CONNECTING THE DOTS TO INNOVATION

USACE-ERDC UNCREWED SURVEY SYSTEM DEVELOPMENT

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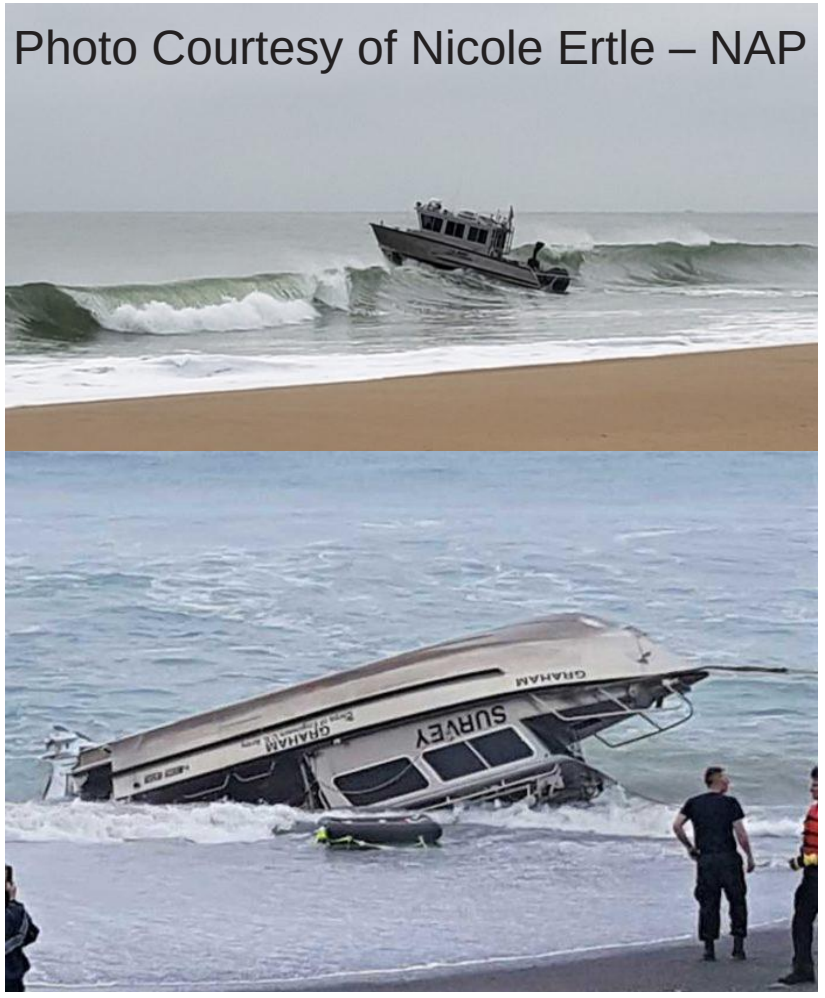
U.S. ARMY

US Army Corps of Engineers®

ERDC
ENGINEER RESEARCH & DEVELOPMENT CENTER

INTRODUCTION

- Traditonal surveys costly, personnel intensive
- Enhance safety; reduce vessel and personnel needs
- Force multiplier for districts
  - More data, faster & cheaper
- Measure storm impacts/recovery, seasonal cyclicity
- Ultimately improve project performance monitoring, design and reduce costs



***PROJECT GOAL**: Provide recommendations to Coastal Practitioner Community focused on USACE Districts*

- *Equipment recommendations*
- *Software/autonomy enhancement for coastal environment*
- *Concept of operations (CONOPS)*
- *Definition of operating envelope*

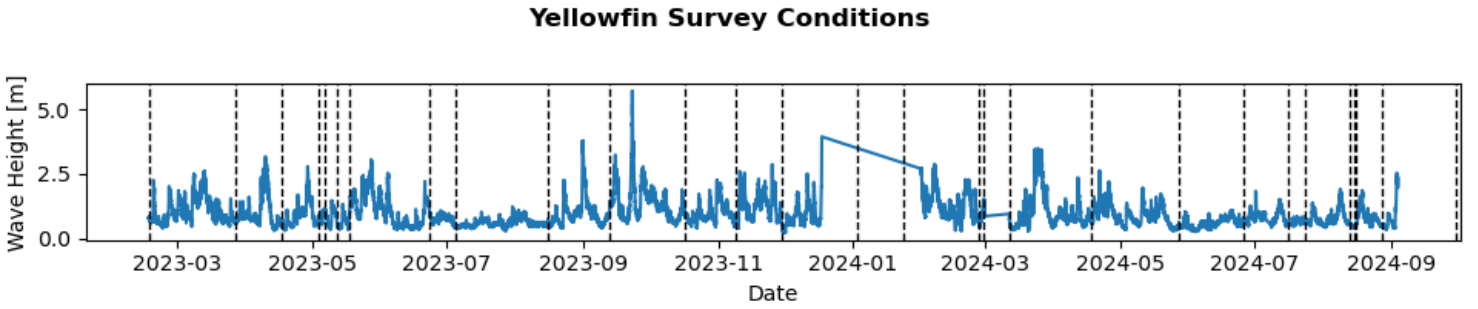
YELLOWFIN ASV

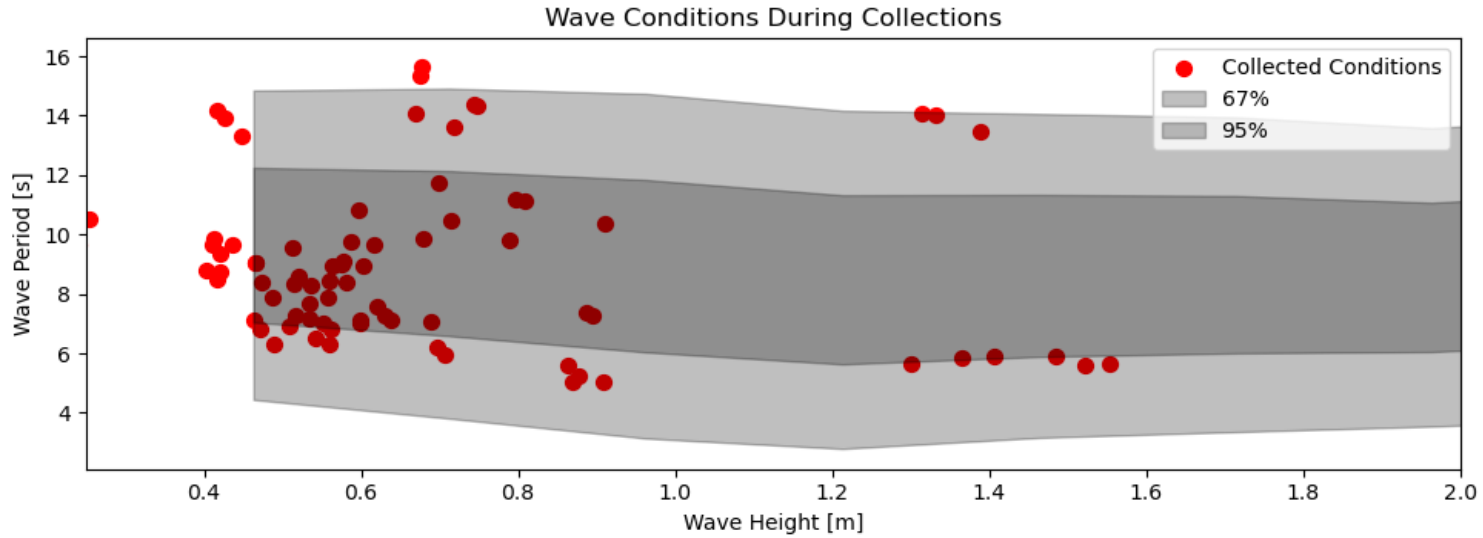
Low-cost platform for surface-based operations in breaking waves

