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Top Stories

Sensor Technology Helps Crews Maintain C-130s

Sensor Data Promises Efficient, Cost-Effective Maintenance

By Ben Craig

Since the first C-130 was deployed in 1956—three years after the Korean War cease-fire—it has supported the Air Force, Navy, Marines, and Coast Guard in a variety of missions. The four-engine turboprop's primary role is to airlift and transport troops, supplies, and equipment to the forefront of hostile territory.

The C-130J is one of several models that benefits from the Air Force use of sensors to measure how weather and the environment affect the aircraft. Photo courtesy of SPG Media.

But these aircraft are also tapped to meet a variety of DoD needs. They are deployed to help perform aero-medical, weather reconnaissance, and fire-fighting missions, as well as make vital ice re-supply flights to the Antarctic.

Throughout its many evolutions, beginning with the C-130A, the aircraft has become increasingly reliable and much easier to maintain. While fulfilling its various missions, though, today's C-130J is exposed to myriad environmental conditions. "As aircraft are deployed world-wide, the actual environment in which the aircraft operates is ever-changing, lending uncertainty to the airframe's condition," said Molly Statham, an engineer in the C-130 Program Management Office.

In June 2005, the Air Force Corrosion Office launched a new program to install data-collection sensors on its C-130 fleet to analyze the effects of weather and environment on specific areas of the aircraft. While the cumulative environmental exposure sensors were not specifically designed for the C-130, they can be quickly and easily installed on a variety of aircraft. Because a data system for the C-130 fleet is already in place, the agency considered it an ideal fleet for the program.

"This program, which is partially funded by the Office of the Secretary of Defense, meets the newly imposed requirements for corrosion management in the DoD," Statham said. "It will demonstrate active usage of a transitioning technology to impact fleet management." The sensors are a mature technology and have been installed on other aircraft, including helicopters, cargo aircraft such as the C-5 and C-141, and fighter planes such as the F-15 and F-16.

Sensors Help Air Force Track Exposure of Specific Areas

The sensors, which cost less than $20 uninstalled, are the size of a credit card and weigh less than one ounce. They can measure the environmental conditions in specific areas of each aircraft and will enable the Air Force Corrosion Office to track actual exposure conditions, Statham explained. By putting the environmental exposure sensors in the same locations on individual aircraft across the fleet, the Air Force can pinpoint corrosion-prone areas.

The useful product of these sensors is the data, which can be used to realize several short- and long-term goals in preventing and controlling corrosion aboard individual aircraft. For example, the sensors can help identify spills or leaks that otherwise would go unnoticed and provide a technical basis to establish optimum wash-and-rinse cycles, which can help ease the burden of the maintenance schedule (see Sensor Data Helps Air Force Improve Wash-Rinse Cycles). They can also evaluate the effectiveness of corrosion preventive compounds (CPCs) to maximize corrosion control.

The cumulative environmental exposure sensor, pictured, is one of many that have been installed on the Air Force C-130 fleet. Photo courtesy of Air Force Corrosion Office.

Early in 2004, the Fabrication Flight Section at Patrick Air Force Base (AFB), south of Cape Canaveral, Florida, installed environmental exposure sensors on six C-130s that are mainly used to refuel H-60 helicopters deployed for long-range operations in conflict areas such as Afghanistan. (See Beating Corrosion is Vital at Patrick AFB.)

The six C-130s were routinely fogged and treated with a CPC. (Fogging transforms the liquid CPC into a vapor and sprays it in a cloudlike mass inside an enclosed area.) At the time, the team noticed that certain spots on the exterior of six aircraft showed a higher rate of corrosion than other areas treated, and they were unsure why, recalled Chief M. Sgt. Tim Tomasko, the Fabrication Flight Chief in charge of the aircraft maintenance team that is performing the sensor testing. Using the sensors, Sergeant Tomasko and his team hoped to learn whether the CPC was working and why there were discrepancies.

