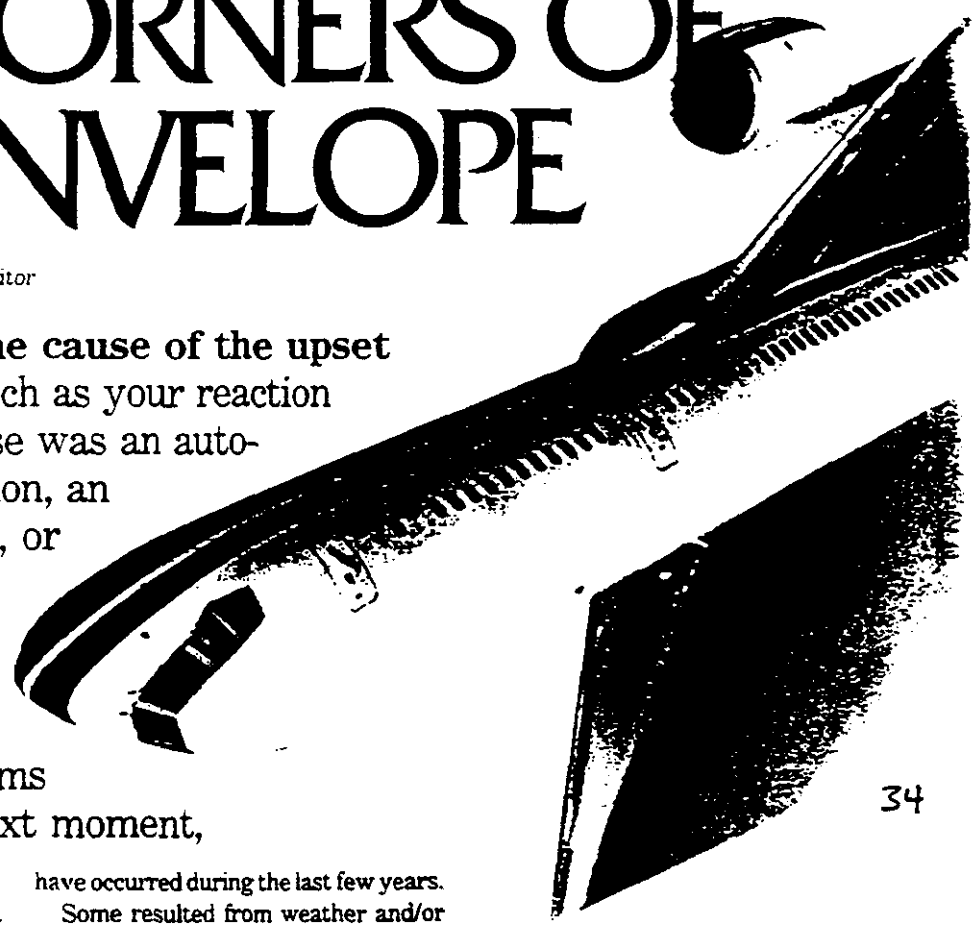
United Airlines is adding an Advanced Maneuvers Package to its flight training to help pilots avoid rare but life-threatening loss-of-control upsets and to make them more

COMFORTABLE IN THE CORNERS OF THE ENVELOPE

By Jan W. Steenblik, *Technical Editor*



In the short term, the cause of the upset may not matter as much as your reaction to it. Perhaps the cause was an autopilot or trim malfunction, an atmospheric condition, or the wake vortex from a much heavier airplane. The immediate reality is this: One moment the flight seems utterly normal; the next moment, your world has turned upside down.

Every year at the awards banquet during ALPA's annual Air Safety Forum, the Association's President points out, when presenting the ALPA Superior Airmanship Award to a well-deserving flight crew, that airline pilots sometimes are faced with emergency situations for which they have not been trained.

Recipients of the Superior Airmanship Award often have had to find their own solutions to unique problems when the required learning curve was extremely steep.

Luck helps, too.

For the unlucky, the outcome may be a *major* accident investigation, or worse.

Several airline accidents and incidents in the United States and abroad in which pilots have temporarily or permanently lost control of their aircraft have occurred during the last few years.

Some resulted from weather and/or mechanical problems that accident investigators found no pilot could reasonably be expected to handle—severe wind shear, a powerplant suddenly going into reverse thrust in flight, or an inflight structural or control system failure.

