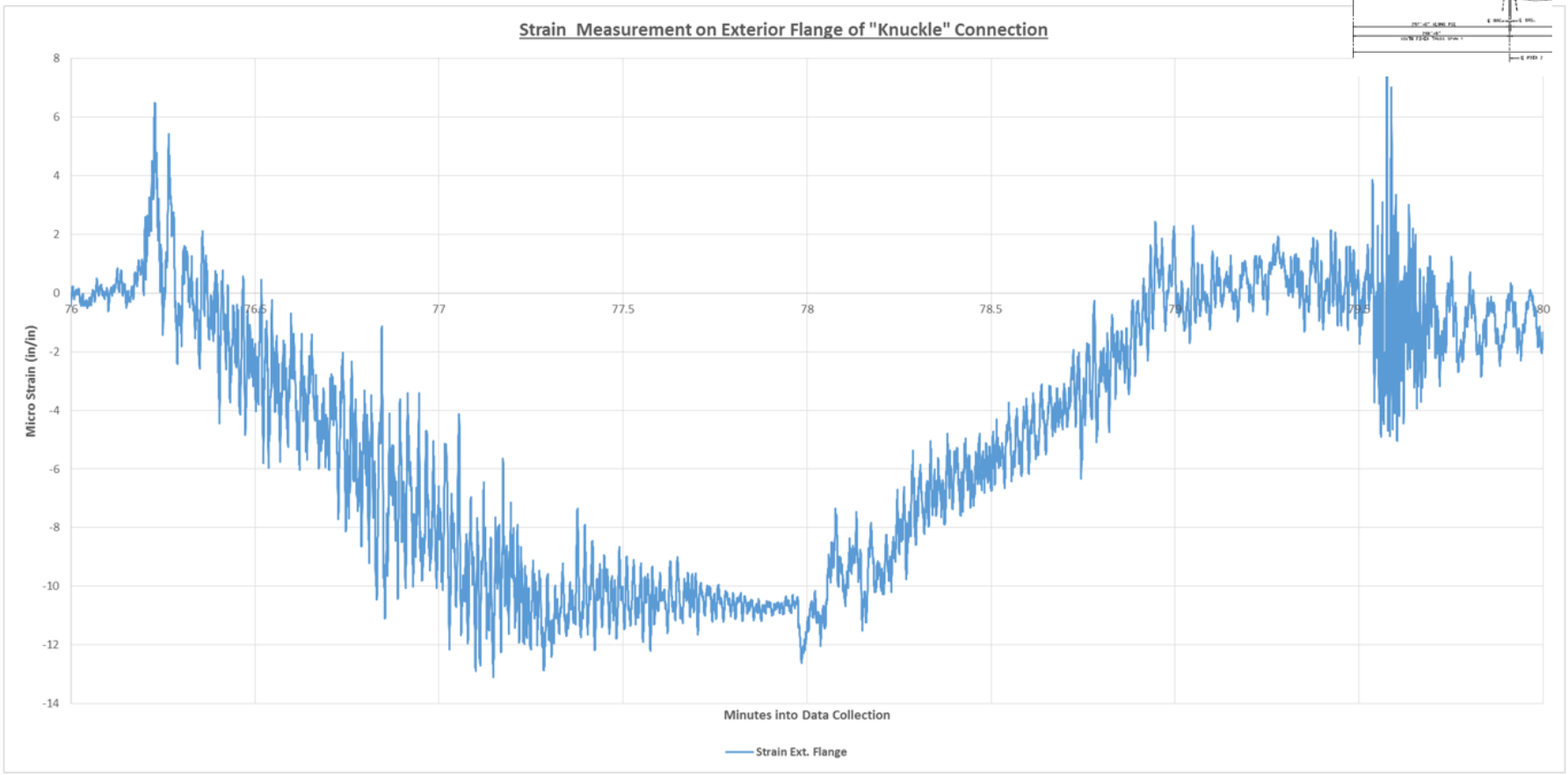




Bridge Lift Event at Location 2



June 10th Strain Data during Lift Event at 11:30 am



Lull in traffic preceding lift

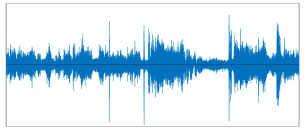
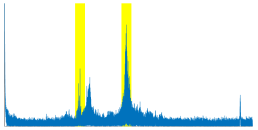
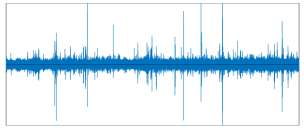
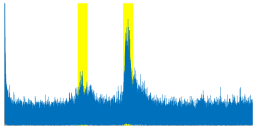
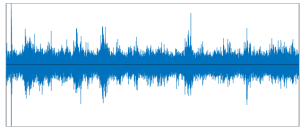
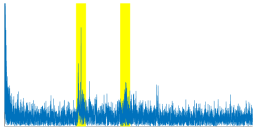
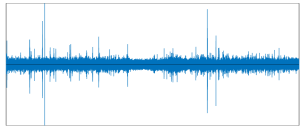
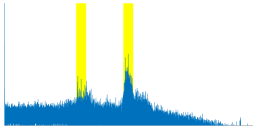
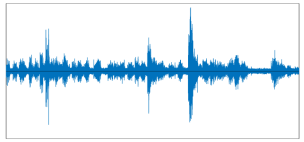
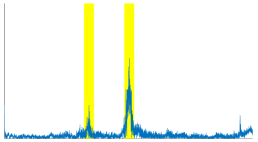
Rotary mechanism induced strain cycle during raising of the central span

