Great Lakes Association of Science Ships 24th Annual Science Vessel Coordination Workshop

January 9, 2020

Jamey Anderson & Chris Pinnow
Great Lakes Research Center (GLRC),
Michigan Technological University

Quick Update and Summary of:

- **Autonomous Surface Vessels (ASV's)**
  - Great Lakes Governors and Premiers – Milwaukee
  - Smart Ships Coalition (SSC)
  - Marine Autonomy Research Site (MARS)
- **DARPA Testing in MARS**
- **High Frequency Radar for the Straits**
- **Recent and Upcoming Work w/ Autonomy**

Great Lakes Governors and Premiers – Milwaukee June 14, 2019

GREAT LAKES ST. LAWRENCE GOVERNORS & PREMIERS

L3 ASV C-Worker 5


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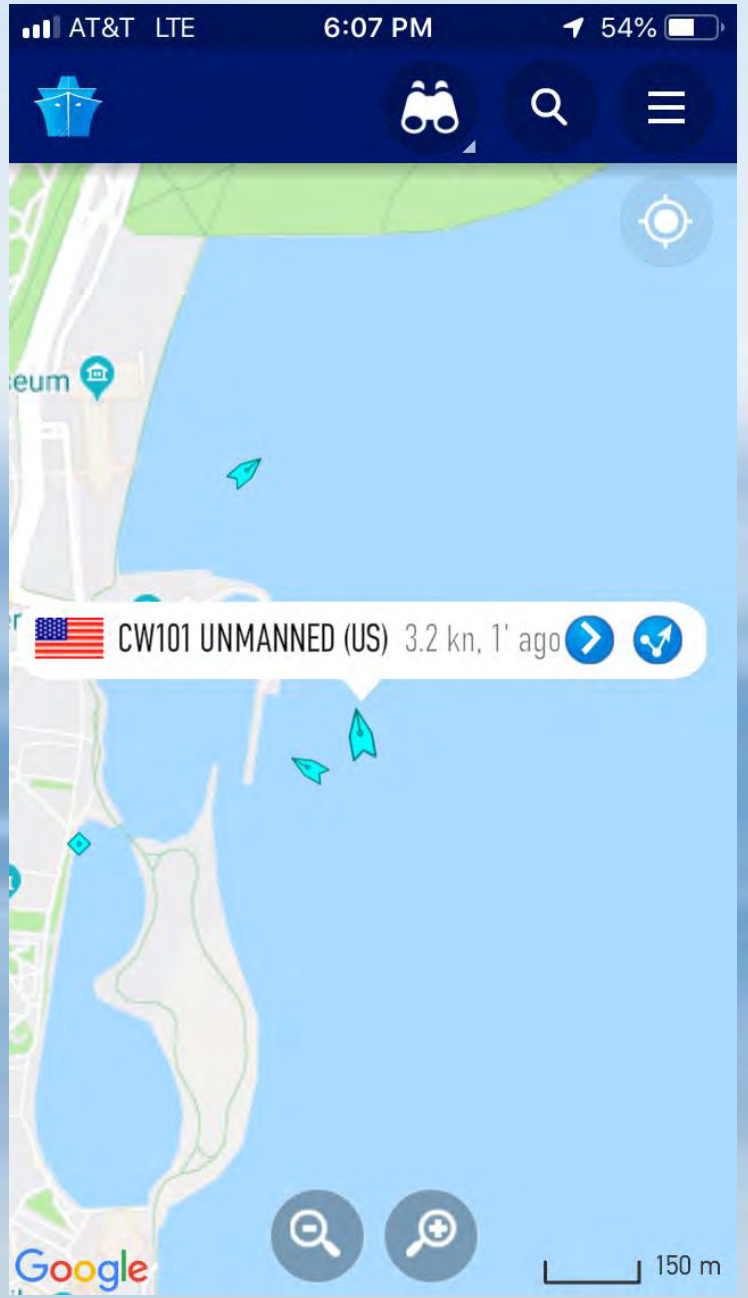
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Michigan Technological University

Smart Ships Coalition - Background

Founding Members

GREAT LAKES ST. LAWRENCE GOVERNORS & PREMIERS

EGLE

Great Lakes Research Center
Michigan Technological University

Detroit, Michigan and Windsor, Ontario
October 20, 2017

RESOLUTION

COLLABORATION

among the

CONFERENCE OF GREAT LAKES AND ST. LAWRENCE

GOVERNORS and PREMIERS

the

MARINE AUTONOMY COALITION

and the

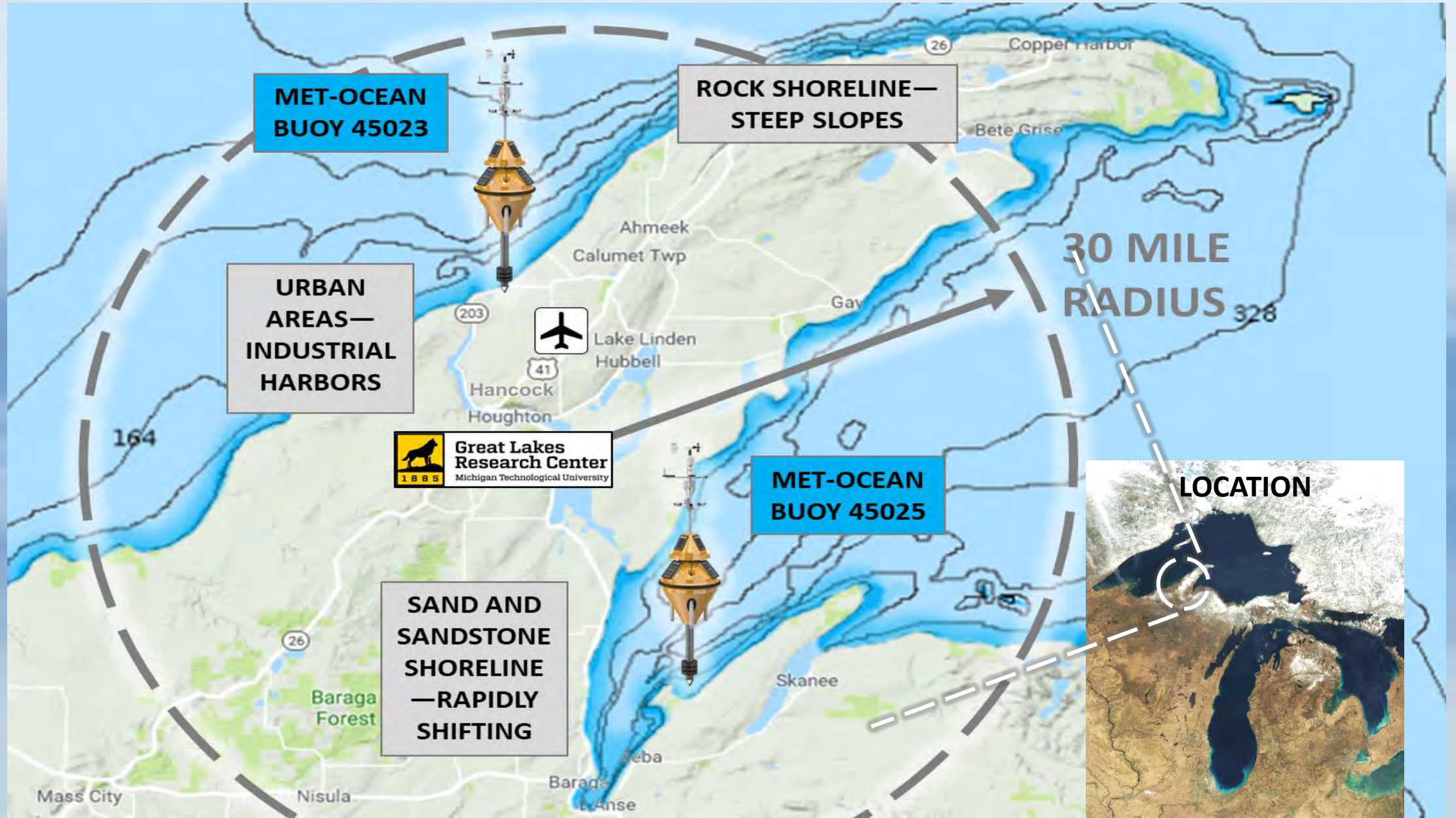
NORWEGIAN FORUM for AUTONOMOUS SHIPS

Advancing Next Generation Marine Technology for the Great Lakes

SSC MEMBERSHIP & ENGAGEMENT


Michigan Technological University
1885
SMART SHIPS COALITION
OF THE GREAT LAKES-ST. LAWRENCE
600 km
Marine Autonomy Research Site (MARS)

