SilentGrid Systems

Advanced Edge-AI Acoustic Intelligence for Subsea Infrastructure Integrity

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Paul-Henry Paltmann
Founder & Lead Researcher

EXECUTIVE SUMMARY

SilentGrid Systems is a defense-technology project developing high-fidelity autonomous monitoring solutions for critical underwater infrastructure. By utilizing on-node neural inference (Edge-AI), we enable **real-time detection and classification of direct threats such as sabotage attempts, unauthorized UUV activity, and infrastructure damage**, alongside baseline environmental anomaly detection.

Unlike traditional solutions, SilentGrid operates independently of the protected asset's power and data lines, eliminating the "single point of failure." SilentGrid has successfully completed **TRL 4 (Hardware-in-the-Loop Laboratory Validation)** and is currently executing **TRL 5 (Open-water field calibration)**, demonstrating an ultra-low latency, hardware-agnostic signal chain from passive acoustic acquisition to AI-driven threat classification.

THE PROBLEM: SUBSEA VULNERABILITY

Modern seabed infrastructure, including fiber-optic data cables and high-voltage power tranches, forms the backbone of European and global security [1]. This vital network is increasingly vulnerable to direct and deliberate threats, which current monitoring solutions are ill-equipped to address effectively due to:

- **Direct Threat Concealment:** Adversarial activities, such as sabotage by specialized equipment or silent Unmanned Underwater Vehicles (UUVs), are designed to be covert and evade traditional active sonar systems [1, 2].
- **High False Positive Rates:** Traditional threshold-based systems struggle to differentiate between benign environmental noise and subtle threat signatures in busy maritime zones, leading to operational fatigue [3].
- **Infrastructure Dependency:** Current continuous monitoring concepts (e.g., DAS) rely heavily on the protected fiber cable itself for transmission. If the asset is compromised or severed, the surveillance capability is instantly lost at the most critical moment [4].

THE SILENTGRID SOLUTION

Our architecture shifts the "intelligence" from the remote control room directly to the sensor node, focusing on efficient, localized, and secure data processing at the edge.

On-Node Neural Inference (Edge-AI)

Instead of transmitting continuous, high-bandwidth raw acoustic audio, SilentGrid nodes process the digital audio stream locally using optimized Convolutional Neural Networks (CNNs) converted to highly efficient ONNX runtime graphs.

- **Resilience:** To mitigate dependency risks, encrypted alerts are forwarded via a **dedicated, independent secure cabling link**. This ensures uninterrupted situational awareness even if the primary infrastructure (e.g., gas pipeline) is compromised.
- **Efficiency & Stealth:** On-node processing reduces data transmission bandwidth to near zero, as only classified "Alert Metadata" is transmitted. The system operates passively, generating zero acoustic emissions.
- **Hardware-Agnostic Deployment:** The inference engine is optimized for low-power operation, capable of running on commercial off-the-shelf (COTS) ARM processors or dedicated NPUs (e.g., NVIDIA Jetson architecture).

Proprietary Acoustic Fingerprinting

Our models are trained on specific mechanical transients and operate alongside an extensive data-augmentation pipeline to filter out localized ambient aquatic noise. SilentGrid can differentiate between:

- Mechanical drilling, cutting, and grinding equipment.
- Small-diameter UUV (Unmanned Underwater Vehicle) propulsion signatures.
- Active sonar pings and unauthorized diver activity (SCUBA).

TECHNICAL PERFORMANCE & METRICS

Current system capabilities and laboratory validation (TRL 4) results:

Metric	Value
Classification Accuracy	95.7% (Baseline Model V1)
False Positive Rate	$< 1.2\%$ (Controlled Ambient Sets)
End-to-End Latency (Inference)	< 30 **ms (ONNX Edge-runtime)**
Operational Duty Cycle	24/7 Persistent Monitoring
System Integration Status	**TRL 4 Completed / TRL 5 Ongoing**

STRATEGIC ALIGNMENT

SilentGrid Systems is operationally aligned with the **European Defence Fund (EDF)** priorities for *Layered critical seabed infrastructure protection (UWW-CSBI)*. Our technology provides the "Early Warning" layer essential for multi-domain naval situational awareness [5], utilizing independent connectivity to ensure unparalleled resilience in line with modern defense strategies and NATO capability gaps [1, 4].

CONTACT & INQUIRIES

We are currently seeking strategic defense integrators and venture capital partners to accelerate TRL 6 autonomous node manufacturing and field deployment.

Contact: silentgrid.info@protonmail.com
Location: Tartu, Estonia
Security Notice: Proprietary Information. No classified tactical data or raw neural network weights are hosted in public repositories.

References

[1] Dimitrios Eleftherakis and Raul Vicen-Bueno. "Sensors to Increase the Security of Underwater Communication Cables: A Review of Underwater Monitoring Sensors". In: *Sensors* 20.3 (2020), p. 737. DOI: 10.3390/s20030737. URL: https://www.mdpi.com/1424-8220/20/3/737.

[2] Xu Lin et al. "Efficient ship noise classification with positive incentive noise and fused features using a simple convolutional network". In: *Scientific Reports* 13.1 (2023), p. 17905. DOI: 10.1038/s41598-023-45245-6. eprint: https://www.nature.com/articles/s41598-023-45245-6.

[3] Janine M. McManus, Barry G. Robinson, and Steven L. Van Wilgenburg. "Efficient quality assurance and quality control for passive acoustic monitoring data: reducing and documenting false-positive and false-negative errors". In: *Bioacoustics* 33.2 (2024), pp. 178–202. DOI: 10.1080/09524622.2024.2327338. eprint: https://www.tandfonline.com/doi/abs/10.1080/09524622.2024.2327338.

[4] Ziqi Shang, Xian Zhang, and Xuehua Li. "Maritime communication networks: A survey on architecture, key technologies, and challenges". In: *Computer Communications* 241 (2025), p. 108255. DOI: 10.1016/j.comcom.2025.108255. URL: https://www.sciencedirect.com/science/article/pii/S0140366425000980.

[5] Robert B. Watts. "Implementing Maritime Domain Awareness". MA thesis. Monterey, CA: Naval Postgraduate School, Mar. 2006. URL: https://calhoun.nps.edu/handle/10945/2945.

Detailed Data Flow Diagram

This appendix illustrates the secure transmission of classified alert metadata via **dedicated proprietary cabling** from the Edge Layer to the Central Monitoring Unit.

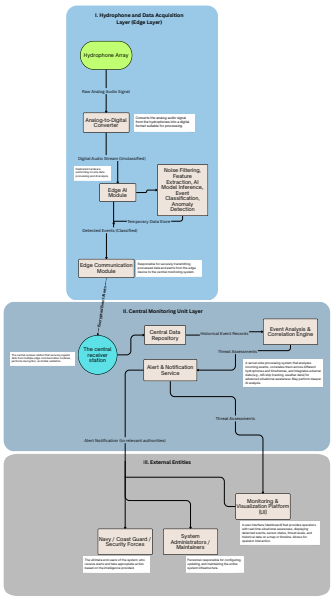

Figure 1: SilentGrid Edge-AI System: End-to-End Data Flow Overview.