# Sentinels: Democratizing Underwater Safety through AI-Driven Multi-Spectral Hazard GIShydromatic

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| Challenge Name | Date Added |
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| Affordable Tools to Find and Mark Underwater Explosive Ordnance | 10/03/2026 |

Creator

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Team Members

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**1. Participation Type - Please select how you are participating in this Challenge:**

Solver (Individual)

**2. Solution Level – Please select the Technology Readiness Level (TRL) of your solution:**

Proof of concept (TRL 4-6)

**3. Partnering - Are you interested in partnering?**

Yes

**4. Problem & Opportunity – Please highlight the innovation in your approach to the problem, its point of difference, and the specific advantages/benefits this brings (up to 500 words)**

## The Problem:

The fundamental challenge in underwater Explosive Ordnance (EO) detection is not only the scarcity of affordable sensors, but also the **"Spatial Blindness"** that prevents the fusion of isolated signals into a coherent, comprehensive, and persistent picture of the threat. Existing low-cost tools fail to address this; they lack the integrated **GIS frameworks** necessary to turn a simple 'blip' on a screen into an **IMSMA**-compliant digital twin of the hazardous area.

## The Opportunity:

The *Sentinels* transforms **EO** detection from a mere hardware task into an integrated Spatial Intelligence Platform. The core innovation lies in leveraging **Edge-AI** to bridge the gap between low-cost "proximal sensing" and high-level Geospatial Information Systems, allowing affordable hardware to perform at a professional standard.

## Points of Difference & Specific Advantages:

1. **HERO-Compliant:** To ensure compliance with the **Hazards of Electromagnetic Radiation to Ordnance (HERO)** program, the system operates as **Passive by Default, Active on Demand**.
2. **Autonomous Spatial Indexing:** The *Sentinels* utilizes **Spatial Data Indexing** and a custom **Layback Estimation Algorithm**. By integrating a "Smart Block" (digital cable counter) with **Inertial Navigation Sensors** and the vessel's GPS, the system automatically corrects for tether lag and curvature. This ensures that the accuracy of the geo-marked surface location.
3. **AI-Driven Multi-Spectral Hazard GIS:** The system utilizes a **Tiered Edge-AI Engine** to automatically filter clutter using fused Acoustic, Magnetic, Optical, Inertial, Orientation, and Depth data streams. This eliminates the need for expert sonar analysis, converting raw signals into a verified **Multi-Layered Spatio-Temporal Record**. Using **interpolation**, the trajectory of mine lines into unscanned areas can be predicted, actively guiding the operator to maximize survey efficiency. This effectively emulate the comprehensive coverage of a massive industrial sensor suite/array.
4. **Democratized Digital Twins:** Leveraging **Structure from Motion (SfM)**, the system performs post-mission **3D Photogrammetric Reconstruction**. This turns raw video and sensors data into an interactive 5D map (Digital Twin) of the seabed. This provides community leaders and national authorities with undeniable visual proof of contamination, facilitating faster funding and prioritization for clearance.
5. **Local-First Intranet Architecture:** Recognizing the "digital divide," the system functions as a **Local GIS Server**. It broadcasts a secure Wi-Fi hotspot, allowing any standard smartphone/tablet to act as a high-performance **GIS Terminal**.

## Innovation Impact:

By leading with a **GIS-centric architecture**, The *Sentinels* ensures that the data collected by a single local fisherman is immediately compatible with global humanitarian standards (IMSMA). This turns every community vessel into a sophisticated data-gathering asset, creating a scalable, "bottom-up" approach to maritime safety that is both technically rigorous and economically accessible.

**5. Solution Overview – Please describe the features of your solution and explain how they address the SOLUTION REQUIREMENTS. In particular, detail the solution's ability to detect EO at depths of 5–30 meters in both freshwater and saltwater, how it marks the EO location, how the marked-location data can be transferred to low-cost GPS devices or mobile phones, and the method by which the solution operates (add supporting data, diagrams, etc. as attachments below) (500 words).**

The *Sentinels* system is an integrated hardware-software platform designed to detect, verify, and geo-mark underwater **EO** from depths of 5 to 30 meters. The solution consists of a **Wet-End** (Passive Towed Wing) and a **Dry-End** (Topside Compute & UI Box), linked by an Ethernet tether.