- COTS Solution
  - Integrated Coastal Solutions LLC
- Self-righting and wave piercing
- Shallow draft & Jet drive
- 4+ hours endurance (Lion powered)
- 10 m/s max speed (3 m/s nominal operation)
- ~35k price point
  - Potential to add multi-beam

Yellowfin Field Data Collection and Analysis

- Monthly surveys continued in a variety of environmental conditions (see figure), providing insight into ***operational envelope***.
- 25 surveys
  - > 200 km survey lines
  - Monthly's, tech demos, testing, Craney Island
- FRF property takes approximately 4 hours (8 hours with LARC)
- Wide range of environmental conditions to define operating envelope





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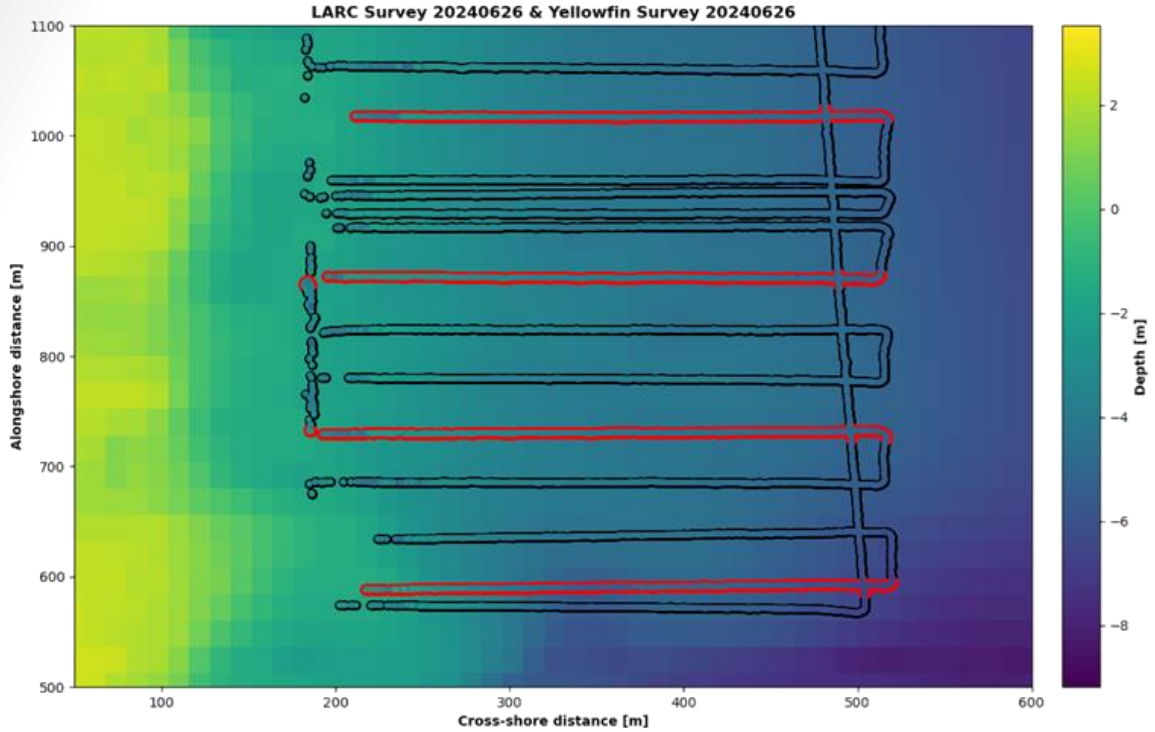

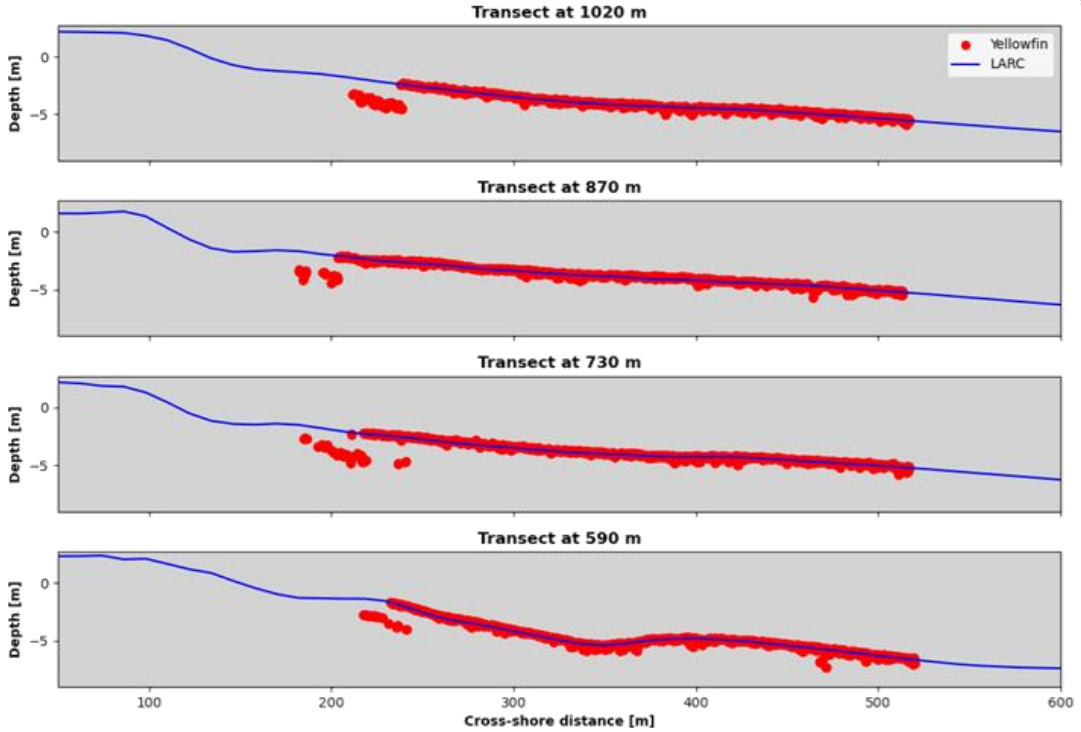

- Preliminary comparisons to LARC show over all good comparison
- Deep water can show deviation from LARC, offset in surfzone (bubbles)
  - Deep water source of error is likely associated with vehicle attitude
- Future work, develop better real-time filter from sonar.
  - Human QA/QC → Machine learning

