

Operationalizing the Waterway Expert Traffic System (WETS) Using A Common Coastal Spar Buoy (CCSB)

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This Presentation is a Mashup of two Systems

- The Common Coastal Spar Buoy (CCSB)
 - A reusable spar buoy platform designed to host multiple applications
 - Common mechanical, electrical, and data interfaces
 - Supports mesh networking and hybrid communications
- The Waterway Expert Traffic System (WETS)
 - An application built on CCSB
 - Uses water-level sensors, wave staffs, and camera systems
 - Designed specifically as a waterways management decision-support tool
- This buoy presentation draws from:
 - Academic research and student-driven innovation (Florida Atlantic University, Nova Southeastern University)
 - Industry development and fielded systems (OSDC, SAIC, McIntosh Marine)
 - Government and Navy operational experience and test environments (FMP, NAVSEA)

Conception 1981

FAU Ocean Engineering Senior Design Project

Mar 1978 FAU Ocean Engineering faculty (left to right) - Dr Dan Wolf; Dr Bill Tessin; Dr Jeff Tennant; Dr Stan Dunn; Prof Blaine Davidson; Prof Emeritus Charlie Stephan; Dr Martin; Dr Bill Hartt; Dr Su; Dr Carl Stevens; Dr Ray McAllister



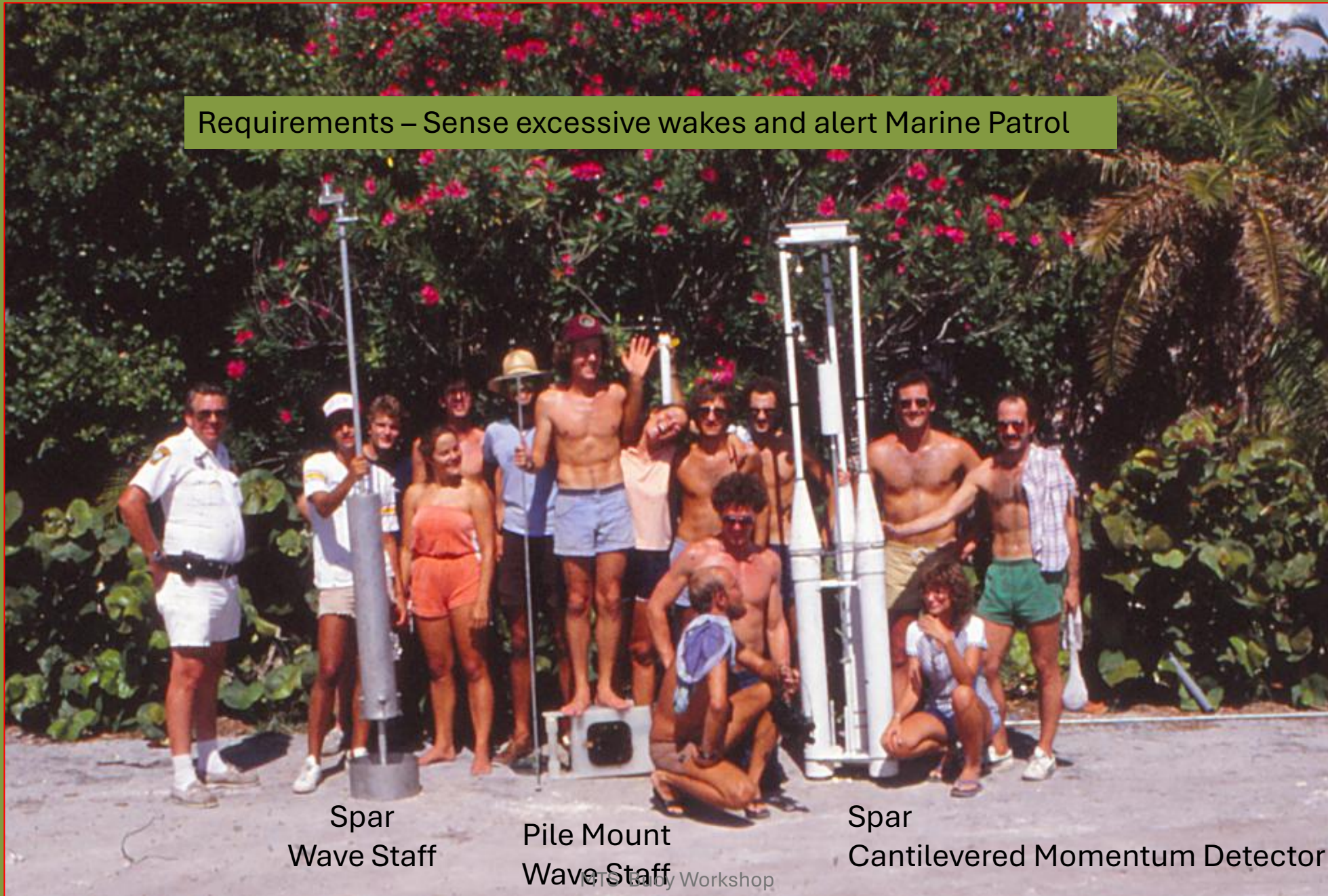
Work was motivated by real questions from:

- Marine patrol and port authorities
- Coastal engineers and planners
- Environmental managers, Navy research

Dr. Ray Mcallister brought forth the Requirements
Sense excessive wakes and alert Marine Patrol

