WHAT WERE THEY THINKING?

DATA
A crash-resistant flight recorder system might have explained the mystery behind this PC-12 accident.

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It was a particularly tragic event when the aircraft crashed near a cemetery in Butte, Montana, USA, on March 22, 2009*. In addition to the sole pilot and six adult passengers, the aircraft carried six children aged three to seven years and one child under the age of two. The aircraft was destroyed by the impact and all occupants perished.

The NTSB launched a full investigation. The investigation in this particular event found no technical aspects about the Pilatus PC-12 single engine turboprop aircraft, but a number of piloting issues from which valuable lessons can be learned. The extensive investigation report and associated Board meeting raised several important issues, which we want to review in this article, including pilot decision making, on board data recording and storage and compliance with AFM requirements.

In spite of the substantial damage to the airframe, the investigators were able to retrieve data from the Central Advisory and Warning System (CAWS) non-volatile memory. The data showed numerous activations of the auxiliary fuel pumps. The fuel pumps are normally not in operation during flight. Further investigation ultimately determined that the pumps were activated automatically due to a loss of fuel pressure to the engine because of impeded fuel flow as a result of fuel icing. Eventually, fuel could not be drawn from the left wing tank anymore and all of the fuel was supplied from the right tank, resulting in an increasing fuel imbalance.

The situation was further aggravated by the fact that part of the fuel supplied from the right tank was supplied back equally to each tank to serve as suction (motive) flow of the delivery ejector pumps. The result was that the unavailable left tank was being filled, and the fuel imbalance developed even quicker. It reached a point at the end of the flight where the low fuel caution illuminated for the right tank, and the left tank was full. In steady flight and at higher speeds, the aircraft was still controllable. But when maneuvering to land the pilot lost control.

The reason for the formation of ice crystals in the fuel and the subsequent abnormal behavior of the fuel system was that the pilot did not use a Fuel System Icing Inhibitor (FSII). He was aware of the requirement: The AFM requires use of FSII for all flights in ambient temperatures of less than 0°C (the accident flight was cruising at FL 250 in an average outside air temperature of -40°C), and use of FSII was a topic in his recurrent PC-12 training.

He was very experienced (more than 8840 hours of flying experience of which over 1700 hours were on the PC-12) and described to have a “very high level” of competence and “superb” professional judgment. So, what was he thinking when he did not comply with the AFM and did not request FSII to be added by fuel providers or add it himself when he fuelled the aircraft?

The investigation showed that he had performed other flights at below freezing temperatures, with no FSII added to the fuel, and experienced automatic activations of the fuel boost pumps. The NTSB finds that “he had likely downplayed the seriousness of the initial warnings because no adverse outcomes resulted from ignoring the warnings during the first flight of the day and during the [earlier] flight”.

The first indication that something was wrong occurred about one hour and 15 minutes into the flight when the left and right fuel boost pumps began cycling, which is indicative of low fuel pressure. A few minutes later, the left fuel boost pump was on continuously and the right pump was off, which is indicative of the automatic fuel balancing system trying to rectify a fuel imbalance. Eventually, the fuel gauges must have indicated a difference in the fuel content of the wing tanks of more than three bars**.

This indicates that the automatic fuel balancing is not able to maintain level fuel distribution. If the imbalance cannot be corrected by manual operation of the auxiliary fuel pumps (which he evidently did) then, in accordance with the AFM, the pilot must land as soon as practicable. Instead, the pilot flew past at least three suitable alternate airports and continued on his course to his destination. What was he thinking?

Thirty minutes later, the imbalance had increased to an indicated fuel content difference of 15 bars on the fuel indicators. At this time the pilot decided to change course by about 25° away from his original destination (Bozeman, MT – BZN) to an alternate airport (Butte, MT – BTM).

By now it was very apparent that the fuel in the right tank was getting low, while the left tank contained more fuel than at an earlier point in time of the flight. A suitable airport was a mere 22 miles or six minutes of flight time away, but the pilot flew on towards his alternate, which was still 97 miles or 24 minutes away. What was he thinking?

By the time the aircraft was in the vicinity of the alternate airport (BTM) the CAWS annunciated the R FUEL LOW caution. The left tank was filled to capacity and the right tank contained 66 pounds of fuel, as indicated by a 27 bar difference on the fuel gauge.

By now the pilot must have been aware of the seriousness of the situation. Although he had experienced situations of fuel pump behavior, which were indicative of low fuel pressure, "the pilot found himself in a situation that he had not previously experienced."

By this stage in the sequence of events, the workload for the pilot must have been increasing dramatically. When he finally decided to divert to an alternate airfield it was not the closest and most suitable, but one from which his passengers could more easily obtain ground transportation to their ultimate destination. He changed the airplane's route of flight towards his new destination without requesting or obtaining ATC clearance. He was eventually cleared for his new destination, and was instructed to maintain FL 250.

Only two minutes later, the pilot initiated the descent from FL 250, without clearance. He was later instructed to advise receipt of Butte Montana weather and notams. The pilot replied wilco, but did not report receipt of weather information. Data from the CAWS indicate that at this time the pilot attempted to resolve the fuel imbalance by manually activating the fuel boost pumps.

Simulations and calculations show that the aircraft was still controllable in steady flight conditions, but was being operated outside its design limits. This condition did not develop abruptly but gradually. It illustrates the fact that strict adherence to the limitations stipulated in the AFM is important. Not only because non-compliance with the AFM is also a legal violation of 14 CFR 91.9 or EU-OPS 1.005, but because pushing the envelope reduces the safety margin. And no matter how often everything goes well, someday it will not.

Big Brother or Essential Data in the Interest of Safety?

For the NTSBA, a core issue of this accident is the fact that the sequence of events could be reconstructed based on data download from non-volatile memory of a piece of avionics that was not intended to be some sort of crash recorder. The CAWS is not a crash resistant system. Had it been destroyed by impact or fire then the complex interplay of technical and human factors could not have been uncovered.

What remains open and will never be determined are questions regarding the thought and decision making process of the pilot. How, when and by whom were his actions influenced? The effects of the (in-)action of not adding a FSII to the fuel could have been easily mitigated, but the sequence of pilot decisions afterwards resulted in a situation where the margin of safety as well as the number of options continually decreased to a point with tragic consequences.

Safety investigation would greatly benefit from not only knowing technical information (what the airplane did) but also knowing about factors that influence the behavior and decision making of the pilot.

The NTSB therefore reiterated its earlier safety recommendations, which asked the FAA to require crash-resistant flight recorder systems aboard existing turbine-powered aircraft that are not equipped with a CVR and an FDR. The NTSB states that "although the download of non-volatile memory data provided key information in determining the circumstances that led to this accident, a flight recorder system that captured cockpit audio, images, and parametric data would have provided additional information about the accident that was not possible to determine from the downloaded non-volatile memory data".

Audio and image capturing is a very sensitive issue for flight crew and operators, but in the interest of safety and prevention it could provide important insights in trying to determine "what they were thinking".

* The full NTSB investigation report can be found at http://www.ntsb.gov/investigations/reports_aviation.html. The Aircraft Accident Report number is NTSB/AAR-11-05.

** The fuel quantity for each tank is indicated on a display which is graduated with 28 segments or bars

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