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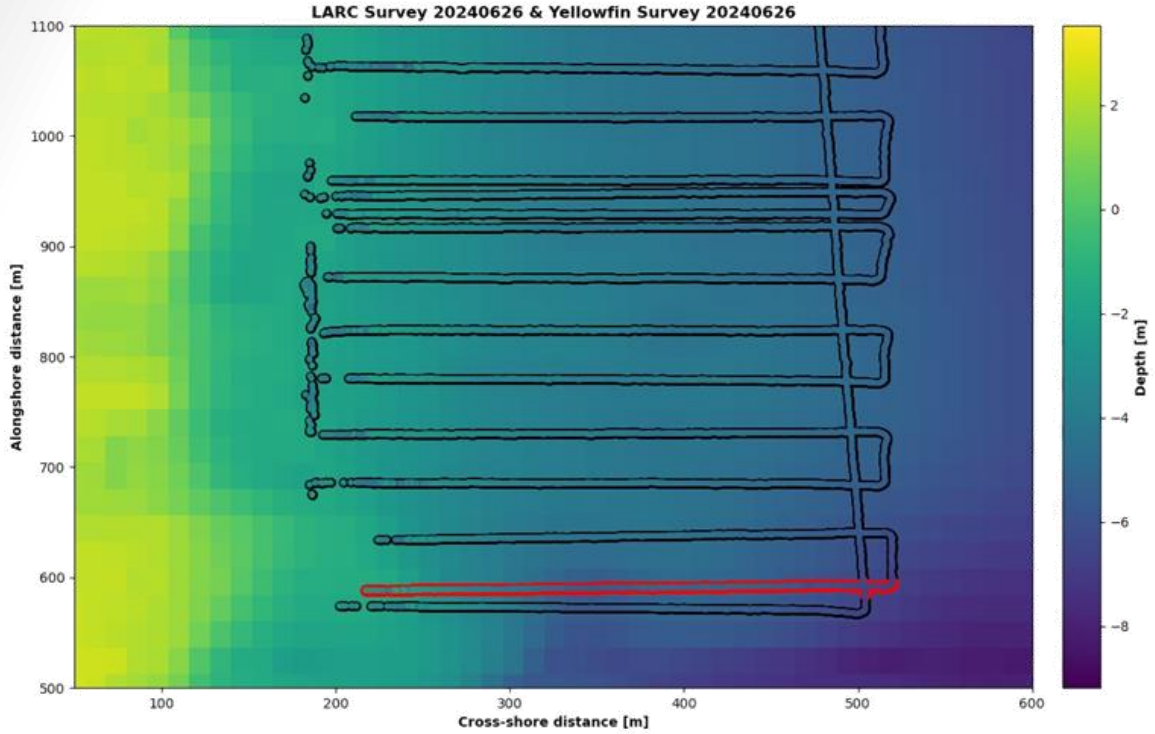

