Naval Surface Warfare Center Dahlgren Division

Navy Initiatives in Distributed Fiber Optic Sensing

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WELCOME

NSRP

Electrical Technologies Panel Meeting

August 18, 2026 – August 19, 2026

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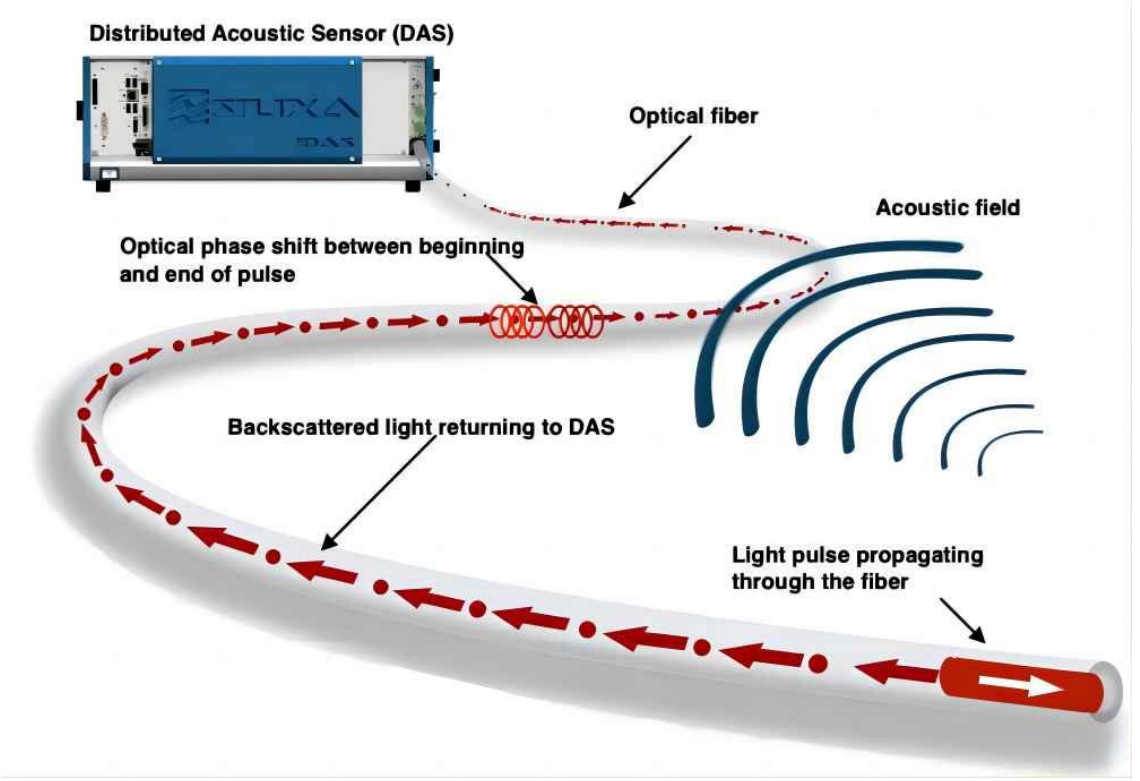
The Vision: A "Shipboard Nervous System"

- The Concept: Transforming standard, new and existing fiber optic infrastructure into a continuous, ship-wide sensor network.
- The Strategic Imperative: Moving away from isolated point sensors to create an integrated system capable of real-time, 3D characterization of the shipboard environment. Using the fusion of the two technologies for comprehensive situational awareness.
- The Ultimate Goal: Enhance warfighter capabilities, enable true Condition-Based Maintenance (CBM), digital twins, and provide continuous monitoring of critical machinery and infrastructure.

DFOS Technology 101 – How it Works

- The Fiber as the Sensor: Instead of using fiber solely for data transmission, DFOS uses the glass core itself as a highly sensitive measuring device.
- The Mechanism: An interrogator sends rapid laser pulses down the fiber. As light travels, tiny imperfections in the glass scatter a small amount of light back to the source (backscatter).
- The Physics: Physical phenomena in the environment, such as temperature changes, strain, or acoustic vibrations alter the fiber's physical properties, which in turn changes the signature of the backscattered light.