1981 FAU Ocean Engineering Senior Design

Requirements – Sense excessive wakes and alert Marine Patrol



Spar
Wave Staff

Pile Mount
Wave Staff

Spar
Cantilevered Momentum Detector

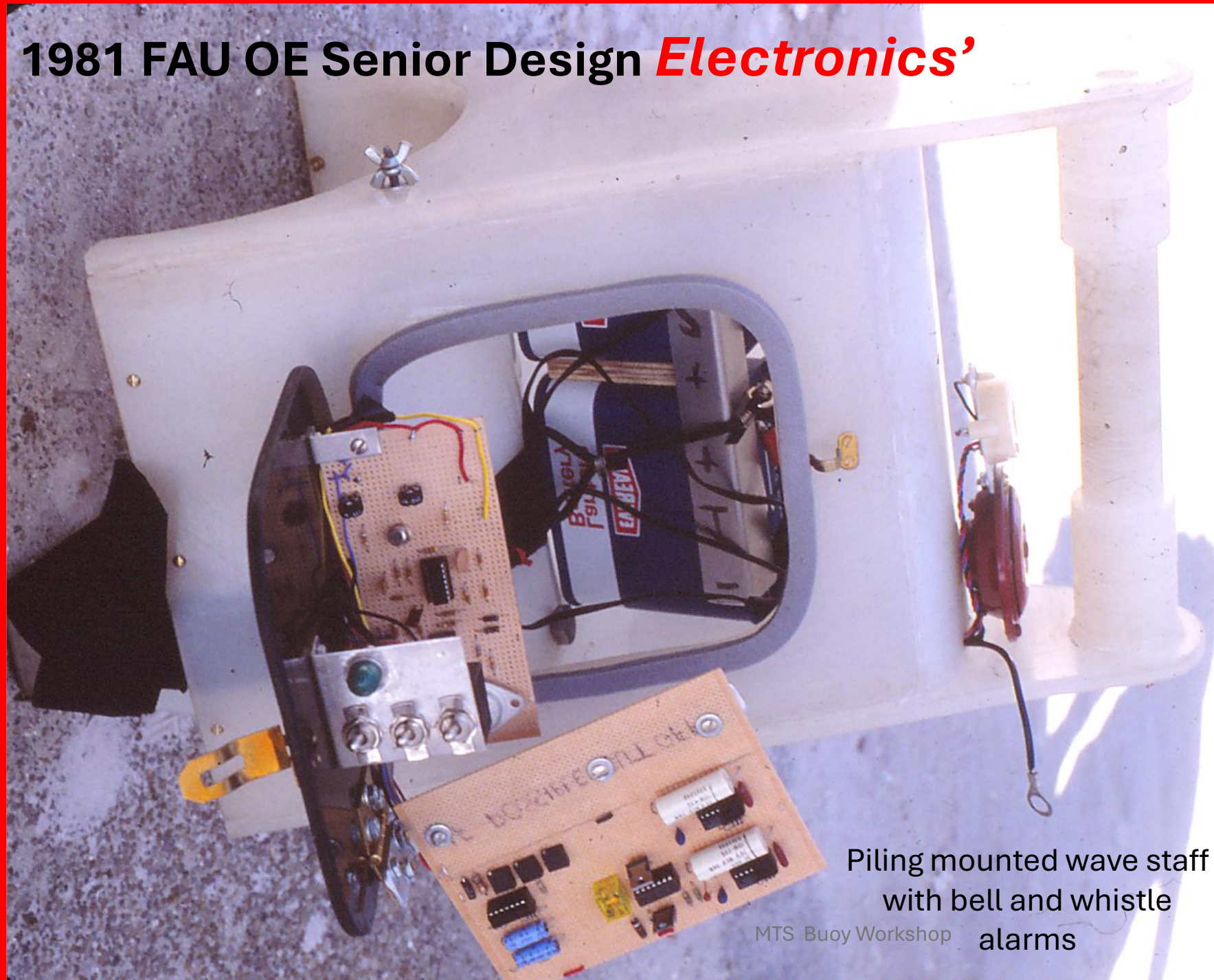


MTS Buoy Workshop



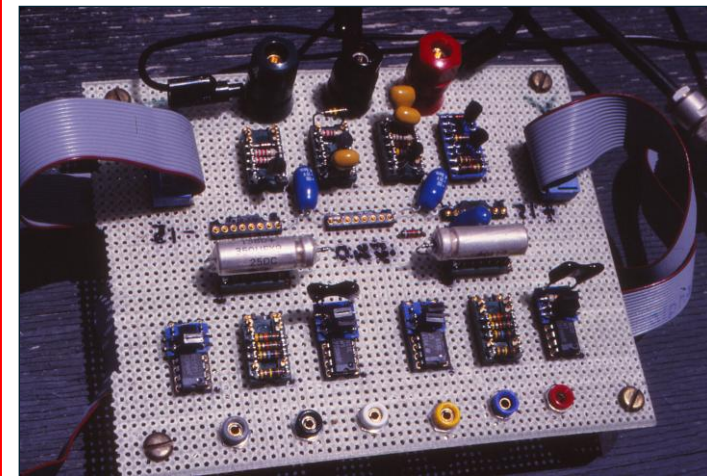
5

1981 FAU OE Senior Design *Electronics'*



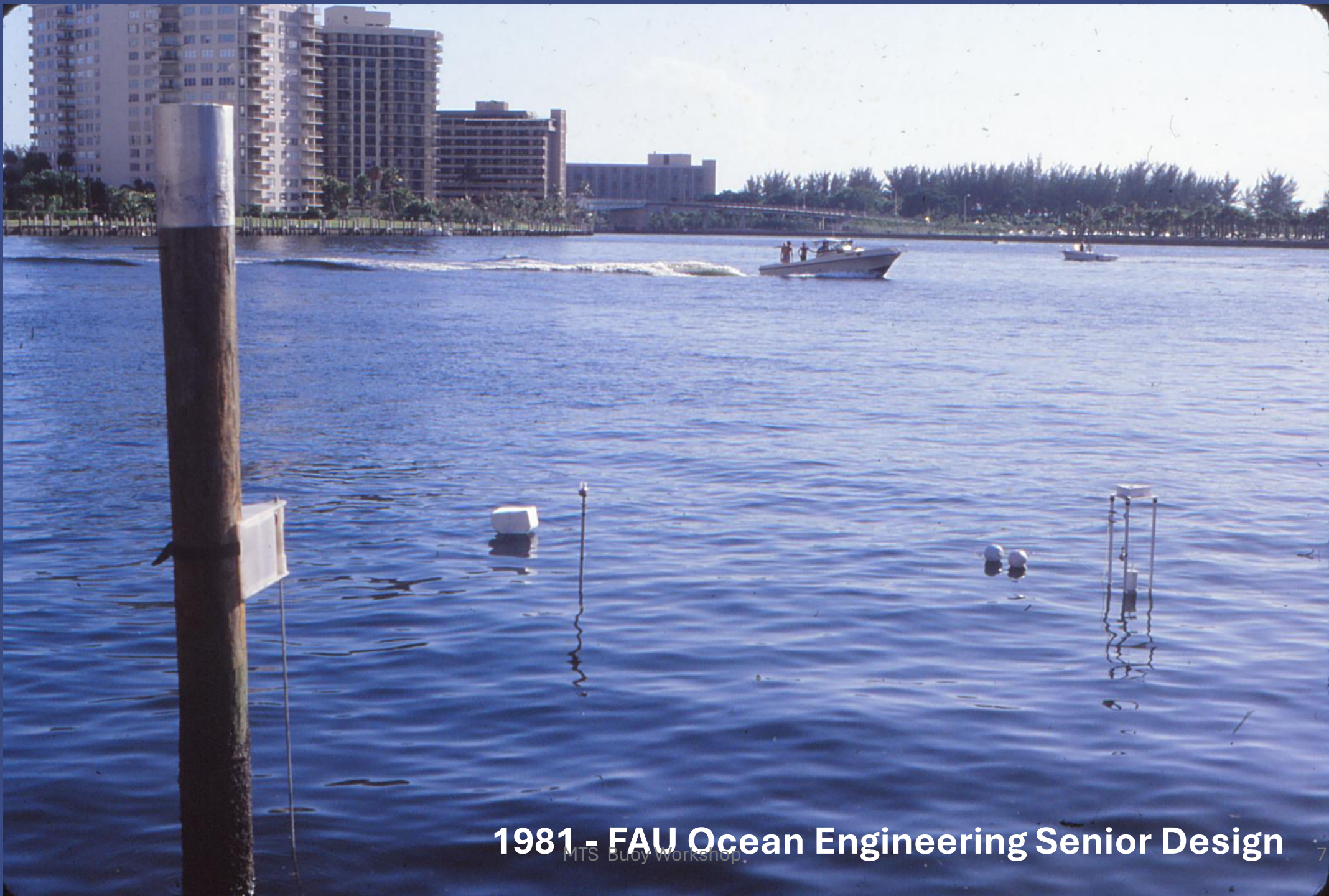
Piling mounted wave staff
with bell and whistle
alarms

MTS Buoy Workshop



Truss shaped spar with
cantilevered moving mass

Simple spar with wave staff
{ *nothing found* }?



1981 - FAU Ocean Engineering Senior Design

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WETS Automated Waterway Sensing

Before “AI at the Edge”

- WETS was developed as an automated coastal zone management tool, not a one-off experiment
- Combined machine vision, in-water sensing, and expert-system analytics
- Operated continuously, produced query able databases, and delivered results over the Internet
- Deployed at multiple live waterways (Fort Lauderdale & Port Everglades)

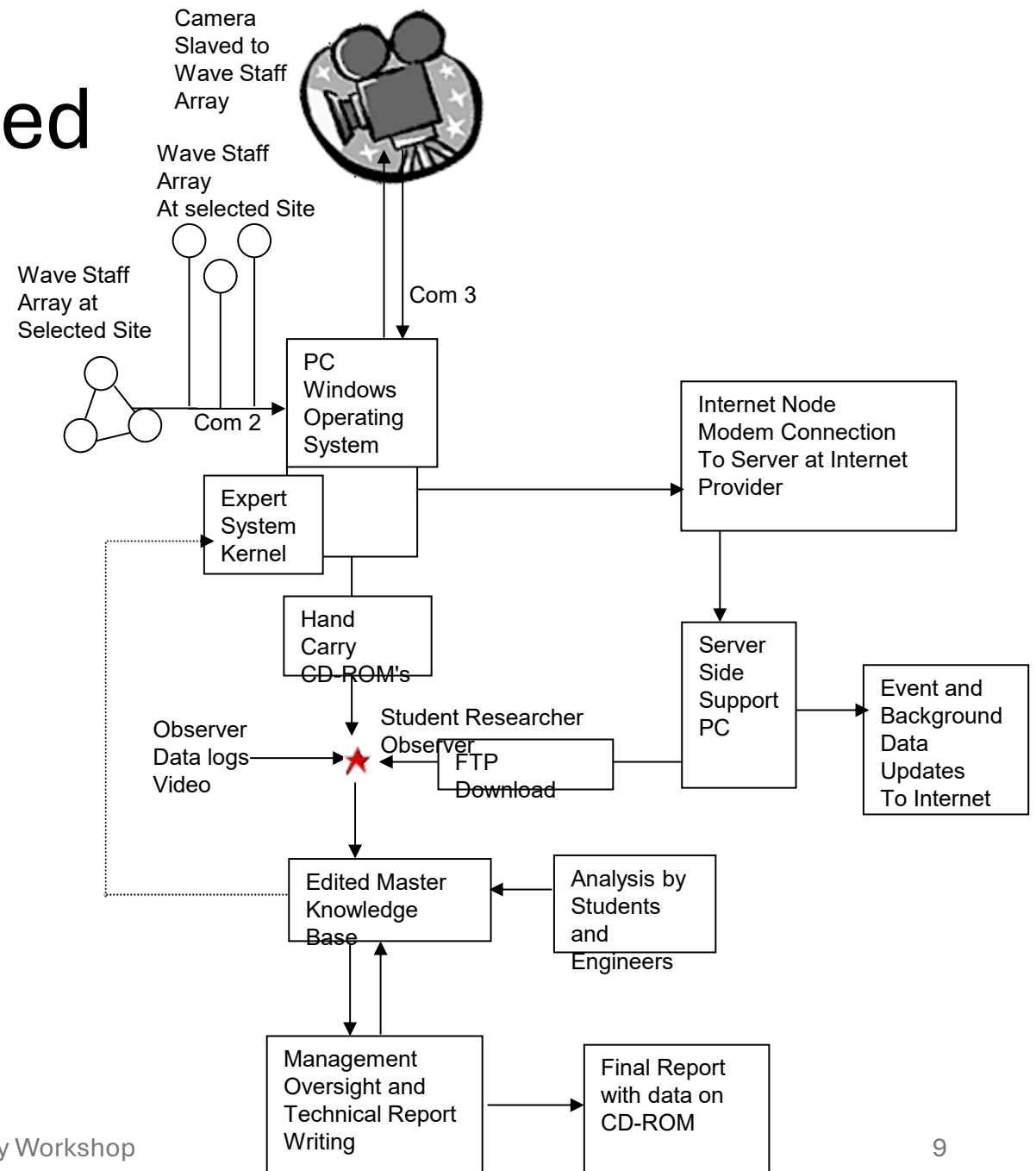


WETS automatically fused physics + vision and generated quarriable event records

- Event-triggered sensing using:
 - Camera (machine vision)**
 - Laser trip wire (event detection)**
 - Triangular wave-staff array (physics-based inference)**
- Time-synchronized, multi-sensor fusion
- Automated data reduction into a **relational database**
- Real-time + historical access via **web queries**

WETS-98: Student-assisted image review
Manual event confirmation
WETS-99: Fully automated event detection
Machine-generated records
Real-time database updates
Clear demonstration of scalability

