Topsy Turvy

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Time in a simulator can enhance a pilot's upset recovery skills, but there's no substitute for aerobatic training.

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Although simulator training significantly improves a pilot's ability to recover an airplane from a serious upset, a large disparity exists between the performances of pilots who undergo upset recovery training in a simulator and those who have actual aerobatic experience, aeromedical researchers say.[1]

Release of their study, conducted for the U.S. Federal Aviation Administration (FAA) Office of Aerospace Medicine (OAM), came several weeks before the U.S. National Transportation Safety Board's (NTSB's) issuance of a safety recommendation calling for U.S. Federal Aviation Regulations (FARs) Part 135 commuter and on-demand operators and Part 91K fractional ownership operators to incorporate into their training programs the same type of upset recovery training already used by Part 121 air carrier operators.

The study evaluated performances by two groups of pilots who received upset recovery training — one group in a "high-end centrifuge-based" simulator and the other group using a desktop computer. A control group received no upset recovery training. Members of all three groups then were asked to fly a Super Decathlon — a single-engine aerobatic airplane — and to recover with minimal loss of altitude from serious in-flight upsets.

In three of the four test upsets, pilots trained in an Environmental Tectonics GL2000 simulator lost less altitude than pilots trained using a desktop computer with Microsoft Flight Simulator (MFS) software and recovered more quickly from the upset (Table 1). Nevertheless, according to the FAA report on the study, "they did not statistically outperform [pilots who received the computer training] to the degree anticipated.

"More important, perhaps, neither trained group performed as well in altitude loss as we would have expected."

The report said that the differences in altitude loss shown in the table "seem to call in question the implicit assumption that airline simulator-based upset recovery training programs impart flying skills sufficient to make it probable that a typical line pilot can recover an airliner from a serious upset with minimum altitude loss."

The participants in the study were students at Embry-Riddle Aeronautical University; each held a current instrument rating and had completed a course for pilots in basic aerodynamics. None had prior experience with aerobatics or advanced upset recovery training. Although the research involved general aviation pilots and a flight test in a general aviation airplane, the FAA said that the findings also have "important implications for heavy aircraft upset recovery trainers."

In this experiment, the participants' time was divided between "no-motion" time, which was used to teach rote skills, and "motion" time, which was used to teach motion-critical skills while also allowing participants to adjust to the motion of the simulator. Training time was limited because some participants suffered from motion sickness.

In reviewing their findings, the researchers said that the GL2000-trained pilots might have registered stronger performances if the experiment had been conducted under slightly different circumstances, including providing the pilots with more time to practice rote responses to upsets before the motion component of the simulator was activated. The researchers said that they would make that change if they repeat the experiment, and that they also would modify the training to alternate motion sessions and no-motion sessions in half-hour segments, depending on how well individual participants were adjusting to the motion, and would extend the training period to three days instead of two.

The researchers noted that, unlike many of their predecessors, today's U.S. airline pilots typically do not have military flying backgrounds that included "extensive opportunity to perform aerobatic flight maneuvers.

"For military trained pilots, there are no *unusual* attitudes, only *unexpected* attitudes. By contrast, most air transport pilots flying today have never experienced the extreme pitch and bank angles and high g forces associated with severe airplane upsets. Indeed, most have never been upside down in an airplane even once."

The researchers noted that, in informal conversations, a "significant number" of airline pilots said that they consider their company-provided upset recovery simulator training "better than nothing

Average and Observed Minimum Altitude Losses for Each of the Four Upsets

	Altitude Loss in Feet			
Data Source	Nose-Low Upright	Nose-High Upright	Nose-Low Inverted	Nose-High Inverted
GL2000-trained pilot average	600	213	885	368
MFS-trained pilot average	565	331	949	382
Control group pilots average	728	340	1,069	465
Observed minimum during safety pilot training	220	–50	350	–30

MFS = Microsoft Flight Simulator; GL2000 = Environmental Tectonics flight simulator

Source: U.S. Federal Aviation Administration Office of Aerospace Medicine

Table 1

but far from what would be desirable if training costs were not a paramount consideration."

The report added that, "although aerobatic training has not so far been authoritatively related to upset recovery success in a transport type airplane, aerobatic flight in a light airplane would provide an opportunity for pilots to practice maneuvering in extreme attitudes across wide airspeed and energy level ranges. This might in turn lead to greater confidence and maneuvering proficiency on an actual upset situation."

The report cited Boeing data[2] showing that loss of control (LOC) — which often results from an aircraft upset — has been a primary cause of hull losses and passenger fatalities in air transport operations worldwide. The data showed that LOC was the cause of about 25 percent of crashes and 40 percent of fatalities from 1998 through 2007, the report said. The report also cited similar percentages for LOC accidents involving U.S. general aviation aircraft. In Australia, LOC accounted for a greater proportion of general aviation accidents and fatalities, the report said, citing the findings of a 2007 OAM report.[3]

Training programs for airline pilots typically include simulator instruction on upset recovery, and earlier studies have found "significant training transfer" for general aviation pilots who complete training using MFS software on desktop computers.