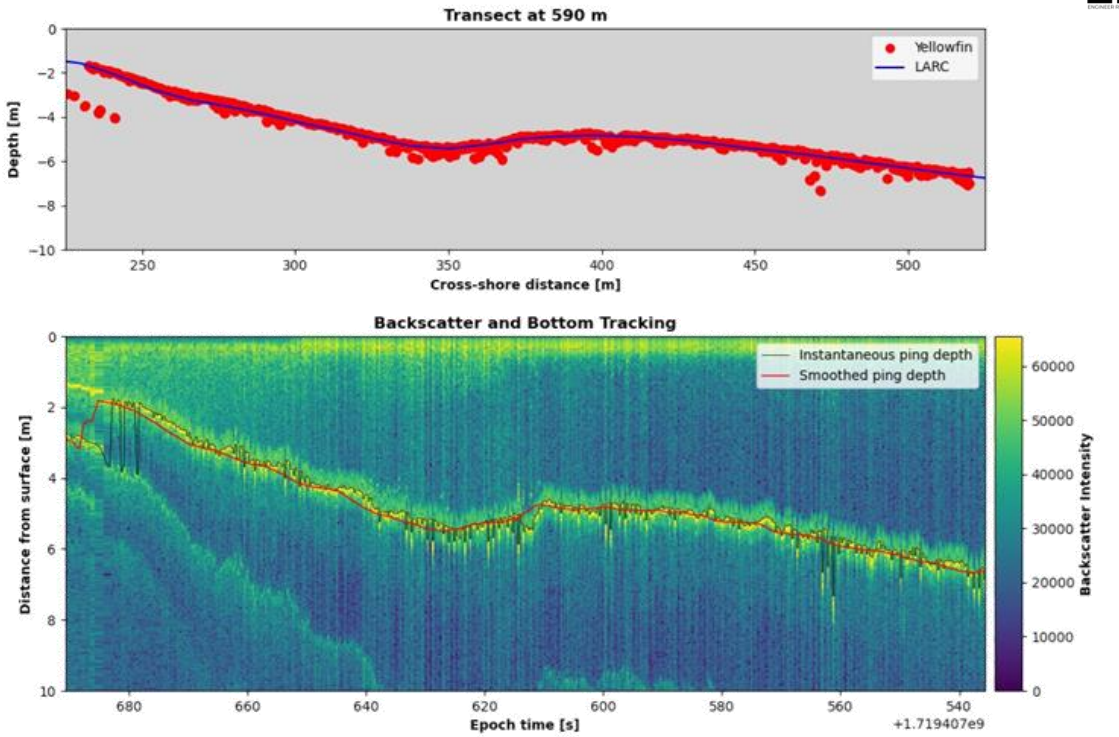

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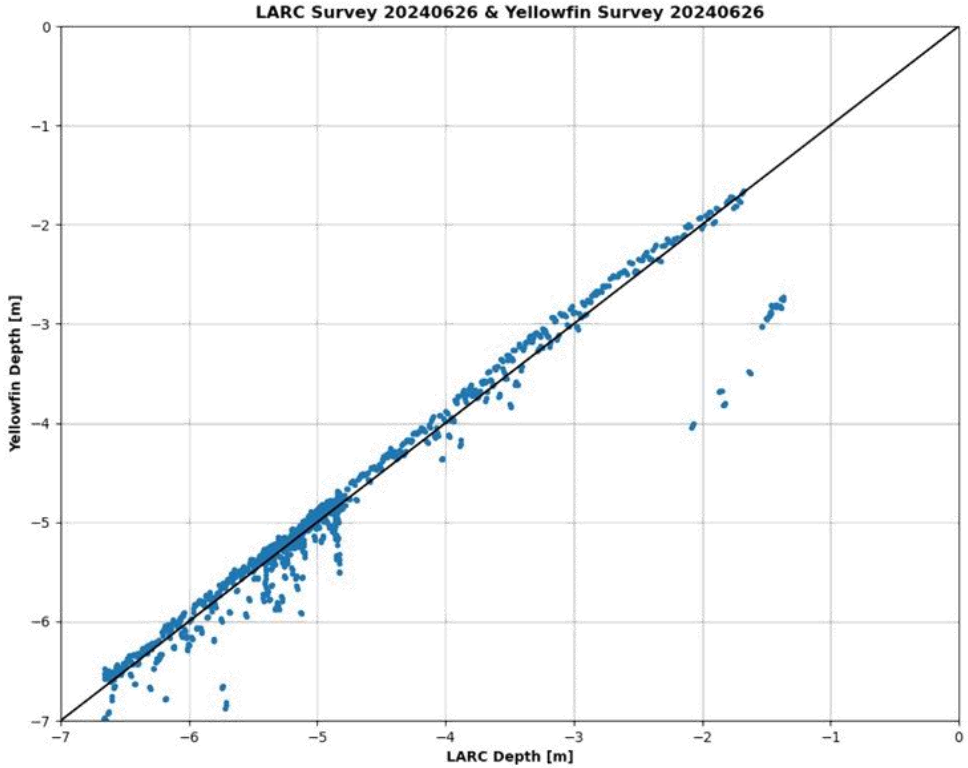

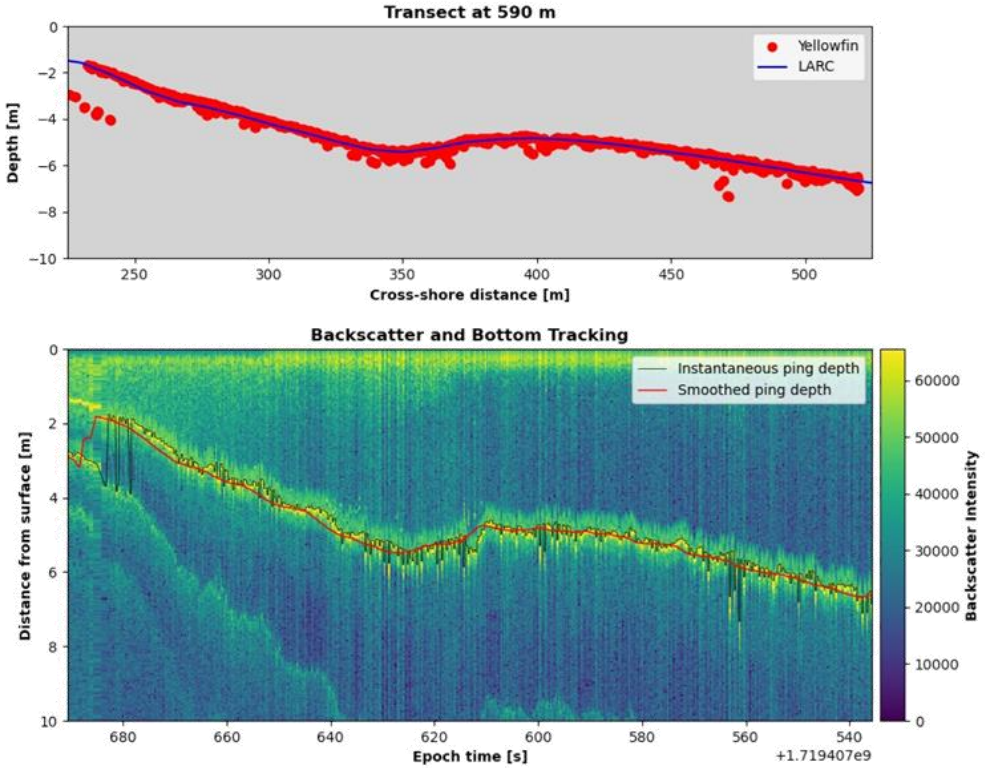

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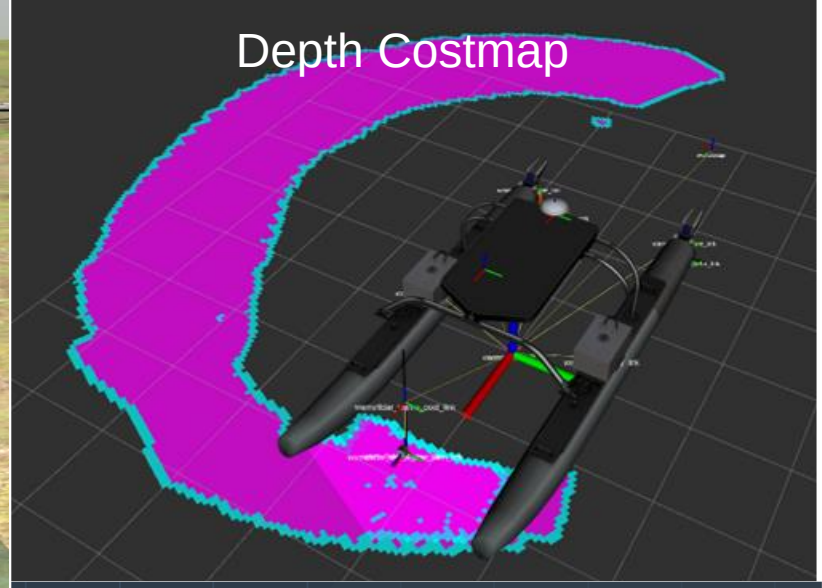
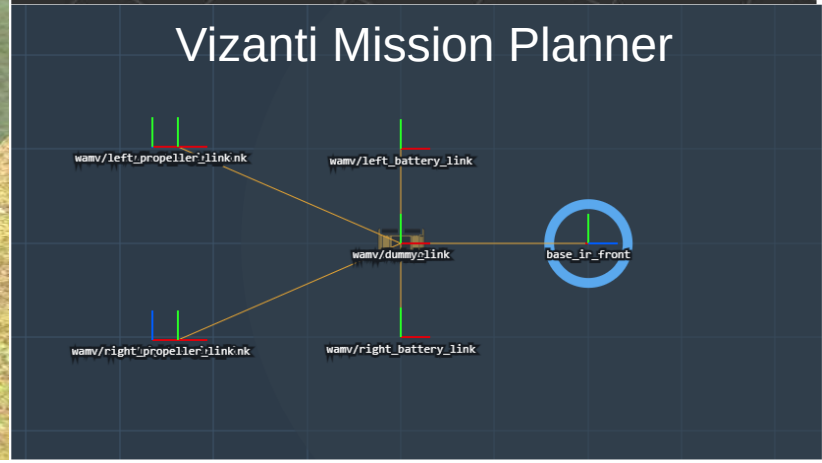
FY24 SOFTWARE DEVELOPMENTS