Marine Autonomy Research Site (MARS)

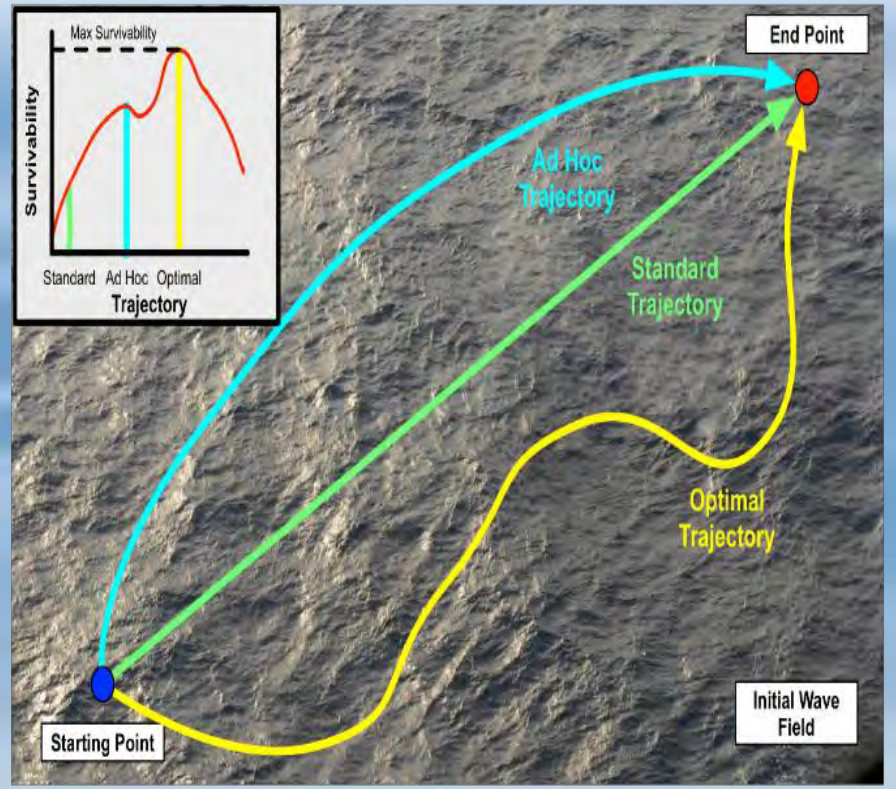


DARPA Testing in MARS

Seaworthiness Through Intelligent Trajectory Control

Program Overview:

- Dynamic Survivability Metrics
- Wave/Vessel Simulation Approach
- **Field Data Collection**
- Wave/Vessel Simulation Dynamics Validation
- Path Optimization
- Summary/Next Steps



Test Vehicle – Concept of Operation

- **Field test objectives**
  - Empirically measure wave / vessel motion dynamics
  - Observe trajectory dependent vessel motions
  - Observe vessel motions under manual wave dodging control by USCG expert
  - Provide data for wave / vessel dynamics simulation validation

- **Two days of tests on Lake Superior**
  - Sept 27
    - **waves** 1.03 – 0.8 m at 4.7 – 5.7 sec. period from 240 degree
    - **wind** 12 – 17 kts from 240 degrees.
  - Sept 28
    - **waves** 1.0 – 1.4 m from 290 degrees.
    - **wind** 14.7 - 12 kts from 018 degrees
- **Test vessel (Jet Ski)** ran a 3 leg course at 5 and 10 kt speed

Field Test Vessel Dimensional Analysis

- Yamaha FX-Cruiser-High-Output
  - Length = 3.58m
  - Beam = 1.27m
- Length/Beam = 3 / 1

US Navy 11m RHIB
Autonomous Vessels

- Jet Ski: 1/3 scale model of Navy vessels

Instrumented Measurements of Wave and Vessel Motions

- Fully instrumented Jet Ski as test vessel
  - Full scale waves, 1/3 scale test vehicle (11m RHIB)
  - HD Stereo Vision
  - Real–time video transmission to shore station
  - Full vessel motions package (9 DOF)
  - INS with dual GPS for precise position
  - USCG certified surf boat operator – wave dodging

