Sensuron Technology Onboard X-56 UAV

For the last decade, NASA Armstrong Flight Research Center has utilized Fiber Optic Sensing (FOS) technology to perform distributed strain sensing and real time structural health monitoring during flight. Compared to traditional sensors, FOS technology provides an unprecedented level of insight into the behavior of a structure. A single hair-like optical fiber spanning up to 40 feet can act akin to over 2,000 strain gauges without the cumbersome and weight prohibitive instrumentation wire. In addition to strain, FOS can be used to measure temperature, deflection, stress, load, stiffness, and various other critical engineering parameters.

The subscale X-56 UAV is the latest aircraft at NASA Armstrong to be instrumented with FOS technology. NASA is using FOS to investigate challenges associated with highly flexible, lightweight wings. In contrast to stiff, rigid wings found on commercial aircraft today, X-56 is outfitted with long, very high-aspect ratio wings which often flex significantly during flight. The use of more flexible wings is considered essential to next generation, fuel efficient aircraft. Commercial aircraft currently do not employ wings of this nature due to their susceptibility to the highly destructive aeroelastic instability known as flutter. NASA is utilizing FOS data to identify the onset of flutter and drive active flutter suppression systems.

Following the schematic shown above, a two-line fiber

Figure 1: NASA's X-56 UAV in flight at Edwards Airforce Base.

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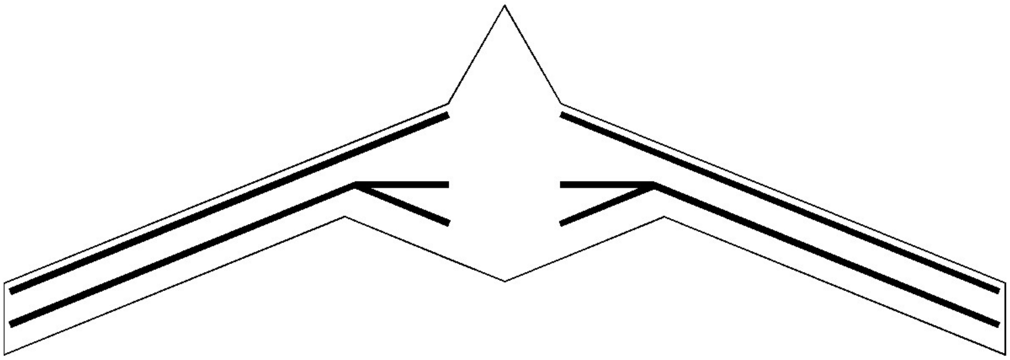

Figure 2: Schematic illustrating the fiber layout of the X-56. Both the top and bottom wing surfaces are instrumented with fiber.

installation is implemented on both the top and bottom wing surfaces of the X-56. This installation layout is strategic in that the bending and cross-sectional rotations of each wing can be simultaneously monitored. The distributed strain data is acquired along the wingspan and used to derive the oscillation velocity of the wings which is indicative of flutter onset. As each fiber line is comprised of hundreds of sensing points, FOS provides significantly more data and greater insight than traditional sensors.

In Figure 3, strain and deflection data acquired along the leading edge fibers over the duration of a flight is shown. The x-axis represents the sensor number, corresponding to a discrete location along the 28 foot wingspan. The color indicates frequency of that level in the data, where pink is the mean over time and blue is less frequent. As seen in Figure 3, the largest deflections occur at the wing tips and the largest bending strains occur a few feet outboard the wing root. Historically, obtaining this level of insight into the overall strain distribution has only been possible computationally via finite element models (FEM). Using FOS, finite element-like data is acquired experimentally on the actual structure. This allows critical areas to be confidently identified instead of just predicted, as well as providing for thorough FEM validation.