Central span lifted and stationary

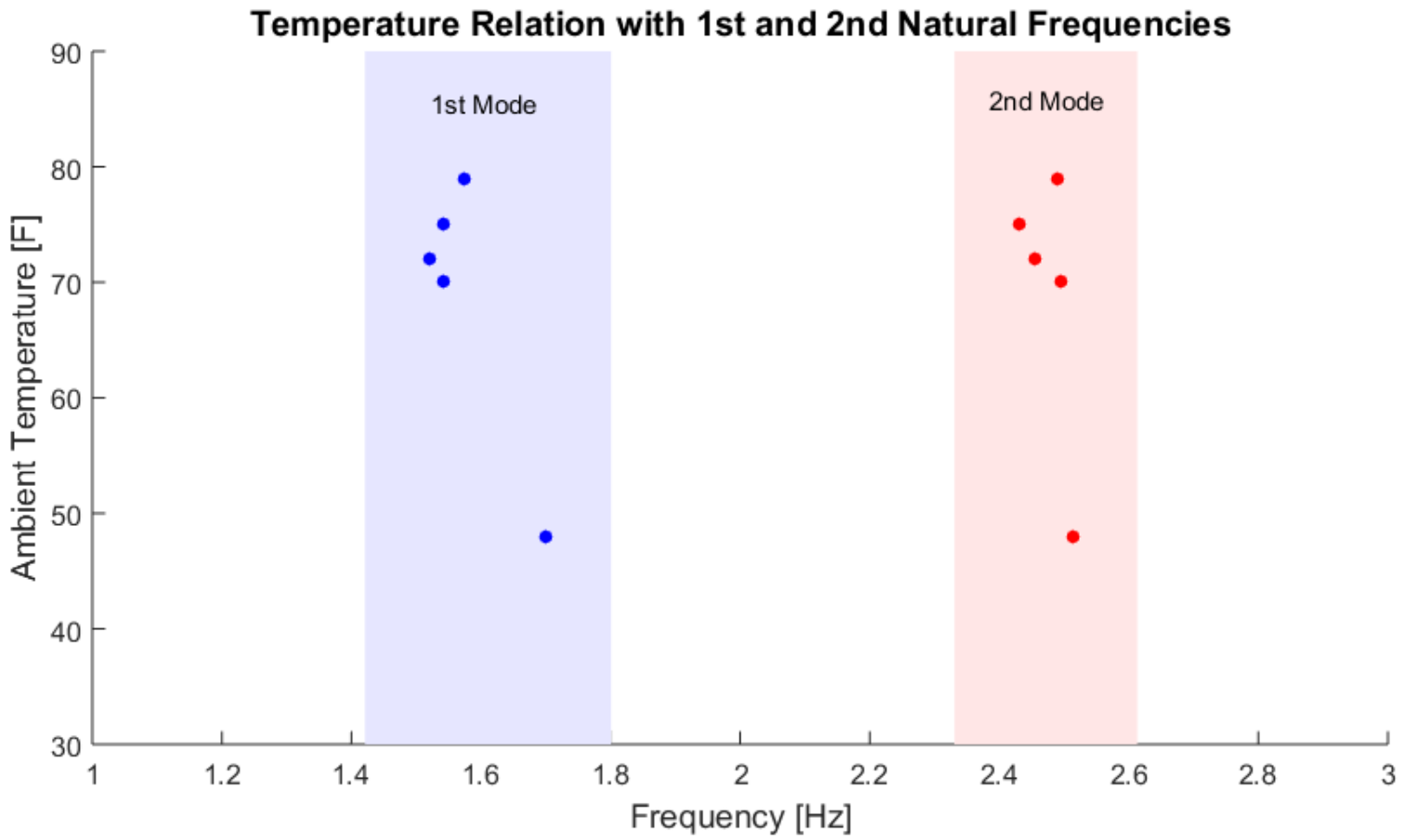
Lowering of the central span, Note strain when the span is set down on the pile cap

Vehicle traffic after lift event

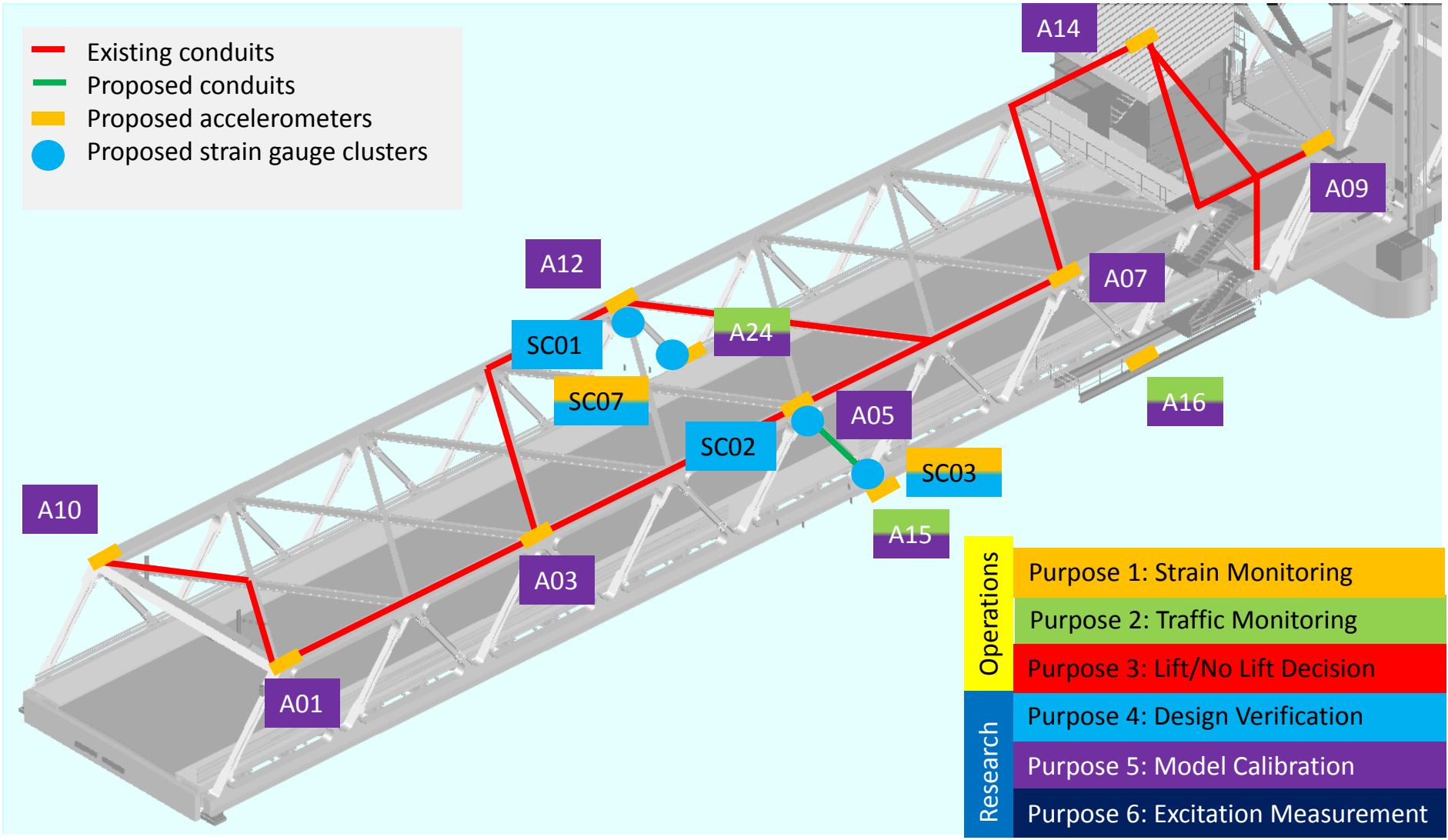
2015 Field Data Collection

Date	Ambient Temp (°F)	Photo	Components Instrumented	Midspan Vertical Acceleration Time History	Midspan Frequency Response
23 June	72°F		Fixed Span		
29 July	79°F		Fixed Span & Tower		
12 August	75°F		Fixed Span & Tower		
27 August	70°F		Fixed Span		
14 December	48°F		Fixed Span		