## Detection Strategy (Tiered AI & Sensor Fusion):

The system utilizes **Tiered AI Inference Engine** processing four synchronized sensing modalities:

- **Acoustic (Shape & Anomaly):**
  - A 455/800 kHz Side-Scan Sonar captures geometric signatures.
  - It identifies the geometric signatures (cylindrical highlights and acoustic shadows) of ordnance, effective even in zero-visibility conditions.
- **Magnetic (Material):**
  - Dual Tri-Axial Fluxgate Gradiometers detect the dipole moment of buried ferrous objects.
  - To guarantee HERO compliance, the system operates as **Passive by Default**.
  - Physics-Informed Sensor Fusion uses Common Mode Rejection to mathematically cancel ambient geomagnetic noise and the towing vessel's EMI signature.
- **Optical (Verification):**
  - An HD camera with Dark-Field Illumination to minimize turbid backscatter.

    - Post-mission, **Structure from Motion (SfM)** algorithms process this footage to reconstruct 3D Digital Twins of the hazard area for forensic analysis.
- **Positional (Geo-marking)**
    - A fused positional array integrating Topside GPS, a digital cable counter, a 9-Axis AHRS, and a Bar30 pressure/depth sensor feeds real-time telemetry into a **Lumped-Mass Model**.
    - This continuous data stream corrects for tether lag and accurately calculates the 3D coordinates of the submerged sensor wing.

## Change Detection & Anomaly Detection:

- By layering scans over time, the system generates 5D Digital Twins, enabling automated **Change** (migration, corrosion, etc.) detection.
- While supervised ML models (YOLO, CNNs, etc.) detect known targets, unsupervised ML models flag **Anomalies** (reconstruction errors) to identify degraded, corroded, encrusted, or novel targets.

## Hydrodynamic Deployment & Modular Ballast:

Utilizing a Two-Part Decoupled Towing architecture, the neutrally buoyant Sensor Wing flies safely at a 1.5m altitude . Depth is strictly controlled by a swappable (3D-printed PETG) Modular Ballast System deployed below the wing:

- **Kinematic Depressor (Lead):**
  For un-stallable depth in shallow rivers.
- **Hydrodynamic V-Fin:**
  For drastically reducing deck-handling weight at 2+ knots.
- **Lateral Paravane:**
  For pullinh the tether out of the vessel's acoustic prop-wash.

## Interoperability & Data Export:

Recognizing the need for standardized humanitarian data, the web interface includes a **Universal Export Module**. Operators can export the data in multiple industry-standard formats (e.g., CSV, KML/KMZ, GeoJSON, ESRI Shapefiles) and **IMSMA-compliant** data schema.

## Operations:

The system is **Headless**: the topside unit (NVIDIA Jetson Nano) broadcasts a **Local Wi-Fi Hotspot** and supports **USB-C Tethering**. Operators use a standard smartphone/tablet browser to view a simplified hazard heatmap (Red=Danger, Green=Safe, Black=Fog of War), powered by real-time **Edge-AI** inference.

**6. Solution Feasibility – Please provide supporting information and rationale, including references and precedents, that will help UNDP evaluate and validate the feasibility of your solution. Be sure to include any details related to cost and its usability or functionality for non-experts (up to 500 words).**

## Cost-Efficiency and Sustainability:

The *Sentinels* system is engineered for maximum feasibility in resource-constrained environments. By utilizing **Commercial Off-The-Shelf (COTS)** components and **Digital Manufacturing (3D Printing)**, the solution achieves a CAPEX under **$2,600**. This budget includes a 50% safety margin for local assembly and logistics. The use of **PETG and Elastomeric Polyurethane** for the hull allows for local repair and part replacement using standard desktop 3D printers, ensuring long-term operational sustainability without reliance on international supply chains.

## Usability for Non-Experts:

The system logic abstracts complex geophysics into intuitive, actionable intelligence. The **"In-Situ Calibration"** protocol allows a novice operator to tow the device over a known dummy target; the software then automatically tunes the sensor thresholds for local salinity, seabed mineralogy, and ambient noise. The **"Headless" Browser Interface** eliminates the "Digital Divide," ensuring that anyone capable of using a smartphone/tablet can operate the system. The AI-driven dashboard removes the need for expert sonar interpretation, providing a color-coded output.

