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BY WAYNE ROSENKRANS | FROM ORLANDO

SPECIAL PURPOSES

Dual HGS, practical stall scenarios and unreliable-airspeed rehearsals help pilots manage risk of airplane loss of control.

Defenses against loss of control in flight (LOC-I) figured prominently in recent conference presentations to pilot training specialists from major and regional airlines. A recurrent theme was how to apply lessons learned from transport airplane accidents that happened in unremarkable flight conditions with properly functioning autoflight systems.

During the World Aviation Training Conference and Trade Show (WATS 2010), presenters from two early-adopter airlines also outlined a related rationale for equipping fleets with dual head-up guidance systems (HGS) and mentioned plans for HGS-qualified first officers to land aircraft after approaches to Category III minimums. Others at the April gathering in Orlando, Florida, U.S., called for stronger emphasis on pilot understanding of aerodynamics and the adoption of updated stall recovery guidance from Airbus and Boeing Commercial Airplanes.

Several presenters concurred that despite measurable improvements since the 1980s, the LOC-I trend of the last five years should ring alarms (Table 1, and Figure 1, p. 32). "If we are going to lower the overall accident rate, we have to address loss of control in flight because it stands alone as the largest threat," said John Cox, president and CEO of Safety Operating Systems.

Regaining Control

Avoidance, recognition and recovery remain essential elements of the LOC-I solution, Cox said. "The first and most critical skill is avoidance — how we teach crews to not put the airplane in a state that has the potential for upset and how to recognize when it is near an upset condition," he explained. "[The industry must teach] not only the incoming, next-generation pilots but equally — or even more importantly — the cadre of pilots on the flight deck today."

A "flawed impression" may exist in the airline industry of the baseline understanding of aerodynamics among today's average pilots, he added, citing answers he heard to questions about aerodynamics that he posed informally to professional pilots from various backgrounds. "Up to a point, they understood the potential consequences of high–angle-of-attack flight," Cox said. But in his opinion, only about 10 percent of the pilots he polled in 2009 and 2010 demonstrated an adequate knowledge of aerodynamics, the limitations of LOC-I training in flight simulation training devices (FSTDs) and recent changes in the response to stall indications recommended for large commercial jets.

"One of the things the industry has taught [inappropriately in FSTDs] is 'power out' recoveries," he said. "We need to rethink this because there are parts of the flight envelope — particularly in high altitude and high drag conditions — where pilots do not have excess thrust, and the airplane will not accelerate out of a stall. There is a high drag coefficient at the critical angle-of-attack near stall, and powering out may not always be possible. 'Powering out' certainly was the way I was taught to fly Boeing 737s in 1981, so we may have been teaching the wrong recovery for a long time."

In those days of 737 training, the hardest maneuver was to set up the airplane for what he used to call a "precision stall." "Trim it carefully, let the airplane slow down, [wait for] stick shaker [to activate], add power and do not lose a foot of altitude," Cox explained. "Those were the criteria; people are still teaching that flawed approach. It's flawed because if pilots don't reduce angle-of-attack and don't accept some altitude loss to quickly get flow reattachment to the wing, they are not maximizing the aerodynamic performance and they are decreasing the likelihood of a successful outcome."

The new aspect is the commitment to accept some altitude loss as a matter of survival. "We should make sure that the pilots in flight decks today — and the incoming generation — learn this well," Cox added. "In April 2010, the U.K. Civil Aviation Authority issued a flight crew training notice in which they said 'reduce angle-of-attack; it is the primary stall recovery step.'