Modal Frequencies vs. Temperature



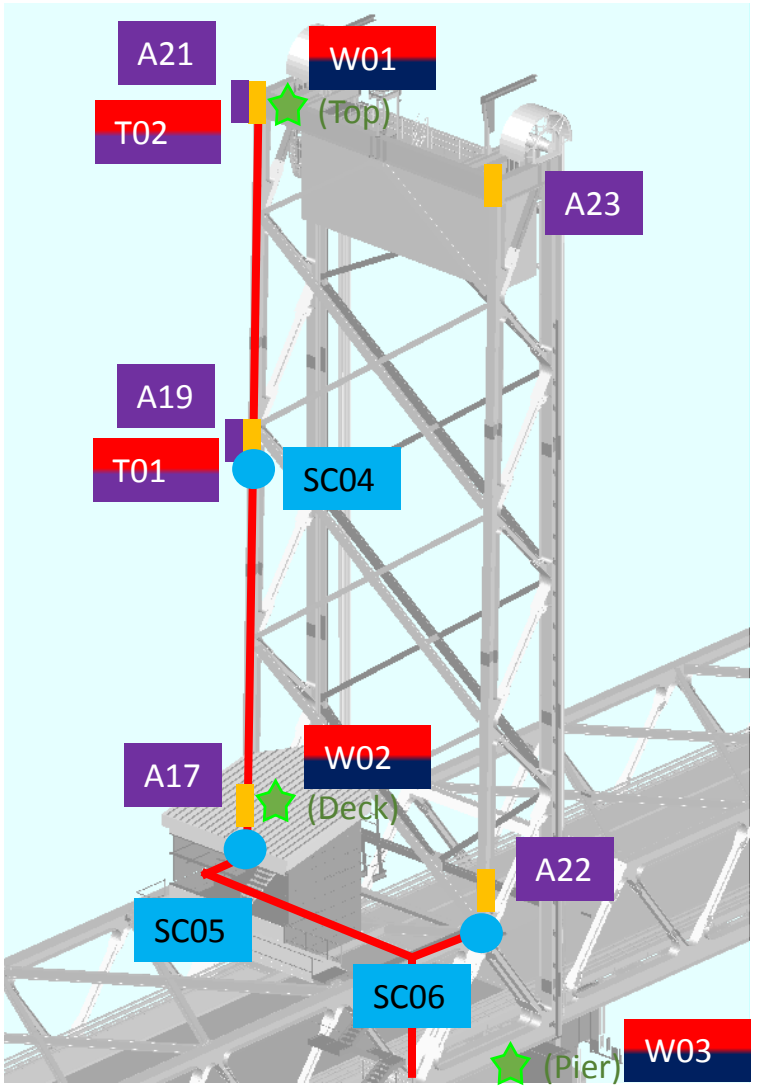
Span Sensors



Tower Sensors

- Existing conduits
- Proposed accelerometers
- # Proposed strain gauge clusters
- Proposed tilt meters
- Proposed weather stations

Operations	Purpose 1: Strain Monitoring
	Purpose 2: Traffic Monitoring
	Purpose 3: Lift/No Lift Decision
Research	Purpose 4: Design Verification
	Purpose 5: Model Calibration
	Purpose 6: Excitation Measurement



Connection Behavior for Design Verification and Condition Assessment

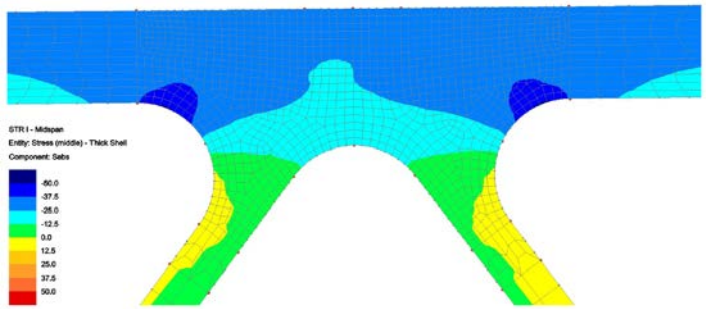


Figure 12: Panel Point U5 Maximum Web Stress - AASHTO Strength I – Linear Elastic Model

