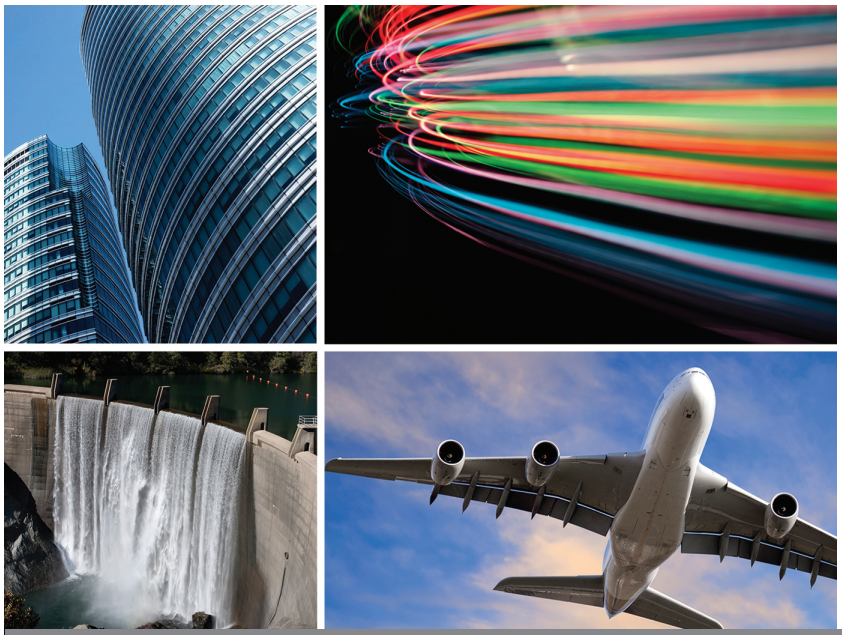

National Aeronautics and Space Administration

TECHNOLOGY SOLUTION

Sensors

Fiber Optic Sensing Technologies

Dramatic improvements for structural health monitoring and tank gauging applications

NASA's Armstrong Flight Research Center is offering companies that provide sensing solutions for monitoring of structures and asset management of storage tanks a unique opportunity to expand their product line to include unprecedented capabilities. Known as FOSS (for fiber optic sensing system), NASA's patented, award-winning technology portfolio combines advanced sensors and innovative algorithms into a robust package that accurately and cost-effectively monitors a host of critical parameters in real time. These include position/deformation (displacement, twist, rotation), stiffness (bending, torsion, vibration), operational loads (bending moments, shear loads, torques), strength/stress (pressure/fatigue, breakage prediction), and magnetic fields (cracks or other flaws in safety-critical metal structures) for structural health monitoring applications. In addition to monitoring the structure of a tank, FOSS is capable of sensing the tank's inventory, including amounts, temperatures, and stratification (oil vs. water, sediment vs. liquid, thermal layers).

BENEFITS

- Low Cost: Provides unparalleled capabilities at a drastically reduced cost, enabling broad usage across industries
- Low Power: Ultra-efficient algorithms and high-speed processing platform allow for rapid processing of data, enabling real-time analysis
- Fast and Efficient: Processes thousands of measurements using computationally fast algorithms
- Adaptive and Accurate: Automatically increases resolution where/when needed across quarter-inch intervals, reducing processing time and data volume
- Easy to Install: Provides a small, lightweight, flexible sensing platform that can be easily applied to or embedded in a structure
- Robust and Reliable: Operates effectively in humid—or even liquid—environments and withstands cryogenic temperatures and mechanical vibrations

THE TECHNOLOGY

The FOSS technology revolutionizes fiber optic sensing by using its innovative algorithms to calculate a range of useful parameters—any and all of which can be monitored simultaneously and in real time. FOSS also couples these cutting-edge algorithms with a high-speed, low-cost processing platform and interrogator to create a single, robust, stand-alone instrumentation system. The system distributes thousands of sensors in a vast network—much like the human body's nervous system—that provides valuable information.

How It Works

Fiber Bragg grating (FBG) sensors are embedded in an optical fiber at intervals as small as 0.25 inches, which is then attached to or integrated into the structure. An innovative, low-cost, temperature-tuned distributed feedback (DFB) laser with no moving parts interrogates the FBG sensors as they respond to changes in optical wavelength resulting from stress or pressure on the structure, sending the data to a processing system. Unique algorithms correlate optical response to displacement data, calculating the shape and movement of the optical fiber (and, by extension, the structure) in real time, without affecting the structure's intrinsic properties. The system uses these data to calculate additional parameters, displaying parameters such as 2D and 3D shape/position, temperature, liquid level, stiffness, strength, pressure, stress, and operational loads.

Why It Is Better

FOSS monitors strain, stresses, structural instabilities, temperature distributions, and a plethora of other engineering measurements in real time with a single instrumentation system weighing less than 10 pounds. FOSS can also discern between liquid and gas states in a tank or other container, providing accurate measurements at 0.25-inch intervals. Adaptive spatial resolution features enable faster signal processing and precision measurement only when and where it is needed, saving time and resources. As a result, FOSS lends itself well to long-term bandwidth-limited monitoring of structures that experience few variations but could be vulnerable as anomalies occur (e.g., a bridge stressed by strong wind gusts or an earthquake).

As a single example of the value FOSS can provide, consider oil and gas drilling applications. The FOSS technology could be incorporated into specialized drill heads to sense drill direction as well as temperature and pressure. Because FOSS accurately determines the drill shape, users can position the drill head exactly as needed. Temperature and pressure indicate the health of the drill. This type of strain and temperature monitoring could also be applied to sophisticated industrial bore scope usage in drilling and exploration.

For more information about the full portfolio of FOSS technologies, see visit https://technology-afrc.ndc.nasa.gov/featurestory/fiber-optic-sensing

APPLICATIONS

The technology has several potential applications:

- Structural health and integrity
- Tank gauging
- Active control
- Safety and protection
- Non-destructive evaluation
- Medical uses

PUBLICATIONS

Patent No: 7,520,176; 8,700,358; 8,909,040; 9,664,506; 10,612,911; 9,009,003; 9,074,921; 8,970,845; 9,274,181; 9,444,548; 10,732,073; 10,422,706; 9,444,548; 9,444,548

Patent Pending

technology.nasa.gov

NASA's Technology Transfer Program pursues the widest possible applications of agency technology to benefit US citizens. Through partnerships and licensing agreements with industry, the program ensures that NASA's investments in pioneering research find secondary uses that benefit the economy, create jobs, and improve quality of life.

DRC-006-024, DRC-006-045, DRC-012-005, DRC-013-022, DRC-017-024, DRC-010-042, DRC-012-006, DRC-011-015B, DRC-011-002, DRC-014-026, DRC-TOPS-37

More Information

National Aeronautics and Space Administration

Agency Licensing Concierge

Armstrong Flight Research Center

PO Box 273, M/S 1100
Edwards, CA 93523-0273
202-358-7432
Agency-Patent-Licensing@mail.nasa.gov

www.nasa.gov

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