"In recent weeks, Airbus and Boeing have changed their stall-recovery procedures, and I commend both organizations. [The updated procedure] is to reduce angle-of-attack, lower the

Fatal Accidents: Loss of Control in Flight vs. CFIT
Worldwide Commercial Jets, Selected Periods, 1988–2009

Period	1988–1993	1991–1995	1992–2001	1993–2002	1994–2003	1997–2006	1998–2007	1999–2008	2000–2009
Percentage of all fatal accidents in period									
LOC-I	34.23	27.1	27.7	25.7	30.5	21.3	24.4	24.2	22.5
CFIT	36.8	28.8	24.1	22.9	22.9	22.5	20.0	18.7	18.0
Percentage of all fatalities in period (onboard and external if reported)									
LOC-I	25.5	39.2	34.3	31.5	39.3	30.4	36.7	40.1	35.2
CFIT	53.6	32.1	31.1	29.6	25.0	30.7	21.0	19.3	18.3
Rate of fatal accidents in period (per million departures; multiply value shown by 10^{-7})									
LOC-I	3.29	2.27	1.90	1.69	1.90	1.06	1.21	1.18	1.06
CFIT	3.54	2.41	1.66	1.51	1.42	1.12	0.99	0.91	0.84

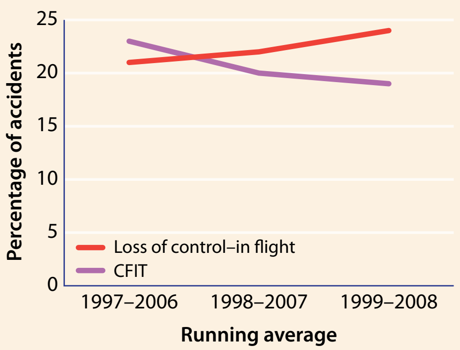
CFIT = Controlled flight into or toward terrain; LOC-I = Loss of control – in flight

Note: Periods are examples selected from 1988–2009 editions of the Boeing Commercial Airplanes *Statistical Summary of Commercial Jet Aircraft Accidents*. Editions vary in the number of years covered, accident-category definitions and onboard/external fatalities counted.

Source: Adapted from Boeing Commercial Airplanes

Table 1

Fatal Accidents: Loss of Control in Flight vs. CFIT



CFIT = controlled flight into or toward terrain

Note: Data are percentages of total fatal accidents involving worldwide commercial jets, based on data published by Boeing Commercial Airplanes.

Source: John M. Cox

Figure 1

nose, level the wings and increase thrust, understanding that with engines mounted under the wing, the pilot may be adding to the [resulting] nose-up pitch. That may have to be countered, so pilots may want to be a bit judicious in how rapidly they apply thrust with very high bypass–ratio fan engines. It is a consideration. [Then the pilot should] reduce speed brakes or retract them, and return to normal flight. … There is a caveat: If the airplane manufacturer has specific [actions for known] flight characteristics, follow them first."

Unreliable Airspeed

Early avenues of inquiry into the Air France Flight 447 accident investigation — the June 1, 2009, crash of an Airbus A330 in the Atlantic Ocean — prompted Czech Airlines to reconsider how it trains pilots to recognize and safely handle situations involving unreliable airspeed, according to Roman Hurych, a captain and chief flight instructor for the company. Recurrent line-oriented flight training (LOFT) with an unreliable speed indication began in September 2009, and ironically around the time the training was introduced, an actual event occurred.

"We reacted very quickly [to Flight 447]," he said. "We realized it could happen to anybody at any time. … We also had to admit that the last time the [typical] pilot operated the aircraft with unreliable speed was during his or her type rating course. So that was the main reason, to give all of our pilots the chance to practice again how to fly the aircraft without the speed indication and, at the same time, to fly manually at high altitude."

The airline designed the FSTD scenario so flight crews would be briefed a few days beforehand that unreliable airspeed could occur any time during the simulated flight from Prague to Moscow. Elements included the auxiliary power unit inoperative per provisions of the minimum equipment list (MEL) and assignment of a departure runway with a tail wind. "We wanted them to come to our recurrent training already prepared," Hurych said. "Our target was to show pilots the behavior of the aircraft and let them practice solving this very difficult situation. They were advised to use all airplane documentation … including an Airbus presentation on unreliable speed, which is of great value."

Early in this simulator exercise, the instructor inserts a frozen standby pitot tube condition and thunderstorms on the weather radar display. Later, in cruise flight, the instructor inserts simultaneous faults on both airspeed channels along with an air data reference–frozen fault. "If this appeared shortly before reaching the [assigned] flight level, the pilot flying still had the speed indication, but unfortunately it was wrong," Hurych said.