Other events have sparked debate about whether pilots could have avoided or minimized risk, damage, and injuries if they had reacted differently to the emergencies—pitch and/or roll upsets from trim or autopilot malfunctions; atmospheric turbulence or aircraft wake vortices; high-altitude, high-speed upsets; and low-speed, low-altitude engine failures.

Regardless of the outcome of that debate, accident investigation authorities have found a disturbing common denominator in some of these events—lack of adequate pilot training.

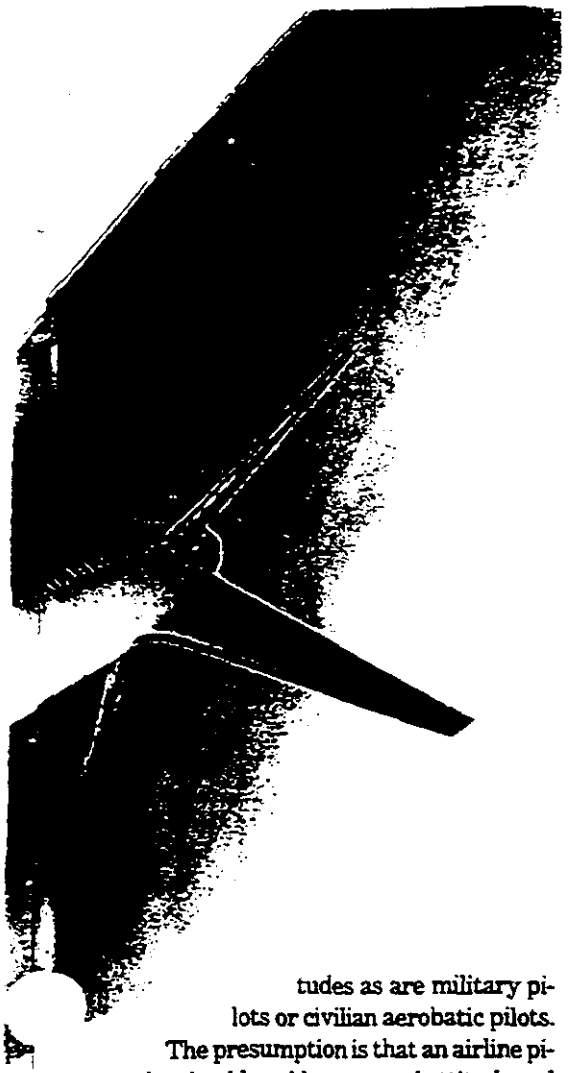
Consider these excerpts from NTSB reports of selected airline accident and incident reports from recent years:

- "... a pilot's reaction, in applying proper rudder pedal forces in response to an engine-out emergency, can become reflexive because of ... training and previous pilot experience. ...

"... the majority of engine-out training provided ... occurred near V_1 when the ... pitch attitude was low, which provided outside visual references, including a runway centerline. ...

"There was very little exposure in training to the potential errors [that] might occur in response to an engine failure after gear retraction." (Midwest Express DC-9, Sept. 6, 1985, Milwaukee)

- "Airline pilots are not periodically trained to recover from unusual atti-



tudes as are military pilots or civilian aerobatic pilots.

The presumption is that an airline pilot should avoid an unusual attitude and will never have a need to recover from one." (Air Transport International DC-8-63, Feb. 15, 1992, Toledo, Ohio)

- "...Contributing to the incident was a lack of pilot training specific to the recovery from high-altitude, high-speed upsets...." (China Airlines MD-11, Dec. 7, 1992, Northern Pacific)
- "NTSB recommends FAA... require operators to provide specific training for the recovery from high-altitude upsets, including those by stall warning." (China Eastern Airlines MD-11, April 1, 1993, Northern Pacific)

The learning curve

One airline has begun an innovative training program to flatten the required learning curve and reduce the importance of luck in escaping these events.

"A few years ago, after we started operating B-757s at John Wayne/Orange County Airport [SNA, in southern California], some of us started to worry about what would happen if we had an engine failure during the initial segment of climb," recalls Capt. Larry Walters, a standards captain for United Airlines' B-757/-767 fleet.

"The noise-abatement departure required rotating to a very high pitch angle—as high as 25 degrees.

