INSTITUTO SUPERIOR TÉCNICO

WAVE TRACKER

Coastal Wave Measurement Sensor and Data Logger

Manuel Silva | Carlos Brito | João Custódio

Pedro Tavares | Matilde Augusto | Diogo Carvalho

Advisors

Scientific Advisor	João Gaspar
Scientific Co-Advisor	Diogo Mendes
Coordinator	Pedro Vitor

The Problem

01

☑ Understanding the Core Issue

Waves are a fundamental part of coastal dynamics, influencing shoreline stability, maritime operations, and climate research. However, obtaining accurate and reliable wave data near the coast remains a challenge. Before developing a solution, we need to ask:

- Why do we need better coastal wave data?
- What problems arise due to a lack of precise wave measurements?
- Are current methods insufficient, and if so, why?

02

The Problem

Coastal Hazards & Infrastructure Risks

Waves significantly impact coastal erosion, flooding, and storm surges.
Without precise data, engineers struggle to design effective coastal defenses.
Unreliable wave measurements hinder early warning systems for extreme weather.

Limitations of Current Measurement Technologies

Buoy-based systems are expensive, require frequent maintenance, and are often positioned further offshore, missing nearshore wave details.
Radar and ultrasonic sensors struggle with resolution near the shore due to wave reflection and interference.
Satellite-based observations lack the precision needed for localized coastal monitoring.
Seabed pressure sensors exist but can be costly and often lack long-term durability in high-energy coastal environments.

Environmental & Scientific Challenges

Researchers studying climate change, sea-level rise, and coastal ecosystems rely on detailed wave data to improve models and predictions.
The lack of accessible, high-resolution data limits our understanding of coastal wave dynamics and their long-term effects on the environment.

03

Who Benefits from This Technology?

Coastal Engineers & Urban Planners

- Better coastal protection strategies
- Improved infrastructure planning

Local Communities & Authorities

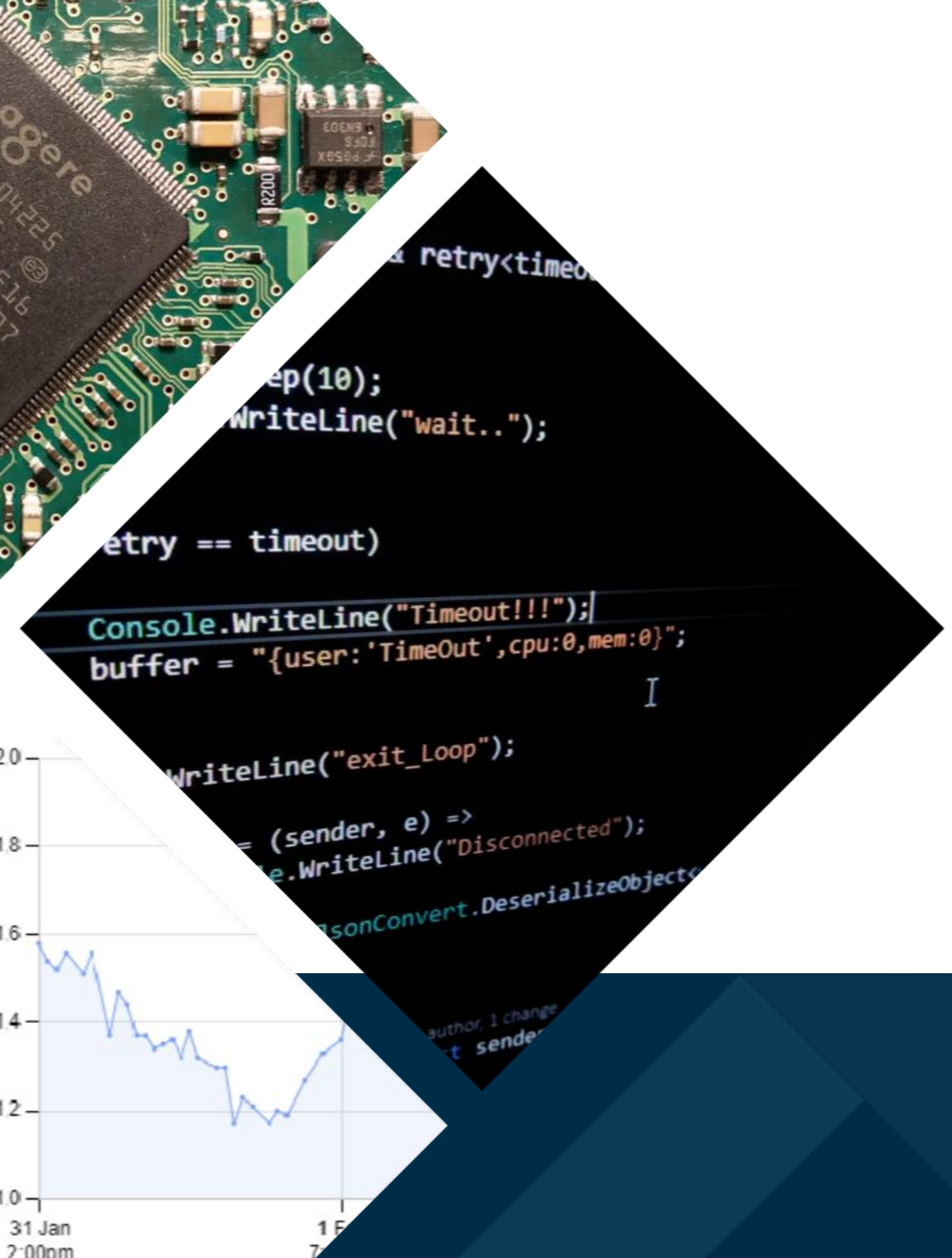
- Early warning systems
- Sustainable tourism & recreation