## Technical and Scientific Validation:

The feasibility of the *Sentinels* is grounded in established hydrographic and computational principles:

- **Hydrodynamic Stability:** The use of a depressor wing to achieve depth stability is a proven maritime technique (e.g., the Oropesa sweep). Our inverted airfoil design ensures the sensors remain at the optimal 1.5m proximal range without expensive active thrusters.
- **Sensing Efficacy:** Peer-reviewed research (*Seidel et al., 2023*) confirms that fluxgate gradiometers are highly effective for detecting small ferrous objects (like 81mm mortars) when stabilized on towed or hovering platforms.
- **Edge AI Performance:** Real-time inference of ML models on **NVIDIA Jetson** hardware has been validated in numerous underwater robotics applications, providing high Mean Average Precision (mAP) for geometric shapes even in low-visibility environments.

## Power and Deployment Autonomy:

The system draws approximately **45W**, allowing the **50Ah LiFePO4 battery** to provide over **12 hours of continuous operation** doubling the challenge requirement. The lack of internal propulsion and the use of passive downforce make the device energy-efficient and compatible with portable solar charging blankets. This ensures the device can operate indefinitely in remote villages without access to fuel or a centralized power grid.

## Fail-Safe and Recovery Mechanisms:

To protect the investment of local communities, we have implemented a **Triple Fail-Safe Strategy**:

1. **Mechanical Shear Pin:** Snaps upon high-tension snagging, allowing the ballast as well as the wing to flip and fly upward.
2. **Sacrificial Weak Link:** Releases the ballast if it becomes entangled in debris.
3. **Electromagnetic Ballast:** A "Dead-Man's Switch" that releases a weight upon power failure, causing the unit to float to the surface for recovery via the integrated **AIS Beacon**.

**7. Experience – Please describe expertise, use cases, and skills you or your organization may have in relation to your proposed solution (up to 500 words)**

The lead developer is an **Assistant Professor of Computer Engineering** with over **24 years of experience** in high-level software development, spatial data management, and digital transformation. This unique intersection of academic rigor (Ph.D.) and executive leadership ensures that the *Sentinels* project is grounded in both technical feasibility and operational scalability.

**Relevant Technical Expertise:**

- **Geospatial & GIS Excellence:** Extensive experience in developing and managing spatial data infrastructures using **ArcGIS, QGIS, and Leaflet**. Expert knowledge in coordinate transformation and spatial indexing is bolstered by the development of custom **ArcGIS utilities** and **Raster-to-Vector Image Transformers**, which directly translate to the project's ability to convert raw sonar/camera data into professional vector maps.

- **AI & Computer Vision:** Deep proficiency in **Digital Signal Processing, Image Processing, Remote Sensing, Neural Networks, and Computer Vision**. The developer has successfully implemented high-

stakes vision systems, including **smart surveillance** and **HCI/HMI**, which require the same high-rate frame analysis and iris/feature detection logic used for underwater target recognition.

- **Automated Classification & Assessment:** Experience in developing **ANN-based Concrete Assessment Toolkits**—which diagnose structural problems from crack imagery—provides a direct precedent for the *Sentinels*' ability to classify ordnance corrosion levels and structural integrity from visual and acoustic inputs.
- **Autonomous Logistics:** Demonstrated capability in building realtime **Fleet/Workforce Management Systems**. These projects prove the ability to manage real-time data telemetry and automated action-logging essential for remote underwater survey operations.
- **Optimization Algorithms:** Expert in high-complexity problem solving, including **Planning, Resource Allocation, and Optimizers with High Dimensional Data**. This mathematical background is critical for optimizing the real-time sensor fusion and path-planning algorithms required for efficient seabed coverage.
- **Government & Digital Leadership:** As an **Advisor to the Minister for Digital Transformation** and **CIO**, the lead champions a "Simplicity First" strategy that maximizes available resources to bridge the "digital divide". This philosophy informs the project's reliance on smart software architecture to minimize hardware costs while enhancing the user experience—delivering professional capabilities via offline-first intranets and intuitive, language-neutral UIs optimized for non-expert operators.

This combination of skills ensures that the *Sentinels* solution is not merely a hardware prototype, but a robust data ecosystem capable of delivering military-grade survey accuracy at a community-level cost. By leveraging a background in **Transformation-Invariant Pattern Recognition** and **Computational Geometry**, the developer ensures that the location data produced is reliable, verifiable, and compatible with global humanitarian standards.