"Like other airlines, our engine-out training focused primarily on the V_1 cut. We didn't train for a 'V_2 cut.' We started looking at ways to change our training to deal with this scenario and with other situations we were concerned about."

By March 1995, more than 400 UAL B-757/-767 pilots had gone through a new unit in transition training for that fleet—a program UAL calls the Advanced Maneuvers Package (AMP). UAL is developing and phasing in the new training in its other fleets as well.

The airline describes the AMP as "a collection of training maneuvers, exercises, and demonstrations that addresses a broad set of training issues not specifically dealt with in earlier programs."

The purpose of the AMP, Capt. Walters explains, is fourfold—to advance pilots' flight skills and knowledge, improve pilots' self-confidence, improve their confidence in the aircraft, and improve pilots' situational awareness.

"We're focusing on how to deal with a flight situation outside the normal flight envelope," explains Capt. Walters, "rather than on the cause. It doesn't matter so much whether you're in a roll upset because you flew into a wake vortex or a rotor—what matters is that you respond properly to recover."

Capt. Walters does not, and will not, fault pilots—of UAL or other airlines—who have come to grief in similar situations. Speaking, for example, of an accident that inspired one of the AMP scenarios, he hastens to express his sympathy and understanding of the dilemma the captain faced. "There, but for the grace of God, go I," he says.

But the purpose of the AMP is to learn from the fears and griefs of the past. Some of the maneuvers are specific to an aircraft type; others are more generic.

The B-757/-767 AMP currently involves about four hours of training time per flight crew, divided between classroom briefings and the full-motion flight simulator, and covers some 13 different maneuvers.

The maneuvers that focus on basic "stick-and-rudder" airmanship stress basic attitude flying, using the EADI as the primary instrument for recovery, and target pitch attitudes that are consistent among different scenarios.

"In many of our maneuvers—for example, for windshear recovery, GPWS, recovery from a full stall—our all-engines target pitch angle for this airplane is 15 degrees nose-up, and 12½ degrees single-engine," Capt. Walters explains.

"We leave the throttles, the speedbrake, the flaps, and the landing gear right where they are. It's important for pilots to know they can't save the situation with power or drag—you have to use *attitude*. You have to get the nose back where it's supposed to be."

Pilot response

Capt. Walters says pilot response to the advanced maneuvers training has been "overwhelmingly positive and enthusiastic. Pilots want this training," he stresses. "They're hungry for it.

"We've found they readily adapt to the training, regardless of their background, whether or not they have previous aerobatic experience. The advanced maneuvers package has greatly enhanced our pilots' skills, knowledge, and confidence in themselves and the airplane."

Capt. Walters adds that one unexpected benefit of the training is that it appears to transfer to other training.

"We were a little surprised at the apparent transferal of skills indicated by improvement in the typical pilot's ability to perform traditional maneuvers such as the V_1 cut and windshear recovery after being trained in the advanced maneuvers," he explains.

Asked if the need for the unusual attitude recovery training is primarily for pilots with no military flight training, Capt. Walters quickly replies, "Oh, no—we've found the need for this type of training cuts across all pilot backgrounds and all fleets."

Which means not just UAL's pilots.

Capt. Walters naturally feels UAL deserves to be recognized as the first airline to develop AMP training for its pilots—just as UAL was the first to develop windshear training and command/leadership/resource management (CLR) training, which came to be known as crew resource management

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(CRM) training in the rest of the airline industry.

But UAL has been working with the Air Transport Association's Training Committee to share what it's learned with other airlines. UAL has hosted not only ATA and ALPA Pilot Training Committee representatives but also FAA and NTSB representatives who have made the pilgrimage to Denver to see the training firsthand.

"What UAL's doing is very impressive," reports F/O Jim Ward (Comair), a member of ALPA's national Pilot Training Committee.

Stall warnings—false, and real

The simulator session begins with a false stall warning on takeoff.

"We stress the importance of not trying to abort the takeoff after rotation," says Capt. Walters. "The instructor gives the pilot a false stall warning at liftoff. We teach pilots to not raise the landing gear or change the flap setting but to fly the aircraft at the windshear recovery attitude until reaching sufficient altitude—based on the pilots' judgment—where they can sort out the cause of the warning. That way, if they actually do encounter a wind shear, they're already flying the correct procedure for that; if it's a false stall warning, no harm's done by flying the windshear recovery procedure."