Maritime & Shipping Industry

- Safer navigation
- Port management optimization

Environmental Scientists and Climate Researchers

- Better climate impact studies
- Enhanced coastal ecosystem monitoring



04

Technological Solution

The sensor will be a sealed, waterproof unit placed underwater at sand level, using pressure sensors to measure wave height. Instead of transmitting data wirelessly, it will store readings on an SD card, allowing users to retrieve the data periodically for analysis.

Components

- Pressure Sensors
- Microcontroller (e.g., ESP32, STM32)
- SD Card Storage
- Power System (Battery-Powered)
- Protective Enclosure

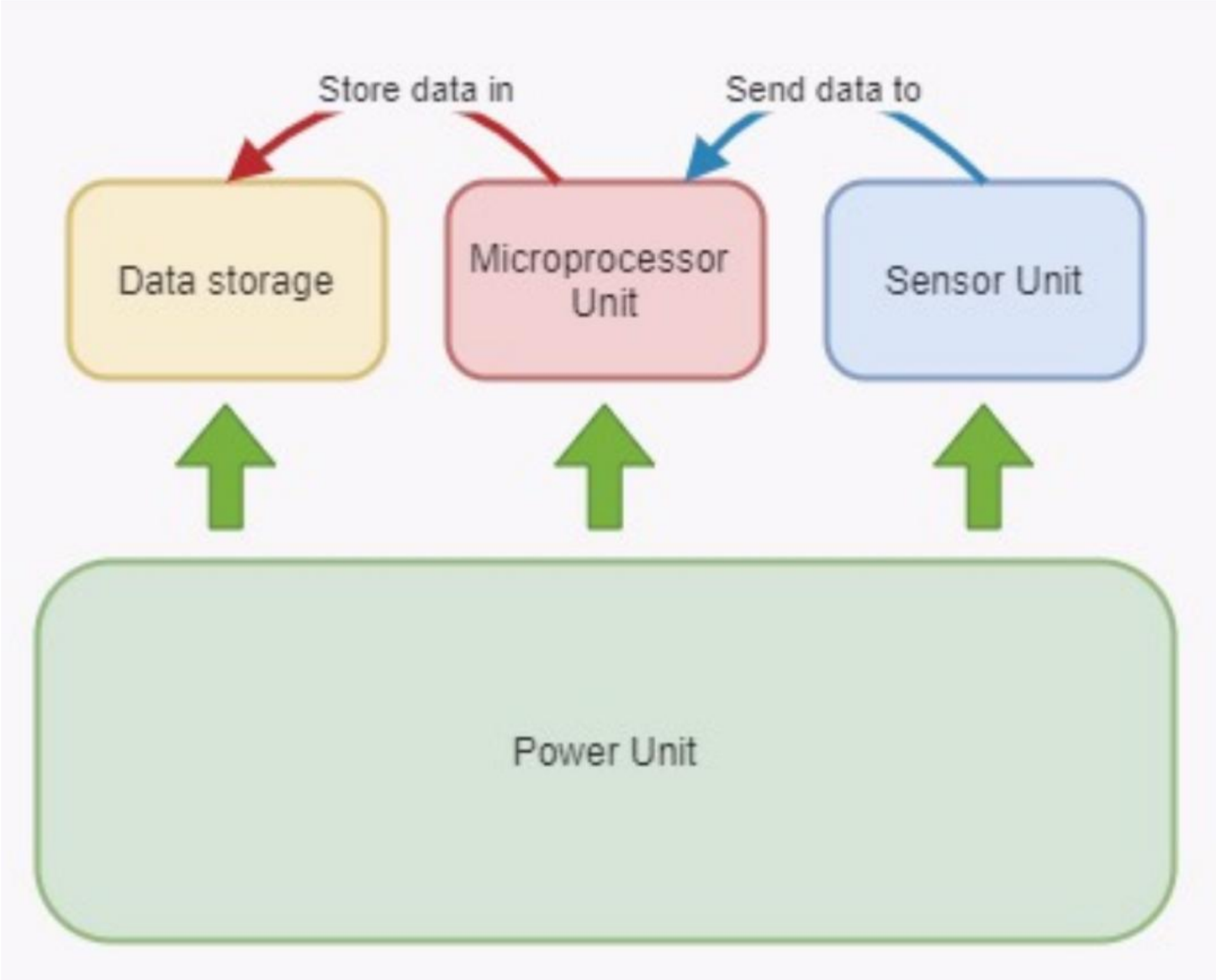
Affordable & Simple: Eliminates costly wireless communication modules.

