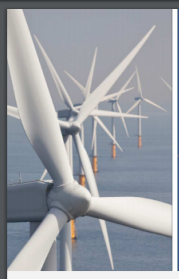

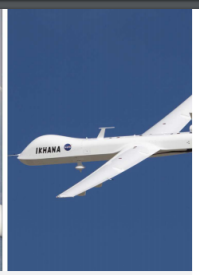

National Aeronautics and Space Administration

NASA

Sensors

Lightweight Fiber Optic Sensors for Real-Time Monitoring of Structural Health

To improve efficiency and safety in aerospace, civil engineering, transportation, oil and gas, renewable energy, and medicine

Innovators at NASA's Armstrong Flight Research Center have developed a lightweight, robust fiber optic sensing system (FOSS) that represents a major breakthrough in sensing technology. The sensors, along with NASA's sophisticated algorithms, can be used to calculate a variety of critical parameters including shape, stress, temperature, pressure, strength, and operational load. This state-of-the-art sensor system is small, lightweight, easy to install, and fast—it processes information at rates of 100 times per second. For the first time ever, real-time strain measurements can be used to determine the shape of an aircraft's wing, monitor the structural integrity of bridges and pipelines, or ensure precise placement of the tiniest catheters, to name just a few potential applications.

BENEFITS

- **High resolution:** Enables thousands of sensors to be placed at quarter-inch intervals for more comprehensive imaging than previously possible
- **Fast:** Provides a 100-Hz refresh rate to enable real-time strain monitoring
- **Small and lightweight:** Uses virtually weightless sensors and hardware the size of a shoebox
- **Comprehensive data:** Calculates shape, stress, temperature, pressure, strength, and operational load
- **Non-intrusive:** Uses a monitoring fiber that does not affect performance
- **Easy to install:** Installs more quickly than conventional strain gauges and in regions previously inaccessible
- **Robust:** Resists radiation and electromagnetic/radio frequency interference

technology solution

www.nasa.gov

THE TECHNOLOGY

How It Works

The FOSS technology employs efficient, real-time, data driven algorithms for interpreting strain data. The fiber Bragg grating sensors respond to strain due to stress or pressure on the substrate. The sensors feed these strain measurements into the systems algorithms to determine shape, stress, temperature, pressure, strength, and operational load in real time.

Why It Is Better

Conventional strain gauges are heavy, bulky, spaced at distant intervals (which leads to lower resolution imaging), and unable to provide real-time measurements. Armstrong's system is virtually weightless, and thousands of sensors can be placed at quarter-inch intervals along an optical fiber the size of a human hair. Because these sensors can be placed at such close intervals and in previously inaccessible regions (for example, within bolted joints, embedded in a composite structure), the high-resolution strain measurements are more precise than ever before. The fiber optic sensors are non-intrusive and easy to install—thousands of sensors can be installed in less time than conventional strain sensors and the system is capable of processing information at the unprecedented rate of 100 samples per second. This critical, real-time monitoring capability enables an immediate and informed response in the event of an emergency and allows for precise, controlled monitoring to help avoid such scenarios.

For more information about the full portfolio of FOSS technologies, see DRC-TOPS-37 or visit https://technology-afrc.ndc.nasa.gov/featurestory/fiber-optic-sensing

APPLICATIONS

The technology has several potential applications:

- **Aerospace:** Sensing shape and structural health monitoring
- **Medical:** Monitoring medical robotics, catheters, MRI machines, and radioactive environments
- **Renewable wind energy:** Monitoring wind turbine blade deformation
- **Civil structures:** Designing and monitoring bridges, tunnels, buildings, and dams
- **Automotive:** Monitoring frame stress for improved safety and performance
- **Transportation and Rail:** Monitoring integrity of train and tracks
- **Marine:** Monitoring oil tankers, navy vessels, competitive yachts, and submarine hulls
- **Oil and Gas:** Detecting leaks, monitoring pipelines, and downhole drilling
- **Power:** Monitoring nuclear power plant vibration and temperature
- **Seismology:** Monitoring shifts in the earth's crust
- **Mining:** Monitoring integrity of shafts
- **Military:** Detecting chemical or biological agents

PUBLICATIONS

Patent No: 7,520,176; 8,700,358; 8,909,040; 9,009,003; 9,274,181; 8,970,845; 9,444,548; 9,664,506; 9,444,548; 9,444,548

Patent Pending