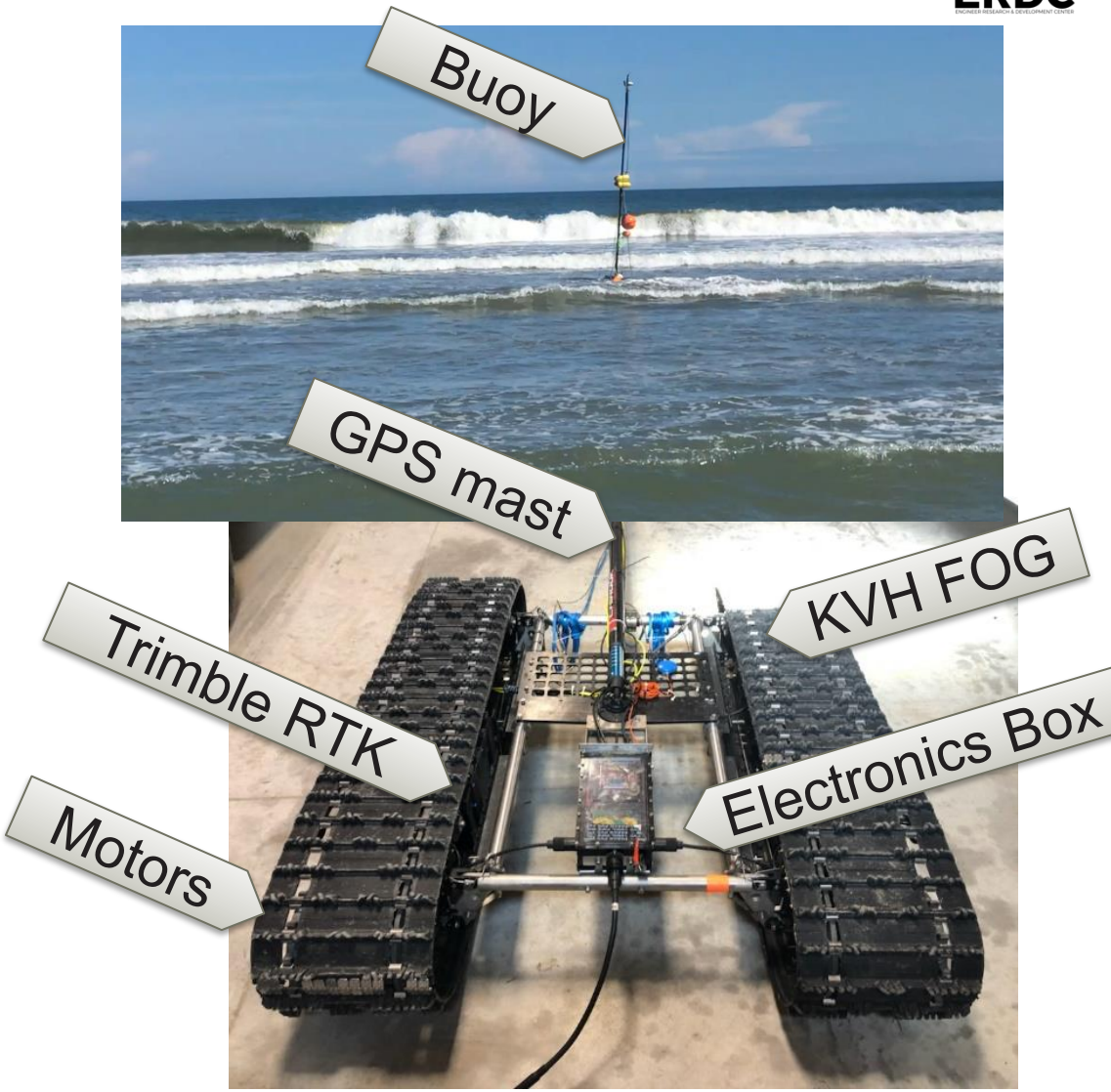




- Developing autonomy software to avoid shallow water hazards using only downward looking single beam sonar
- Simulation environment setup, built using Robot Operating System (ROS) middleware
- Tech report in progress

AMPHIBIOUS UNCREWED GROUND VEHICLE (AUGV)

- Vehicle platform made by Bayonet Ocean Vehicle (GSIQ)
- 1m x 1.25m x 30 cm ; 250 kg
  - Navigation System by GreenSea Systems
    - Encoder based odometry
    - KVH 1750 Fiber-Optic Gyro for attitude
    - Sp32arton M2 AHRS for heading
    - Pressure sensor (3 bar) -- e-box
    - Trimble BX992 RTK GPS
- Radio communications back to “base station” through buoy tethered to vehicle