A repackaged version of Sensuron's RTS125+ interrogator

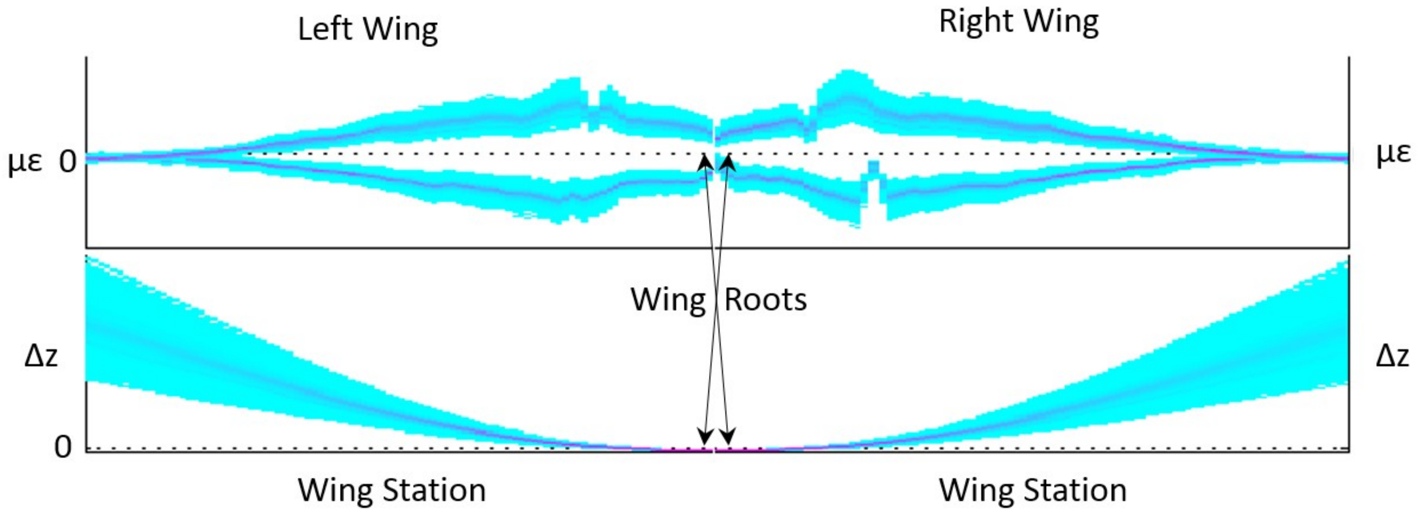

Figure 3: A histogram of bending strain and deflection data acquired via FOS over the duration of a flight. The x-axis is sensor number along the leading edge fiber. The color indicates frequency of that level in the data, where pink is the mean over time and blue is less frequent.

flew onboard the X-56 to acquire the FOS data. Considering the specific environment the RTS125+ had to perform in, the system's size and weight were optimally adjusted while still offering a level of ruggedization that would ensure it would perform well throughout the mission. In the photo below, the location onboard the X-56 of the repackaged RTS125+ (orange chassis) is shown. Overall weight of the interrogator was reduced from 13 lb to 6.7 lb.

Sensuron's RTS125+ monitors continuous strain distributions along up to 8 optical fiber simultaneously. Each optical fiber can span up to 40 ft and contain over 2,000 sensors.

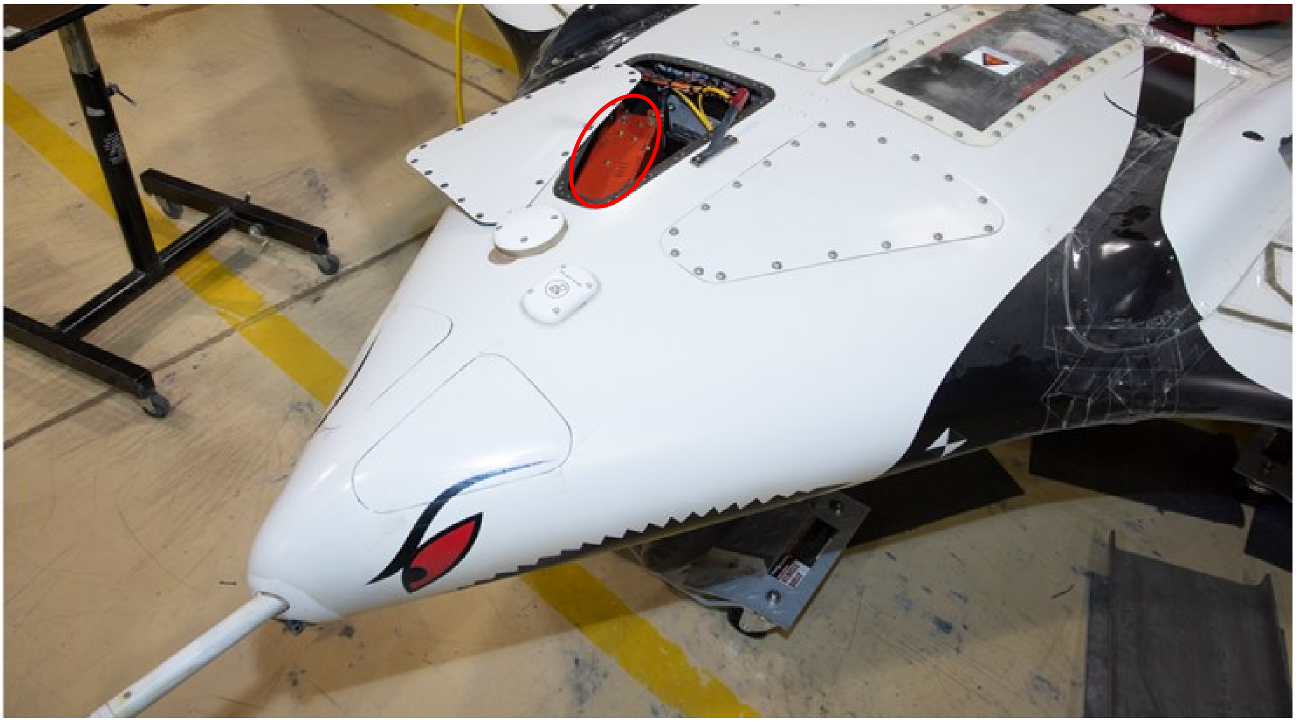

Figure 4: A repackaged version of Sensuron's RTS125+ flew onboard X-56 to acquire the FOS data.

Sensuron's RTS125+ acquires continuous strain and temperature distributions on up to 320 ft of small, virtually weightless, and long-lasting fiber optic cable. Optimized for flight applications at NASA Armstrong, this technology provides test and instrumentation engineers a new level of insight into the strain distributions, fatigue life, and in-operation performance of aerospace structures. In addition to real-time, in-flight structural health monitoring, there are a multitude of applications within the aerospace industry where the Sensuron technology is being utilized. These include subcomponent through full scale structural testing, crack detection, composites embedment and cure monitoring, finite element validation, flight loads monitoring, and many more. For applications that necessitate the use of hundreds or even thousands of electric strain gauges, a significant reduction in installation time, weight, and complexity is realized by switching to the Sensuron technology. For smaller scale applications, significantly more sensors can be installed in the same amount of time that it takes to install only a few traditional strain gauges. Regardless of the application, Sensuron's fiber sensing technology enables engineers to capture significantly more data than they can practically with traditional sensors.

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