"With the help of the sensor readings, we identified certain areas of the aircraft that we weren't fogging and treating as well as we thought, and were able to correct the problem," said Sergeant Tomasko. "We also realized we were washing and cleaning off the CPC product, resulting in areas of the aircraft that were left unprotected. This also caused us to apply CPC more often than necessary, causing the ripple effect and leading to higher costs because of the unnecessary reapplication of CPC."

By analyzing the sensor data, the maintenance team can easily adjust the fleet's usual wash-and-rinse cycle if they see a drastic increase in corrosion. "The sensors help us measure everyday maintenance on these aircraft, which is vital to our mission of doing combat search-and-rescue over water and in the desert and the jungle," Sergeant Tomasko said. "I was skeptical about the sensors at first, but now I see their value."

A set of sensors (approximately 20 per aircraft) will gather data during operation that will help implement a proactive corrosion management plan for each individual aircraft. The actual degradation of each unique airframe can be assessed in order to support decisions about the best approach to prolonging the life of the aircraft. "Cumulatively, the data will also assist in assessing the overall health of the fleet," Statham said.

Using DoD funding earmarked for fiscal year 2006, the sensor installation will involve 40 aircraft and will be completed in a 12-month period. The Air Force estimates the program will yield a return on investment (ROI) of almost 10 to1, which does not include savings incurred over the life-cycle of the aircraft, as a result of a more effective corrosion mitigation plan.

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"The results will be used to determine corrosion inspection frequencies, tailor wash cycles, and determine the frequencies of corrosion-preventive maintenance actions," Statham explained. A preliminary estimate puts the direct cost of corrosion associated with the C-130 fleet at more than $120 million. Additionally, there are other costs that cannot always be associated with a dollar amount, such as the reduction in aircraft availability and readiness.

More than 600 sensors have already been installed on a variety of aircraft, accumulating approximately 300,000 flight hours. When the Air Force completes this pilot program and validates the ROI projections for the program, they will install the sensors on a broader portion of the fleet.

There is much to be learned and gained from the corrosion sensors, Statham contended, which will not only help reduce maintenance costs, but should also increase aircraft readiness. "The overall result will be a lower maintenance burden, a better understanding of structural integrity, and less maintenance impact on operational availability."

Sensor Operation and Installation

The sensors are composed of printed copper circuits that can measure a change in resistance caused by corrosion of the copper as a result of exposure to the surrounding atmosphere. Resistance changes due to temperature fluctuations are accounted for by the sensors in order to maintain accurate environmental readings. Handheld devices are used to download the data from the sensors during regular maintenance sessions.

Installing the sensors is simple, quick, and has virtually no impact on form, fit, or function. The devices add negligible weight to the aircraft. The full installation of a set of sensors on a large transport aircraft can be accomplished by two people in less than four hours. In less than 24 hours after the adhesive has cured, the aircraft can be flown.

Overcoming Current Maintenance Challenges

"A continuing challenge of managing DoD fleets is to ensure structural integrity while managing cost, prescribing effective maintenance, and maximizing readiness," said Statham. To preempt classic failures of the airframe, the Air Force currently monitors flight loads and load pathways, maintenance history, fatigue data, and assumed or known flaws. In addition to looking for cracks and other flaws during routine inspection, corrosion inspection and maintenance is a major cost. "With different mission assignments, the corrosion rate of the airframe structure could increase or decrease substantially to impact the service life of the aircraft," she said.

Before implementing the current program, the Air Force could not track the actual environmental conditions that each aircraft had been exposed to. Statham noted, "The Environmental Severity Index was a significant development toward quantifying the corrosiveness of the home station environment and is used to assign wash cycles; however, it represents only one aspect of the airframe's actual operating environment."

Without an established method for tracking actual environmental conditions, Statham said, there must be standard, fleet-wide inspections and maintenance actions on a routine schedule. "Many of these inspections and actions may not be urgent or even necessary," she said. As a result, the Air Force is directing the use of a mature and simple technology in the form of the sensors to establish more efficient and effective maintenance practices.

Cynthia Greenwood contributed to this article.