Screen Test

Some light-airplane pilots are not fully trained for electronic displays.

REPORTS

No Measurable Improvement

Introduction of Glass Cockpit Avionics Into Light Aircraft

U.S. National Transportation Safety Board (NTSB). Safety Study NTSB/SS-01/10; PB2010-917001. March 9, 2010. 87 pp. Figures, tables, appendix.

Thanks to trickle-down technology, new light aircraft have undergone a transition from analog flight instruments to computer screens similar to those on modern transport category aircraft. The "glass cockpit," in which the electronic displays integrate aircraft control, autopilot, communication, navigation and systems monitoring, represents a significant change for general aviation.

But does the glass cockpit make flying light aircraft — defined here as having a maximum gross weight of 12,500 lb/5,700 kg — safer?

So far, no. "The introduction of glass cockpits has not resulted in a measurable improvement in safety when compared to similar aircraft with conventional instruments," the study says.

The report says that the accident data analysis of conventional versus glass light airplanes included "(1) a comparison of specified aircraft models manufactured during the five years from 2002 through 2006, the years that spanned the transition of the fleet from conventional to glass cockpit displays, (2) statistical comparisons of retrospective accident data for the years 2002 through 2008 by display type, and (3) a comparison of aircraft and flight activity data obtained from the FAA [U.S. Federal Aviation Administration] aircraft registry and an analysis of GAATAA [*General Aviation and Air Taxi Activity and Avionics*] Survey data for the years 2006 and 2007." Accident data came from the NTSB Aviation Accident Database.

Of the 8,364 airplanes included in the study, 2,848 had conventional cockpit displays and 5,516 had glass cockpits. Variables selected for analysis included accident severity, weather, time of day and the purpose of the flight. Pilot information, such as age, highest certificate level, possession of an instrument rating and flight hours, also was analyzed.

The researchers identified 266 accidents between 2002 and 2008, 62 of them fatal. The report says, "The cohorts [groups of subjects with a defining characteristic] selected had similar airframes, numbers of engines and engine types but differed principally in their type of primary flight instrumentation," glass versus conventional.

"The percentage of accidents resulting in fatality was about twice as high for the glass cockpit cohort as for the conventional cohort," the report says.

For another viewing angle, researchers looked at accident rates based on flight hours.

"Those results indicate that the total accident rate per 100,000 flight hours was higher for the glass cockpit cohort in 2006 but higher for the conventional cohort in 2007," the report says, noting that the cohort rates for the combined years were roughly the same. The rates for fatal accidents in both years were higher for glass cockpit aircraft, although the report cautions that the rates were based on small numbers and therefore subject to a large standard error.

Accident rates per 100,000 flight hours for 2006 and 2007 combined were greater for conventional aircraft than for glass cockpit aircraft during the daytime, with the relative positions reversed at nighttime. Fatal accidents occurred at a higher rate for glass cockpit aircraft during both daytime and nighttime. Accident rates in visual meteorological conditions were similar for both groups but higher for glass cockpit aircraft in instrument meteorological conditions (IMC). The glass cockpit cohort had higher fatal accident rates in both meteorological conditions.

"Both cohorts experienced equally low fatal accident rates for instructional flights, but the glass cockpit cohort experienced a higher fatal accident rate during personal/business flights," the report says.

In 255 accidents for which sufficient information was available from NTSB records, the only statistically significant difference in accident event categories was a higher percentage of collision with terrain for the glass cockpit cohort — 16 percent versus 8 percent.

As a group, "accident pilots of glass cockpit–equipped aircraft were older, held higher levels of pilot certification, were more likely to hold an instrument rating and had more flight hours than those flying aircraft with conventional instruments," the report says.

Despite those pilots' relative maturity, could inexperience *with glass cockpits* have been a factor? The evidence was ambiguous. Distributions of flight time in type were not significantly different between pilot cohorts, the report says. It adds, however, that "data concerning flight experience in aircraft make and model made no distinction in cockpit design, so some pilots may have been experienced in the aircraft type while having little experience with the particular cockpit display in the aircraft."