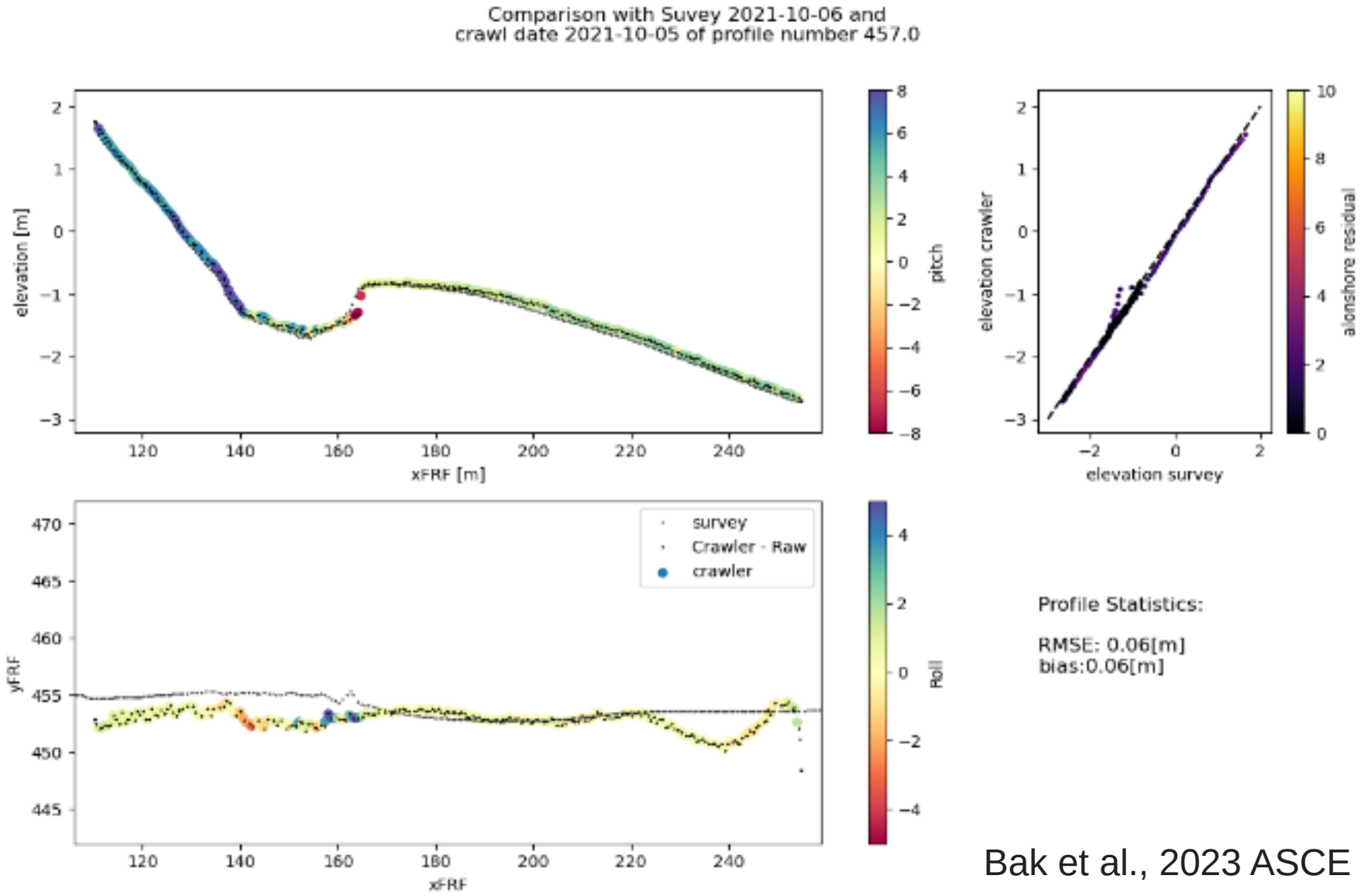


RESULTS: EXAMPLE LOW ERROR PROFILES

Typical profile comparing crawler measurement to CRAB/LARC

- Typical values of bias range [-1, 5] cm
- Typical values of RMSE range from: [4, 6] cm

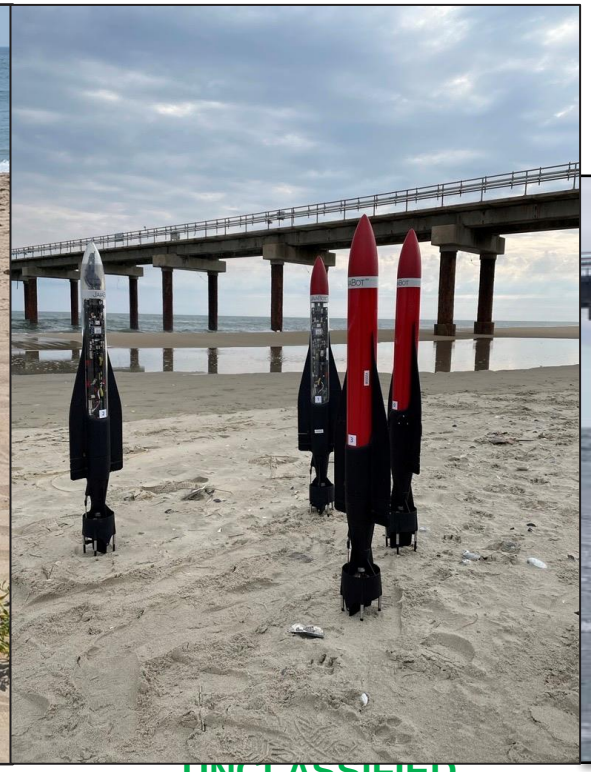
- Comparing GPS derived position to navigation solution confirms slippage