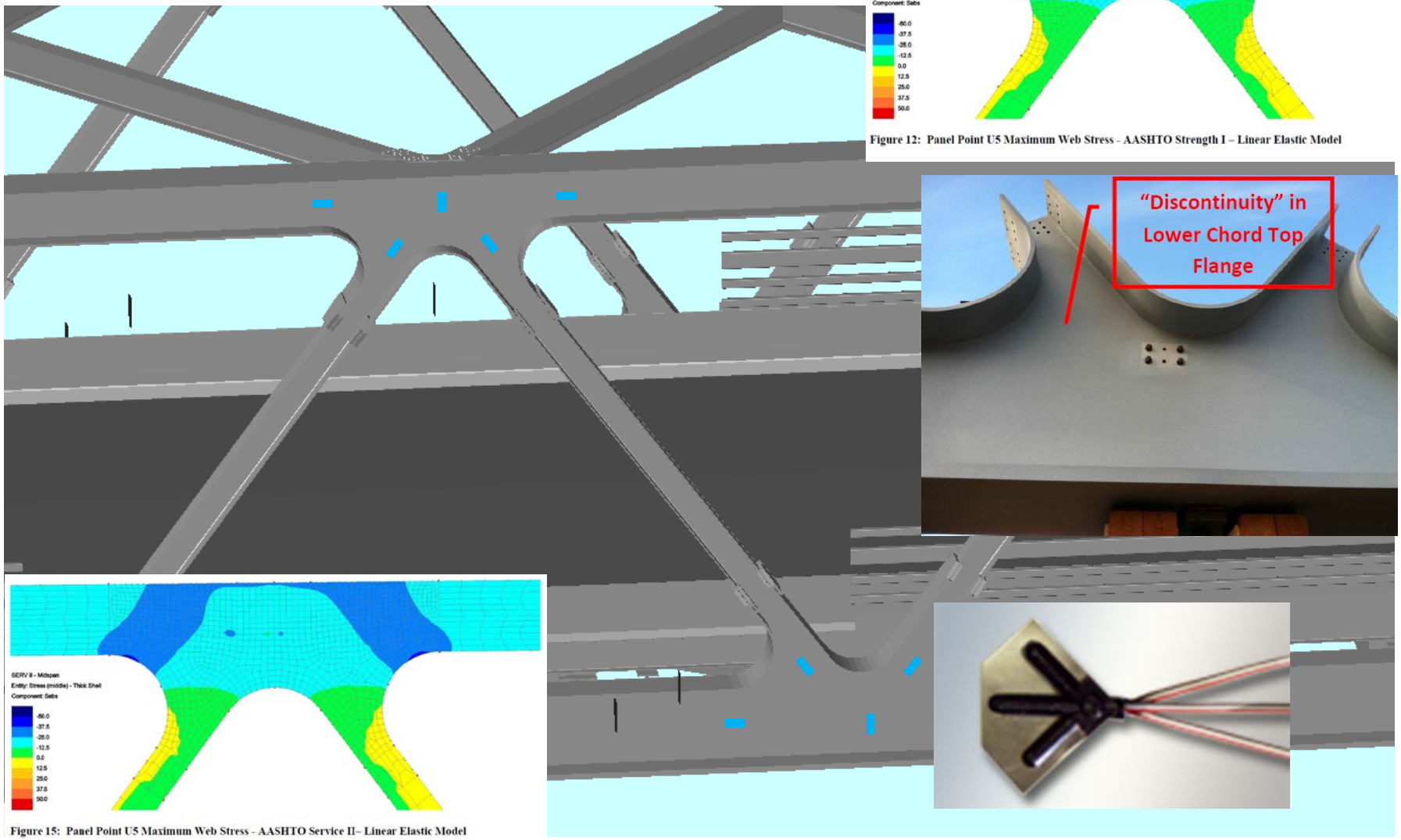
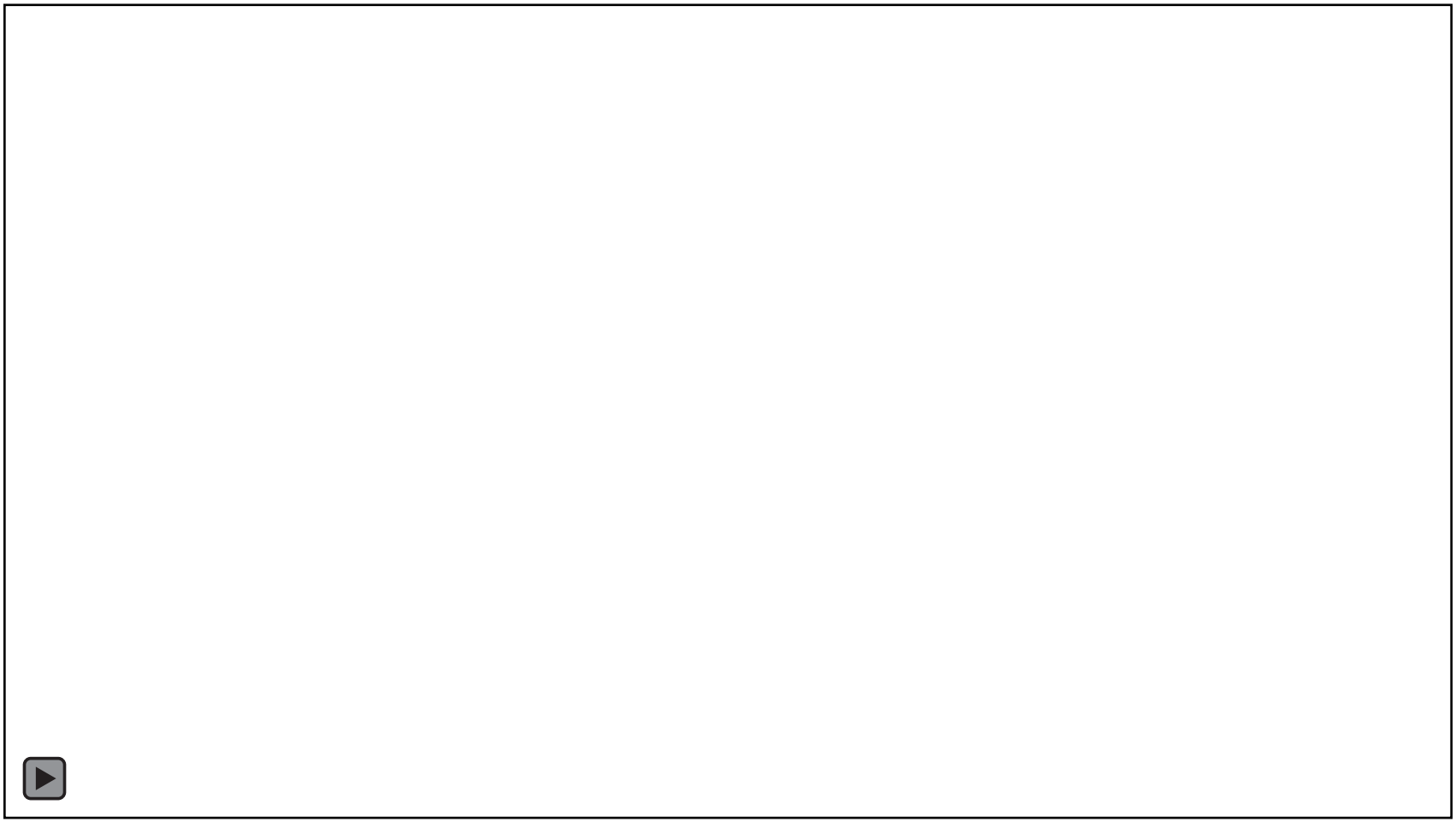


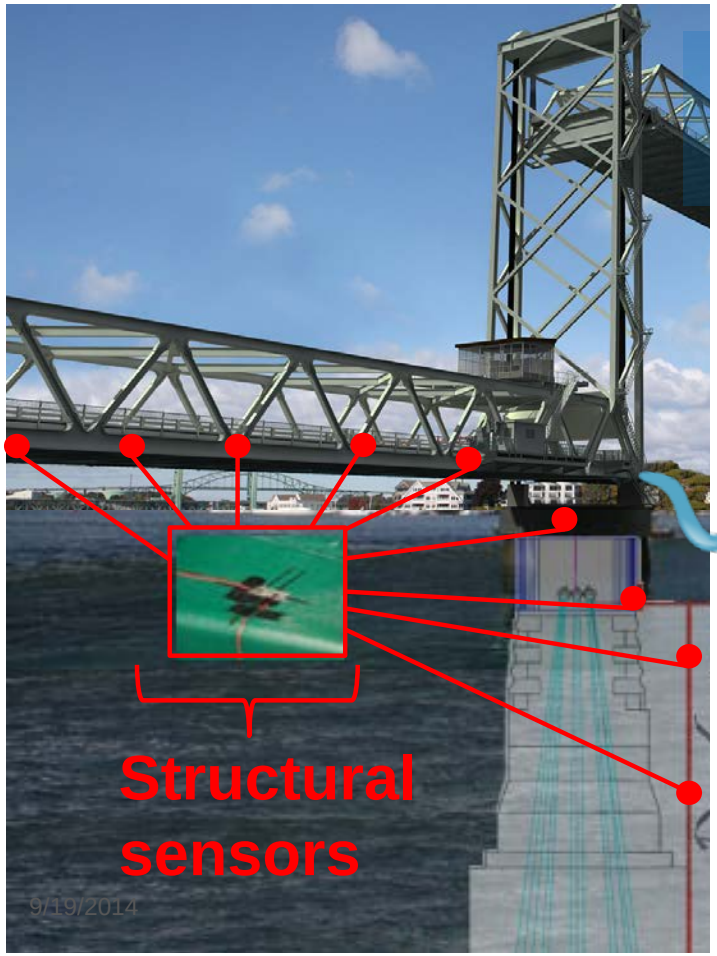
Figure 15: Panel Point U5 Maximum Web Stress - AASHTO Service II– Linear Elastic Model

Covington, Engel, Kelly-Sneed, Noh and Zoli, "Portsmouth Memorial Bridge Replacement" 2013 SEI Illinois Chapter Lecture

Tracking Vehicle / Bike / Pedestrian



Smart, User-Centered Transportation Infrastructure - how will we power it?