**8. Solution Risks – Please describe any risks you see with your solution and how you would plan for this (up to 500 words)**

The deployment of the *Sentinels* system involves specific operational and environmental risks, which are addressed through a "Defense-in-Depth" engineering strategy:

## Accidental Ordnance Detonation (HERO):

- *Scenario:* Impact with a contact mine or triggering an influence mine during a proximal scan.
- *Mitigation:* The system adheres strictly to the Hazards of Electromagnetic Radiation to Ordnance (HERO) program by operating as **Passive by Default**. By default, the dual tri-axial fluxgate gradiometers measure existing magnetic anomalies without emitting active pulses.

## Equipment Loss via Snagging:

- *Scenario:* The towed wing becomes entangled in a shipwreck, reef, or discarded fishing net.
- *Mitigation:* The **Flip and Slip** breakaway rigging completely neutralizes this threat. The main tether is permanently shackled to the tail of the depressor and secured to its nose with a sacrificial fuse. In a snag, the fuse breaks, transferring the pull to the tail. This instantly flips the depressor backward, stripping its hydrodynamic downforce and pulling it safely out of the snag in reverse.

## Geo-Marking Inaccuracy:

- *Scenario:* Inaccurate geo-marking leads to the failed relocation of detected **EO** by clearance teams.
- *Mitigation:* We move beyond the "Straight-Line Assumption" typically found in low-cost devices. The system integrates real-time pressure (depth) data with a **Lumped-Mass Model** that accounts for cable curvature caused by drag and gravity. This reduces horizontal positioning error from the industry-typical 20% of depth to **<5%**, ensuring coordinates are reliable for follow-up intervention.

## High False-Alarm Rate (Environmental Clutter):

- *Scenario:* Metallic debris (trash, scrap metal, basaltic rocks) triggers the alarm, causing "Alarm Fatigue."
- *Mitigation:* The system uses **Cross-Modal Verification** via **Tiered AI**. First, Physics-Informed Sensor Fusion allows filtering ambient geomagnetic and vessel noise. Second, the Edge-AI requires both a CNN-verified magnetic dipole (material composition) and a YOLO-verified sonar signature (geometric shape) before flagging a definitive hazard.

## Connectivity Failure in Denied Environments:

- *Scenario:* Loss of signal in areas with heavy RF interference or lack of cellular infrastructure.
- *Mitigation:* The system utilizes a **Local-First Architecture**. All AI inference and GIS processing occur on the **Edge (NVIDIA Jetson Nano)**. Connectivity between the operator and the device is maintained via a redundant **Local Wi-Fi / USB-C Tethering** stack, requiring zero internet access for full mission functionality.

## Permanent Data Loss (Hardware Destruction/Loss):

- *Scenario:* The physical device is lost at sea or the topside unit is damaged, destroying the mission logs.
- *Mitigation:* The web application utilizes a "Store-and-Forward" Cloud Sync protocol. This not only ensures zero data loss during offline operations but also enables Crowdsourced Validation, instantly exposing the Digital Twin to remote experts for analysis and to local fishermen for avoidance.

**9. Timeline, capability, and costs – Please describe what you think is required to deliver the solution, including estimated time and cost (up to 500 words)**

## Project Timeline (6-Month TRL 6 Development)

- **Phase 1: Hardware Integration & Testing (Months 1, 2):**
  - 3D printing of the PETG wing and hydrostatic/hydrodynamic testing.
  - Sensors integration and testing.
- **Phase 2: Algorithm & GIS Development (Months 3, 4):**
  - Precision geo-marking and GIS software development.
  - Training of the **Supervised** and **Unsupervised** ML models.
- **Phase 3: Field Trials & System Calibration (Months 5, 6):**
  - **In-Situ Calibration:** Development of the automated calibration wizard where the user tows the device in a "Star Pattern" over a known inert surrogate. The system auto-tunes magnetic and acoustic thresholds to account for local salinity and mineralogy.
  - **Validation:** Final testing in littoral environments to verify detection rates and the "Auto-Float" fail-safe mechanisms.