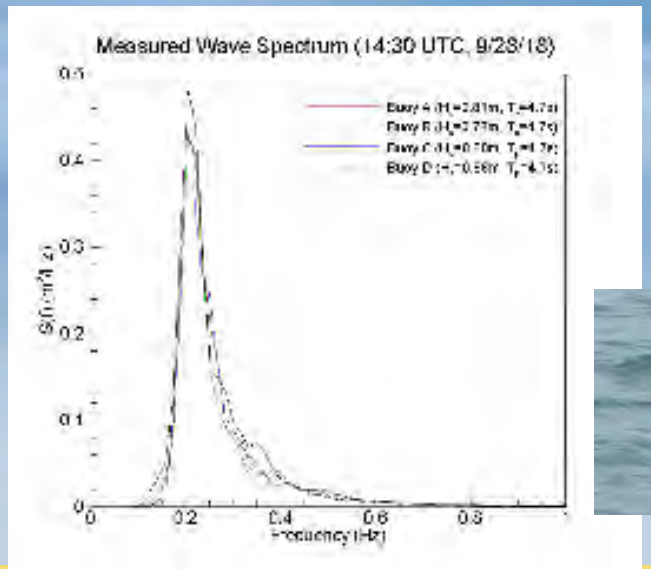
360 degree panorama from jet ski

MTRI Buoy

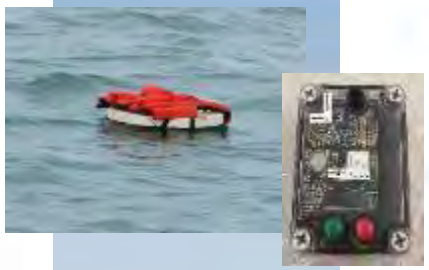
Wave Dodging Trajectory Test

Wave Buoy Ground Truth Data
Position of Buoys Test Area

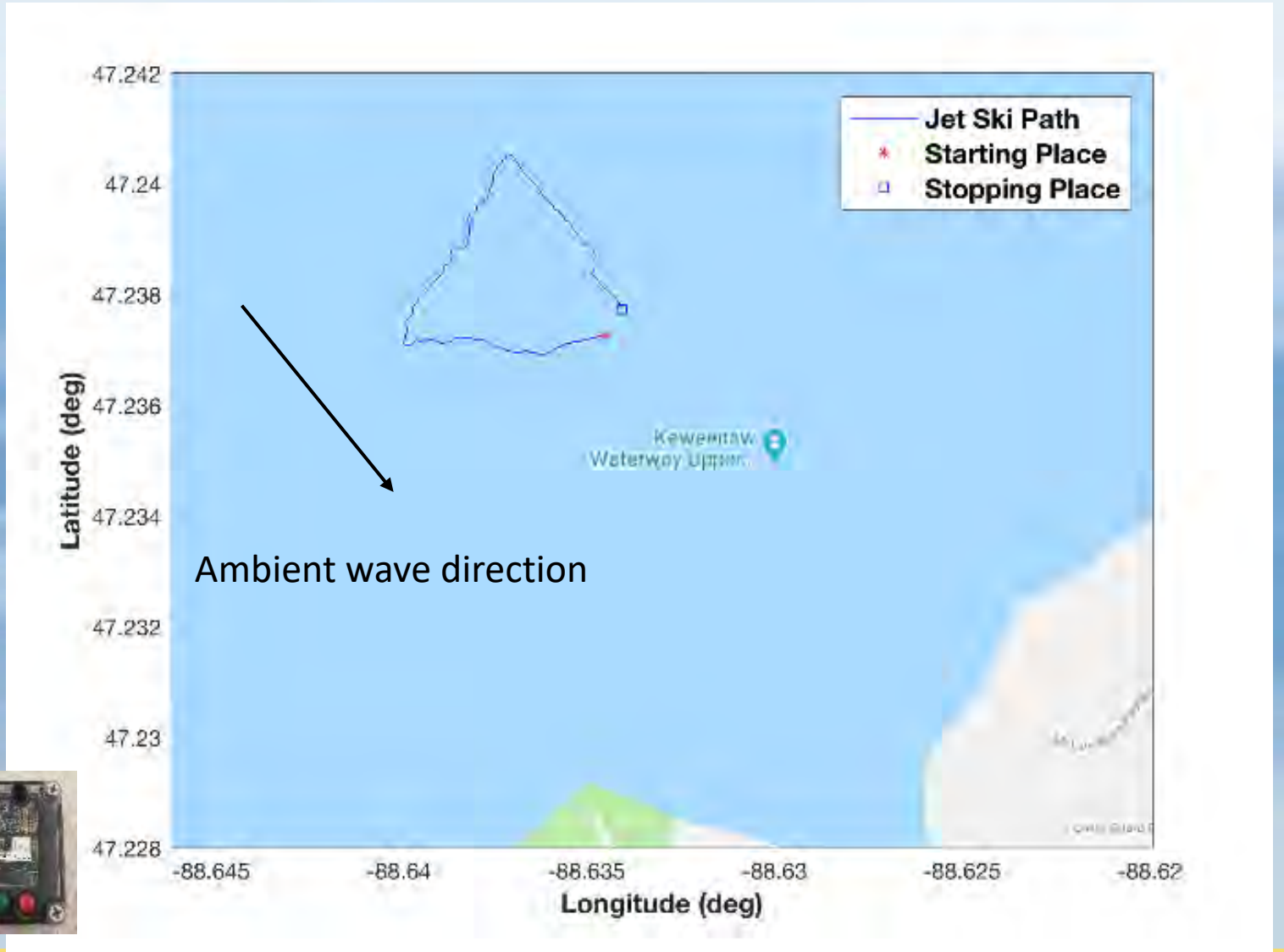
Wave spectra from all buoys consistent



Wave Buoys



Path of Jet Ski Relative to Shore and Ambient Wave Direction



Field Test Summary

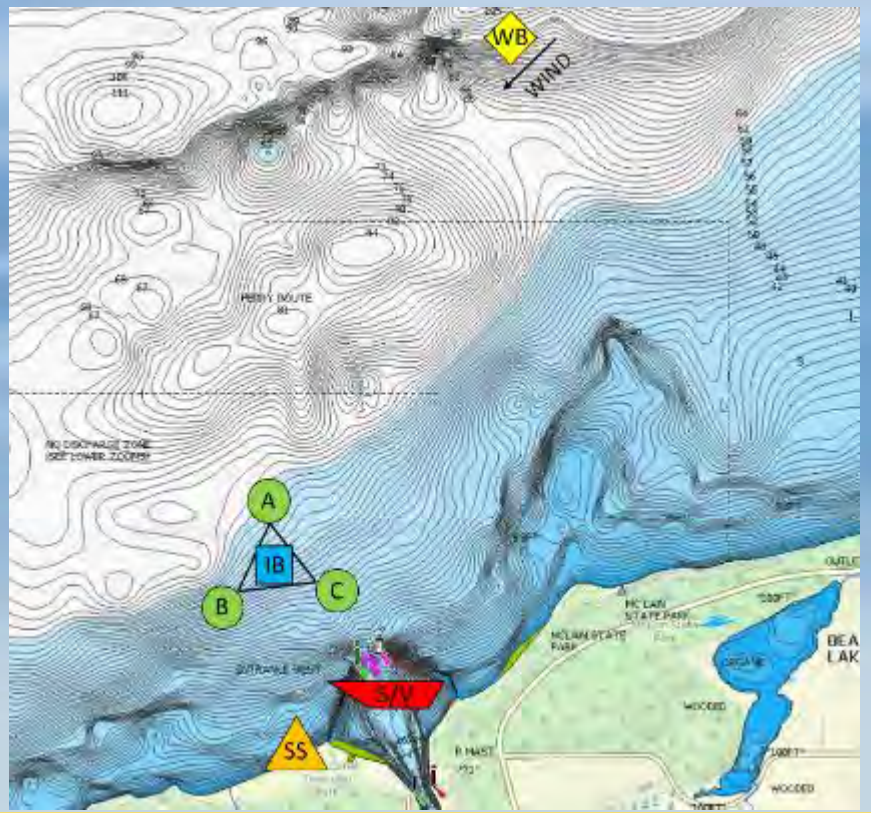
- Course was run at each speed twice
  - Once in straight line trajectories
  - Then repeated in wave dodging mode
  - Second day a third set of legs was run in wave dodging mode with variable speed

- Test vehicle was piloted by a Senior Chief in US Coast Guard with full certification operating life boats in surf and other extreme weather conditions

- Day 1 : 8 Runs
  - 4 straight line runs
  - 4 wave dodging runs
- Day 2: 6 Runs
  - 2 Strait line runs
  - 2 wave dodging runs
  - 2 wave dodging plus varying thrust for enhanced maneuvering
- Conducted at two vessel speeds
  - Froude number = 0.5 and 1.0

Monitoring Assets:

- **Wind and Wave Monitoring buoy NDBC 45023 (WB)**
- **Wave Buoy – Spectral (IB)**
- **Wave time series buoys (3) at A, B and C**
- **Chase boat video**
- **Aerial Drone tracking video**
- **Vessel motions and tracking**