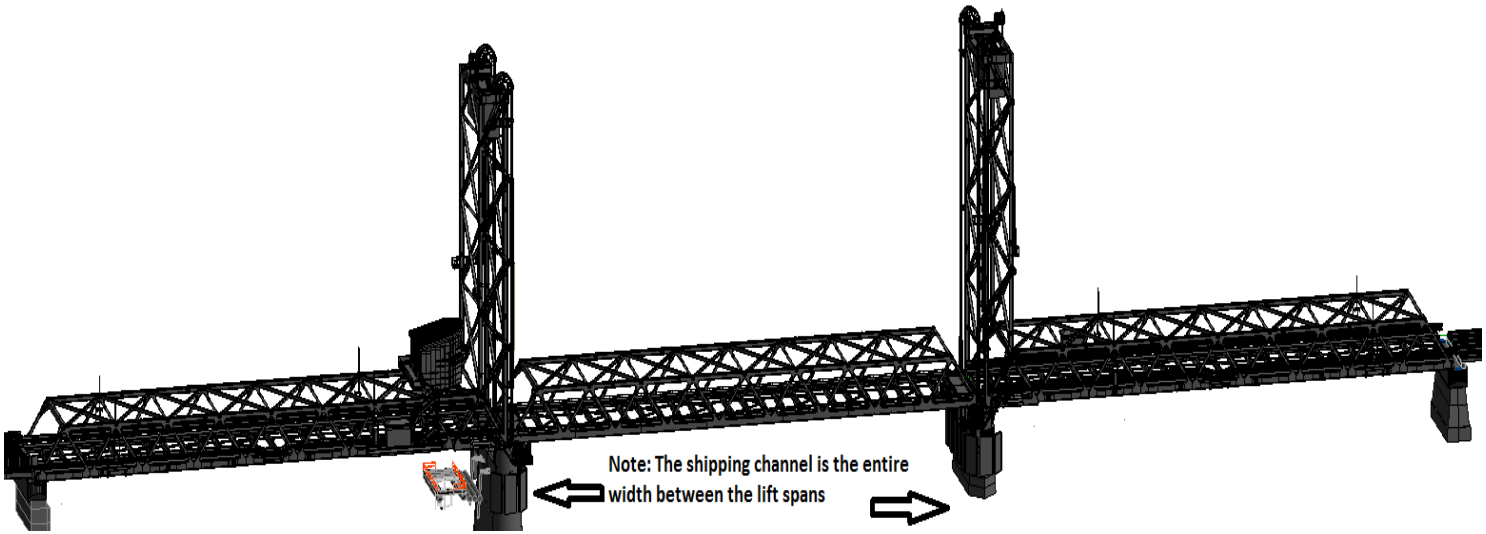


- Electric grid

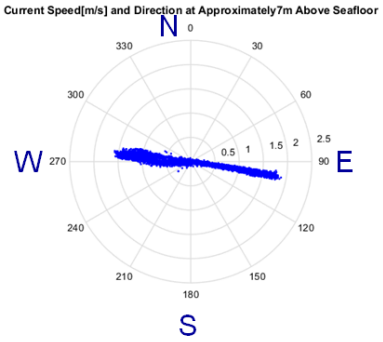
- Locally available renewable energy
  - Solar
  - Wind
  - **Tidal**

    → ***Sustainable***

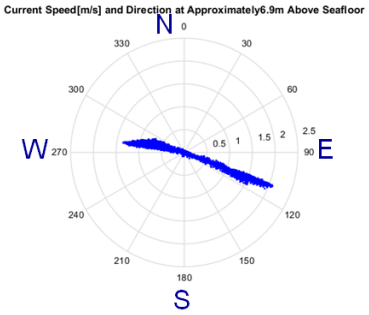
Turbine Energy System



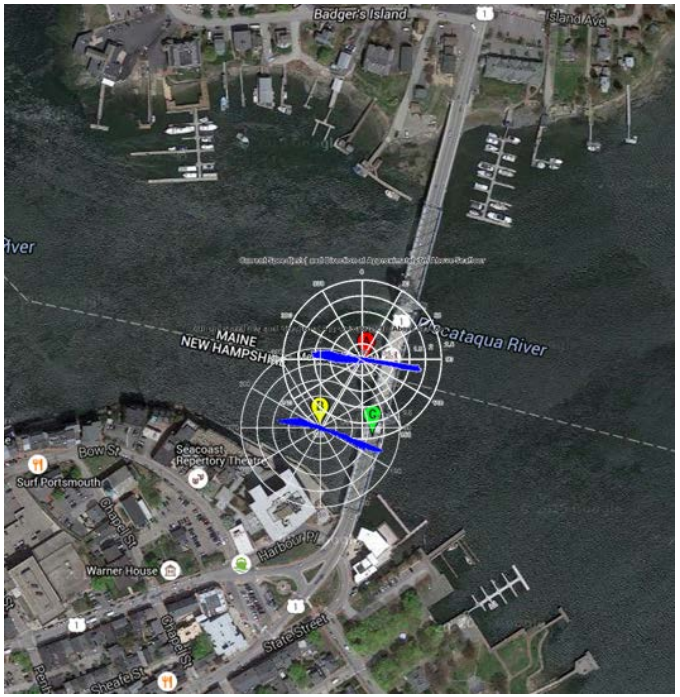
Kammerer/ NOAA NOS 2007 ADCP Survey



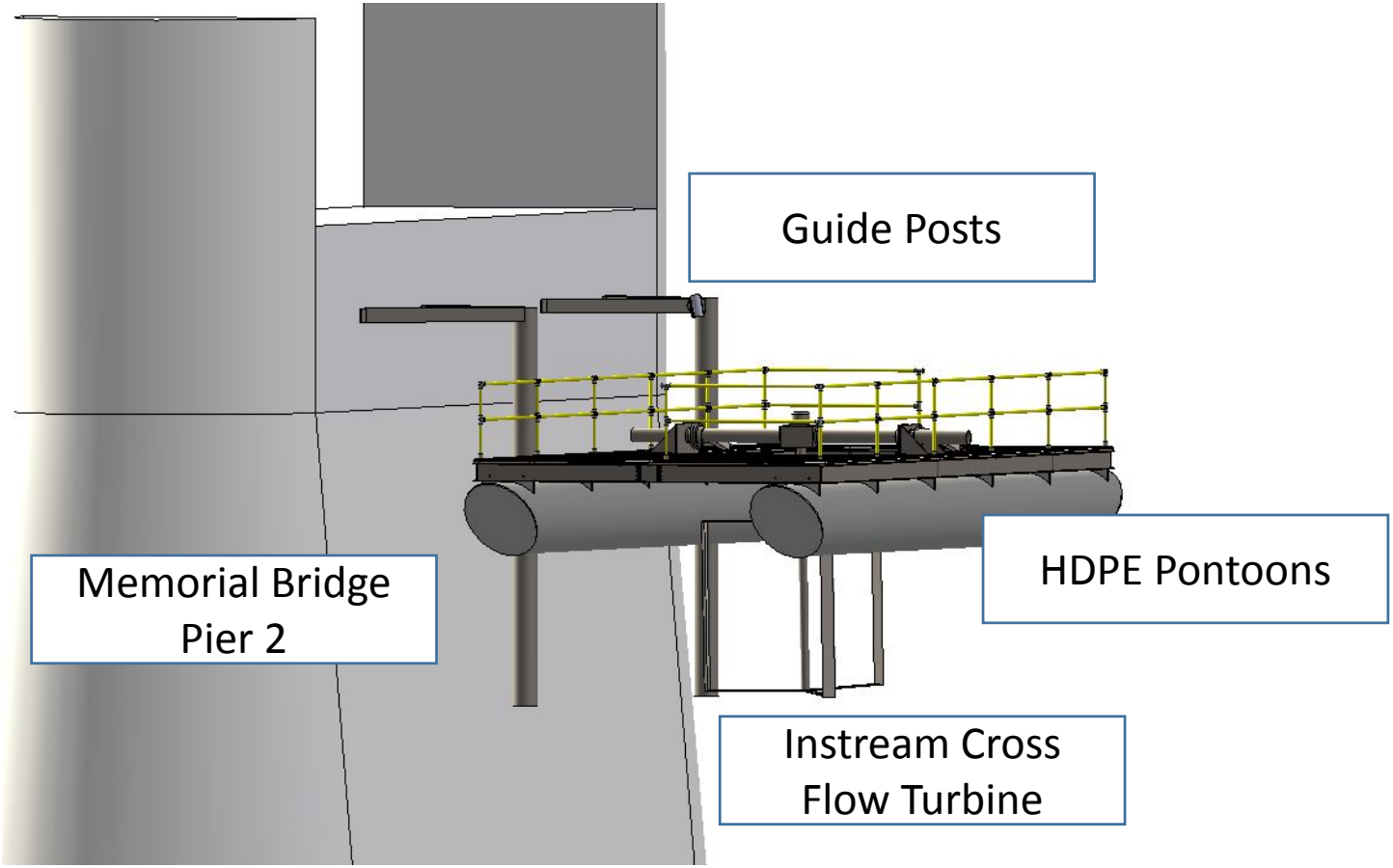
Hicks, Griffith/ UNH 2014 ADCP Survey (approximate location)