At altitude (15,000 feet), pilots fly a full stall recovery with the aircraft in a clean configuration. To get into the stall, they hold full up elevator for several seconds but do not trim to less than stickshaker speed.

"This is a maneuver you could fly only once in a 727," Capt. Walters grins, "but in the 757/767, you have control authority in all three axes, even in a deep stall. We demonstrate the aileron authority. We also show them that adding full power will not get them out of the stall.

"You have to push the nose over a lot more to break the stall and stop the stickshaker than you do to recover from an incipient stall."

Pitch and roll upsets

Recoveries from high-bank upsets and high-pitch upsets both involve rolling maneuvers, so the AMP training includes warming up with "rolls and returns" at 15,000 feet and maneuvering speed.

The syllabus calls for performing rolls to 90-, 120-, and 135-degree banks and returns. The instructor discusses the importance of making large, smooth control inputs; of maintaining G-load awareness; of noticing the nose fall through the horizon at high bank angles; and of using rudder at low airspeed when rolling back to the upright attitude.

If you've been living a clean life up to this point, you may not have ever moved the flight controls to the stops except during preflight control checks. You pride yourself on rarely even rippling the passengers' coffee—*you're* the sultan of smooth, gentle, frequent control inputs.

"We teach the *difference* between *full-throw* and *violent* control movements," says Capt. Walters. "Most line pilots are not used to making full-throw control inputs.

"We also stress the importance of using coordinated controls throughout the roll maneuvers. When I say *coordinated*, I don't necessarily mean with the ball absolutely centered—I mean using rudder with aileron to help the roll rate."

The instructor emphasizes not pulling back on the elevator before rolling wings-level. "This is the most important single thing for a pilot to learn from this exercise—to not pull until after rolling upright again," says Capt. Walters.

Upset recoveries

Then it's on to upset recoveries:

The instructor causes the simulator to induce a roll to 135 degrees of bank; the pilot recovers by opposing the roll with full aileron and rudder to roll upright, then pulls the nose up to the target pitch of 15 degrees nose up.

In the high-pitch upset, the instructor causes the simulator to pitch the nose up to about 40 degrees. The pilot, finding that pushing full forward on the yoke won't stop the pitch-up, is supposed to roll to 60–90 degrees of bank —using the bank to lower the pitch — and to roll level again after the nose falls through the horizon.

The "V_2 cut"

One of the specific concerns that eventually led UAL to create the AMP—i.e., the noise-abatement departure at SNA—is germane to other cases in

"Step and roll toward the sky pointer," says Capt. Larry Walters, showing how United is now training B-757/767 pilots to respond to roll upsets.

which pilots must deal with an engine failure at low altitude and low airspeed—either just after takeoff, or during a go-around.

"We talk about the effect of previous training for V_1 cuts on pilots' immediate reaction," Capt. Walters explains. "During a V_1 cut, you're still on the ground in a level attitude. You have obvious visual clues—the major one being the runway centerline—to show you which way the nose is yawing. And on the ground, you have to control your heading with rudder. So pilots are used to getting on the rudder right away in a V_1 cut.

"In the 'V_2 cut,' the greatest danger is loss of airspeed. The second is pushing the wrong rudder pedal—you can get yourself into a situation from which you can't recover.

"So we stress the importance of going through the correct order of immediate inputs for recovery:

"(1) immediately lower the nose to 12½ degrees pitch attitude;

"(2) level the wings using aileron only; and

"(3) apply correct rudder—that is, the one on the same side as the low side of the yoke—to maintain wings level while rolling the yoke back to neutral aileron.

"Then you stop the climb, using the attitude indicator and cross-checking

the IVSI, to gain speed; steer to the proper heading; and then continue with the regular engine-failure-on-takeoff profile."

One might ask if the noise-abatement departure procedure at Orange County isn't a bad case of the tail wagging the dog: Should any airline allow itself to be bullied into flying a procedure that reduces the margin of safety so much that the airline feels compelled to develop special training to reduce the added risk?

That issue aside for the moment, at least it is to UAL's credit that the airline has made the effort to develop the new procedure that will handle an engine failure at SNA, or anywhere else, and train its pilots to fly it.