In sum, glass cockpit aircraft had lower total accident rates. But accident and fatal accident rates were higher for the glass cockpit cohort in IMC and at night, despite the capabilities of digitally based displays, which might have been expected to be helpful in those conditions.

"The NTSB reviewed FAA and manufacturer training materials and programs applicable to glass cockpit aircraft and visited aircraft manufacturers to observe factory training available to general aviation pilots transitioning to glass cockpit avionics," the report says.

Prospective pilots must pass a knowledge test and obtain an instructor's endorsement to be eligible to take the practical test for a certificate or rating. Questions on the test do not assess the candidate's knowledge of electronic flight instruments. However, the report says, "there are general requirements for all pilots to be knowledgeable about the operation and limitations of the aircraft they fly — including all aircraft systems — and to be proficient in the use of those systems." But aside from the general requirements, there is no FAA mandate for equipment-specific training.

"With the exception of training provided by airframe manufacturers with the purchase of a new aircraft, pilots must currently seek out and obtain equipment-specific glass cockpit training on their own," the report says.

Some of the larger avionics manufacturers provide software for personal computers that allows pilots to interact with the display. "These software simulators are not intended to replicate the functionality of an approved flight simulator or training device, but rather to serve as interactive procedural trainers that allow pilots to practice using glass cockpit avionics and experience various display system malfunctions and failures that may not be easily or safely replicated in the aircraft," the report says.

Insurance companies often require training requirements for pilots transitioning to glass cockpits as a condition for coverage. But, the report says, those requirements are tailored to individual pilots and vary among insurance companies.

"The lack of equipment-specific training requirements from the FAA and the variability of insurance company requirements result in a wide range of initial and recurrent training experiences among pilots of glass cockpit aircraft," the report says.

Fatal accidents occurred at a higher rate for glass cockpit aircraft during both daytime and nighttime.

Researchers considered several accident case studies that raised issues about the functional differences between electronic and conventional displays.

"The wide variety of complex glass cockpit equipment designs, and their proprietary technology, demands that any discussion of these displays be system-specific," the report says. "Consequently, as electronic systems replace analog gauges, the expectation that average general aviation pilots will understand the inner workings of their cockpit instruments is no longer realistic. This problem is compounded by the fact that, unlike analog gauges, the functionality and capability of electronic display systems can continue to evolve after they are installed because of subsequent software revisions."

Glass cockpit displays may fail differently than conventional displays. The report describes one accident in which a blocked pitot tube, which would have affected only the airspeed indicator of a conventional cockpit display, resulted in the loss of airspeed plus altitude and rate-of-climb information in a glass cockpit display. "The information provided to the pilot indicated only that the air data computer had failed, with no indication of why it had failed or whether the situation could be safely corrected in flight," the report says. "The NTSB concludes that pilots are not always provided all of the information necessary to adequately understand the unique operational and functional details of the primary flight displays in their airplanes."

The NTSB made six recommendations to the FAA, including these:

"Revise airman knowledge tests to include questions regarding electronic flight and navigation displays … ;

"Require all manufacturers of certified electronic primary flight displays to include information in their approved aircraft flight manual and pilot's operating handbook supplements regarding abnormal equipment operation or malfunction due to subsystem and input malfunctions … ; [and,]

"Incorporate training elements regarding electronic primary flight displays into your training materials and aeronautical knowledge requirements for all pilots."

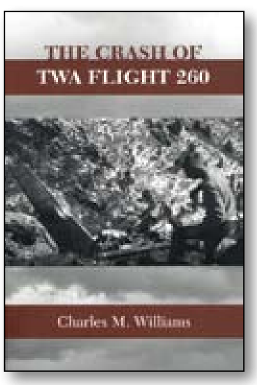
— *Rick Darby*

BOOKS

Reasons Unknown?