This was edge processing before we used that term





11-10-1999



13:44:21

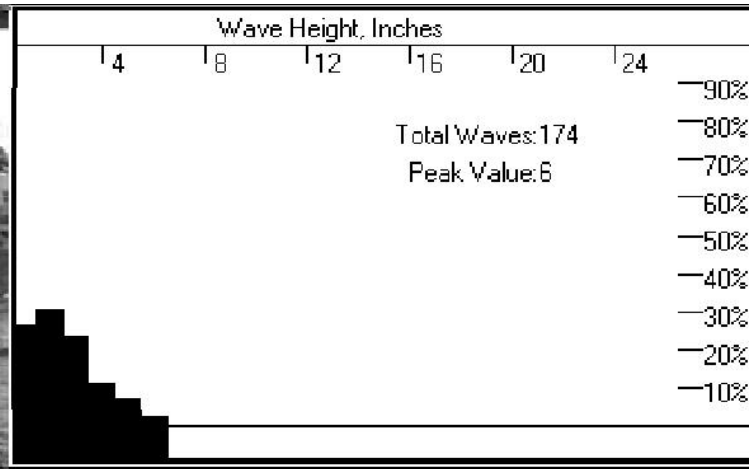
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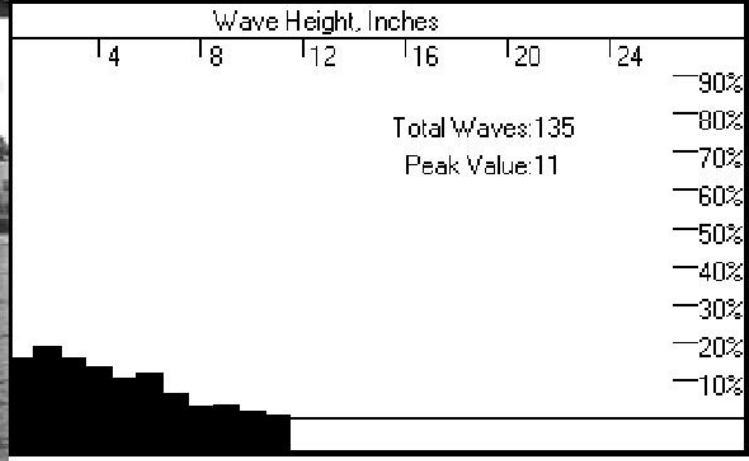
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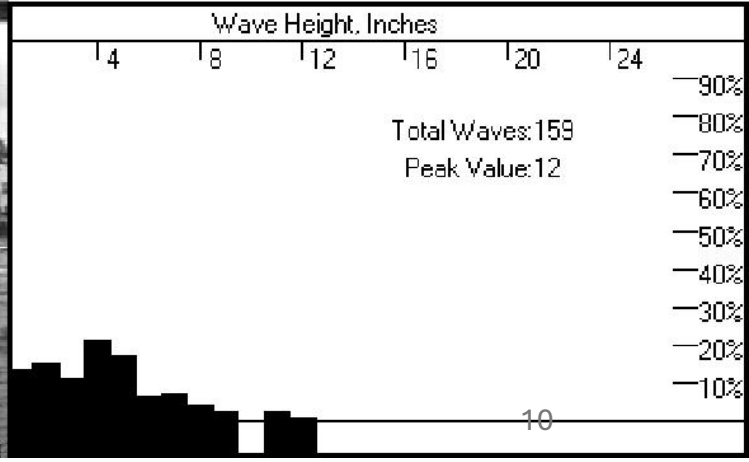
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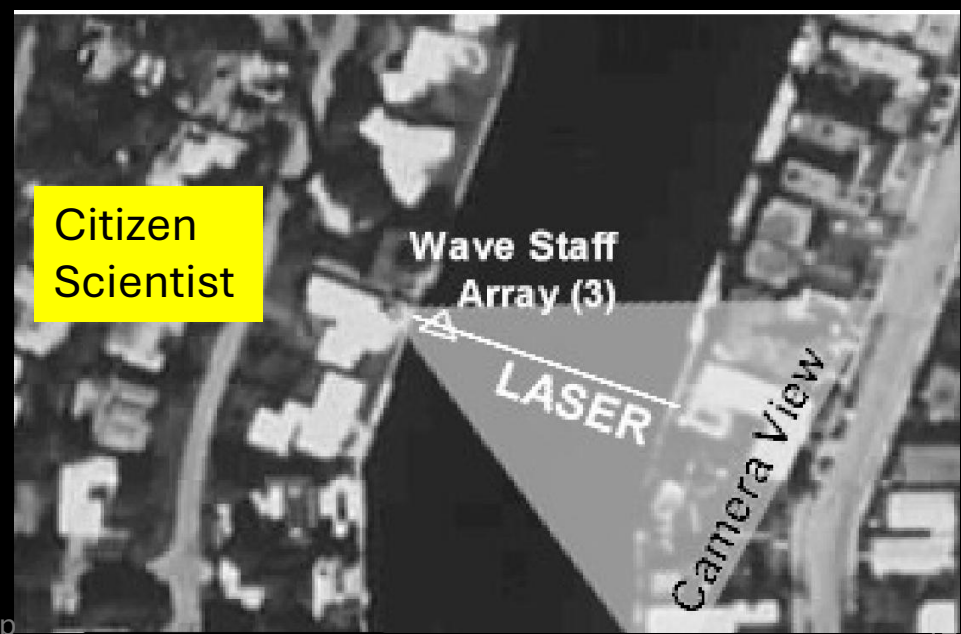
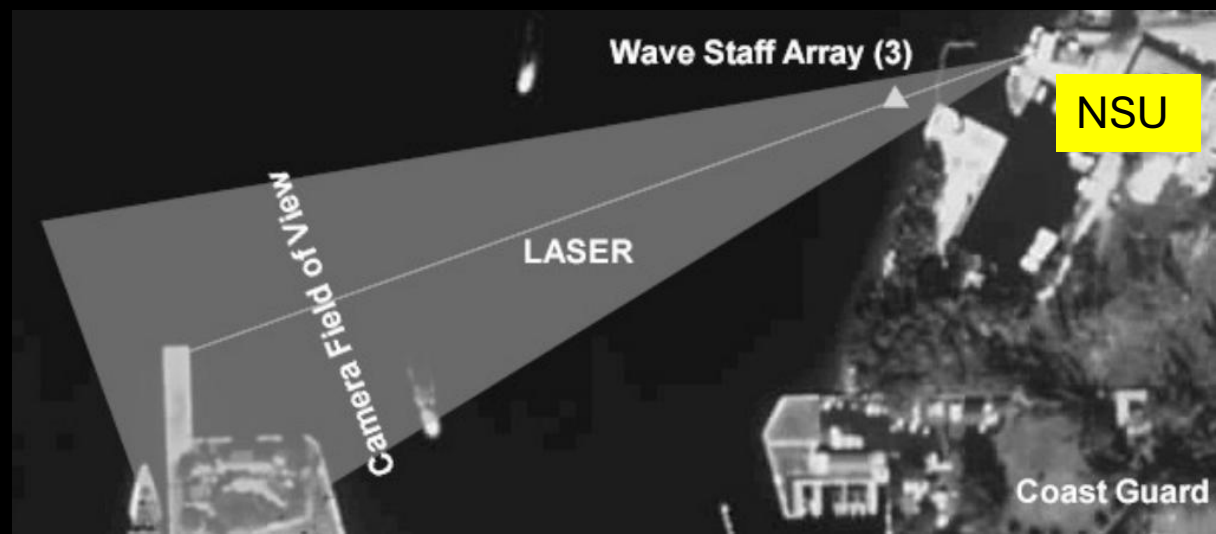
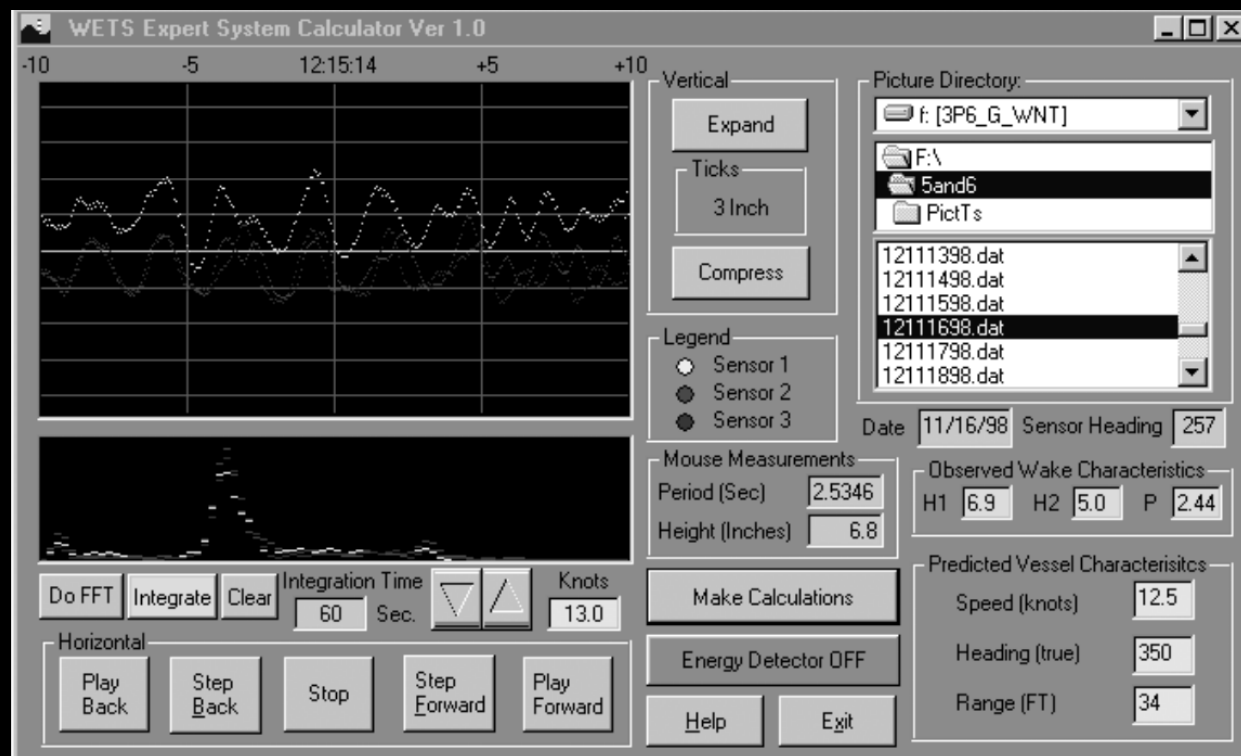
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WETS-99 Machine Vision Database: The Proof of Principle