Durable & Long-Lasting: Designed for long-term deployment.

Accurate & Practical: Provides precise nearshore wave height data.

Technological Solution:

System Diagram



06

Challenges

Environmental Durability

Saltwater corrosion, pressure variations, and sediment buildup.

Power Management

Low-power components and efficient data logging strategies.

Data Storage & Retrieval

Must log data efficiently and have a user-friendly retrieval process.

Calibration & Accuracy

Pressure readings must be converted into precise wave height values.

Deployment & Maintenance

Needs to be easy to install and remove for occasional maintenance.

Partners 07

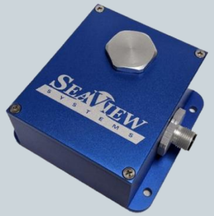
☑ Haedes

HAEDES is a consultancy and engineering firm specializing in challenges related to coasts, estuaries, rivers, and oceans. With hubs in Belgium and Portugal, they offer sustainable engineering solutions grounded in nature-enhanced frameworks and system thinking. Their services cater to governments, contractors, developers, and partners worldwide.

We are interested in learning from their expertise and exploring potential insights from their projects and team members.

Competitors

08

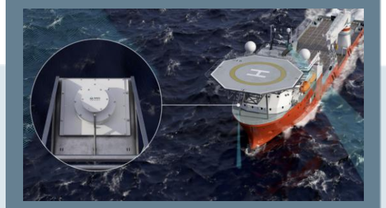


SeaView Systems

Market leading, surface level sensor placed on a buoy

Nortek Group

Deeper sensor systems, great for oceanography



Miros Group

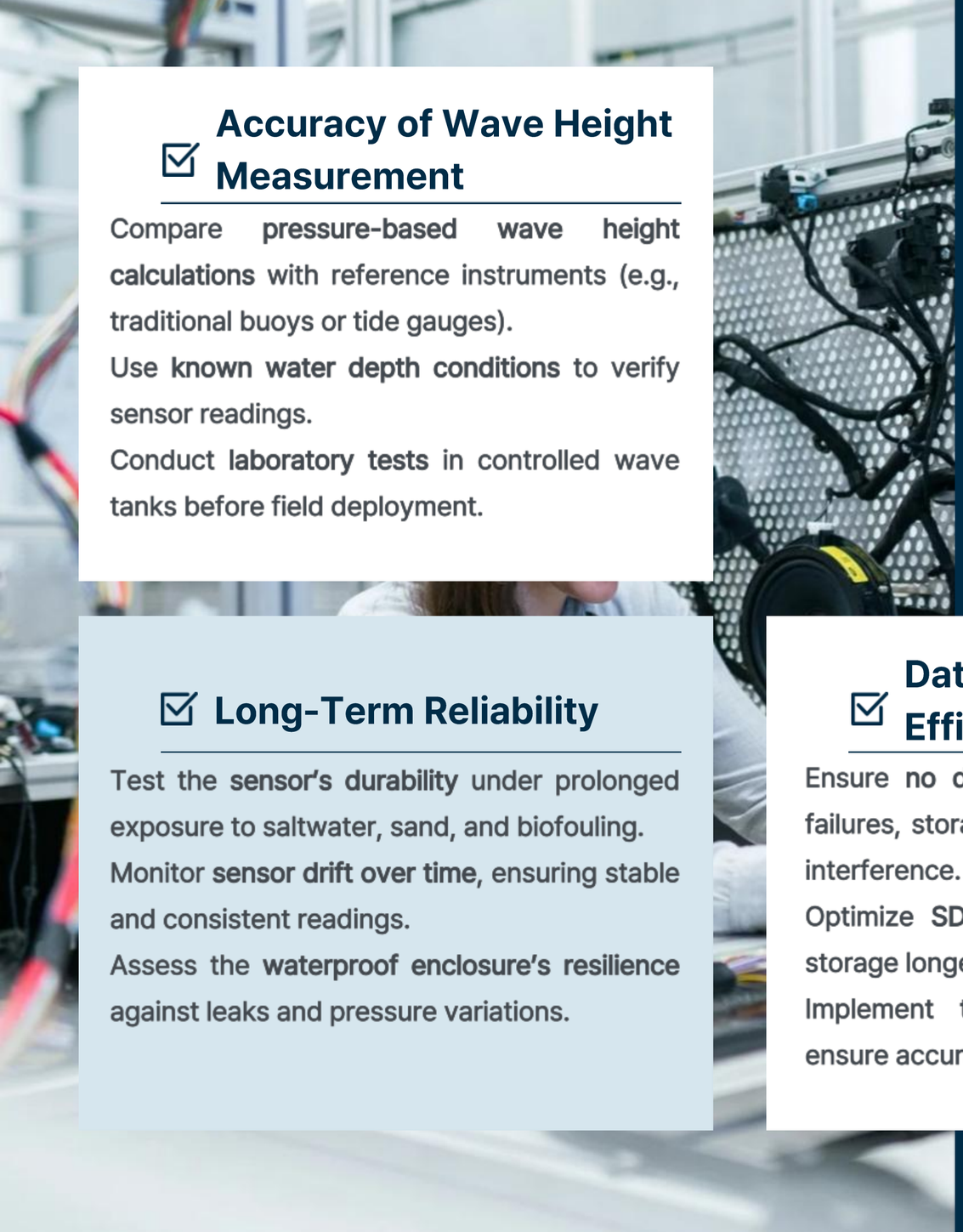
Sensor that needs a vessel, more accessible than buoy sensors

RBR

Wave data logger, measures data and stores it (no real time)

AANDERAA

Surface level sensor placed on a buoy



09

Validation metrics

To ensure the sensor provides precise and reliable wave measurements, we will evaluate its performance using key validation metrics:

Accuracy of Wave Height Measurement

Compare **pressure-based wave height calculations** with reference instruments (e.g., traditional buoys or tide gauges).

Use **known water depth conditions** to verify sensor readings.

Conduct **laboratory tests** in controlled wave tanks before field deployment.

Long-Term Reliability

Test the **sensor's durability** under prolonged exposure to saltwater, sand, and biofouling.

Monitor **sensor drift over time**, ensuring stable and consistent readings.

Assess the **waterproof enclosure's resilience** against leaks and pressure variations.

Data Integrity & Storage Efficiency

Ensure **no data loss** occurs due to power failures, storage corruption, or environmental interference.

Optimize **SD card write cycles** to balance storage longevity and frequent logging.

Implement **timestamped data logging** to ensure accurate wave event tracking.

Power Efficiency

Measure **battery life** under real operating conditions.

Assess **power consumption** per **logging cycle** and optimize sleep modes if necessary.