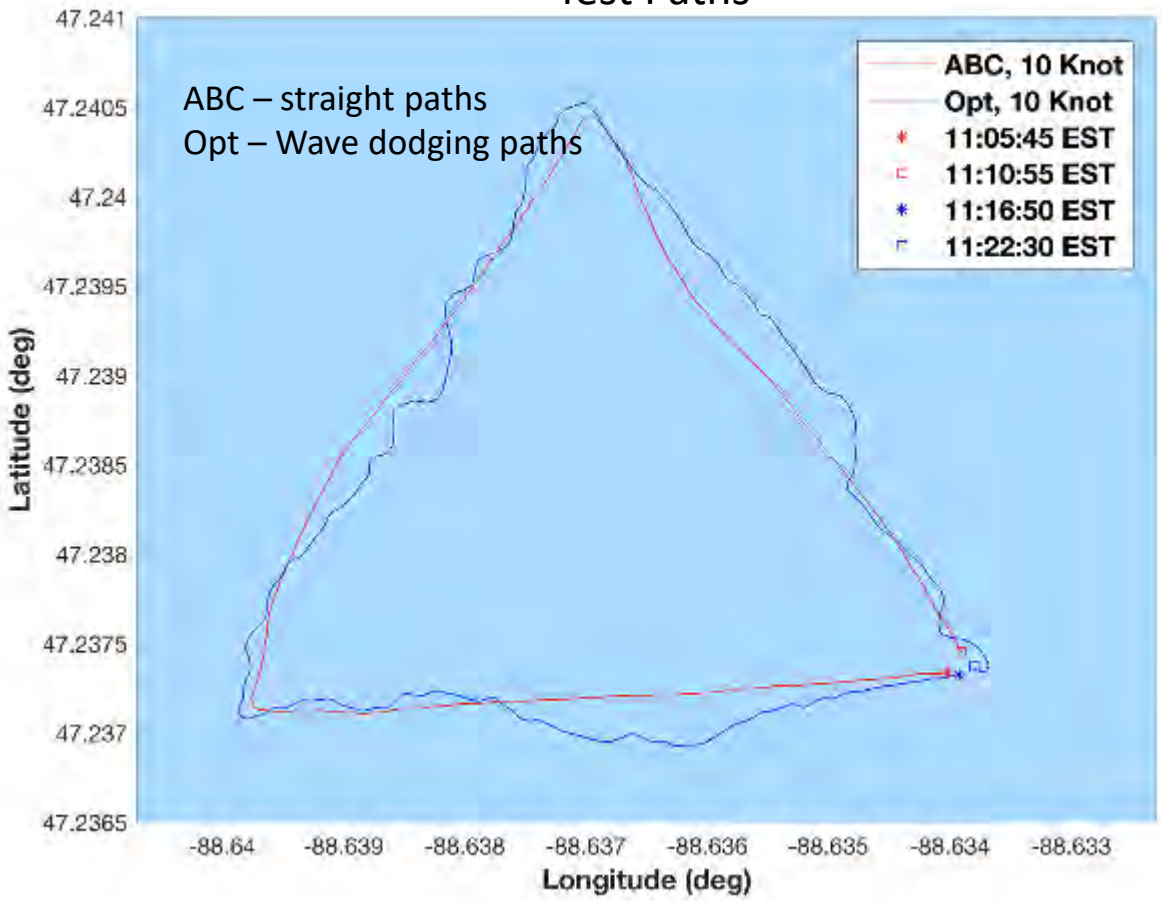


Michigan Technological University

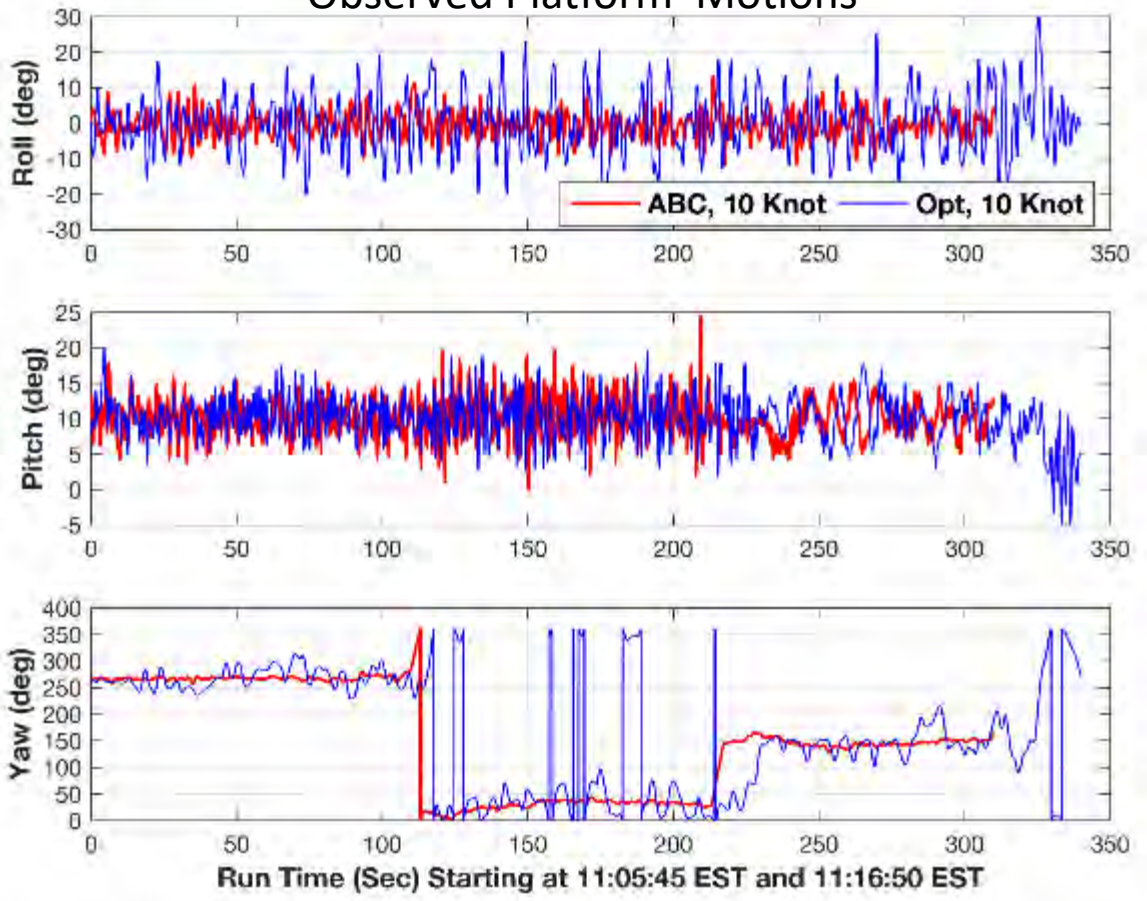
Observed Vessel Motions:
Comparison of Straight and Wave Dodging Course

Wave dodging mode optimizes propulsor contact with water to maintain control and reduce slam. Wave dodging increases roll, but decreases pitch

