CASE STUDY

US Coast Guard extend service life of HC-130H

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Challenge

- The United States Air Force Academy teams up with the Coast Guard to forecast the Safe Operational Service Life of the HC-130H by monitoring the Center Wing Box (CWB)

Solution

- To determine the severity of the flying environment of the HC-130H, an aircraft was instrumented with a KAM-500 Data Acquisition Unit connected to accelerometers, strain gages, and pressure, temperature, and humidity sensors. The KAM-500 also monitored aircraft parameters, such as airspeed, altitude, gear and flap position, and ramp door position

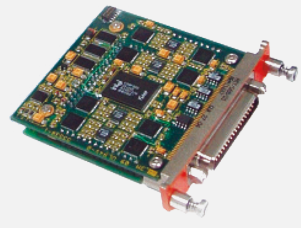
Results

- Aircraft life extended by 20% for 16 of the Coast Guard's 26 HC-130H aircraft
- An 11% reduction in fleet age, resulting in approximately three additional operational years
- Additional environmental data collected for future C-130 corrosion studies

Challenge

The C-130 Hercules family has the longest continuous production run of any military aircraft in history. Over 40 models and variants of the Hercules serve with more than 60 nations. The United States Coast Guard (USCG) employs the HC-130H for long range search and rescue, drug interdiction, illegal migrant patrols, homeland security, and logistics. Currently, the life-limiting critical fatigue component for the C-130 fleet is the center wing box, making it a prime structural focus area. The safe useful life of the C-130 wing structure was called into question in 2002 following the highly publicized Center Wing Box (CWB) failure on a retrofitted C-130 fire tanker. At approximately the same time, the U.S. Air Force (USAF) was finding fatigue cracks in the CWB structure earlier than predicted by previous modeling efforts.

With a small fleet of C-130s (some of which were nearing the end of their service lives), the USCG expressed interest in participating in an assessment of the effects of corrosion and fatigue on the CWB with the U.S. Air Force Academy's (USAFA) Center for Aircraft Structural Life Extension (CAStLE). The assessment plan included the teardown of a retired CWB, the development of structural damage management tools, and the collection of representative flight data for the purposes of updating and validating finite element tools.



A U.S. Coast Guard HC-130H was instrumented with a Curtiss-Wright Defense Solutions KAM-500 Data Acquisition Unit (DAU) which monitored the loading and environmental conditions affecting the CWB. The primary instrumentation consists of the DAU, accelerometers, strain gages, and sensors for cabin and pressure altitude, temperature, and humidity. Other aircraft parameters, such as true airspeed, weight-on-wheels, ramp door position, and flap position were also collected by an analog voltage monitoring module in the KAM-500 system. The new CWB life limit was defined in terms of USAF Equivalent Baseline Hours (EBH). EBH for any given flight is calculated by multiplying the flight hours by the mission severity factor.

Collecting aircraft parameters facilitates matching loads and environmental information to different phases of flight and flight conditions. Prior to this effort, usage and flight severity data were primarily inferred through surveys of aircrew and fleet managers. In five years of operation, the system has collected over 2800 in-flight hours of data during operational missions including a mix of ferry, training, sea surveillance, resupply, and search and rescue. With this flight data now in hand, survey data has been supplemented with actual usage data collected by the KAM-500 DAU. Originally intended to be a one year program, the data proved so useful the program was extended to 5 years. This data were used by the U.S. Coast Guard to assess and update the usage severity factors used to model life predictions whilst making fleet management decisions for the HC-130H, resulting in the previously mentioned life extension.

Solution

To determine the environmental conditions affecting the CWB structure the HC-130H aircraft was instrumented with an Curtiss-Wright Defense Solutions KAM-500 Data Acquisition Unit (DAU).

The DAU is connected to the following devices to complete the Data Acquisition System (DAS):

- 33 strain gages to monitor the strains in the wing beam, and other fatigue critical locations
- 11 Resistance Temperature Devices that characterize the thermal environment to which the CWB is exposed
- A pressure, temperature, and humidity (PTH) transducer and remote probe that records cabin pressure and measures temperature and humidity to help characterize the external environment to which the aircraft is exposed
- A GPS receiver and antenna
- 2 DC single-axis accelerometers
- 2 Precision Pressure Transducers to record cabin pressure and aircraft static pressure
- A GPS receiver and antenna
- A Flap Position Sensor which measures position by counting revolutions of the flap torque tube
- A mounting pallet that contains the KAM-500, GPS, PTH transducer, and one of the pressure sensors

The total system weight is approximately 63 lb., of which only 8 lb. is the KAM-500. Data is recorded on 3Gb and 4Gb Compact Flash (CF) cards located inside the DAU and easily accessible via an external slot. The system is configured to record whenever the aircraft DC power bus is energized.

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The KAM-500 DAU runs on hardwired finite state machines as opposed to microprocessors, thus it is live on power-up. Because in-flight time constitutes only about two-thirds of the “poweron” time, much of the data is not flight data. However, this “always on” approach ensures that virtually all flight data will be collected, as no one needs to remember to activate the recorder prior to flight. The CF card is removed and replaced approximately every three weeks and sent to the CAStLE research center for processing.

At CAStLE, the data is converted to engineering units, and then transferred to Lockheed servers for additional analysis.

Cards typically arrive at CAStLE 45% to 65% full, and a typical card contains between 60 and 100 power-on events. Only about 10% to 25% of those events are flight events, and the duration of an average flight in this program, as measured by weight-off-wheels time, has been about 3.8 hrs.

Results

Raising the level of confidence in determining the Equivalent Baseline Hours (EBH) of the aircraft in the fleet has had the effect of eliminating some of the (understandable) conservatism built into the usage survey data. The actual flight data have shown that, for all basing locations except one, the operating environment is less severe than originally thought. Thus, not only did the overall fleet age get reduced, but the rate at which subsequent EBH is accumulated was also reduced.

22 Aircraft gained hours, 5 lost hours The ultimate life of a C-130 CWB is limited to 45K EBH regardless of further inspection or imposition of flight restrictions, so the reduction in EBH led to significant life extension.

An 11% reduction in fleet age post rebaselining,resulting in approximately three additional operational years until CWB life limits reduce the unrestricted fleet to 16 aircraft. The HC-130H CWB rebaselining initiative bought the C-130 program time to effectively and responsibly plan its retirement, and now it’s time for its younger, more nimble J-Model offspring to take the Watch.

Additional environmental data collected for future C-130 corrosion studies. Over 2800 hours of in-flight pressure, humidity, and temperature data is available for future study topics, including environmentally assisted cracking and corrosion.

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