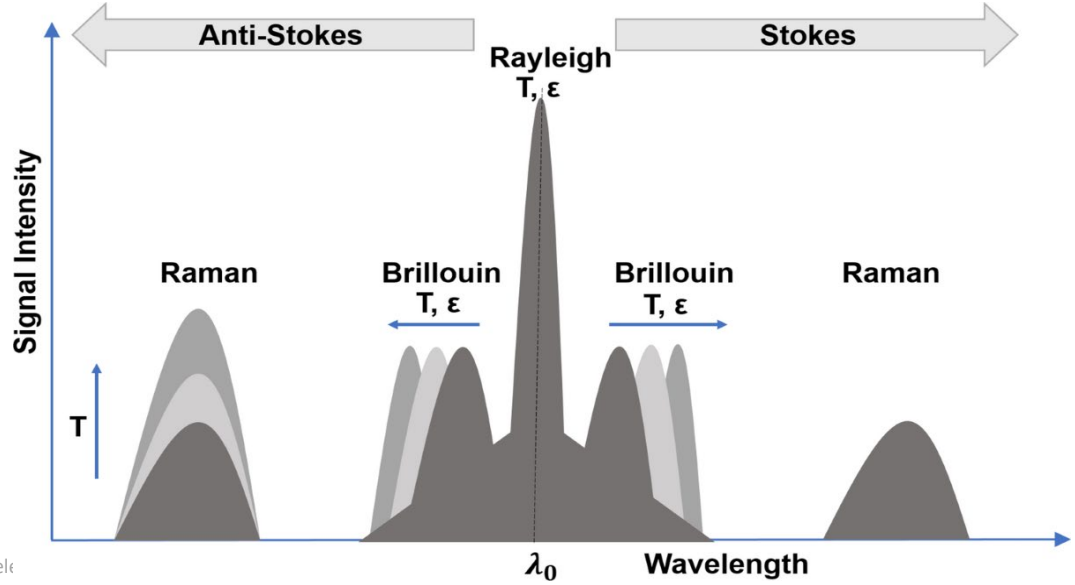


Core Sensing Modalities

- Distributed Temperature Sensing (DTS):
  - *How it works:* Analyzes Raman backscatter, which is highly sensitive to temperature shifts.
  - *Use Case:* Continuous thermal mapping and rapid anomaly detection.

- Distributed Acoustic Sensing (DAS):
  - *How it works:* Uses coherent Rayleigh backscatter to measure micro-strains caused by sound waves or vibrations.
  - *Use Case:* Detecting dynamic acoustic events, structural vibrations, and machinery health signatures.

- Fiber Bragg Gratings (FBG):
  - *How it works:* Utilizes inscribed gratings at specific points along the fiber that reflect particular wavelengths of light. Shifts in the reflected wavelength indicate localized strain or temperature changes.
  - *Use Case:* High-precision, quasi-distributed point sensing for targeted structural or equipment monitoring.



High-Level Implementation & Applications

- Damage Control & Safety: Continuous monitoring of spaces for thermal events to enable early fire detection and localization.
- Machinery Health (CBM): Listening to the acoustic signatures of motors, pumps, and generators to detect anomalies before failure.
- Structural Integrity: Monitoring hull strain and deformation under operational stress.
- The AI/ML Engine: Fusing this massive influx of raw environmental data with Artificial Intelligence to establish "nominal baselines" and automatically flag deviations.

Current Navy Initiatives & NSRP Research

- Anomaly Detection & Localization: Repurposing active and "dark" fibers to transform fleet safety by rapidly identifying and localizing thermal/acoustic events.
- Specifications and standards: Developing a disciplined requirements detailing the architecture, installation and integration phases for DFOS systems across the fleet.
- NSRP Research Announcements (RAs):
  - Active and proposed projects (e.g., RA 2025-04, RA 2026-02) focused on adapting commercial DTS systems for naval electrical plant monitoring and fire detection.
  - Ongoing field demonstrations on active vessels to gather baseline data and validate sensor performance.

Expanding Momentum – The DFOS Consortium

- Building an Ecosystem: What started as localized Navy research has grown into a powerful Community of Interest (COI) comprising over 39 organizations across Government, Academia, and Industry.
- Proven Impact: The community has secured over $24 million in project funding (ONR, NSRP, etc.), proving the immense viability of this technology.

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Conclusion & Path Forward

- Summary: DFOS represents a paradigm shift—turning passive cables into an active, intelligent safety and maintenance network.
- The Big Picture: By combining active research with a strategic, multi-organizational partnership model, the Navy is ensuring it remains at the leading edge of global sensing innovation at no extra cost to internal resources.
- Community of interest meeting at SPIE Optics + Photonics next week

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23 - 27 August 2026
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