Test Paths



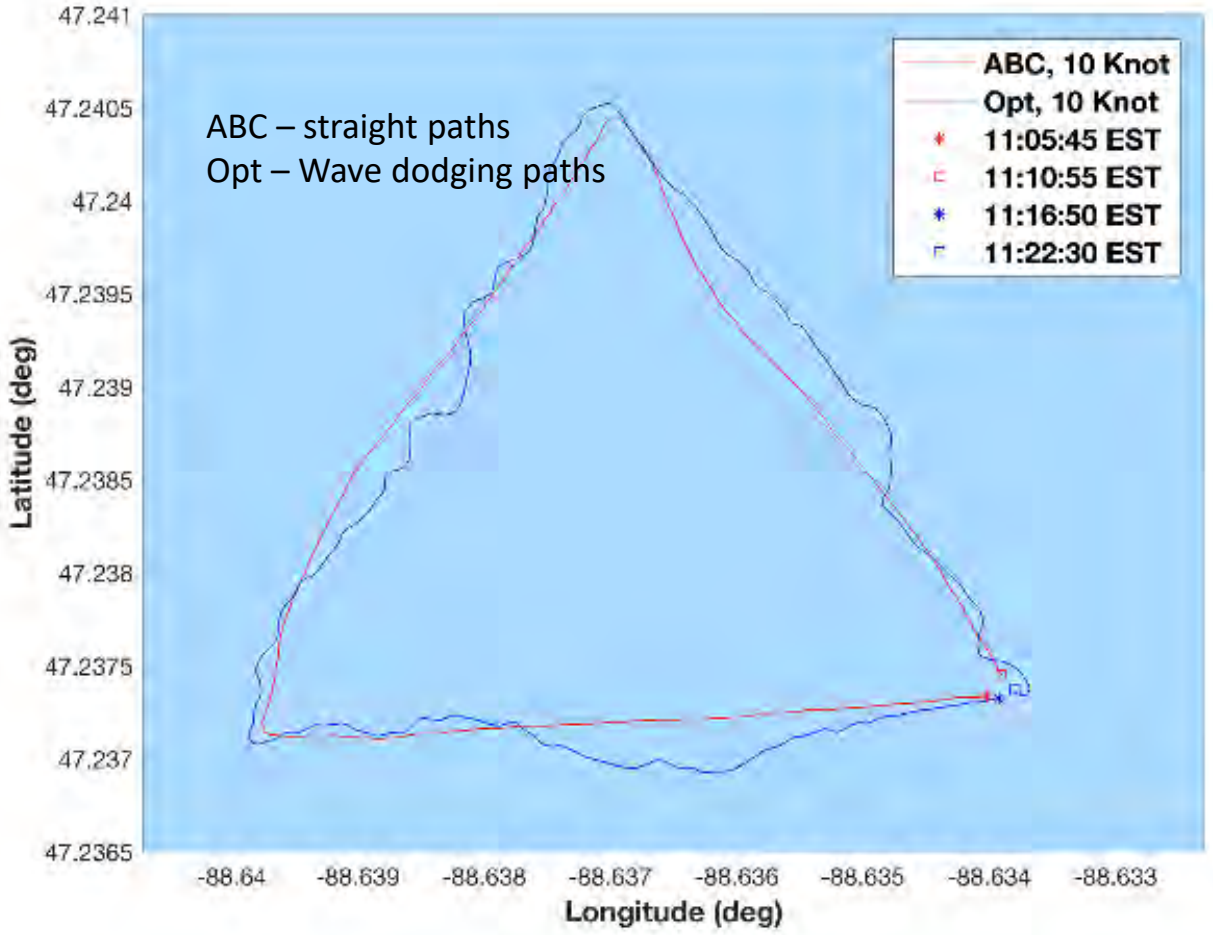
Observed Platform Motions



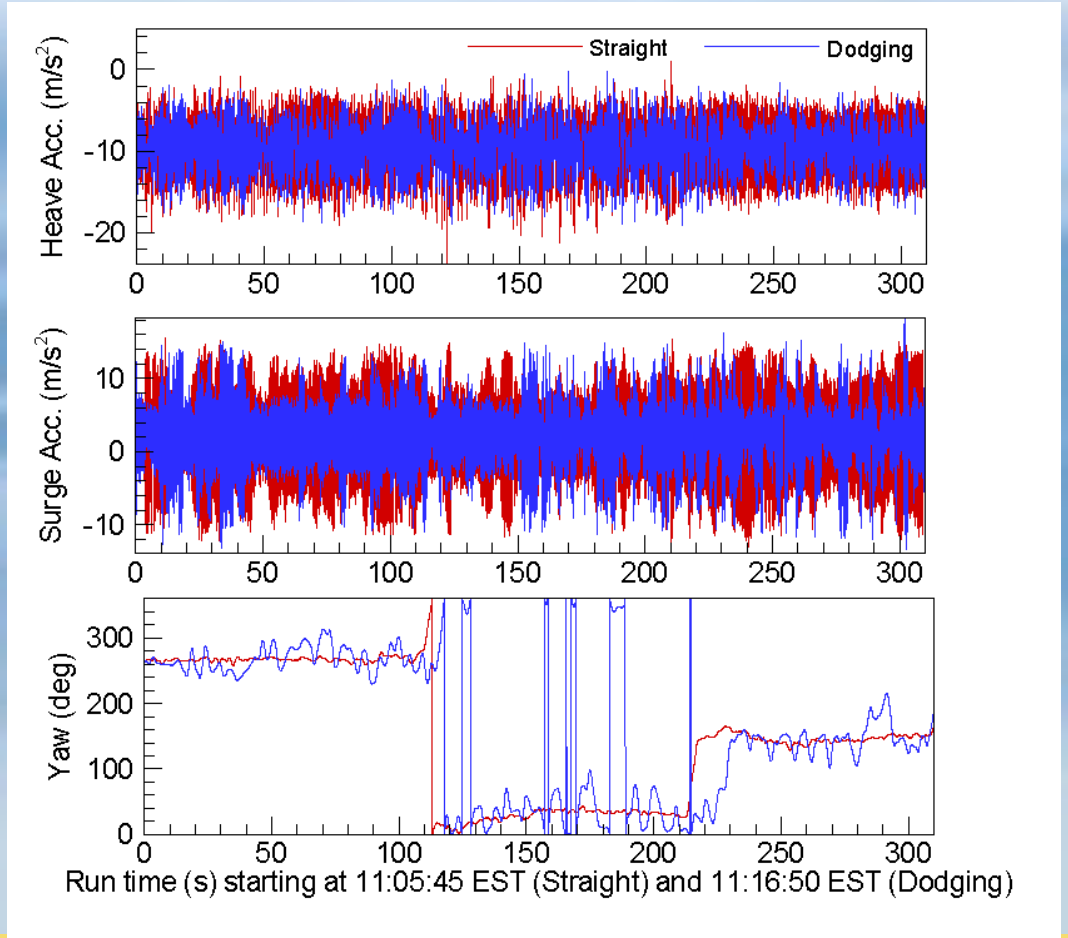
Observed Vessel Motions: Comparison of Straight and Wave Dodging Mode

Wave dodging mode reduced accelerations in heave and surge

Test Paths

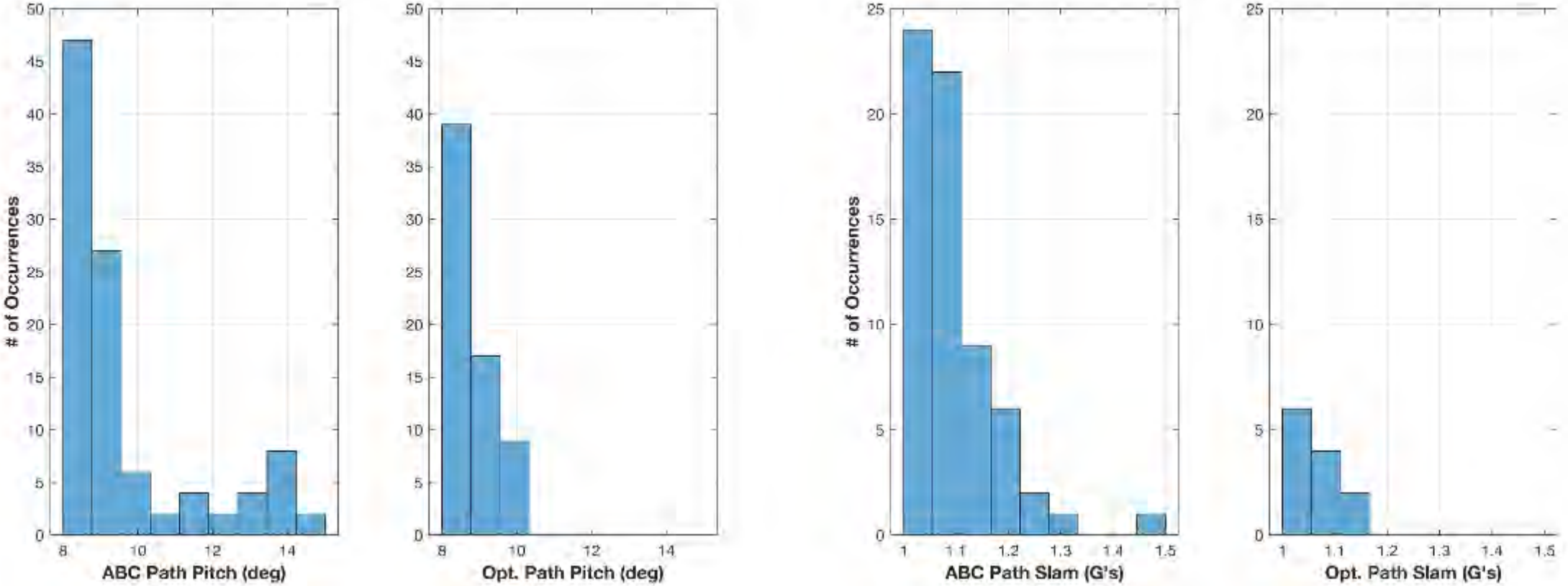


Observed Platform Accelerations and Yaw



Comparative Histograms of Pitch and Slam

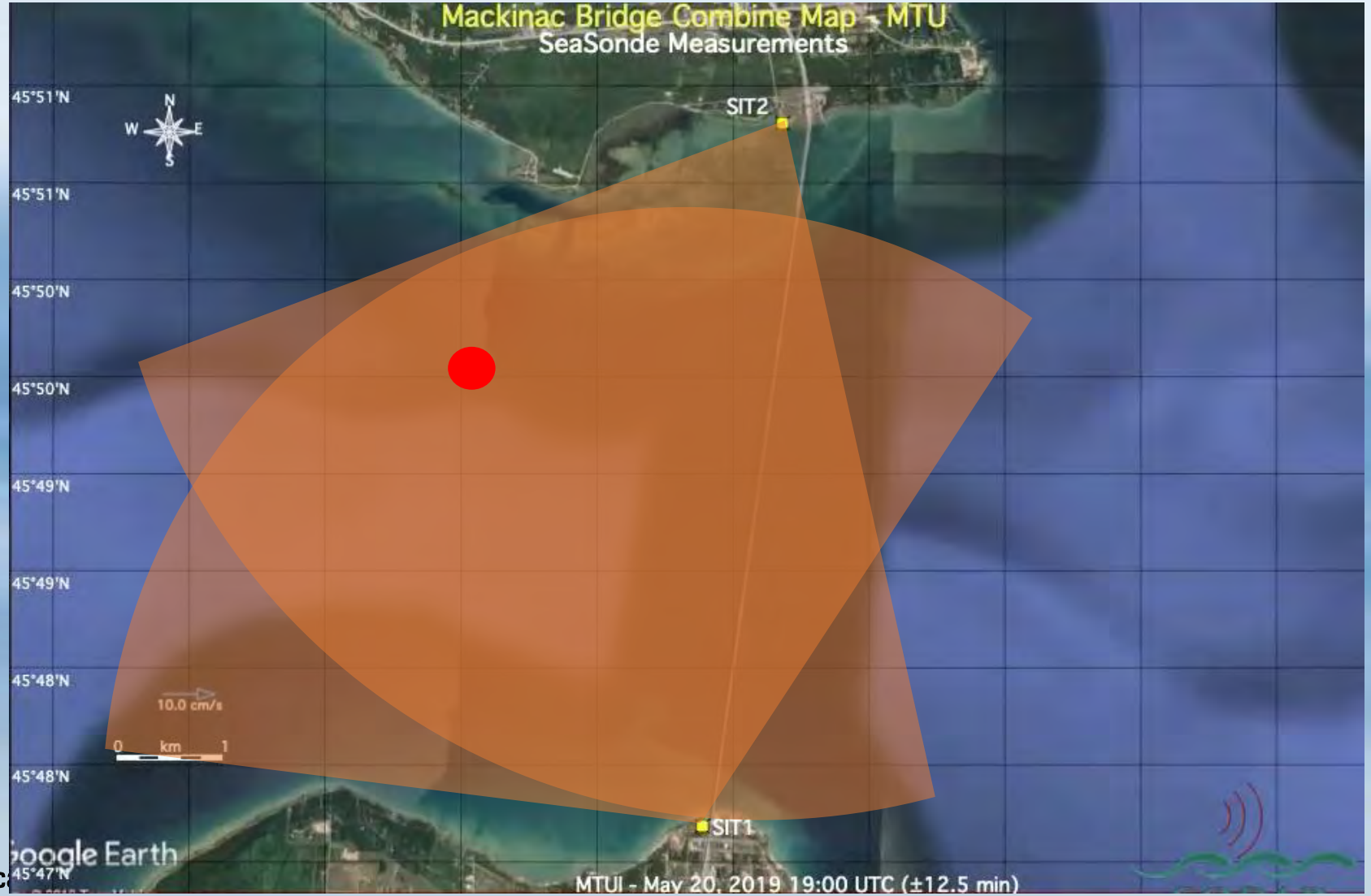
Pitch and slam smaller in optimal path than that in straight line ABC path