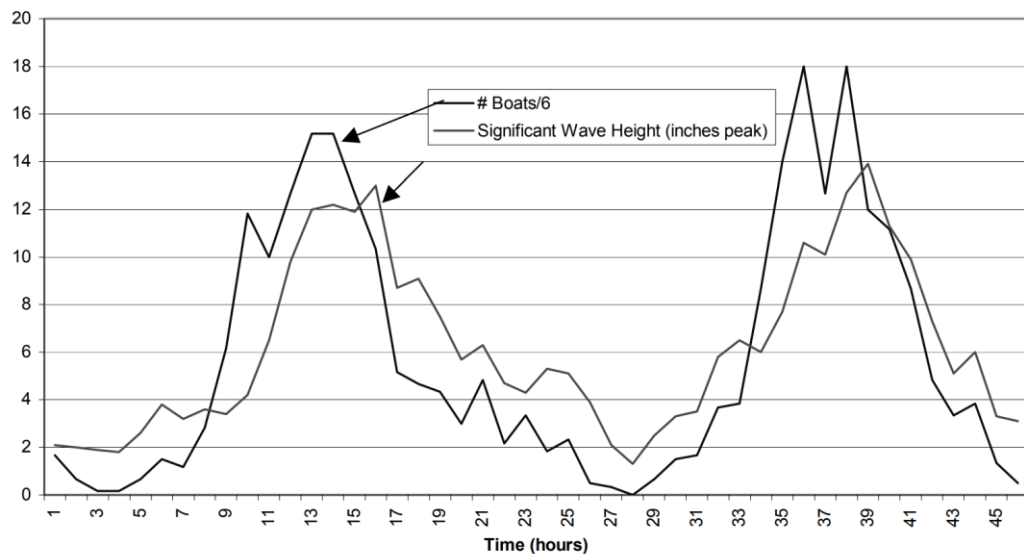
- Every vessel passage generated a **machine-readable event record**
- Each record fused:
 - **Images** (wide, medium, close views)
 - **Wake physics** (histograms, peak heights, energy)
 - Derived motion (speed, heading, range)
- Events were **automatically indexed, stored, and query able**
- Created a **labeled dataset** linking *what was seen* to *what it physically did*

This was an early labeled training dataset for maritime activity, created automatically

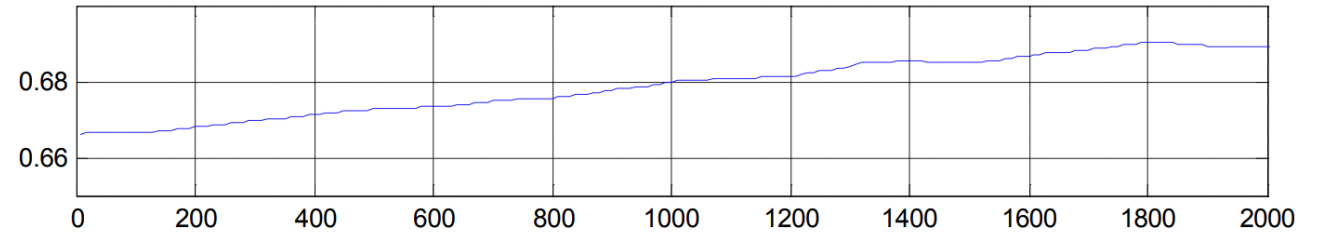
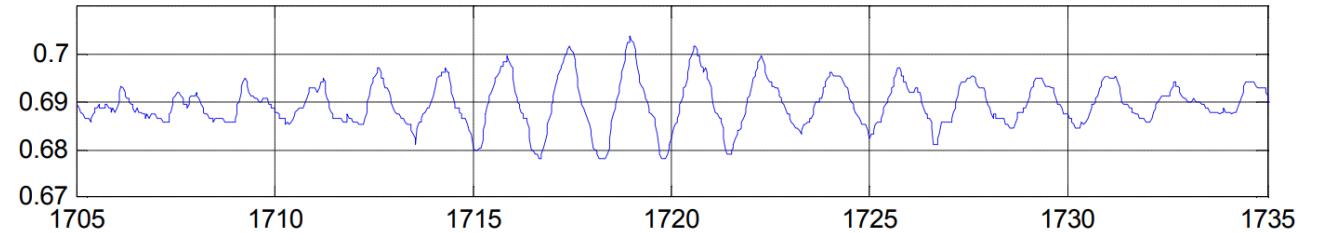
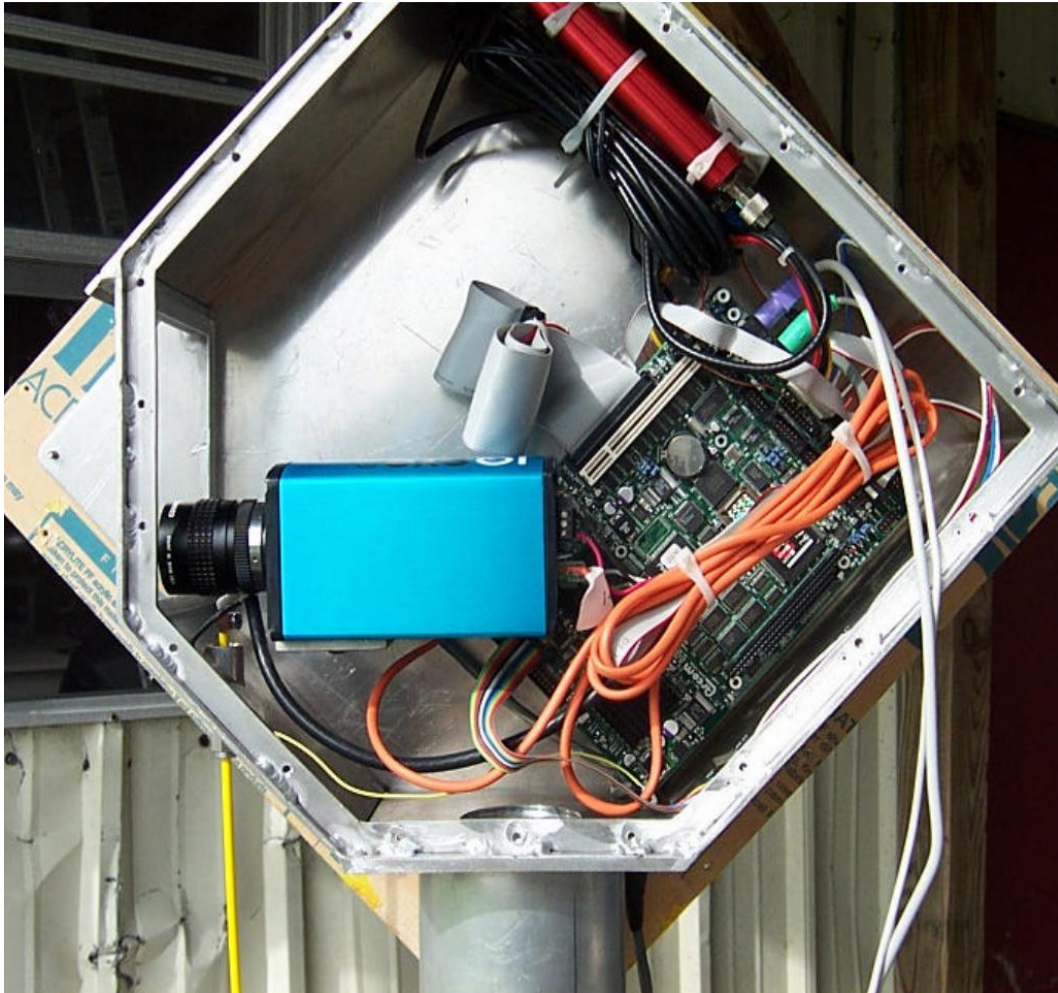


WETS 99 image viewer.
 This viewer runs on a
 personal computer to
 rapidly access data
 and time stamped
 images.

Corelation of Seastate and Vessel Traffic (Weekend)



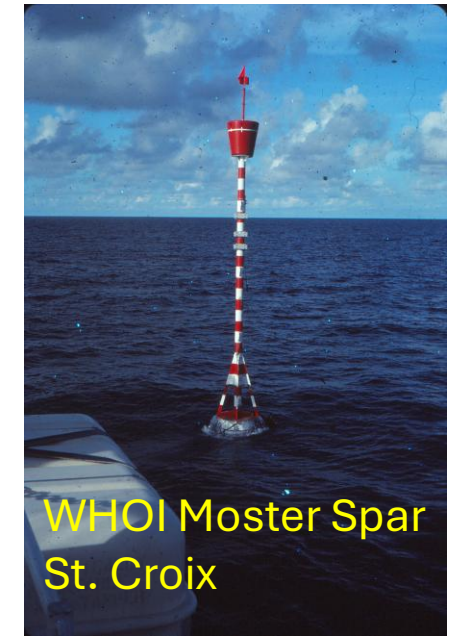
WETS → IoT evolution *before IoT buzzwords*



Hobe Sound Florida Prototype IoT Sensor Host and Camera/ data telemetry within WETS signage.