Training in an Environmental Tectonics GL2000 simulator was a key element of an upset recovery study.

"Upsets are known to be a primary cause of fatal commercial air transport accidents," the report said. "Passenger and air crew safety considerations mandate that air transport pilots be able to recover from the infrequent but potentially catastrophic upsets that inevitably will occur from time to time in air transport operations. Although our research implies that simulator-based upset recovery training is a value-added activity and that introducing higher levels of fidelity may to some extent enhance skills transfer, additional work is needed to optimize ground-based flight training devices and their utilization to ensure they provide highly effective upset recovery training."

Safety Recommendations

The NTSB recommendation for expanded upset recovery training was a result of its investigation of the June 4, 2007, crash of a Cessna Citation 550 into Lake Michigan about three minutes after departure from General Mitchell International Airport in Milwaukee, Wisconsin, U.S., for a flight to Willow Run Airport near Ypsilanti, Michigan. Everyone in the Marlin Air Citation — two pilots and four passengers who were members of a medical organ transplant team — was killed.

The flight was conducted on an instrument flight rules (IFR) flight plan, with marginal visual meteorological conditions on the ground and instrument meteorological conditions aloft.

The NTSB said that information on the cockpit voice recorder indicated that, almost immediately after takeoff, the captain recognized a flight control problem that continued throughout the brief flight while the crew tried to troubleshoot and to maneuver for a return to the airport.

Abnormal Situation

The NTSB said the probable cause of the accident was "the pilots' mismanagement of an abnormal flight control situation through improper actions, including failing to control airspeed and to prioritize control of the airplane, and lack of crew coordination."

Investigators were unable to determine exactly what type of flight control problem the crew experienced, but the two most likely scenarios involved the inadvertent engagement of the autopilot or runaway electric pitch trim, the NTSB said.

However, the NTSB said in a letter to FAA Administrator Randy Babbitt that accompanied the safety recommendation, "Regardless of what the initiating event was, evidence from Cessna flight test records, post-accident simulator tests and the NTSB's post-accident performance study indicated that the result should have been controllable if the captain had not allowed the airspeed and resulting control forces to increase while he tried to troubleshoot the problem."

The captain had maintained control of the airplane "without much exertion" immediately after takeoff, when the airspeed was relatively slow, the NTSB said, "but he increasingly struggled as the airplane accelerated and the control forces increased. …

"If the pilots had simply maintained a reduced airspeed while they responded to the situation, the aerodynamic forces on the airplane would not have increased significantly; at reduced airspeeds, the pilots should have been able to maintain control of the airplane long enough to either successfully troubleshoot and resolve the problem or return safely to the airport."

Earlier Recommendation

A previous NTSB safety recommendation, issued in 1996 in the aftermath of several upset-related air carrier accidents, led to an FAA-industry project to develop the *Airplane Upset Recovery Training Aid*, designed to provide pilots with information on how to recognize and avoid situations likely to lead to upsets and how to recover aircraft control after an upset. The training aid, revised in 2008, presents information about high altitude aerodynamics and safe flight techniques for most jet airplanes that operate above Flight Level 250 (about 25,000 ft). Airbus, Boeing and Flight Safety Foundation led the working group that developed the information.

The FAA issued a notice of proposed rulemaking early in 2009 that called for minimum standards for training air carrier pilots in upsets and loss of control, with references to the training aid. Noting that the training aid initially was intended for operators of airplanes with at least 100 seats, the NTSB said that the information also is relevant to smaller jet airplanes, including the accident airplane, that are operated in the same environments inhabited by air carrier aircraft operated under FARs Part 121.

The NTSB said that similar training requirements must be adopted for commuter and on-demand companies operating under Part 135 before the FAA's response to the 1996 safety recommendation will be considered acceptable.

"Pilots would benefit from training and readily accessible guidance indicating that, when confronted with abnormal flight control forces, they should prioritize airplane control (airspeed, attitude and configuration) before attempting to identify and eliminate the cause of the flight control problem," the NTSB said. "The NTSB recommends that the FAA require all … Part 91K and Part 135 operators to incorporate upset recovery training (similar to that described in the *Airplane Upset Recovery Training Aid* used by many Part 121 operators) and related checklists and procedures into their training programs."

Notes

1. Leland, Richard; Rogers, Rodney O.; Boquet, Albert; Glaser, Scott. *An Experiment to Evaluate Transfer of Upset Recovery Training Conducted Using Two Different Flight Simulation Devices*. DOT/FAA/AM-09/17. September 2009.
2. Boeing Commercial Airplanes. *Statistical Summary of Commercial Jet Airplane Accidents, World Wide Operations, 1959–2007*. <www.boeing.com/news/techissues/pdf/statsum.pdf>.
3. Rogers, Rodney O.; Boquet, Albert; Howell, Cass; DeJohn, Charles. *Preliminary Results of an Experiment to Evaluate Transfer of Low-Cost, Simulator-Based Airplane Upset Recovery Training*, FAA Technical Report DOT/FAA/AM-07/28.