BY WAYNE ROSENKRANS

Vibration monitoring preempts emission of smoke and burning odors by airplane cooling fans.

Great Shakes

Pilots confronting smoke and burning odor (SBO), a frequent reason for aircraft diversions, gain a decision-making advantage if electric cooling fans can be ruled out as the source, a U.S. manufacturer of cooling fan monitors has concluded. The advantage derives from vibration-sensing technology introduced about eight years ago to automatically detect symptoms of incipient fan failure and shut down the fan to prevent an SBO event in the first place, says Joseph Barclay, president and CEO of IWS Predictive Technologies.

Measuring temperature — the long-established method of protecting fans from a variety of hazardous conditions — has not proved effective in detecting the worn, rough, inadequately lubricated or "dry" fan impeller bearings responsible for a high proportion of all SBO events reported by airlines (Figure 1), Barclay said. His company basically adds a new type of predictive sensor that supplements conventional means of protecting the fans with thermal sensor–relay switches embedded in motor windings.

The typical cooling fan has a rotating impeller with bearings, rotating blades and blade-tip design that will allow interference between the blade tips and fan housing/frame if the condition of bearings deteriorates sufficiently. Company documents summarize the root cause: "Fan bearings fail often as a result of lubricant loss from high stress or high temperature conditions. Ultimately, this can result in bearing cage failure. Cage failure allows unbalanced rotation of the fan, causing fan blade tips or rotors to rub against the fan fixed assemblies [housing/frame]. This occurs at high speeds — some fans rotate in excess of 12,000 rpm — allowing friction to produce smoke and odor." The fan continuously feeds smoke/odor into the cabin or flight deck without a failure warning or indication of cause to the flight crew.

The IWS Predictive Technologies solution requires mounting a vibration monitoring unit (VMU) on the top or

The blue vibration monitoring unit includes an accelerometer and proprietary algorithms to analyze fan vibration signatures, balance and other parameters.

side of the fan housing using a bracket, vibration-transmitting feet and band-type clamps, and external cables for power and communication with the aircraft environmental control system. A VMU measures about 2 by 2 by 5 in (5 by 5 by 13 cm), and the largest eligible aircraft have eight or nine cooling fans.

The applicable supplemental type certificates (STCs) today allow VMU integration with specific types of cooling fans aboard the Boeing 747-400, 757-200/300, 767-200/300/400 and 777-200/300 series. They are fitted, per regulator approvals, to fans used for avionics equipment supply and exhaust; upper/lower cabin air recirculation; gasper; galley chiller boost/exhaust; and crew rest area ventilation. The company's first application for Airbus-related STCs, currently in the final approval stages, is expected to allow VMUs for avionics fans on the A318/A319/A320/A321 aircraft series.

As of March 2011, 12 airlines operate airplanes equipped with about 3,500 VMUs.

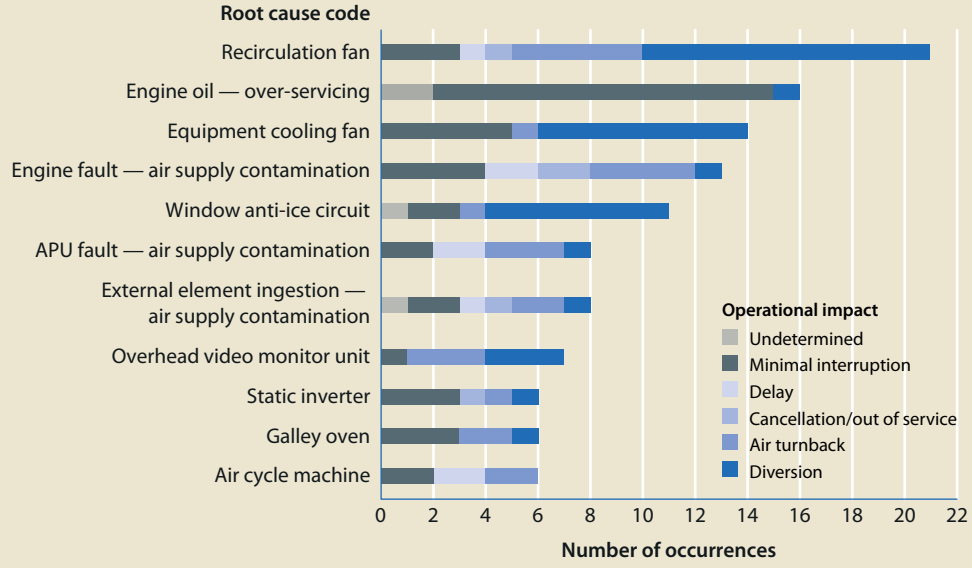
"Before VMUs were added, one of our customers averaged one SBO event every 12,000 flights from fans," Barclay said. "Since they began installing these monitors in 2003, we know that among the equipped aircraft, their equipped fans have completed more than 1 million flights without a single SBO event."

He therefore expects flight crews to rely on this technology to rule out their VMU-equipped cooling fans as a smoke source as part of making timely decisions. "The flight crew can know 100 percent that the SBO is not a fan-induced event," he said. "Smoke from the fan itself is harmless, but when the flight crew is flying an aircraft without VMUs and does not know where the smoke/burning odor is coming from, they are left trying to troubleshoot the system" — ideally following a checklist that conforms to the latest industrywide consensus on pilot responses to smoke/fire/fumes.

VMU logic also can identify some safety-critical failures at the aircraft system level, revealing information likely to be missed by routine maintenance checks, Barclay said. The worst-case scenario is a malfunctioning fan that overheats in flight but continues running until a "catastrophic, critical meltdown-type condition" and an in-flight fire, he said. Diagnostics provided by the VMU after fan shutdowns also help ensure that the unit's programmed relays function properly to preclude unwarranted fan shutdowns.

To read an enhanced version of this story, go to <flightsafety.org/aerosafety-world-magazine/march-2011/great-shakes>.

Smoke and Burning Odor Events, Boeing 757, July 2004–August 2008



APU = auxiliary power unit

Note: Since 2004, Boeing Commercial Airplanes has studied events in which "human senses detect a condition inside the pressurized area of an airplane that may result in a conclusion that there is a potentially dangerous ignition source or atmospheric contamination present that needs immediate corrective action." Human detections of automated alarms were excluded, and "airplane on ground" was not among operational impacts. These study results are for one airplane model.

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Figure 1