"Shortly after, the crew lost all the [airspeed] indications, had to start with the memory items and then had to revert to the paper checklists for unreliable speed indication. The scenario's intent was for the flight crew to bring the aircraft back to Prague. The emergency was declared, and while using the paper checklists, the crew began their descent in preparation for approach and landing."

Czech Airlines found that the advance briefing and pre-exercise preparation made all crews hyperattentive to any airspeed fluctuation as a possible anomaly, and some began troubleshooting suspected unreliable-airspeed indications caused by normal turbulence encounters during climb. "They knew what was to happen, but they didn't know when," he said. "We saw crews comparing indications that they almost never compare and monitor during normal line flying. Generally, all crews came very well prepared for the session and coped very proficiently with all [aspects] of the scenario."

The real incident in late 2009 also occurred during a flight from Prague to Moscow. During climb on autopilot, the crew noticed their altitude modes disappear, and then the autopilot disconnected. Airspeed on one side showed 170 kt while the other side showed 210 kt. "An instructor in the right seat took over the controls and continued to climb out using the initial pitch and thrust as per memory items," Hurych said. "At about thrust-reduction altitude, they were in clean configuration because they had retracted flaps before recognizing the speed discrepancy."

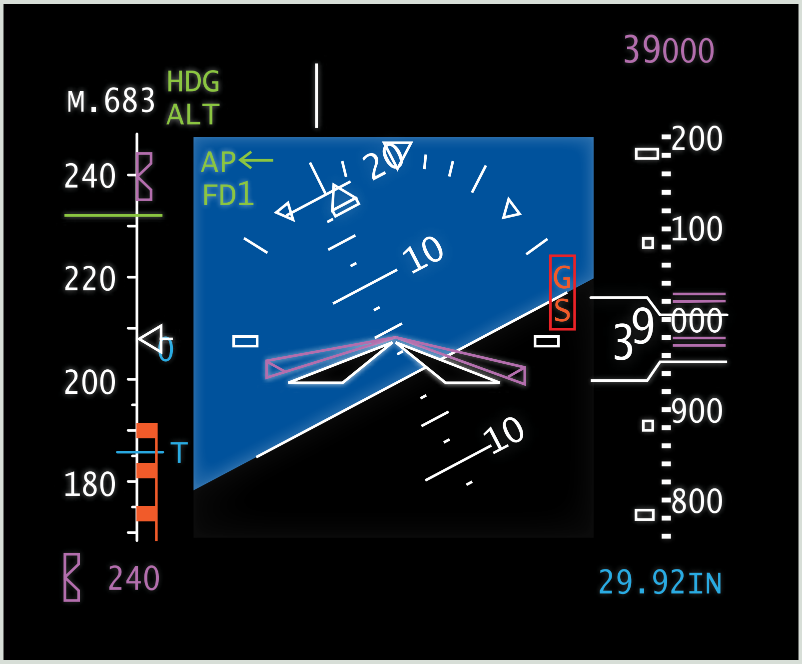
Effective crew resource management helped the crew to maintain control, compute pitch and thrust values for level off, perform actions on the paper checklist, declare an emergency, turn back to Prague and complete an uneventful landing, he said. The cause of this unreliable airspeed was still under investigation as of April. The basic procedure being taught in recurrent training, however, worked as advertised.

Approach to Stall

In just a five-week period in 2009, three fatal airline accidents involving stalls occurred while flight crews were flying approaches to land with the autopilot engaged, said Paul Kolisch, manager, flight operations training, Mesaba Airlines. "My contention is that these pilots were not trained for these events," he said. "I don't know any pilot in the airline business, or operating sophisticated corporate airplanes, who has arrived at an inadvertent stall while hand flying the airplane. … Traditional [FSTD] stall training has shifted to an artificial choreography where the pilot stops trimming in order to keep good control of the airplane during the recovery, sits there and waits until [the stick shaker activates], then recovers. Not one of the 2009 accidents happened that way."