Sept 28 data

Histograms for excursions over 8 degree for pitch and 1 G for slam

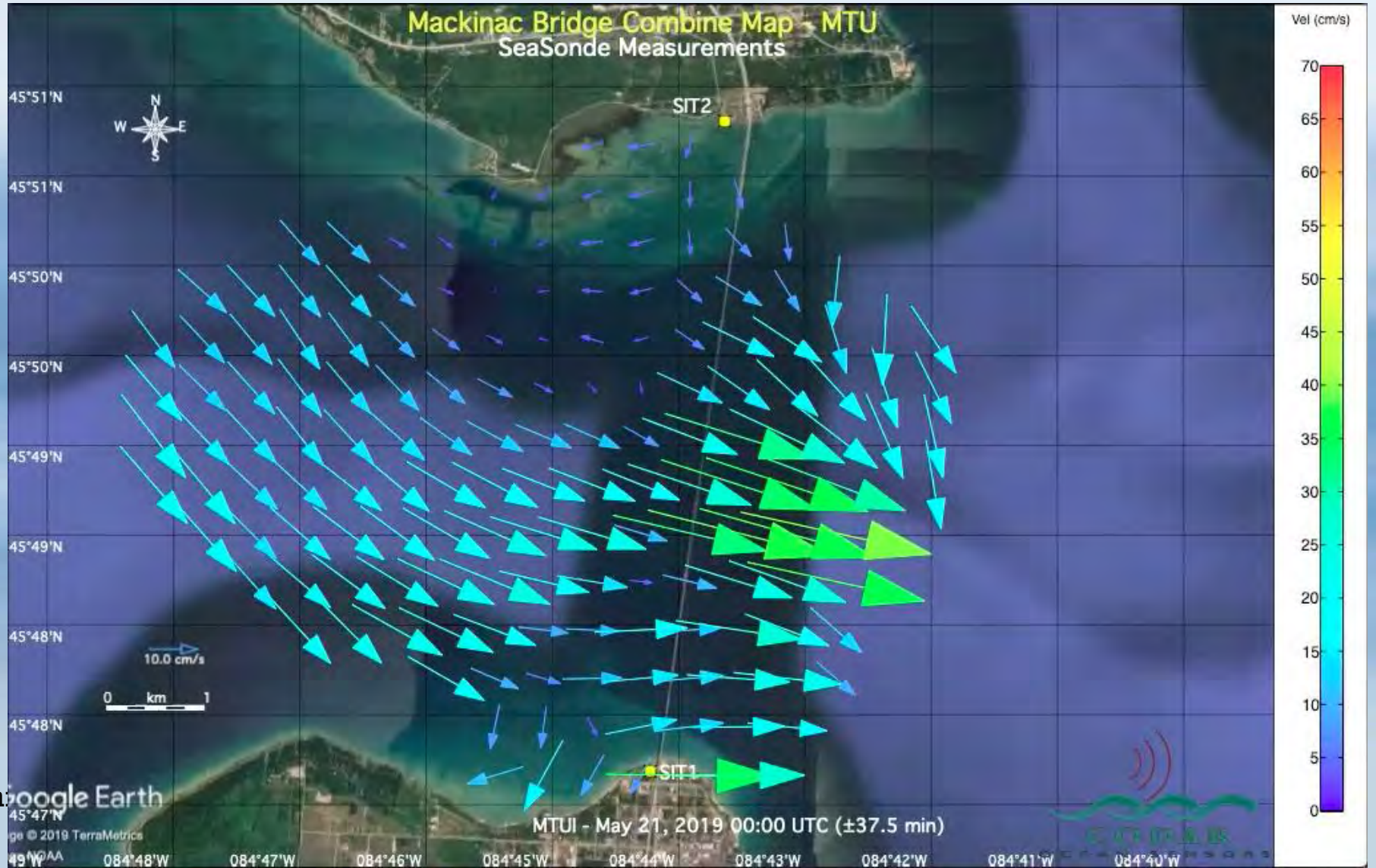
High Frequency Radar
Straits of Mackinac