Partners, FMP, NOVA/OSDC/OSSI (2002)

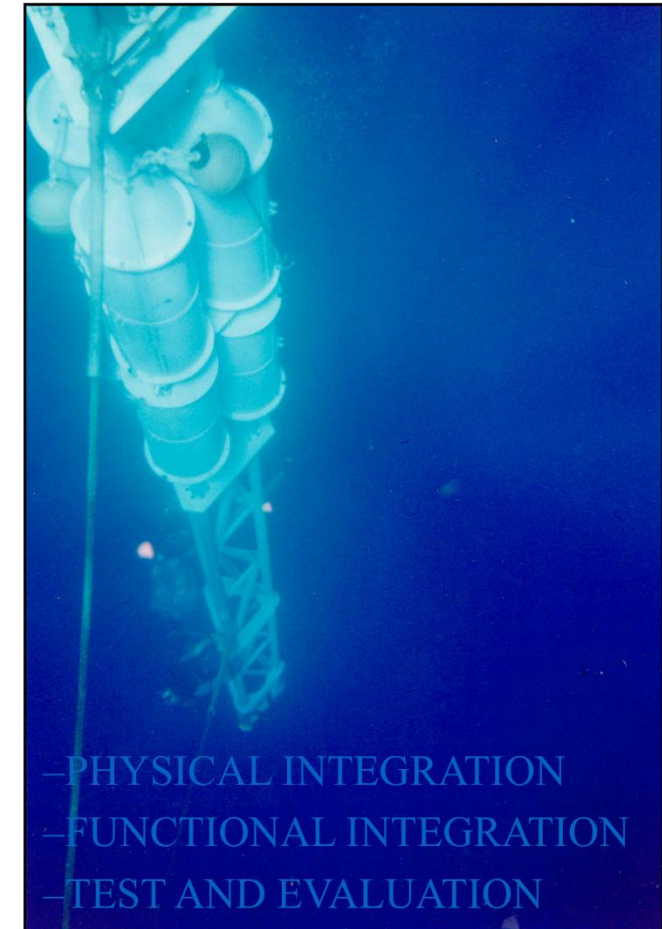
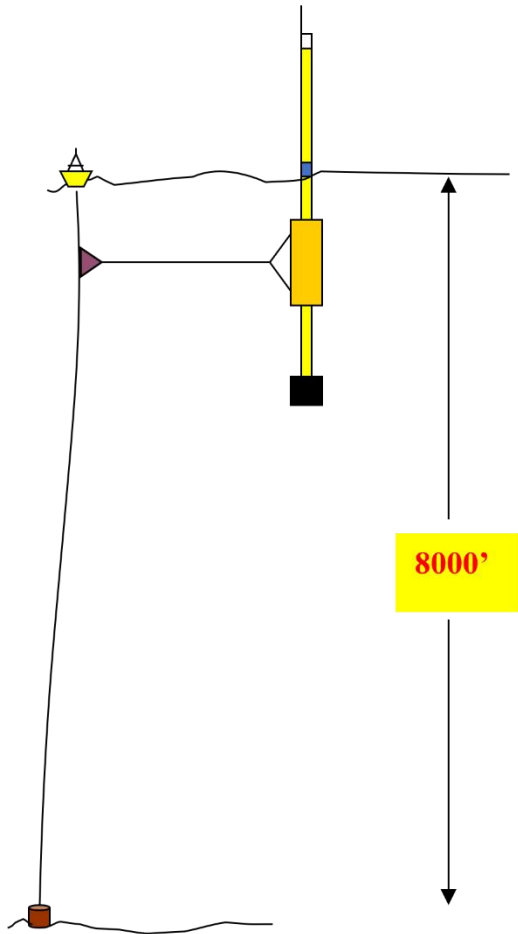
Ocean Engineering Assisted Navy RDT&E



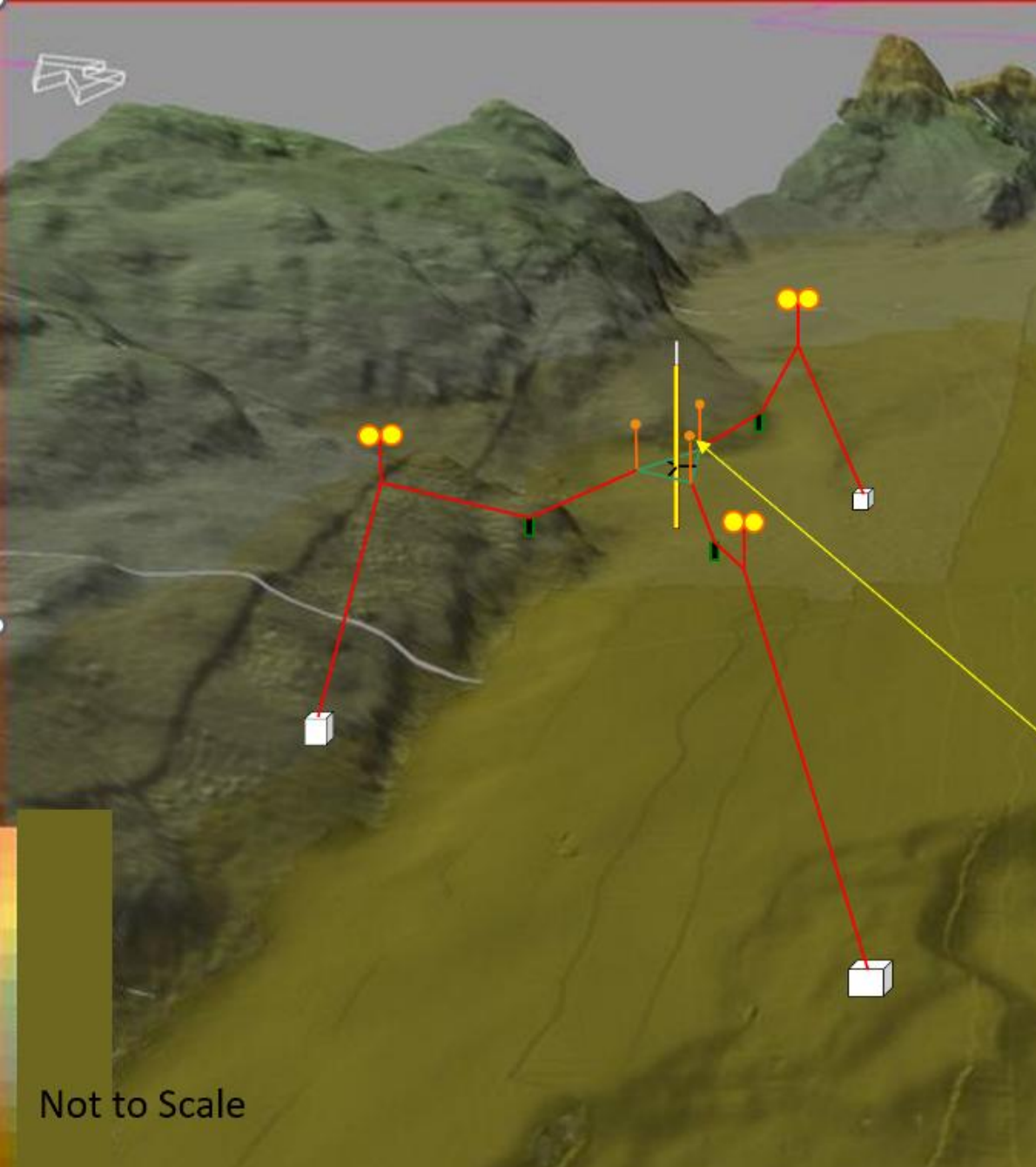
Spar Buoy Support for early applied ocean physics to modern networked coastal sensing



Mooring will need to work Deep and Shallow *to Standardize across all Navy ranges*



VHF Transmit Array: Kauai Hawaii 20nmi from at sea Receive Array: 10m high, +/- 5-degree roll, +/- 1 foot heave SS5, Nonmetallic above water line built by OSDC at and with FAU



Not to Scale

Common Coastal Spar Buoy (CCSB)

Department of Ocean & Mechanical Engineering
Team 4 Members: Griffen Bono, Jack Szuluk, William Pratt

Faculty Advisor:
Dr. Pierre-Phillipe Beaujean

Advisor:
Dr. William Venezia



FLORIDA ATLANTIC UNIVERSITY

Project Mission

The goal of this project is to develop an offshore coastal spar buoy capable of extended operation and utilize LoRaWAN radio to transmit oceanographic measurements in real-time. This system will also be equipped with Bristlemouth, a new technology that delivers “plug and play” hardware interfaces for a wide range of oceanographic applications that allows for seamless integration of various sensors tailored to user-specific requirements. This design enhances operational flexibility and adaptability in diverse marine environments and applications from monitoring water quality to collecting meteorological data. By focusing on ease of deployment by a 2-person team and ensuring compliance with safety regulations, the CCSB aims to provide versatile and cost-effective solution that can be rapidly deployed in the field. This project seeks to support effective and non-invasive marine monitoring while exploring new applications of advanced technology.