10 Status

Requirements

Operating Environment: Beach

Maximum Depth: Maximum coastal depth (~5m)

Durability and Resistance: The enclosure must be resistant to seawater and corrosion, and have a durability of 15 to 30 days without requiring maintenance

Data Communication: Data transmission via Wi-Fi to the surface when the box is removed from the water

Power Supply: Battery-powered, ensuring sufficient autonomy for the operational period

Maintenance and Accessibility: Allow sensor calibration whenever the device is removed from the water — it must be easily accessible

Cost and Budget: Less than €100

Measurement Interval: Perform measurements continuously

Data Storage: Store data locally on an SD card

Materials

- ESP32
- PowerBank
- SD card
- SD card module
- Enclosure IP68
- Cable USA-A-Micro-USB
- Pressure and Temperature sensor

Division of labor

Manuel Silva

- Website Development & Testing

Pedro Tavares

- Prototype Development & Data Analysis & Code Testing

Carlos Brito

- Website Development & Video Editing

Matilde Augusto

- Data Analysis & Code Testing

João Custódio

- Software Development & Interviewer

Diogo Carvalho

- Prototype Development & Testing

Achieved Results

Displaying Data

Implemented an intuitive data visualization solution using Grafana and InfluxDB for stakeholders.

```
#include <Wire.h>
#include <SPI.h>

MS5611 baro;
int32_t pressure;

void setup() {
  // Start barometer
  baro = MS5611();
  baro.begin();
  // Start serial (UART)
  Serial.begin(9600);
  delay(2);
}

void loop() {
  // Read pressure
```

Software

We wrote the software that runs on the sensor, allowing it to read data, save measurements, and control the different components.