Turbine Location



Tidal Energy Conversion System

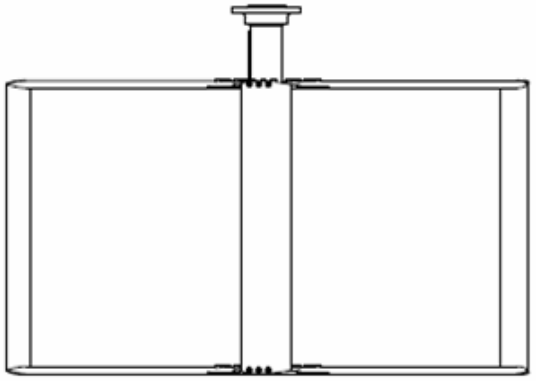


Note: For clarity fenders are not show on the pier structure

Tidal Turbine

- **Instream Energy Systems** selected as turbine provider (w/ BAE Systems)
- Instream: Successful deployment at the Roza Canal (USBR, Sandia)
- Instream: synergistic “floating tidal energy” projects funded in Canada
- Cross-flow turbine: similar to turbines tested by UNH-Center for Ocean Renewable Energy (in tow tank & open water)
- Includes gearbox, generator, rotor brake, instrumentation
- “Turbine on a stick”

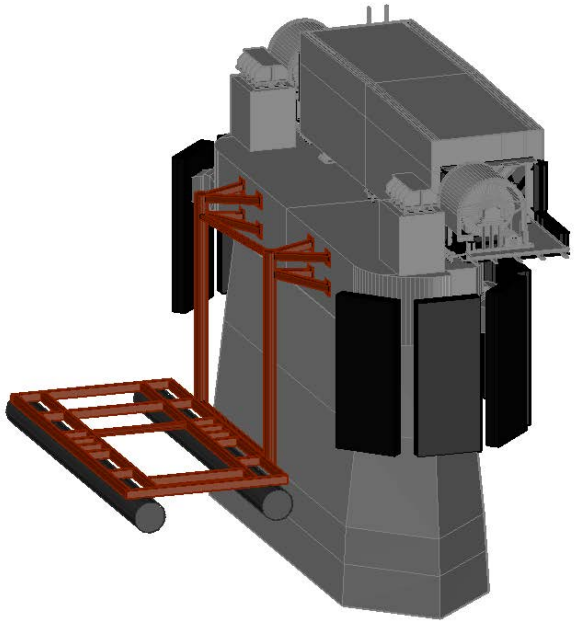
Roza Canal, WA



Instream Gen 1 (BAE) rotor, side view

Turbine Deployment Platform

- Positions turbine at deployment location
- Rigid platform for turbine operation and some maintenance
- Removable structure
- Turbine removable under load during both ebb/flood tide
- HDPE Pontoons, Rigid steel frame, Moon Pool



Effects of Climate Change on Estuarine Environments

- Increases in concentrations of greenhouse gases are expected to cause an increase in average air and ocean temperatures in coming years.
- What effects do sea level change, ocean temperature change, precipitation pattern change, and frequency and intensity of coastal storms have on estuaries?
- Predicted effects include alterations in:
  - Estuarine stratification (salt/freshwater demarcation)
  - Residence time (how long it takes to “flush” an estuary)
  - Eutrophication (enrichment of nutrients)
  - Sediment load
  - Toxic bacteria levels/increased algae blooms