Project Requirements

Level 1:

- Two-person deployable and secured to existing anchor in 15-65 ft of water
- Support standard size/form payload
- Establish and maintain communication with CCSB 2-3 km offshore
- Operate for one week within the designated area (near Port Everglades)

Level 2: Requirement 1+

- Model the spar as a damped harmonic oscillator and calculate the natural periods in response to a pluck/impulse
- Perform OrcaFlex modeling to compare with the spar
- Perform OrcaFlex software modeling with the wave spectrum that accurately describes the test site and predict the spars response

Level 3: Requirement 2+

- Prior to and after connecting the spar to the mooring, conduct a physical pluck/impulse
- Calculate the Heave and Roll response operators for the buoys mooring system
- Calculate the sea state spectrum



MTS Buoy Workshop

Sponsored by: NSWC-CD, Dr. Paul Rushfeldt and OURI

System Capabilities

1. Autonomous offshore operation for up to 1 week
2. Integrated Bristlemouth telemetry for wide range of oceanographic sensors
3. LoRaWAN radio capable of wireless communication up to 4 km
4. Warning system designed to alert nearby traffic of the CCSB presence and local anchorage laws, including a maritime caution light, radar reflectors, bright paint and imprinted lettering.
5. Monitor offshore sea state using onboard pressure transducers
6. System check sensors to observe the state of internal electronics and automatically alert team of any disturbances, such as a leak and temperature sensor, and a battery monitor.
7. Modular and lightweight structure for ease of disassembly/assembly and transport

Bristlemouth

Bristlemouth is a cutting-edge advancement in marine technology, promoting the use of a plug-and-play system for a wide range of oceanographic applications. Bristlemouth utilizes their protocol in conjunction with their development kit to manage power distribution and data messaging in the form of DoPL, allowing communication a great depths in marine environments. The Bristlemouth Protocol is capable of using a diverse array of oceanographic measurement tools, allowing it to collect comprehensive data on marine ecosystems, monitor environmental changes, and support advanced research in oceanography.

Team Introduction



William Pratt	Griffen Bono	Jack Szyluk
Software	Mechanical	Electrical
Purchasing and EH&S	Team Lead	Boat Scheduling



Detailed Design – Electrical: PCB



Pressure Sensors/
RS485 Interface

GPS/LoRaWAN

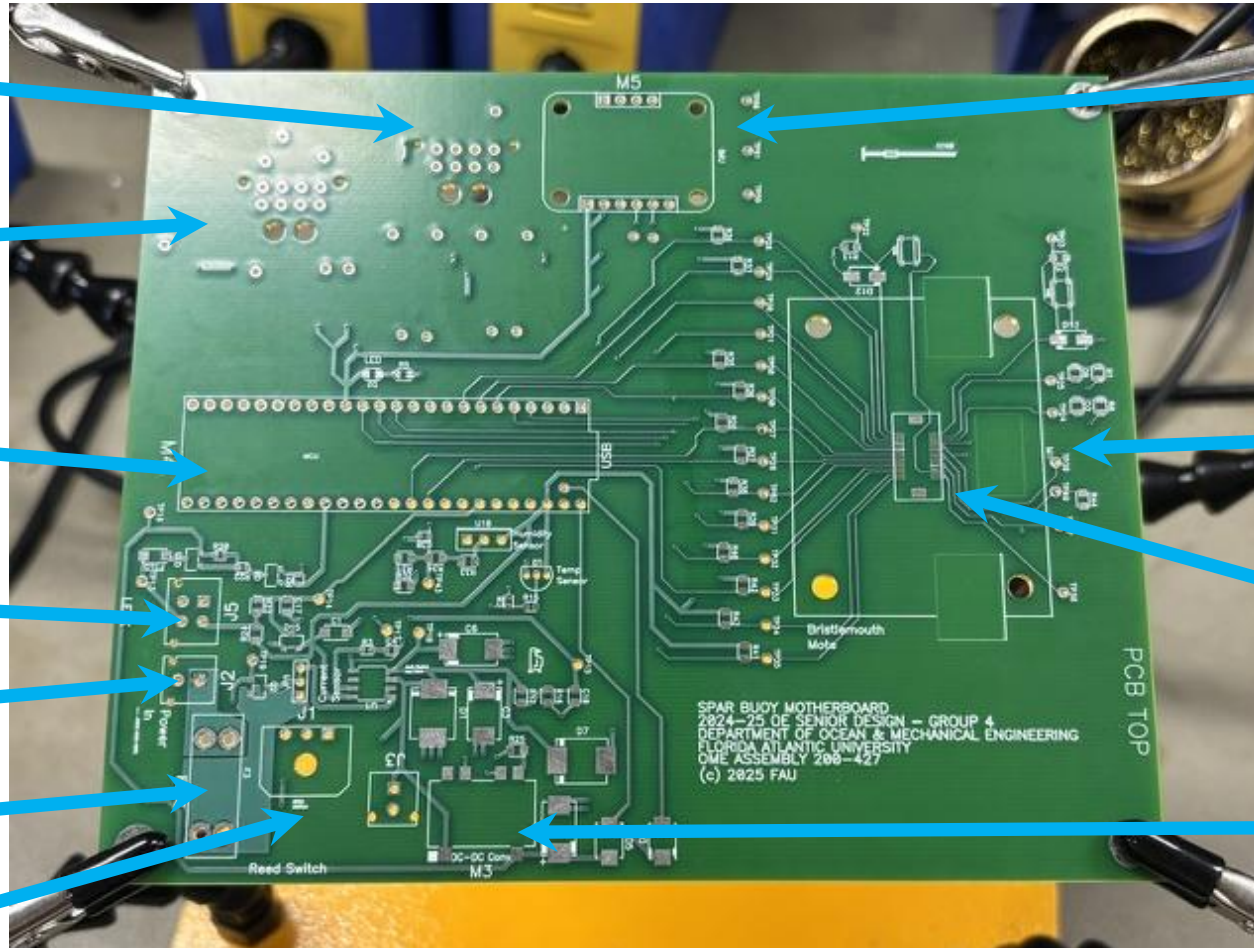
TEENSY 4.1

LEAK SENSOR

POWER IN

FUSE

HALL SWITCH



IMU

TEMP & HUMIDITY
[located in center]

BRISTLEMOUTH
MOTE

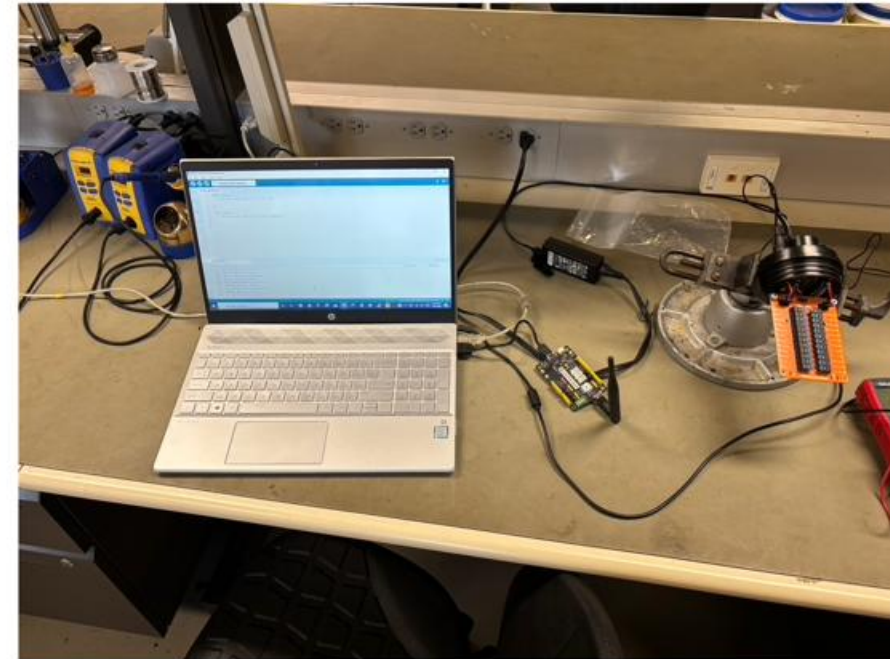
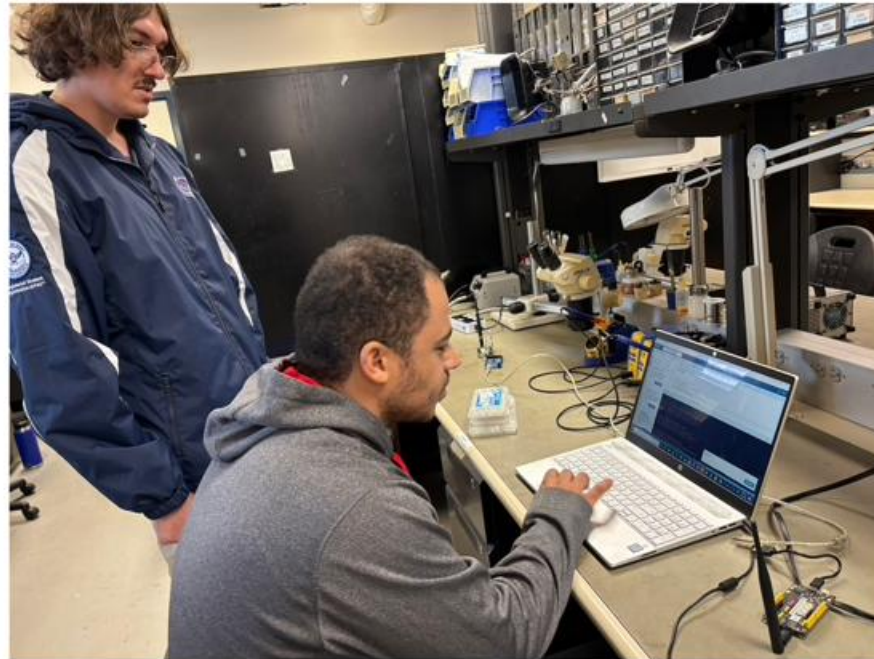
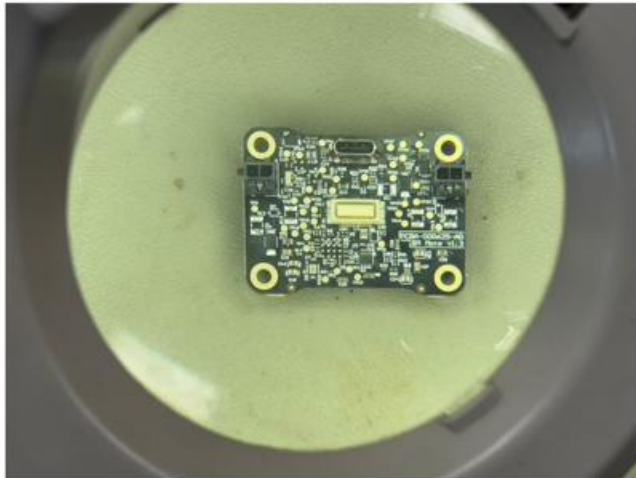
BRISTLEMOUTH
MEZZANINE

DC/DC Converter

Construction Process – Electrical: Bristlemouth



- Emerging Technology – New
- A lot more work can be done with this product in the future.