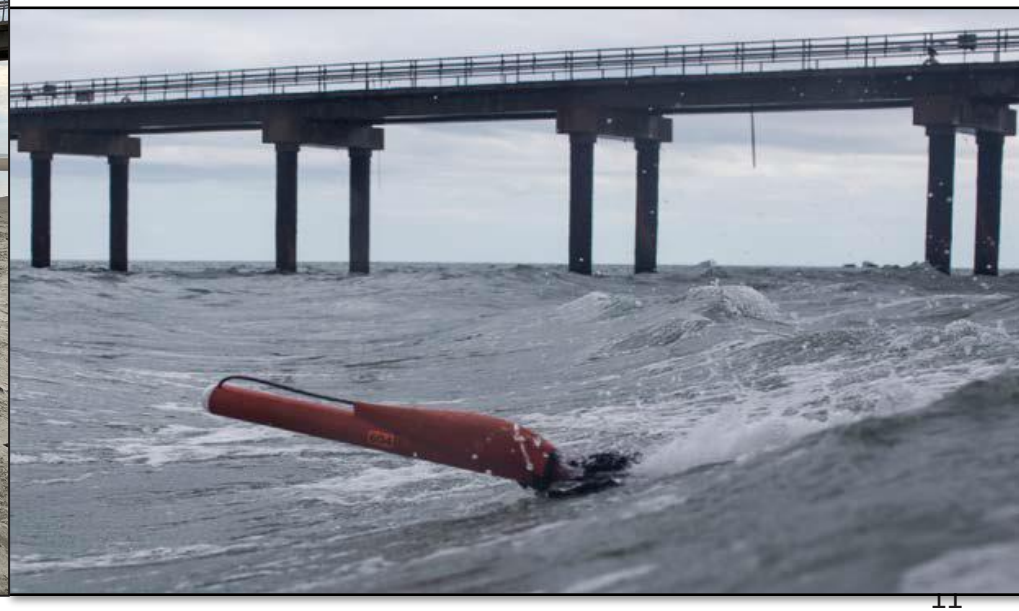


Bak et al., 2023 ASCE

JAIABOT MICRO-ASVS

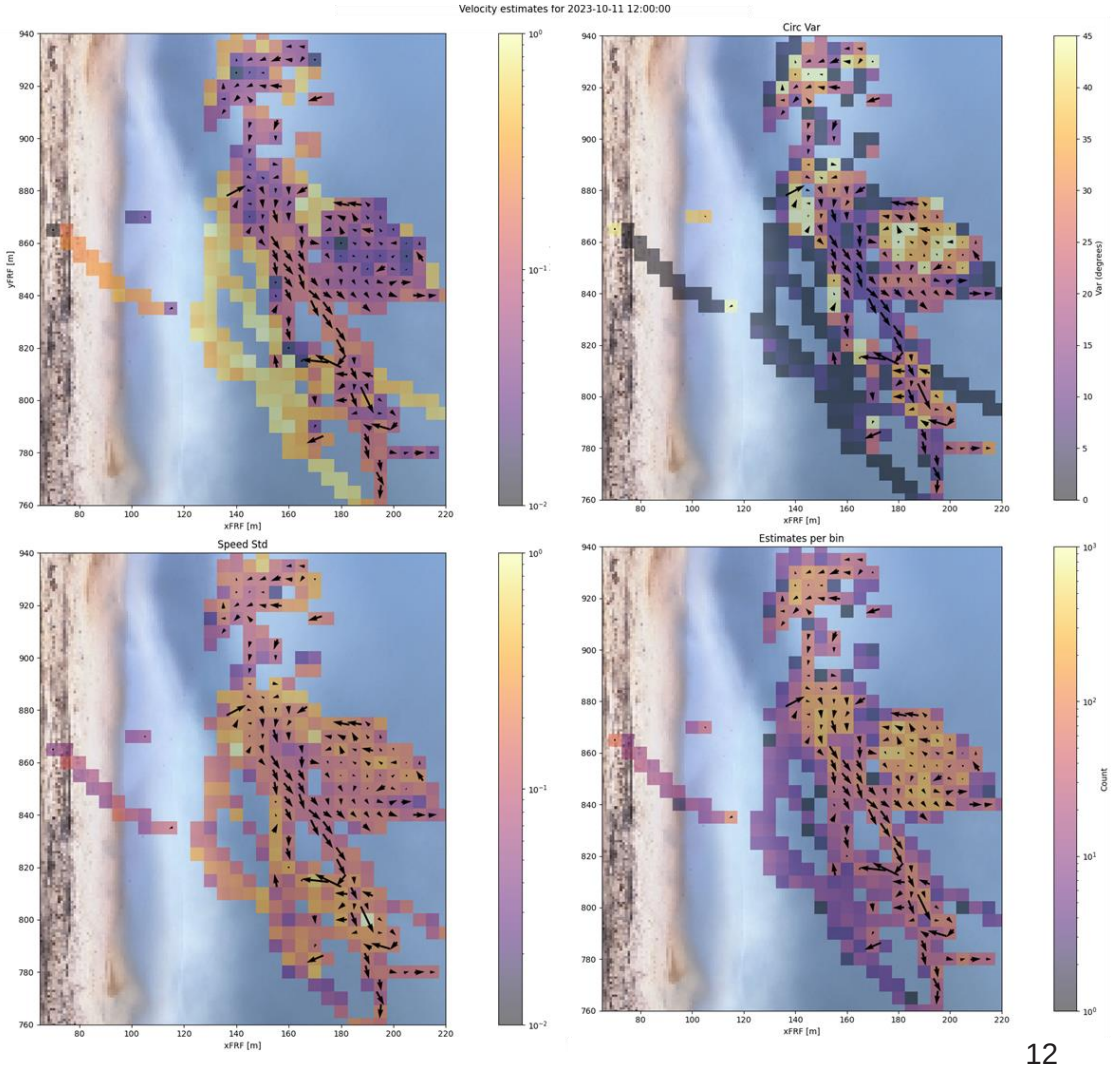
- Micro-ASV with capability to dive to gather water column data/depth
- Capability to operate multiple assets collaboratively
- Robust to breaking wave conditions
- Can measure currents, depths for rapid site characterization
  - With development waves, sound velocity, bottom composition





JAIABOT MICRO-ASVS: FLOW

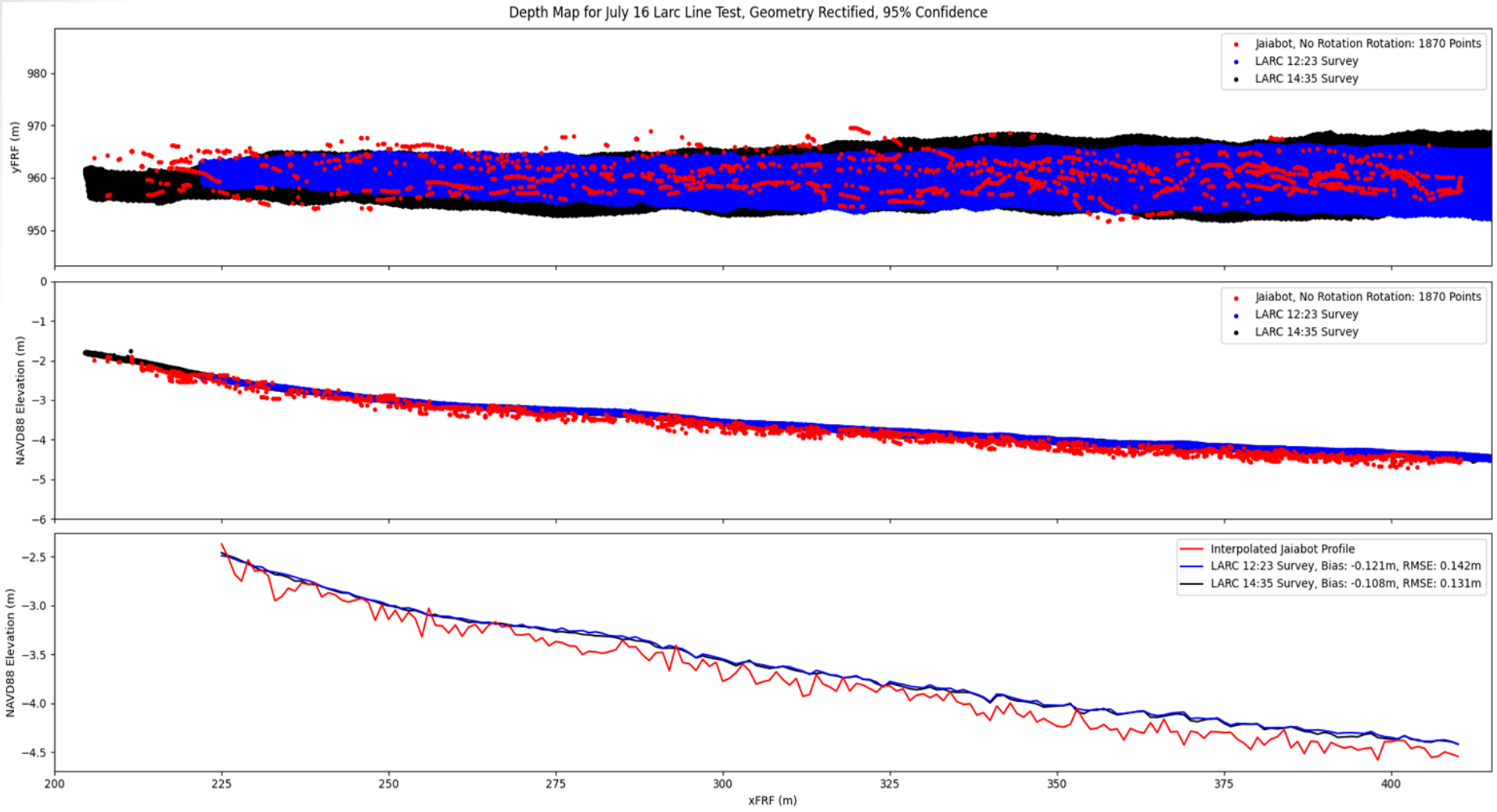
- Turn motors off to take consecutive GNSS points to get velocities
- Exploring ways to make statistically robust flow measurements
  - Creating gridded data from individual drifts
- Optimizing time/battery on site for data collection
- Platform costs ~10k/each → < $5k