The Crash of TWA Flight 260

Williams, Charles M. Albuquerque, New Mexico, U.S.: University of New Mexico Press, 2010. 268 pp. Figures, end notes.



If TWA 260 sounds unfamiliar, it is not a sign that you are losing your memory. You may not have been born yet when the accident occurred, on Feb. 19, 1955.

The Martin 404 was engaged in a short passenger flight from Albuquerque to Santa Fe, about 60 mi (97 km) to the northeast. To avoid the Sandia Range that looms over northern and western Albuquerque — and was hidden by storm clouds at the time — the flight was routed indirectly. Something went wrong.

As Williams tells it: "At 7:12 [a.m. local time, Capt. Ivan] Spong was in the act of changing radio frequencies when the terrain-warning bell suddenly sounded its alarm. Instinctively, both pilots looked out the window. Nothing but gray cloud, but then, flashing through a weak spot in the cloud just beyond the right wing tip, they saw the sheer cliff side of Sandia Crest — an appalling shock, for they should have been 10 mi [16 km] from the mountain.

"Reacting instantly, they rolled the airplane steeply to the left and pulled its nose up. The heading indicator spun rapidly. When it was indicating a westerly heading, they started to level the wings. This was their final act. Hidden by the dense cloud, another cliff side lay directly ahead. When they struck it, they were still in a left bank, nose high. The airplane exploded."

Bad weather hindered search parties trying to reach the wreckage, of which little was visible except the airplane's tail, but that did not matter much. According to a report by a helicopter pilot, it was definitely the accident aircraft and "there was no possibility any survived."

The author, a member of a mountaineering club who had been hiking in the Sandia

Range the day before, volunteered to join one of the search parties. He was among those who reached the nearly inaccessible accident site.

Why return after 55 years to this story, involving an airliner type that has long since been retired from service and flight technology that is primitive by today's standards? Williams believes that the accident investigation by the U.S. Civil Aeronautics Board (CAB), a predecessor of the National Transportation Safety Board, reached conclusions that were seriously mistaken. Additionally, the controversy over the probable cause, which continued for years and resulted in the Air Line Pilots Association (ALPA) dissenting from the CAB findings, offers the drama of a detective story.

The CAB accident report released in October 1955 said, "The weather was such that the visibility all along the airway was good for many miles ahead to the north. … Even if all navigational aids and instruments had failed, all the captain had to do was look outside to determine that he was not following the airway.

"Therefore, from all available evidence, and the lack of any evidence to the contrary, the Board can conclude only that the direct course taken by the flight was intentional."

Williams says, "ALPA pointed out that another airline pilot had taken off minutes after Spong and had testified that the mountains and the Rio Grande valley were completely obscured by a snowstorm, but it fell on deaf ears. The weather was *good* — the report said so!

"When ALPA asked CAB whether they really believed — as their report had seemed to imply — that the TWA pilots had entered into some sort of a suicide pact, they replied, 'No. No. We meant no such implication. We believe they were taking a shortcut."

The Board's determination of probable cause was "a lack of conformity with prescribed en route procedures and the deviation from airways at an altitude too low to clear obstructions ahead."

TWA pilots and those from other airlines were overwhelmingly skeptical that the captain had knowingly changed course from the approved flight plan. "Those who had personally known the pilot, Ivan Spong, knew that he was not a happy-go-lucky fly guy recovering from a rough night on the town," Williams says. "His peers regarded him as a serious and highly competent professional who adamantly refused to deviate in the slightest degree from flying regulations."

Another TWA Martin 404 pilot, Larry DeCelles, "had recently succeeded in discovering both the nature of and the correction for some fluxgate compass errors aboard TWA aircraft," Williams says.

Williams explains that the fluxgate compass "sensed the direction of the horizontal component of the Earth's magnetic field and generated a small electrical voltage that was compatible with the commonly available electric meters already in use on the instrument panel. To maintain accuracy during the twists and turns of normal flight, the compass was kept as level as possible by mounting it on a gyroscope-and-gimbal system.