Mesaba has adopted what it calls "practical training for approach to stalls" from a conviction that unrealistic traditional training generates unsafe expectations of what actually will occur. "We do the training primarily in a classroom or briefing room prior to going into the simulator," Kolisch said. "When we get into the simulator, we don't do a 'stall series.' Those two words don't occur together in our syllabus. [Instead,] at some point, the pilot encounters the stall as a surprise … if at all possible. We will use any [tactic] necessary for distraction."

A U.S. Federal Aviation Administration (FAA)–industry working group that studied stall training was concerned that misconceptions about the practical implications of the agency's practical test standards could amount to negative training. "The practical test standards say that the applicant for a pilot certificate 'recovers to a reference airspeed, altitude and heading with a minimal loss of altitude,'" Kolisch said. "We do our approach-to-stalls [in airplanes] at practical high and low altitudes, including at 400 ft." Mesaba's



Source: Paul Kolisch, Mesaba Airlines; Illustration: Susan Reed

training strongly emphasizes the "recovers to a reference altitude" and de-emphasizes "minimal," which it considers difficult to define. No training injuries or fatalities have resulted despite the intentional distractions that startle pilots, he said.

One concern of FAA-industry committee members was the fidelity gap between the stall characteristics of typical FSTDs and aircraft performance in stalls, he said. "I am opposed to trusting computer 'speculation' when we fly the simulators — we just don't know how the airplane would behave," Kolisch said.

"If we don't take pilots up high in these jet airplane simulators, they won't understand

Exposure to high-altitude stalls in an FSTD will lack some fidelity but reinforce awareness of the risk factors in line flying.

this [gap]. … If the first time they experience a high-altitude stall event is in an airplane, they're going to be in big trouble." Based on review of Mesaba's videos, the opinion of some airplane upset specialists was that some stall recoveries that were successful in an FSTD would have been an airplane upset in reality, he added.

Head Up Constantly

JetBlue since 2007 has deployed dual Rockwell Collins HGS-5600 HGSs on its Embraer 190 regional jets. From the last quarter of 2009 through the first quarter of 2010, Lufthansa CityLine partnered with the company to do the same for its 190/195 fleet after more than three and a half years of preparation, said Christof Kemény, a captain with Lufthansa CityLine, in a joint presentation with Mark Maskiell, a captain with JetBlue. The systems are now used routinely by all pilots in all weather conditions, and safety enhancement remains high on their lists of objectives, they said.

Lufthansa had analyzed advantages and disadvantages of HGS compared with autoland systems and envisioned how HGS could be used in the context of air traffic management transformations imminent in Europe, the United States and elsewhere.

Kemény cited findings of the most recent Flight Safety Foundation study of safety benefits from HGS technology (*ASW*, 5/10, p. 38) as a reinforcement of Lufthansa CityLine's conclusions that the technology could deliver significant safety advantages. Analysis of company Bombardier CRJ landings with crews using HGS also demonstrated unprecedented, consistent touchdown-zone accuracy compared with landings by crews flying non-equipped CRJs.

"By its design and certification, autoland is not capable of any advantage for required navigation performance approaches or nonprecision approaches, whereas a head-up display [HUD] can be used from taxi before takeoff until after landing," he said.

Among HGS capabilities most relevant to safety are the speed error tape, graphically depicting the offset between the selected speed and aircraft speed; an acceleration carat that transforms to an energy symbol; and tail-strike advisory information. "Every time the pilots look out of the [forward windshield through the combiner (i.e., the HUD screen)], they see the energy status for precise energy management of the aircraft with the flight path," Kemény said. "After landing, we have the same capability as an instantaneous indication of the aircraft brake performance. This is an immediate decision-making tool; after the touchdown, the pilots have the picture of deceleration values."

If unsafe deceleration on a contaminated runway or brake problems occur, the flight crew sees the remaining runway and the point at which the aircraft will stop — rather than relying on imprecise sensations that something is going wrong after landing, he added.

During HGS training, Lufthansa CityLine had to encourage pilots "to be patient with themselves" as they advanced through four levels of proficiency (Table 2), learning the new skills and presentation of the world outside the aircraft. About six months typically elapse from the first day in an HGS FSTD to line flying at level 4, in which the pilot is fully "proficient using HUD as another flight deck tool," he said.