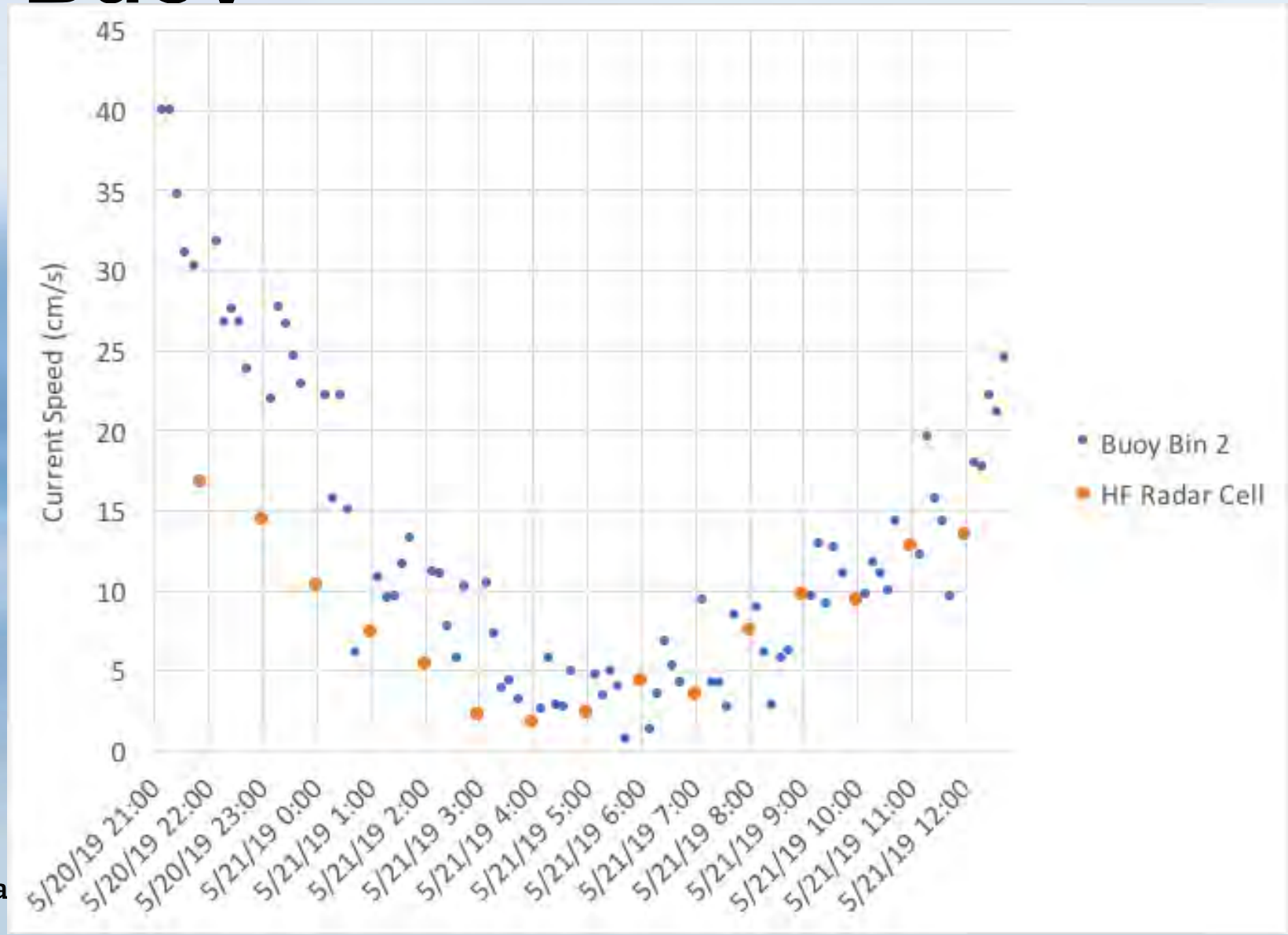
South Site

North Site

Sample Vector Map



Comparison with Straits Buoy



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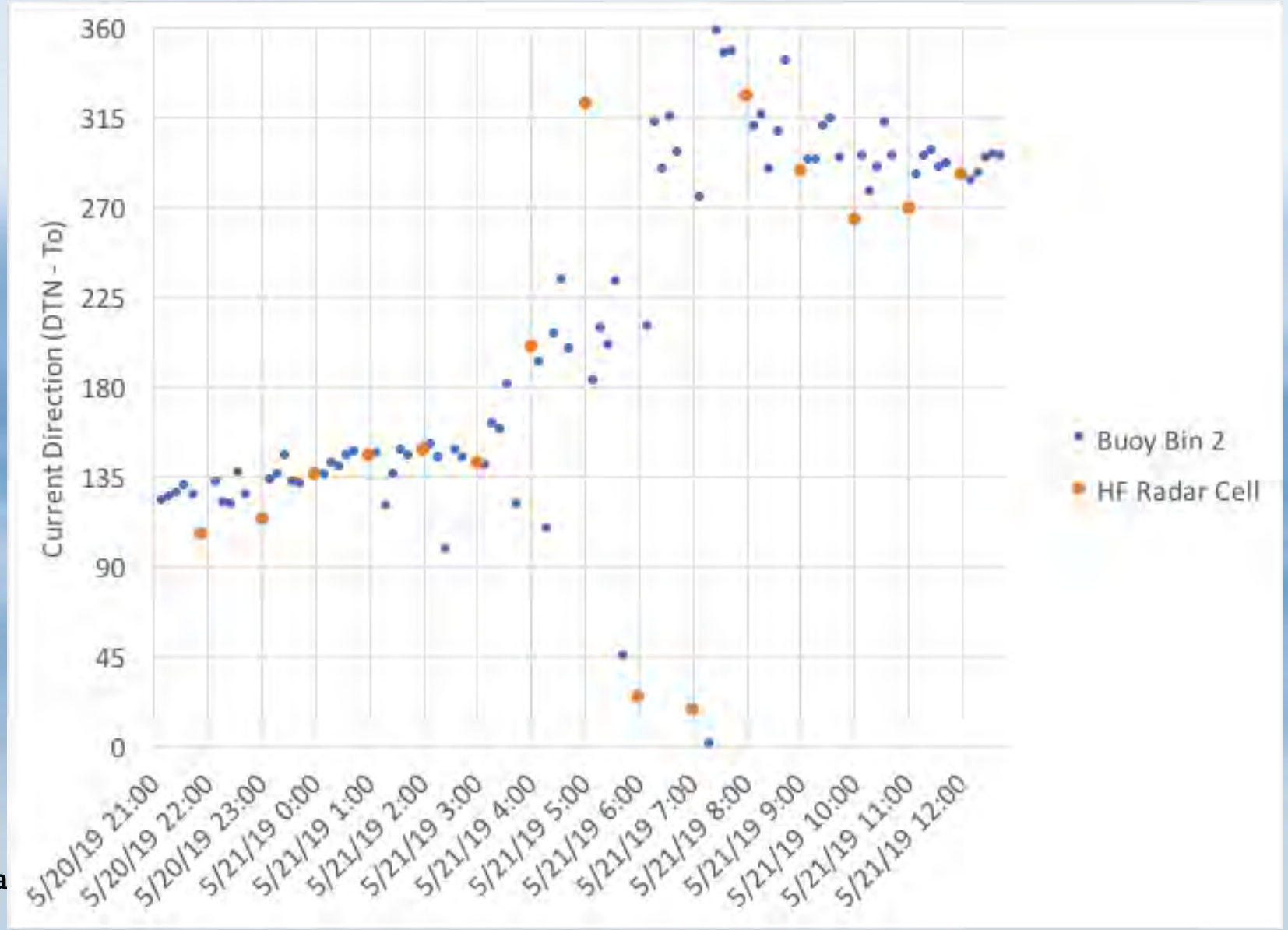
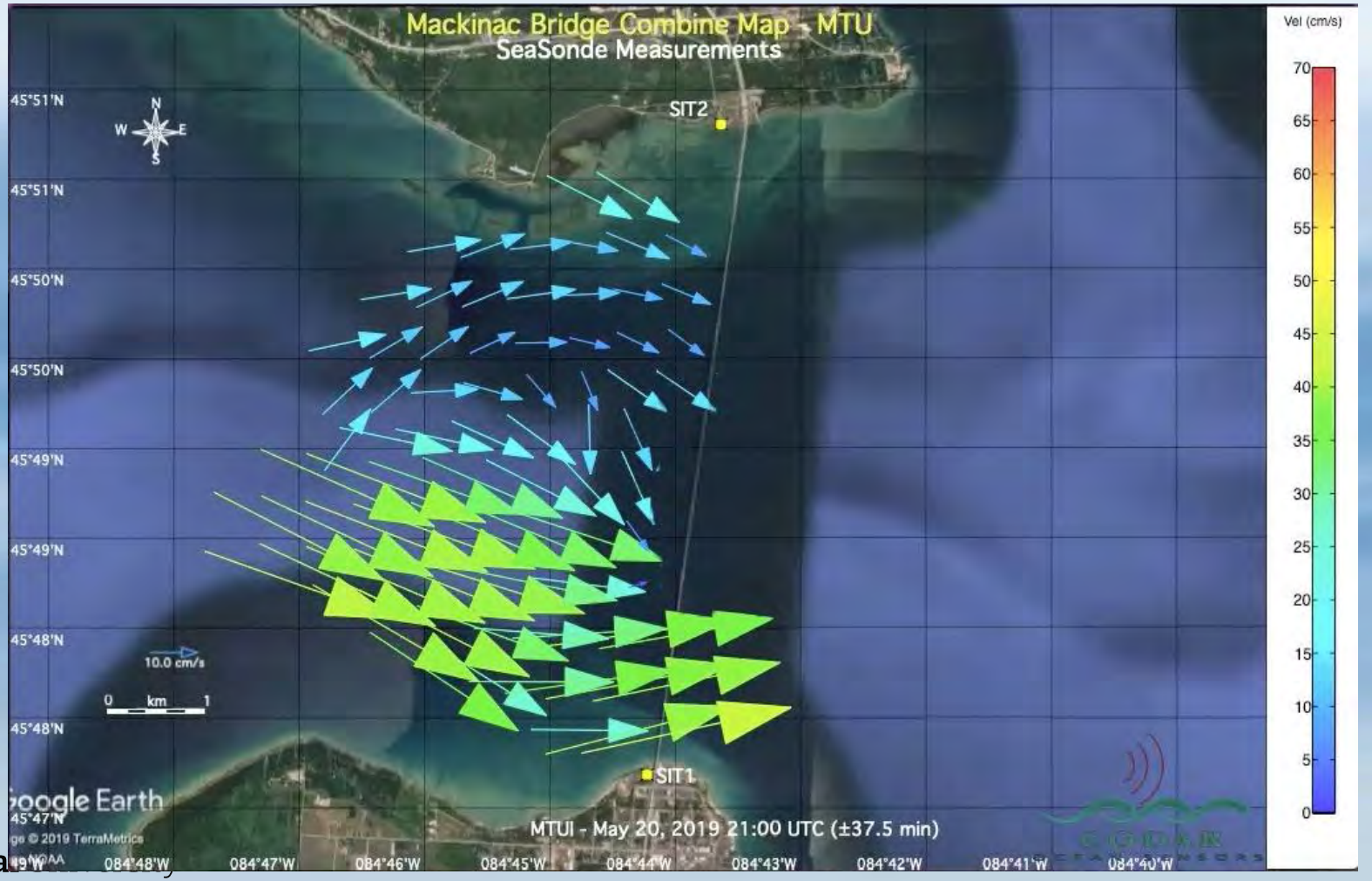


