FLIGHT SAFETY FOUNDATION
Accident Prevention
Vol. 52 No. 1 For Everyone Concerned with the Safety of Flight January 1995

Stall and Improper Recovery During ILS Approach Result in Commuter Airplane's Uncontrolled Collision with Terrain

The captain elected to bleed off the aircraft's excess speed by reducing power to idle thrust on both of the turboprop engines during the coupled approach. He failed to monitor the instruments and when the stick shaker activated, the captain was surprised. He called for retraction of the flaps and pulled back the flight controls, fighting the stick shaker.

Editorial Staff Report

The crash of a Jetstream Aircraft Ltd. Jetstream J-4101 has resulted in recommendations by the U.S. National Transportation Safety Board (NTSB) to the U.S. Federal Aviation Administration (FAA) regarding training programs for pilots operating under Federal Aviation Regulations (FARs) Part 135 that place more emphasis on stall warning recognition and recovery techniques, and that train pilots to proficiency for both high-speed and coupled approach profiles. The two pilots, flight attendant and two passengers were fatally injured in the Jan. 7, 1994, accident. Three passengers survived.

The crew of the twin-engine turboprop aircraft was conducting an instrument landing system (ILS) approach in instrument meteorological conditions (IMC) at night to the Port Columbus International Airport (CMH), Ohio, U.S. Moderate rime/mixed icing had been reported by the pilots of several aircraft in the Columbus area. To minimize their exposure to icing, the captain of the accident flight decided to make a rapid descent from altitude, according to the NTSB accident report. When air traffic control (ATC) instructed the crew to slow the airplane to 170 knots, the power was reduced to flight idle, the report said.

The NTSB report said that the airplane crossed the outer marker at 178 knots, which was above the maximum landing gear and flap extension airspeeds for the Jetstream. The crew flew an autopilot-coupled approach, and did not extend the landing gear and the flaps until the aircraft was three miles (five kilometers) from the runway threshold. As the airplane decelerated with the power at flight idle, the autopilot continued to trim the airplane nose-up to remain on the glideslope. The airspeed continued decreasing, and the stick shaker activated and pitched the nose down. The captain then pulled back on the controls, fighting the stick pusher. The airplane remained in an aerodynamic stall and crashed into a warehouse 1.2 miles (1.9 kilometers) short of the runway.

The NTSB said that the probable causes of the accident were:

> "(1) An aerodynamic stall that occurred when the [flight crew] allowed the airspeed to decay to stall speed following a very poorly planned and executed approach characterized by an absence of procedural discipline;
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> "(2) Improper pilot response to the stall warning, including failure to advance the power levers to maximum, and inappropriately raising the flaps;
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> "(3) Flight crew inexperience in glass-cockpit automated aircraft, aircraft type, and in seat position, a situation

exacerbated by a side letter of agreement between the company and its pilots;

"(4) The company's failure to provide adequate stabilized approach criteria, and the FAA's failure to require such criteria;

"(5) The company's failure to provide adequate crew resource management training, and the FAA's failure to require such training; and,

"(6) The unavailability of suitable training simulators that precluded fully effective [flight crew] training."

The Jetstream J-4101, owned by Atlantic Coast Airlines Inc. (ACA) and operated by United Express as Blue Ridge Flight 291, was operated as a scheduled passenger flight from Washington Dulles International Airport (IAD), near Herndon, Virginia, U.S., to CMH. While en route at 14,000 feet (4,270 meters), the crew was told by the Indianapolis FAA air route traffic control center (ARTCC) that the pilot of another aircraft had reported moderate rime icing at 14,000 feet, and that aircraft had climbed to 15,000 feet (4,575 meters) and was on top of the clouds. The crew of Flight 291 then asked for and was given approval to climb to 15,000 feet. The captain (the pilot flying) told the first officer, "Since we gotta descend down in it [the icing conditions] … get it up in the clear and keep her dry as long as possible," the report said.

The first officer briefed the captain on the most recent automated terminal information service (ATIS) for CMH, which indicated that ILS approaches were being conducted to Runways 28L and 28R. The weather reported on the ATIS was 1,100 feet (335 meters) overcast, visibility six miles (9.6 kilometers) in light snow and fog, temperature 23 degrees F (-5 degrees C), dewpoint 22 degrees F (-6 degrees C), wind 330 degrees at four knots. When the first officer briefed the captain on the weather, he told the captain that the ceiling was 11,000 feet (3,355 meters) overcast, instead of the 1,100 feet that was actually reported, the report said.