## Capability & Team

The project requires a multidisciplinary team proficient in **Geospatial Engineering** to handle precision geo-marking, alongside expertise in **Embedded AI** for automated underwater target recognition. Additionally, the team must possess competencies in **Marine Hydrodynamics and Digital Manufacturing** to ensure the stable, low-cost deployment of a multi-spectral sensor payload in littoral environments. These technical skills must be underpinned by experience in **Mechatronics** to integrate complex hardware with robust, fail-safe recovery protocols.

## Estimated Capital Expenditure (CAPEX) per Unit

The system achieves professional-grade survey capability while remaining strictly under the $5,000 threshold:

| Category | Component | Technical Specification | Estimated Cost (USD) |
|---|---|---|---|
| **Acoustic Sensing** | Side-Scan Sonar | 455/800kHz COTS Transducer & Processing Board | $450 |
| **Magnetic Sensing** | Fluxgate Gradiometer | Dual Tri-Axial Array (Differential Mode) | $600 |
| **Computer Vision** | HD Camera & Optics | Low-light CSI/USB Module + Wide-angle Lens | $100 |
| **Edge Intelligence** | AI Compute Module | NVIDIA Jetson Nano + 128GB Industrial SSD | $200 |
| **Hydrodynamics** | Wing Structure | PETG Modular Sections + 316 Stainless Hardware | $140 |
| **Hull Protection** | Marine Coating | Elastomeric Polyurethane (Impact/ Waterproof Skin) | $75 |
| **Depth & Motion** | Navigation IMU | 9-Axis AHRS + Bar30 Pressure/ Depth Sensor | $125 |
| **Power Supply** | Battery System | 50Ah LiFePO4 Battery + Smart BMS | $300 |
| **Tethering** | Data/Tow Cable | 50m Shielded Cat6 + Kevlar Strength Member | $250 |
| **Cable Management** | Smart Block | 3D-Printed Housing + Hall-Effect Encoder | $120 |
| **Safety/Recovery** | Fail-Safe Systems | AIS Beacon + EM Ballast Release + Shear Pins | $205 |
| **Total CAPEX** | | | **$2,565** |

## Operational Expenditure (OPEX):

- **Running Costs:** <$1.00/day (Electrical recharge).
- **Maintenance:** The modular design allows for local replacement of individual 3D-printed wing sections (approx. $15 each) and COTS cables, ensuring a sustainable life-cycle in remote regions without the need for bespoke factory servicing.

## Notes:

- Costs of the GIS software development and the compute resources for AI training are not included.
- The total of $2,565 leaves a significant buffer of **$2,435** under the $5,000 challenge limit for unforeseen costs including specialized connectors, better cable/cable grippers, etc.

**10. Online References – Please provide links to any publications, articles or press releases of relevance (up to 500 words)**

- **Hazard of Electromagnetic Radiation to Ordnance (HERO)**
  Ammunition and Explosives Safety Standards
- **IMSMA**
  IMSMA Core: The Information Management System for Mine Action
- **81mm Mortars**
  - Underwater UXO detection using magnetometry on hovering AUVs
  - Low-Cost Ultra-Wideband EM Sensor for UXO Detection and Classification