"Ironically, the Achilles heel of the system was the very stabilizing gyroscope that was the key to its reliability. Steep turns could induce torques that surreptitiously caused … erroneous readouts until it eventually realigned itself — a process usually requiring several minutes of straight and level flight."

The CAB amended its report in 1957, deleting the word "intentional." Nevertheless, says Williams, "a lengthy paragraph had been inserted that said the same thing in a roundabout way. … ALPA's arguments for an instrument malfunction were dismissed — almost contemptuously. They did not, said the Board, even 'warrant serious considerations [*sic*].' They were not a possible contributing factor."

ALPA sent the CAB a critique of its amended report in 1958, with a copy to TWA pilots. The report and ALPA's responses are reprinted in the book. Most of the CAB text and ALPA replies are too long to quote, but here is one brief sample:

The CAB report said, "It is difficult to understand why the flight took the heading it did from the airport to Sandia Mountain."

ALPA responded, "It is not difficult to understand this. The flight experienced a

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malfunction of the fluxgate compass system which was providing heading data to each pilot's RMI [radio magnetic indicator]. No other conclusion is reasonable."

In 1960, the CAB issued a supplement to its revised report, saying that the probable cause was "a deviation from the prescribed flight path for reasons unknown."

— *Rick Darby*

WEB SITES

European ATM Safety

Eurocontrol Safety, <www.eurocontrol.int/safety/public/subsite_homepage/homepage.html>

The Eurocontrol Safety Web site is an easy access point to air traffic management (ATM) safety enhancement programs and publications. Access points include the safety library and links to several key safety programs and their publications.

The Safety Library. The library is a collection of documents and materials from several ATM programs. Listed by topic for quick reference and easy access, most are in Adobe Acrobat format and may be read online or printed. Newsletters and posters, guidance and workshop materials, reports and other documents cover topics such as air-ground communications, safety improvement initiatives, airspace infringement risk analysis, Eurocontrol human factors guidelines, shift work practices, "level busts" (altitude deviations), and more.

European Safety Programme (ESP) for ATM. Launched in 2006, the safety plan's focus is to increase European ATM safety maturity across the European civil aviation conference states to a common minimum level through safety management, safety regulations and relevant technical topics. The ESP library contains downloadable reports, workshop presentations and "just culture" materials. Additional documents, CDs, DVDs and reports, such as *Airspace Infringement Risk Analysis*, are available in the ESP Portfolio Literature section.

Safety Alerts Board. Proactive messages for the ATM community identify safety concerns and best practices. Safety alerts from 2004 to the present are available. Readers may also subscribe for electronic delivery.

Human Factors. This section discusses human performance in safety management systems and normal safety operations. The Web site has its own publications lists and human factors newsletter.

Eurocontrol Voluntary ATM Incident Reporting (EVAIR). The Eurocontrol Safety Web site does not link directly to the EVAIR section; however, it does link to the latest EVAIR Safety Bulletin. The first voluntary ATM incident data collection scheme organized at a pan-European level, EVAIR receives data from air navigation service providers and airlines with the goal of improving safety by identifying issues and providing quick fixes and timely communication. Additional information about EVAIR may be accessed at <www.eurocontrol.int/safety/public/standard_page/evair.html>.

The latest EVAIR Safety Bulletin, No. 5, covering 2006–2009, says, "Currently 67 commercial airlines are providing ATM incident reports. The airlines which provide these reports to EVAIR account for more than 50 percent of the overall European air traffic."

The bulletin reports that "among six phases of flight (landing, standing, taxiing, takeoff, approach and en route) for the period 2006–2009, the statistics (in absolute figures) show that the largest number of incidents (78.8 percent) occur within the en route and approach phases." Main ATM incident contributors during this same period were "mistakes," spoken communication and operational communication.

Previous editions of safety bulletins are also available online.

— *Patricia Setze*