At about 2310 local time, the crew contacted CMH approach control and reported that they were descending to an assigned altitude of 11,000 feet. Flight 291 was assigned a 285-degree heading to intercept the ILS to Runway 28L, and was cleared to descend to 10,000 feet (3,050 meters).

Five minutes later, the approach controller advised the crew of updated weather at CMH: measured ceiling 800 feet (244 meters) overcast, visibility 2.5 miles (four kilometers) in light snow and fog, wind 300 degrees at four knots.

At 2316:28, Flight 291 was 10 miles (16 kilometers) from the outer marker, and was cleared for the ILS approach to Runway 28L. At this point, the Jetstream's airspeed was 248 knots. About one minute later, the controller told Flight 291 to reduce speed to 170 knots and to contact CMH tower. The crew acknowledged, and the power was reduced to flight idle. The airplane crossed the outer marker at 178 knots, with the landing gear up and the flaps retracted. When the airplane had slowed to the maximum flaps extension speed of 170 knots, the captain called for the flaps to be extended to 15 degrees and for the landing gear to be lowered. The first officer responded that the flaps were set at 15 degrees, the landing gear was down and the airplane was three miles (4.8 kilometers) from the runway.

The crew was flying an autopilot-coupled approach, but the autopilot did not have autothrottles. With the power at flight idle, the autopilot continued to trim the nose up to remain on the glideslope. The airplane decelerated to 104 knots (26 knots below the minimum approach speed specified by the airline's procedures) and the stick shaker activated. "Immediately after the stick shaker warning, the autopilot disconnected, and the airplane started to pitch down at approximately three degrees per second," the report said. "Warning tones (presumably from the autopilot disconnect) started about 0.6 of a second after stick shaker. There was no dialogue heard on the CVR [cockpit voice recorder] until the stick shaker deactivated."

The crew was flying an autopilot-coupled approach, but the autopilot did not have autothrottles.

The captain was apparently surprised by what had happened, and asked the first officer, "What did you do?" The first officer responded, "I didn't do nothing," the report said.

"FDR [flight data recorder] data indicate that the captain applied nose-up elevator without adding power," the report said. "The airplane pitched up in response to the nose-up elevator command, but the airspeed was too low to arrest the descent rate, and the AOA [angle of attack] increased to the point that the stick pusher activated. The stick pusher quickly moved the elevator nose-down, which caused the airplane to pitch down, preventing a stall. However, FDR data indicate that the captain fought the stick pusher with large aft (nose-up elevator) control column inputs."

Some power was applied to both engines, and the engine torque reached 50 percent, 10 seconds after the stick shaker first activated. When the stick pusher activated for a second time, the captain commanded the first officer to fully retract the flaps. "The stall speed for zero flaps is about 11 knots above the [flaps-15-degrees] stall speed," the report said. "Thus, the captain's action of raising the flaps and the failure to apply maximum power placed the airplane within the aerodynamic stall region."

The airplane had descended below the glideslope, and continued descending until it collided with trees and came to rest upright in a storage warehouse, 1.2 miles east of the runway. "Ground and tree impact marks," the report said, "were consistent with the airplane being in a relatively high nose-up [22 degrees], and near wings-level attitude when it hit the trees. An intense postcrash fire consumed most of the airplane and the building … . Three of the five passengers were able to exit the airplane before the post-crash fire enveloped the fuselage. Two of them sustained minor injuries, while the third reported no injuries."

Postmortem examinations of the flight crew and two passengers were conducted. The report said, "Autopsy information indicated that the captain died as a result of severe blunt force traumatic injury to his head and thorax, followed by thermal damage during the postcrash fire. The first officer died as a result of severe blunt force trauma to his neck and thorax followed by thermal damage, and soot was found in his esophagus. The flight attendant died from traumatic injuries to her left side followed by thermal damage, and soot was found in her trachea. The [two] passengers … died from smoke and soot inhalation, followed by thermal injuries."