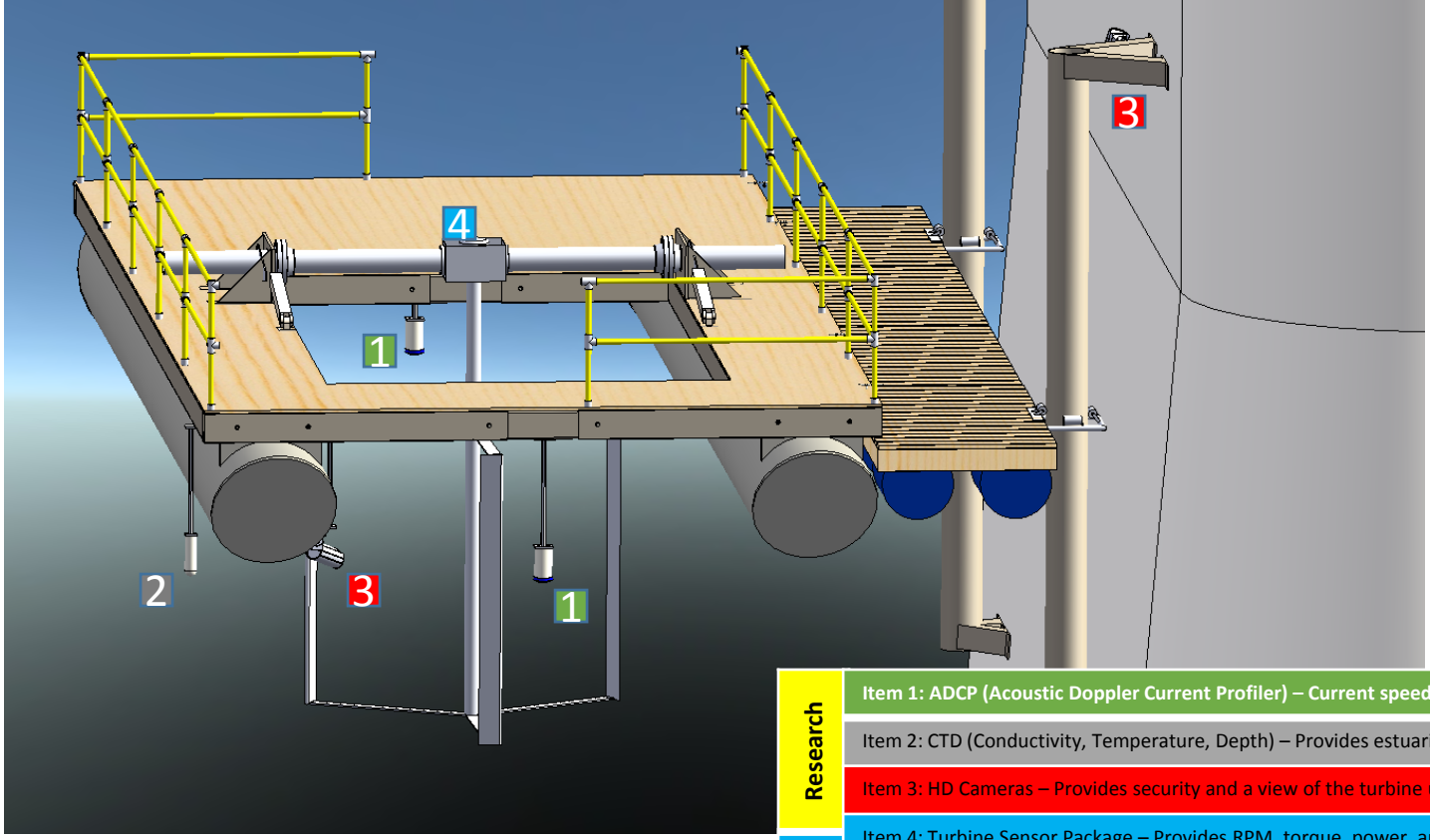
Effects on Fishes, Plants, Shellfish

- The Piscataqua is home to commercial fisheries and shellfisheries
- Increases in hypoxia (oxygen deprived states) leads to lower survival rates of fish embryos
- Increases in water temperature are linked to population declines and lower egg survival rates
- Changes in temperature and salinity can narrow the areas where filter feeders like clams, mussels and oysters thrive, causing die-off and affecting the clarity of the water
- Changes in salinity can kill off sensitive estuarine grasses, which are also “home” to small crabs, shellfish, fish, invertebrates, and birds.
    - Sea grasses are also a large contribution to global oxygen levels and are estuarine filters. Loss of seagrasses will cause increased turbidity and less atmospheric oxygen

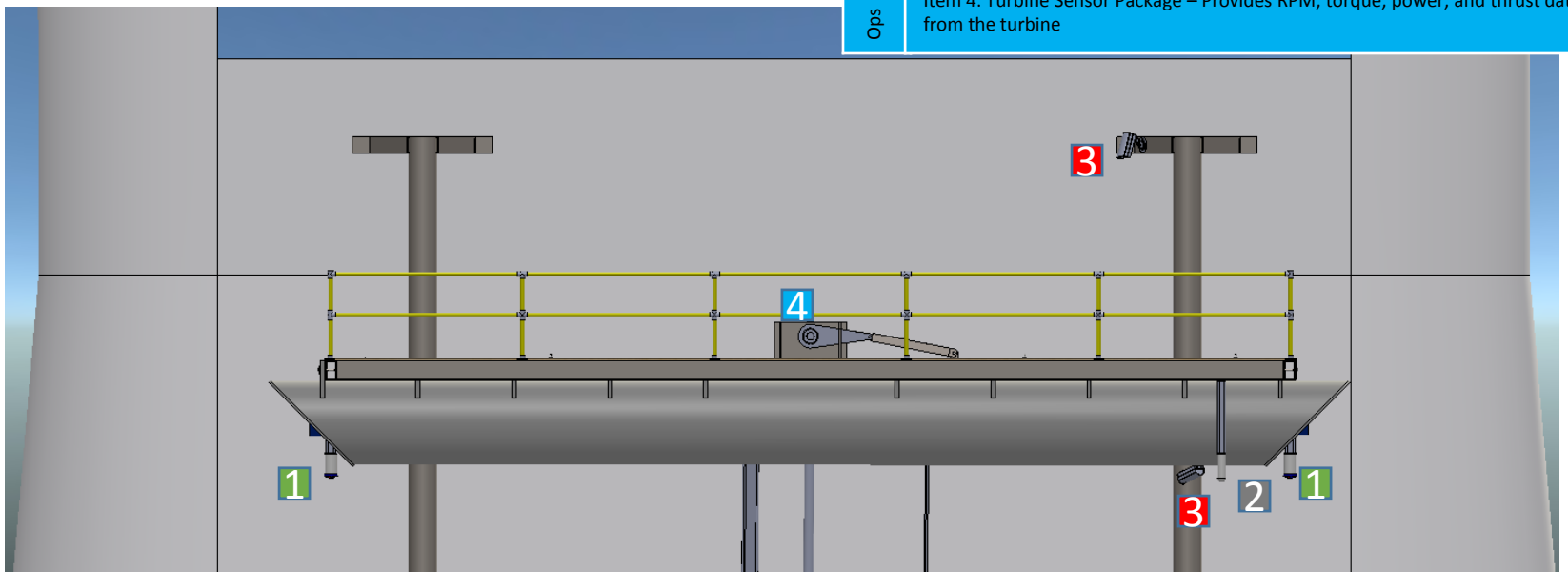
How Are We Monitoring?

- Valeport MIDAS CTD+ with modular sensors from SeaPoint can measure:
  - Turbidity
  - Fluorometery
  - Salinity
  - pH
  - Temperature

Seapoint Sensors, inc.