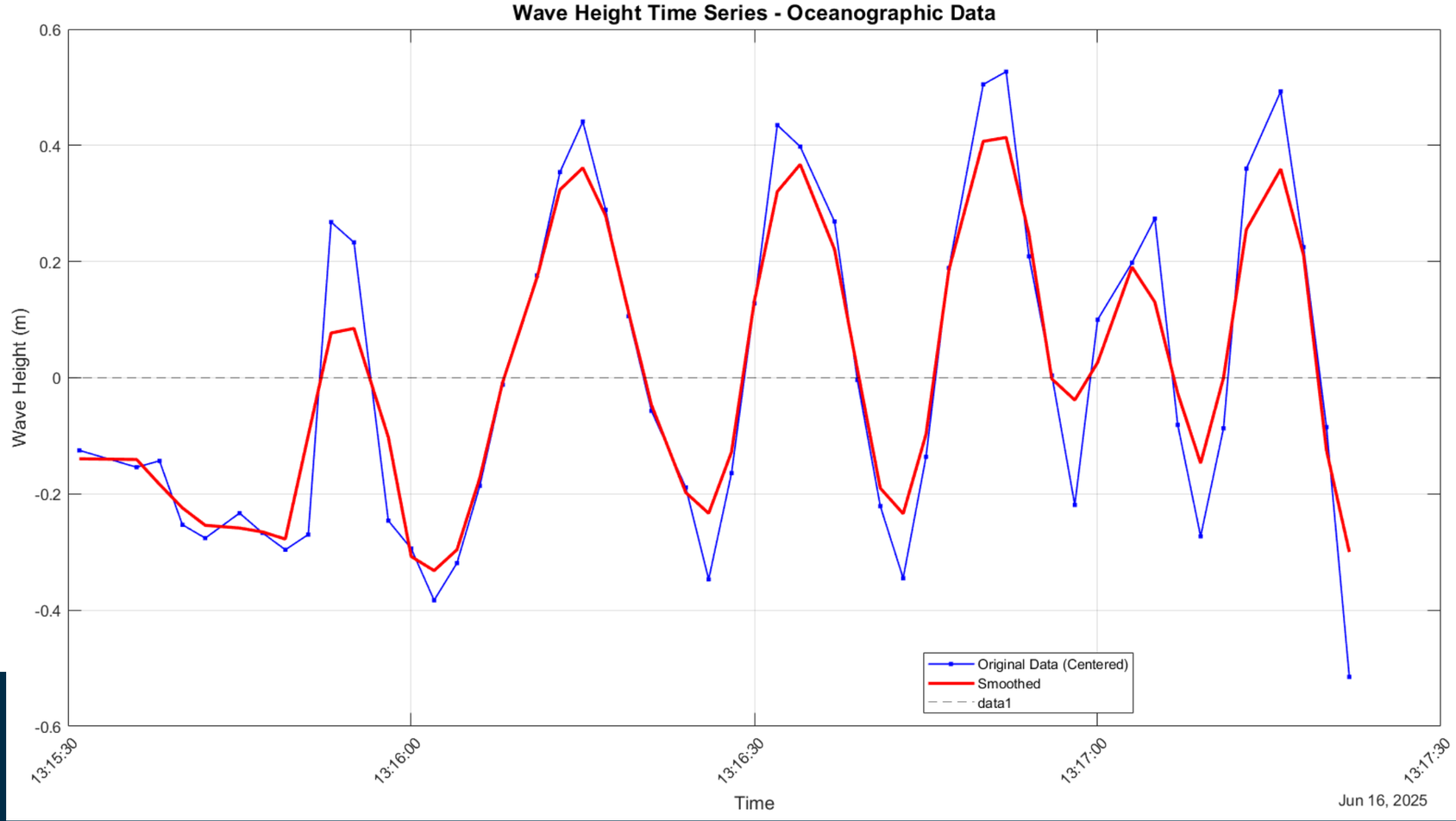
Prototype Layout

We've finalized the internal layout, including the positioning of components, the sensor hole placement, and the mounting method for all parts.

Results

Plotting the Data

After successfully testing the prototype, we retrieved the data from the SD card and confirmed that it accurately produced the expected sinusoidal waveform.



Deviations and Difficulties Encountered

Power bank & low energy consumption

- Low consumption led to the power bank turning itself off

Real Time Data

- Wi-Fi signal loss from water submersion prevented live data transmission.

Stakeholders

- We don't get as many stakeholders as we expect

Temperature Sensor

- Add temperature data collection

Poster



WaveTracker



Problem?

Coastal communities face growing risks from erosion, flooding, and rising sea levels. The study of wave dynamics often depends on **expensive pressure sensors and unvalidated numerical** models, making it difficult to trust simulation results. This data gap compromises decisions in coastal planning, environmental protection, and research.

WaveTracker

We developed a low-cost, robust wave monitoring device for coastal environments. Installed at sand level and powered by a power bank, it uses a pressure sensor to measure wave height. **The system stands out for its simple installation,** easy maintenance, and affordability.

Cost?