Stepping Through Demonstration Timeline…




Mackinac Bridge Combine Map - MTU
SeaSonde Measurements
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© 2019 TerraMetrics
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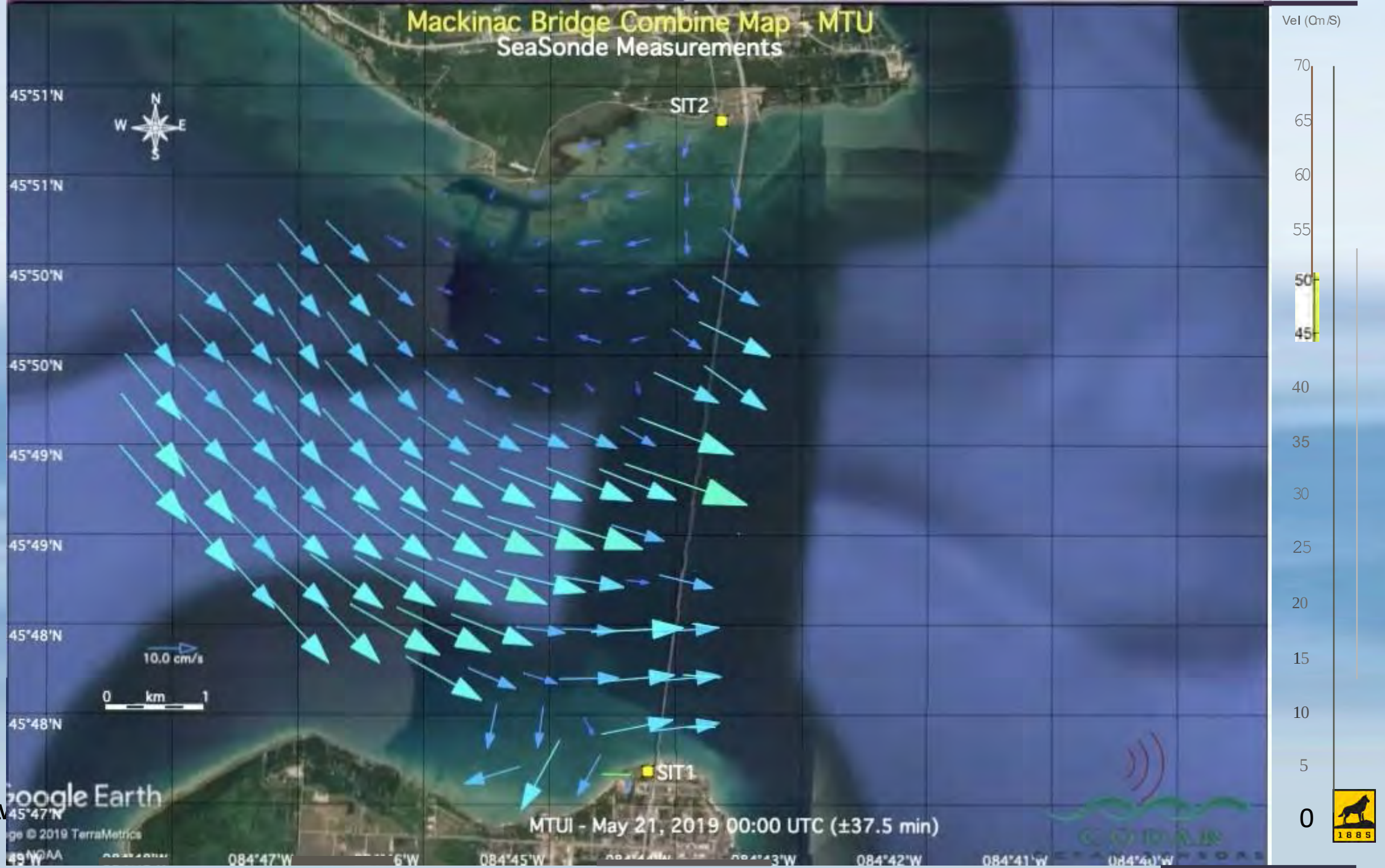
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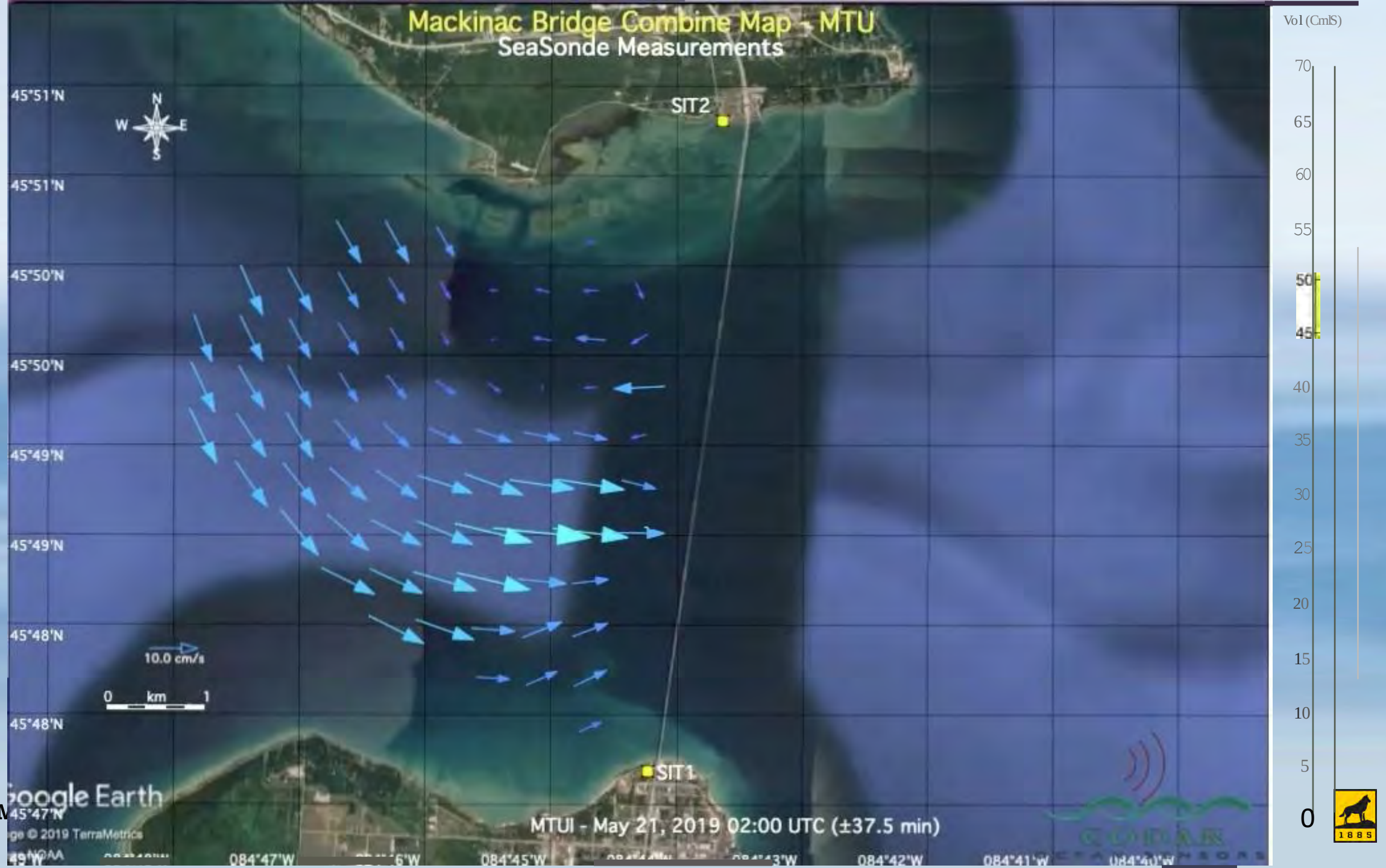
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Google Earth
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Recent and Upcoming Work w/ Autonomy

- USGS GLSC, Machine Vision/3D Construction/Simultaneous Ops – Peter Esselman
- University of Michigan, Paleo Indian Artifacts – O'Shea/Lemke
- Grand Valley State, Bathymetry and periphyton mapping – Woller-Skar

- Woods Hole/Homeland Security Arctic Domain Awareness Center, LRAUV under ice testing
- NOAA GLERL WaveGlider (Camaro) Lake Superior deployments
- USACoE – Buffalo Reef AUV mapping

Thank You For Your Interest!

Questions ?