Testing Process – Phase 2: Sea Trial

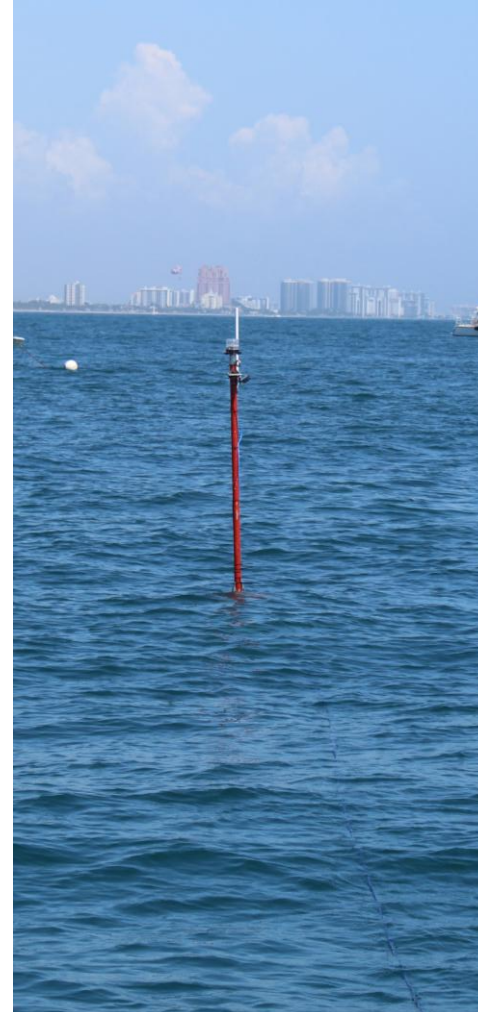
Griffen Bono, Jack Szyluk, William Pratt class of 2025



Test Details: Using the R/V McAllister, our test was conducted approx. 0.9 miles offshore using a Barracuda Reef Mooring. In a depth of approximately 35 ft.

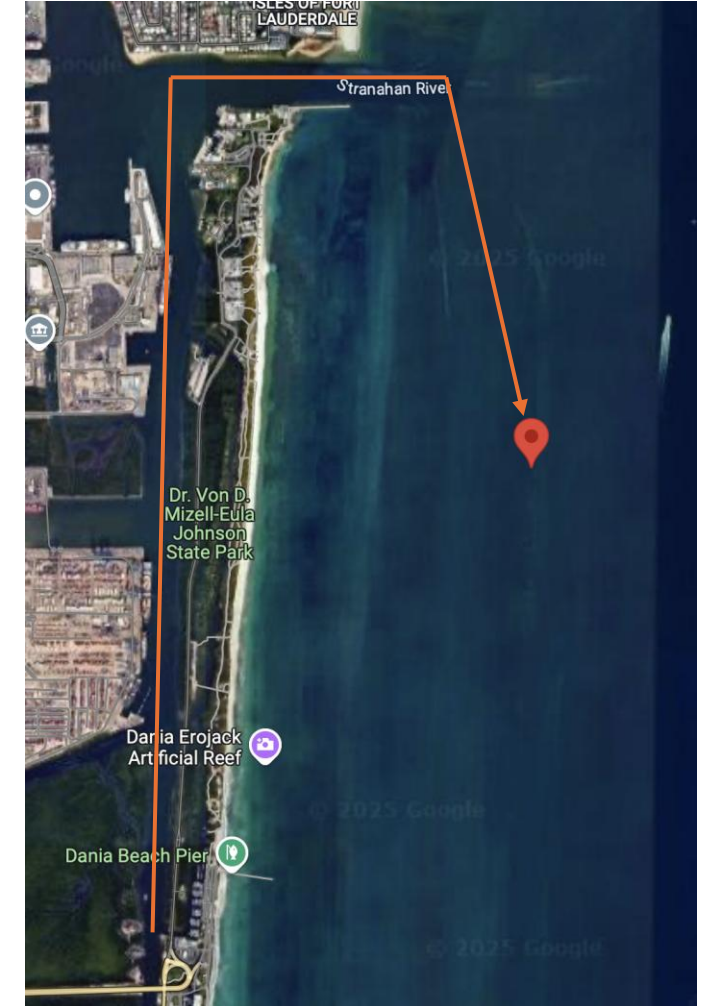
Test Procedures:

- Real-time LoRaWAN telemetry test
- GPS tracking of buoy drift and position
- Battery draw monitored via onboard sensors
- Physical inspection of structure and seal post-retrieval
- Pressure Sensor Data Taken to Observe Wave Height



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Testing Location: (26.0765, -80.0961)