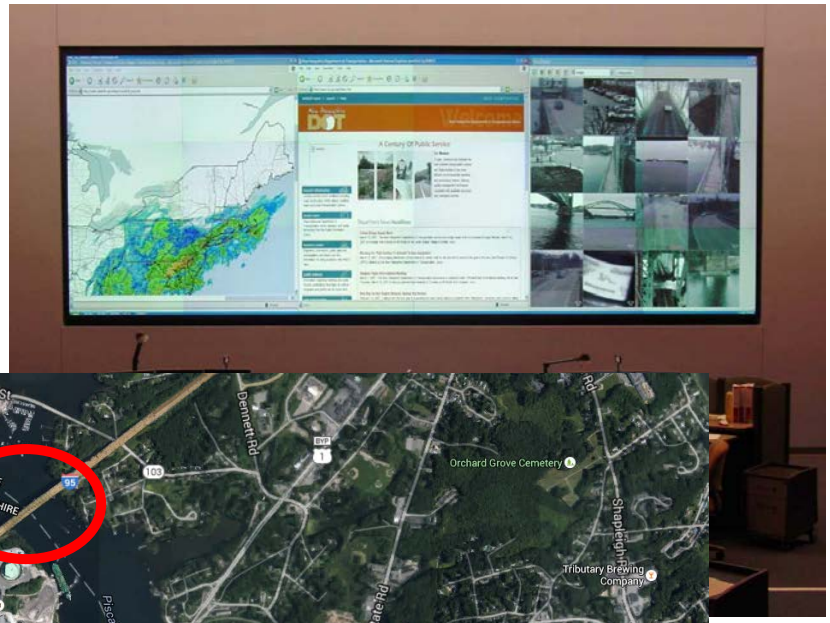


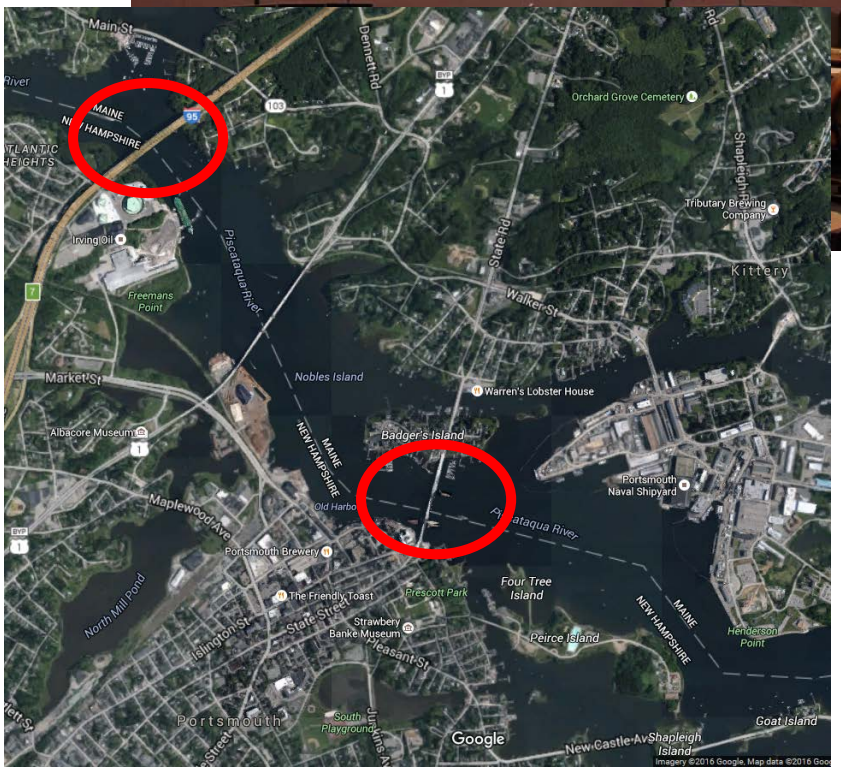
Research	Item 1: ADCP (Acoustic Doppler Current Profiler) – Current speed for turbine
	Item 2: CTD (Conductivity, Temperature, Depth) – Provides estuarine health data
	Item 3: HD Cameras – Provides security and a view of the turbine underwater
Ops	Item 4: Turbine Sensor Package – Provides RPM, torque, power, and thrust data from the turbine



How will this data be used by the TMC?

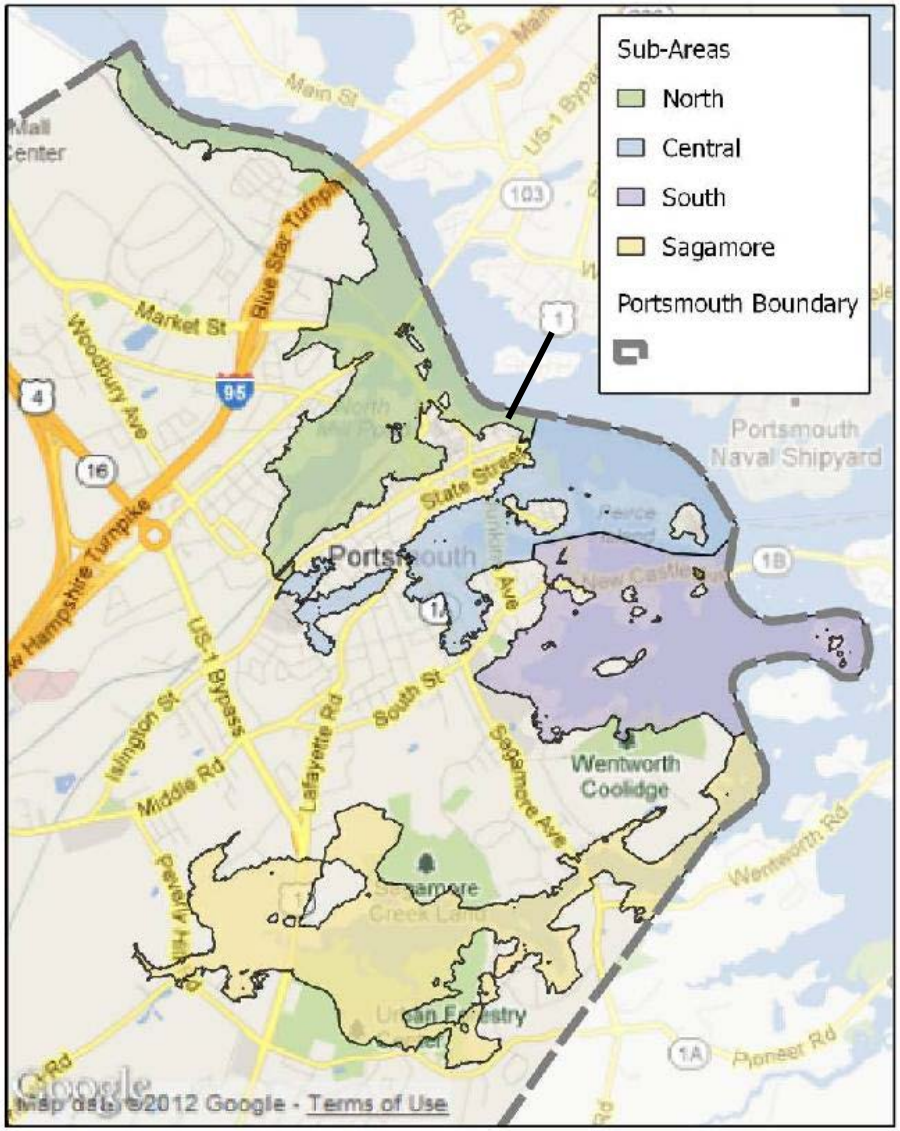
- Weather Data Collected at the Memorial Bridge can inform drivers of high wind conditions on the I-95 Bridge





How will this data be used by the TMC?

- Tidal Data Collected at the Memorial Bridge can inform surrounding area of coastal flooding



http://www.planportsmouth.com/cri/CRI-Report.pdf

Website: memorialbridgeproject.com

- Instagram Feed
- 3D interactive model
- Live Cam

Collaborating with the City of Portsmouth:

- Weather Forecast
- Current Tidal Current Speed

The "Living" Bridge

Thank you for Listening

Please email, erin.bell@unh.edu, with any comments, suggestions or criticism.

Civil Engineering

Erin Bell

Tat Fu

Mechanical/Ocean Engineering

Ken Baldwin

Martin Wosnik

University of New Hampshire