JAIABOT SINGLE BEAM INTEGRATION

- Depth estimates available through diving for single point measurement
  - Sparse data and battery expensive
  - 40 cm RMSE/ 20 cm bias
- Integrated cheap single beam sonar
- Early investigation of integrated sonar showed good results
- Developing new in-line mount (3rd body) for improved buoyancy, hydrodynamic efficiency
- Runs on separate payload board in 3rd body, creates hot-swappable capability

BATHYBOT SURVEY COMPARISON VS LARC



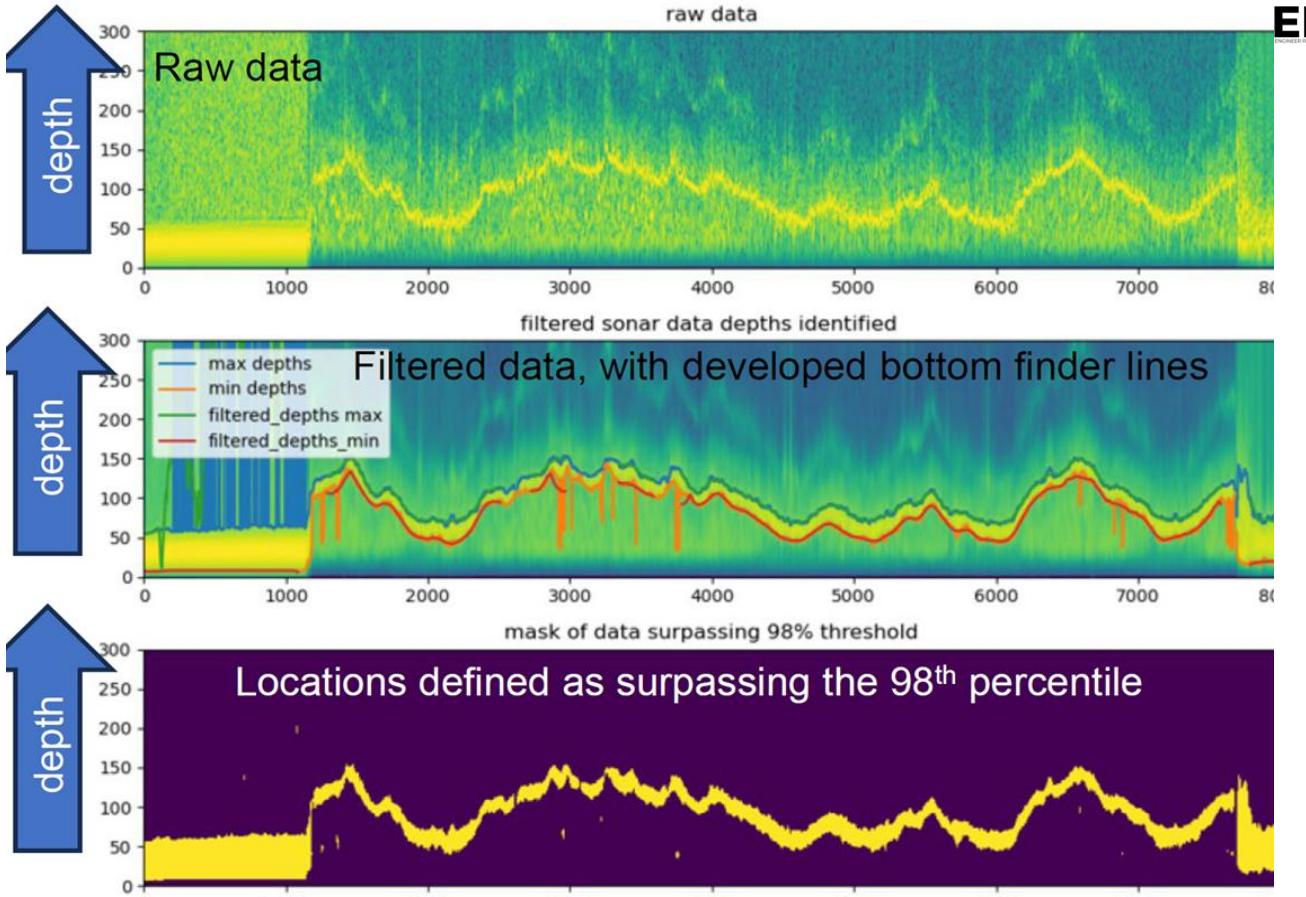
Preliminary comparison:

12:23 LARC Survey Stats
- Bias: -12.1 cm
- RMSE: 14.2 cm

14:35 LARC Survey Stats
- Bias: -10.8 cm
- RMSE: 13.1 cm

Things not accounted for:
- Vehicle pose
- Speed of sound
- Precision of GNSS

Norfolk District Interaction



- Craney Island, VA (NAP) dredge disposal site initial monitoring effort completed (DOTS request; see figures). The shallow water/fluid mud environment presents challenges to traditional survey methods.

- Scope of work (MIPR) in development for future work using multi-frequency echosounder

THANKS! QUESTIONS?

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