Port Everglades

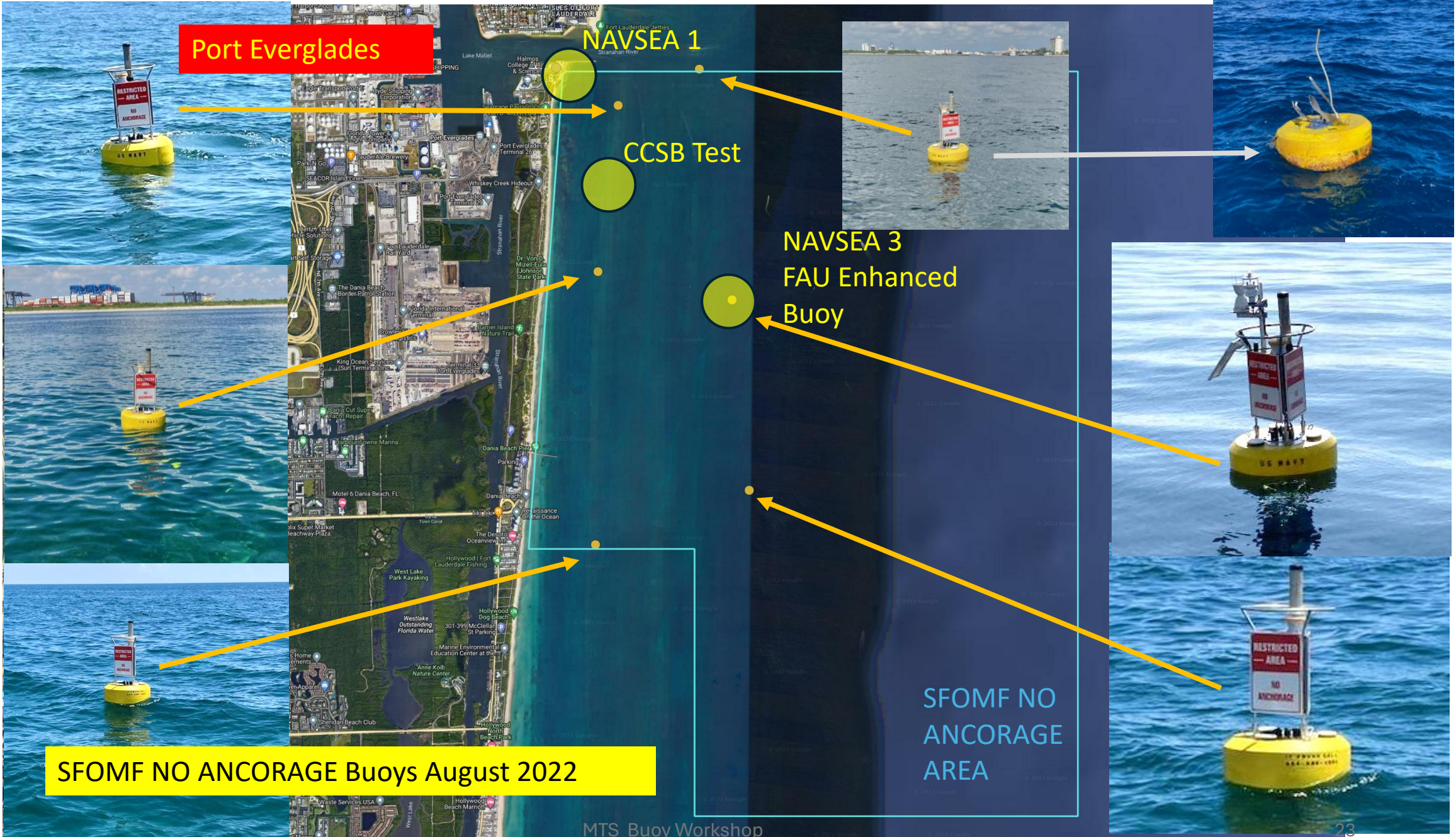
NAVSEA 1

CCSB Test

NAVSEA 3
FAU Enhanced
Buoy

SFOMF NO ANCHORAGE Buoy August 2022

SFOMF NO ANCHORAGE AREA

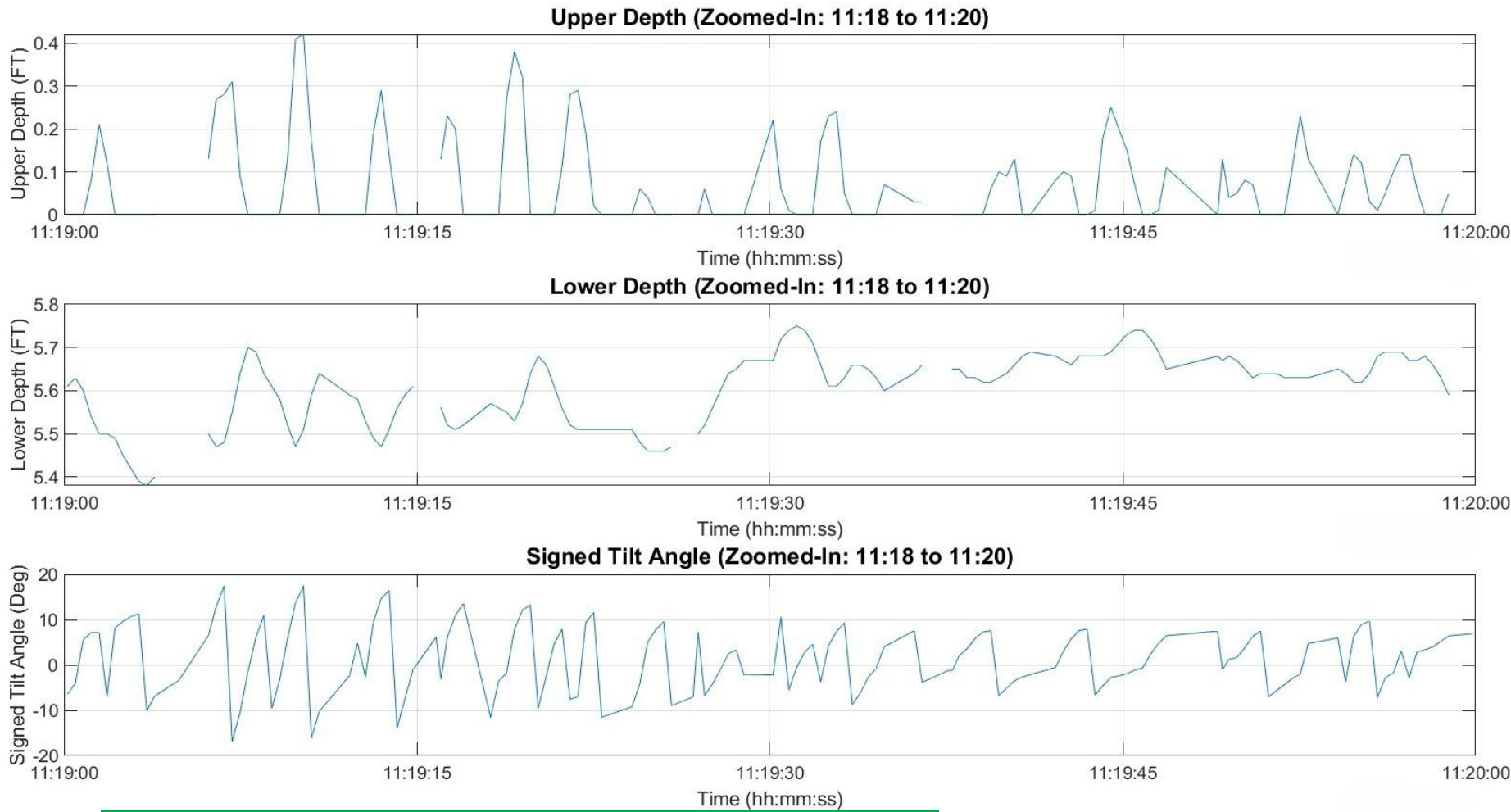


Off-Shore Testing Analysis



MTS Buoy Workshop

Off-Shore Testing Analysis



Using two pressure sensors to get wave height

- Tilt angle spikes to 17.5° as a yacht passes, exceeding the normal $\pm 10^\circ$ range.
- Upper depth increases to 0.4 ft, reflecting temporary surge in wave energy.
- Event reveals reduced stability, likely worsened by decreased buoyancy from waterline shift.
- Minor data gaps present due to the LoRa's slow communication speed, but do not compromise interpretation of this disturbance.

Summary of Systems Evaluation Outcomes



Subsystem	Evaluation Outcome
Mechanical	Float, mast, and damping plate maintained structural integrity during pool and sea trials. Pressure vessel remained sealed under stress.
Electrical	Custom PCB regulated power effectively. All sensors functioned as expected. Battery capacity supported >13-day runtime.
Software	Teensy firmware handled data logging and sensor reads without crashes. Time-sync and serial logging verified.
Communication	LoRaWAN successfully transmitted GPS and sensor data during sea trial. GPS remained locked during drift.
Integration	All components fit and operated within pressure vessel. Fallback wiring plan worked when Bristlemouth failed to integrate.
Testing	Pool and open-water tests validated motion response, stability, and sensor accuracy. No leaks or critical failures observed.

My Take: They show: Real data, Real stress, Real analysis, This is strong technical credibility.

Accomplishments



- CCSB meets design goals: modular, stable, and two-person deployable
- Fully operational in testing—collected and transmitted data offshore
- Bristlemouth integration failed, but backup system ensured pressure transducer data collection
- Platform is expandable for future sensor upgrades and mission profiles
- Electrical and mechanical subsystems functioned reliably under sea state conditions
- Project provides a foundation for future low-cost coastal monitoring systems

WETS = data concept, CCSB = mechanical host, *Bristlemouth = scaling mechanism*

- What We Attempted with Bristlemouth

- What Was Achieved

- Physical integration of Bristlemouth Mote
 - Power interface provided
 - Mezzanine mounted to Teensy 4.1 host
 - RS-485 and sensor pathways available

- What Was NOT Fully Achieved

- No standardized wet-mate subsea connector
 - No multi-node Bristlemouth network demonstration
 - No cross-vendor plug-and-play validation
 - No demonstration with Sofar Ocean ecosystem

Bristlemouth was not rejected because it failed — it simply did not solve the primary system constraint, which is low-bandwidth long-range telemetry and event-driven data management.

“Separate ‘internal interoperability’ from ‘external communications.’ Bristlemouth remains relevant for modular payload integration; LoRaWAN is the operational range link for alerts/summaries.”

This shows maturity, not failure.

Standards Adoption Is the Difference Between Prototype and Platform

“The architecture is modular, but we did not yet standardize external interfaces.”

Physical Architecture & Work Breakdown Structure



Physical Architecture

- Float + Mast → Supports antennas and sensors
- Pressure Vessel → houses sensitive electronics
- Antennas → GPS & LoRaWAN
- External Sensors → pressure sensors
- Power → 4, 3.2V 50Ah Batteries inside PV

Work Breakdown Structure

- Mechanical: Float, Mast, Damping Plate, Pressure Vessel
- Electrical: Battery System, Sensor Wiring, Fusing
- Software/Comms: Teensy code, LoRa, GPS, Data logging
- Testing: Pool Testing, Sea Trial, Stress & Leak Testing

What Do We Mean by Standardized Interfaces?

- Mechanical: Standard mast diameter, pressure vessel form factor
 - Small, Medium, Large - from one-man shoreline deployable to BIG
- Electrical: Common power bus, fuse architecture
- Data: RS-485, Bristlemouth, LoRaWAN
- Software: Open-source firmware & GitHub-based libraries

This gap is an opportunity

- We successfully show
 - 1981 wake detector origin
 - WETS-99 machine vision database (true proof-of-principle edge AI)
 - Navy RDT&E spar lineage
 - CCSB mechanical maturity
 - Bristlemouth hardware physically integrated (PCB + mezzanine, student deck)
- But what is unresolved?
 - Bristlemouth was wired... but not truly operationalized
 - Sofar-style “plug and play ocean node” was not demonstrated
 - No standardized wet-mate connector strategy
 - No demonstration of multi-vendor interoperability
 - No experiment that proves CCSB is a standards-compliant host platform

From early wake physics to modern networked coastal sensing

Backup - Three Proposed Experiments

- WETS 2.0 – Physics + Vision + Networked Edge AI - 4 slides
 - Deploy Ft. Lauderdale canals / Port Everglades. Real-time edge AI classification, Automated violation flagging, Direct marine patrol interface, Fully labeled training dataset generation (again) Includes *FWC virtual public meeting 25 September 2026*
- Living Shoreline Spar Monitoring Node - 8 slides
 - Deploy Martin County mangrove restoration PE nearshore seagrass beds. It ties to resilience, It ties to Florida funding, It ties to environmental science, It ties to Navy coastal infrastructure protection. Includes *UF Extension service meeting 26 February 2026*
- Range Interoperable Watchdog Spar Node (ONR-Aligned Demonstration - 6 Slides
 - Deploy at SFOMF. Demonstrate CCSB as a reusable, standards-compliant host platform requirements for value added for Navy test range users/customers. Includes discussion of *ONR Recommendation for further action 17 February 2026*

Edge analytics + event-driven logging + selective transmission

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Questions