"The instructor emphasizes not pulling back on the elevator before rolling wings-level."

Autopilot pitfalls

Two of the maneuvers involve demonstrations of situations involving the autopilot:

The first is a demonstration of single-engine minimum control speed (V_{mc}) on autopilot. The instructor stresses the importance of maintaining awareness of airspeed and trim with one engine failed. At 7,500 feet, flaps 5, the pilot trims the rudder for maneuvering speed and reduces thrust to allow the airspeed to bleed off. The exercise soon demonstrates the inability of the autopilot to counter the adverse yaw with high thrust and low airspeed. The pilot, says Capt. Walters, gains a better understanding of how difficult regaining airspeed without losing altitude is in this situation.

The other autopilot demonstration is a single-engine, autocoupled ILS approach and miss in 300 and 1.

"We teach our pilots to make a single-engine, hand-flown approach to Category II minimums," Capt. Walters explains. "FAA requires it on a checkride. But it isn't always the best way to fly. We teach pilots a *proper* way to fly a single-engine *autocoupled* approach."

The instructor talks about past training and checking practices. He then discusses the importance of

- using only one autopilot and trimming the rudder;
- maintaining awareness of airspeed (no autothrottle), and
- following through on the controls and being ready to hand-fly.

The instructor demonstrates the missed-approach technique, discussing when to disengage the autopilot and how to fly the procedure.

"After the China Airlines A300 accident at Nagoya [in April 1994]," Capt. Walters adds, "United found that, on the B-757, pitch inputs to the yoke don't override the autopilot. The moral is, Don't try to hand-fly with the autopilot engaged."

Other aircraft systems problems

The B-757/-767 AMP also includes a handful of other scenarios that deal with potential problems with aircraft systems.

"We fail both engines at high altitude," Capt. Walters continues. "You lose both generators and revert to standby instruments. The cabin altitude rises; eventually, you get a cabin altitude warning; the [supplemental oxygen] masks drop.

"One engine might relight, which can cause a sudden yaw and roll.

"We teach what a runaway stabilizer would feel like," he says, "how to manage an approach and landing [with that problem]."

Another landing problem that pilots confront in the AMP is forgetting to stow the speedbrake after a steep descent into the traffic pattern.

"We're not supposed to use the speedbrake below 1,000 feet AGL," Capt. Walters explains. "If you land with the speedbrake deployed, you'll get a tailstrike, because you have to pitch up more to arrest the sink rate at touchdown.

"But we have had pilots do that because they were given a slam-dunk approach.

"Our procedure for maximizing the descent angle is to configure the airplane with gear down, flaps 30, and speedbrake deployed, and fly a target airspeed. Sometimes pilots get distracted and forget to close the speedbrake before landing.

"We show them what the descent looks like with the speedbrake still out to help them recognize the situation if they get into it.

"Of course," he says, "we would like pilots to *plan* better so they don't *have* to use the speedbrake for descent; but in the real world, it does happen from time to time."

Appropriateness of simulators

Acknowledging that even the most sophisticated airline flight simulators cannot fully duplicate the G-forces—and related factors, such as unsecured objects and dirt flying around the cockpit—often associated with actual upsets, Capt. Walters reports that UAL's flight simulators have proven to be "very effective" as training devices for the advanced maneuvers package.

Their main advantage—besides the fact that a wrong move in the simulator won't have the same consequences as it would in the airplane—is that the engineers and computer programmers who developed the software for the maneuvers managed to develop very realistic entries into the upsets.

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"Evolutionary" pilot training

United represents AMP as an "evolutionary," rather than "revolutionary" change in pilot training. That may be true, but it does not diminish the profound difference that AMP extends between old and new ways of approaching the goal of training.

The new thinking says, it is not enough to train pilots to avoid wind shear, deep stalls, upsets, and other hazardous situations. They must be prepared for the times, albeit rare, when they find themselves in a corner of the flight envelope—despite their best efforts to avoid it—and only they can turn the world right-side-up again.

ALPA's national Pilot Training Committee supports the AMP concept and suggests that, to take full advantage of this training concept, industry and government establish a task force similar to the Windshear Training Program to examine issues such as the adequacy of simulator aerodynamic performance packages and industry consensus on upset recovery techniques.