The decision to replace autoland with dual HGS worked out as expected, Kemény said. "Analysis of results showed that we have increased situational awareness for both pilots," he explained. "The conformal flight path vector of the HUD is comparable to what pilots would see head down, and we have real-time aircraft energy monitoring and improved assessment of deviations. … After six months of operating, the data are proving that with the Embraer 190, we see much less deviation on the glideslope and localizer, and in speeds during the final portion of the approach. This means increased landing accuracy. There is good reason to believe that we also have a reduced risk of hard landings and tail strikes. The visual indication of our brake performance after landing is something no other system provides while looking out of the window."

The present and future role of HGS as an aid in unusual attitude recovery has been especially

"We see much less deviation on the glideslope and localizer, and in speeds during the final portion of the approach."

gratifying, Kemény said. "We have intuitive guidance during abnormal situations such as unusual attitude recoveries, engine failures and traffic-alert and collision avoidance system resolution advisories." For further enhancement of aid to unusual attitude recovery, the platform can be configured to display g-loads in the combiner, he said.

At the beginning of 2011, Lufthansa CityLine will qualify all first officers to conduct Category III approaches. Steep approaches using HGS in the 190 already have been approved by European authorities along with constant descents on all nonprecision approaches, he added.

JetBlue's Maskiell said that as of April 2010, 40 of the airline's 190s have dual HGS. Acquiring the capability — and the requisite FSTDs — was on the agenda from the company's founding. On the training side, all of the company's FSTDs have dual HGS. "More than a handful of pilots have shared with me that maybe the most challenging event they'd had was conducting a flight without dual HGS when the system was [inoperative per provisions of] the MEL for some reason. … They become very reliant on that device — not to the point of being unsafe [without it] but definitely to the point of knowing that there is a difference. … In four years, there has not been a single [HGS-induced] safety event noted."

Four HGS Proficiency Levels in Pilot Training

Level 1	**Initial introduction**
	Tunneling, fixation and adaptation can be reduced using an FTD
Level 2	**Secondary awareness**
	Prioritizing the information acquisition (FFS phase)
Level 3	**A world beyond the combiner**
	Integration of HGS into conformal world and combining other cockpit information
Level 4	**The HUD as another flight deck tool and the HGS as the primary flight display reference**
	Final stage of proficiency; symbology becomes second nature
	Pilot becomes more aware of air mass effect and performance of aircraft

HGS = head-up guidance system; FTD = flight training device; FFS = full flight simulator; HUD = head-up display

Source: Christof Kemény, Lufthansa CityLine

Table 2

Human Factors

LOC-I also has been linked with concerns about how best to instill safety attitudes and a positive culture of professionalism from one generation of pilots to the next, said Cor Blokzijl, director flight operations, Mandala Airlines. Unease about pilot professionalism (*ASW*, 6/10, p. 24) has been increasing in some parts of the world — especially the perception that within today's generation of pilots new to their airline careers, some lack self-motivation or are too distracted by other pursuits to study beyond minimum requirements or to read aviation safety media. "This affects their in-flight situation recognition," Blokzijl said.

Preparation to manage automation and LOC-I risks also requires a distinction between recitation of rote facts about airplane systems — knowing only the standard operating procedures and the flight crew operating manual (FCOM) — and genuinely understanding systems.

"Nowadays, understanding systems is of much more value than knowing information by heart," Blokzijl said. "I have pilots in my airline who can recite the Airbus FCOM backwards and forwards without a mistake … but they are unable to transfer that knowledge into practical [application] in the aircraft. If we can make them understand why things are happening and the influence of certain failures in the system on the rest [of the system], a 'light goes on' and the pilots are able to do what's required."

Continual transfer of expertise to less experienced pilots ought to bridge the gap between practicing narrowly focused tasks during recurrent training in FSTDs and truly enhancing cognitive skills. Understanding of systems, system interfaces and dynamics of system failure — "if this is failing, what else?" — have become a key factor today in successful threat management, he added.

To read an enhanced version of this story, go to <flightsafety.org/asw/aug2010/pilot_training.html>.