The system was developed using cost-effective components: an MS5803-14 pressure sensor, an ESP32 microcontroller, a power bank for power supply, an IP68 waterproof enclosure, and an SD card reader with memory card. The total estimated cost of the prototype is **€80**.

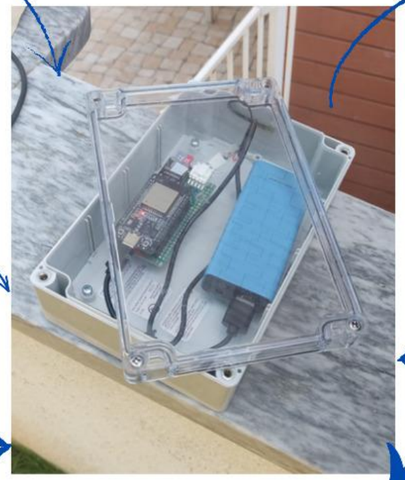
+Info

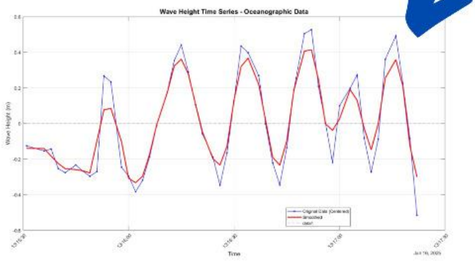
Want to know how WaveTracker is revolutionizing coastal monitoring? **Scan me!**

Cordinator: Prof. Pedro Vítor
Scientific Advisor: Prof. Diogo Mendes
Mentor: João Gaspar

Target Audience

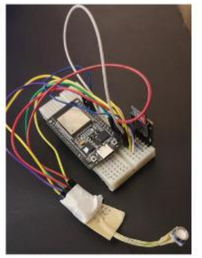
- **Coastal monitoring companies**
- Researchers in hydrodynamics and marine life
- **Government bodies and local authorities** involved in coastal management
- Environmental projects requiring **real-world wave data**





Process Photos





Data Transmission

Using the **I²C protocol**, the sensor transmits pressure and temperature data to the microcontroller at a sampling frequency of **1 Hz**. The pressure values are then converted into **tidal height measurements** and stored on the SD card for later analysis.

Testing

To validate the reliability and performance of the wave measurement sensor, two tests were carried out in a controlled domestic environment.

- The first involved **submerging the IP68-certified enclosure for 12 hours** to verify its waterproof integrity.
- The second test was conducted in a swimming pool, where **artificial waves were generated** to assess the sensor's ability to detect and measure wave motion accurately.

Links

Website

Blog

Video