- **Muddy Environments**
  - Unexploded Ordnance Characterization and Detection in Muddy Estuarine Environments
- **(ML + GIS) & IMSMA-compliance**
  - Practical Guide for Environmental Monitoring of Conventional Munitions in the Seas (**4. Methodologies**)
  - Bridging Human Expertise with Machine Learning and GIS for Mine Type Prediction and Classification
  - A Location-based Model using GIS with Machine Learning, and a Human-based Approach for Demining a Post-war Region
- **YOLO for Acoustic Shape Recognition**
  - Cross-Modality Object-Level Knowledge Distillation for Enhanced Underwater Sonar Object Detection
  - Underwater Side-Scan Sonar Target Detection: An Enhanced YOLO Framework Integrating Attention Mechanisms
- **CNNs for Magnetic Classification**
  - On the Development of a Neural Network Architecture for Magnetometer-Based UXO Classification
  - Machine learning methods for the classification of unexploded ordnance from electromagnetic data in marine settings
- **Underwater SfM**
  - Cutting-edge 3D reconstruction solutions for underwater coral reef images: A review and comparison (**full text**)
  - Overview of Underwater 3D Reconstruction Technology Based on Optical Images
  - Optical Detection and Classification of Military Munitions Underwater
  - 3D Reconstruction of Unstable Underwater Environment with SFM using SLAM
  - UV3D: Underwater Video Stream 3D Reconstruction Based on Efficient Global SFM
- **Underwater Change Detection**
  - Image-Based Relocalization and Alignment for Long-Term Monitoring of Dynamic Underwater Environments (**full text**)
  - Seagrass restoration monitoring and shallow-water benthic habitat mapping through a photogrammetry-based protocol
  - Detecting change in coral reef 3D structure using underwater photogrammetry: critical issues and performance metrics
  - Multitemporal monitoring of a coastal landslide through SfM-derived point cloud comparison
  - Cost-effective erosion monitoring of coastal cliffs
- **Digital Twin (Clone)**
  Toward digital twin of the ocean: from digitalization to cloning
- **Married Tether**
  Ocean Sonics Tow Fish User Guide
- **Lumped-Mass Model**
  Dynamics of a towed cable with sensor-array for underwater target motion analysis
- **3D-Printed Underwater Vehicle**
  kalypso - Autonomous Underwater Vehicle: A 3D-Printed Underwater Vehicle for Inspection at Fisheries
- **Two-Part Underwater Towed System**
  - Hydrodynamic Design and Analysis of a Towed Environmental Sensor Vehicle
  - Stability of towfish as sonar platforms and benefits of the two-part tow
  - Design and Simulation of a Towed Underwater Vehicle
  - Depth Enhancement of an Underwater Towed System using Hydrodynamic Depressor
  - Underwater Video Sleds: Versatile and Cost Effective Tools for Habitat Mapping (**full text**)
  - A vessel-towed camera platform for surveying seafloor habitats of the continental shelf (**full text**)

**Solution Summary – Please include any other information you wish to add about your solution here (if applicable)**

The Sentinels solution integrates a neutrally buoyant Free-Flooding Sensor Wing and a Modular Depressor System to achieve depth stability. Adhering to HERO compliance, the Multi-Spectral suite is Passive by Default, utilizing Side-Scan Sonar, Fluxgate Gradiometry, and HD Optical streams. To ensure equipment survivability, the hardware features a Triple Fail-Safe Recovery protocol, including a mechanical shear-pin release for snags and an electromagnetic "Dead-Man's" ballast that forces the unit to surface upon power loss, where an integrated AIS beacon facilitates immediate recovery. Intelligence is localized on a "Headless" NVIDIA Jetson Nano, broadcasting a local Wi-Fi hotspot for real-time mission monitoring via any standard smartphone/tablet browser. The system employs a

Tiered AI Inference Engine to maximize detection probability: supervised models identify known geometric and magnetic dipole signatures of ordnance, while an unsupervised Autoencoder monitors for seabed Anomaly Detection. By calculating "Reconstruction Errors", the system can flag degraded, corroded, encrusted, or novel ordnance types that traditional supervised models might overlook, ensuring a comprehensive safety net for all man-made hazards. The core innovation of the platform is its move from isolated "point detection" to persistent Spatio-Temporal Awareness. Unlike traditional sensors that treat each reading in isolation, our GIS-Centric Architecture uses the spatial context to provide Neighborhood Reinforcement; an ambigious (weak) signal at a given location can be mathematically validated by data received in neighboring areas. This is supported by a Lumped-Mass Model for precision geo-marking and Neighborhood Aggregation algorithms that cluster individual anomalies into high-confidence hazard zones. The result is a system that differentiates between random clutter and organized mine lines, automatically generating IMSMA-compliant risk heatmaps and universal data exports (CSV, KML/KMZ, GeoJSON, ESRI Shapefiles) to bridge the gap between detection and clearance. The Sentinels solution is fundamentally evidence-based, grounded in established hydrographic principles and peer-reviewed maritime research. The use of Fluxgate Gradiometry for the detection of buried ferrous objects is a validated standard in underwater UXO detection. Similarly, the efficacy of Tiered AI Inference, specifically using YOLO for acoustic shape recognition and CNNs for magnetic time-series classification is documented in contemporary research for reducing false-alarm rates in noisy littoral environments. By utilizing a Lumped-Mass Model, the solution adopts the same rigorous mathematical framework used in professional cable-laying and hydrographic surveying to ensure sub-meter positioning accuracy. Furthermore, the integration of IMSMA-compliant data schemas ensures that the system's outputs meet the global standards making the results immediately actionable by international clearance teams.

**How did you hear about this Challenge?**

Direct search