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A passenger survivor said that one of the passenger nonsurvivors had assisted in attempting to open an emergency exit, but they were unsuccessful. Then, the report said, the nonsurvivor became involved in "looking for something on the floor. ... The investigation did not disclose what had captured the nonsurviving passenger's attention, nor why he failed to exit the airplane."

The report said that when investigators examined the wreckage, they found "no evidence of an in-flight fire. The airplane was consumed by postcrash fire, and no seats, interior furnishings, fuselage walls or ceiling remained. Cockpit instrument panels, control pedestal and overhead panels were heavily damaged by impact and postcrash fire. … The airplane's value was estimated at [US]$7 million."

Investigators reviewed the equipment and maintenance history of the accident airplane, which had been acquired by ACA as a new airplane in July 1993. The report said, "It was certificated as a J-4101 in the [United States] as a transport-category airplane and was approved for operation in icing conditions … . The airplane was equipped with an autopilot, ground-proximity warning system (GPWS), CVR and a digital flight data recorder (DFDR). The airplane had been maintained in accordance with an FAA-approved block inspection program … . All periodic and nonroutine inspections had been completed. There were no 'open' discrepancies, and no problems were reported on the last three flights."

The GPWS on the accident airplane was evaluated to determine whether it had given the proper warnings during the accident sequence. "At radio altitudes between 150 and 925 feet [45.7 and 282 meters], a GPWS 'glideslope' callout will be heard when the airplane is on an ILS approach and descends approximately 1.3 dots below the glideslope," the report said. "At 2320:50.2, linearly interpolated FDR data show that the radio altitude on the accident flight was approximately 339 feet [104.4 meters] as the ILS glideslope deviation reached approximately 1.3 dots low. However, the stick shaker started less than one second later, which would inhibit all GPWS callouts. The glideslope callout was not heard on the CVR."

Just before the stick shaker activated for the third time during Flight 291's approach, one abbreviated "pull" callout was heard from the GPWS. The report said, "According to the GPWS manufacturer, after the warning envelope has been entered, the GPWC [ground-proximity warning computer] will start/stop the voice callout rapidly with stick shaker deactivation/activation. … The CVR indicated that the 'pull' callout … by the GPWS is consistent with an abbreviated 'pull up' when the stick shaker activated for the third time. … The sound of [the] stick shaker continued, and no other GPWS callouts were heard … ."

ACA's Jetstream training was conducted under contract to a former British Aerospace training division, which had been sold to Reflectone Training Center (RTC) in Sterling, Virginia. Initial ground training was 64 hours, including four two-hour cockpit procedure training sessions that used paper/photographs of the Jetstream 4101 cockpit to train the pilots in cockpit orientation, profiles, flow patterns and checklist practice.

At the time that the accident pilots received their training,the report said that they each had "attended a one-hour class ... that addressed previous accidents/incidents, human factors/consideration, and the [U.S.] National Aeronautics and Space Administration [Aviation Safety Reporting System (ASRS)]. All human factors topics, including crew resource management (CRM), were taught within this one-hour class ... ."

Pilots received 10 hours of flight training.

The report said, "New-hire pilots for ACA contract with RTC for their training and pay the costs associated with the training directly to RTC."

The background and qualifications of the crew were reviewed. The captain, age 35, held a U.S. airline transport pilot (ATP) certificate with ratings and limitations for airplane multi-engine land, Jetstream 4100 and commercial pilot privileges for single-engine land airplanes. He also held a flight instructor certificate with ratings and limitations for airplane single- and multi-engine, instrument airplane. At the time of the accident, he had 3,660 hours total flight time, of which 1,373 hours were in turboprop airplanes. He had 192 hours in the J-4101, of which approximately 151 hours were as pilot-in-command. The captain held a current FAA first-class medical certification with no limitations.

The captain, a college graduate with a degree in urban systems, had worked as a computer programmer. He began his aviation training in 1985, and was employed as a flight instructor in 1987. The report said that a check of FAA records showed that the pilot "failed in his first attempt to obtain his flight instructor certificate because he failed both the flight and oral portions of the test because of 'analysis and performance of flight manuevers.'" Less than a month later on Nov. 8, 1987, he passed both portions of the test and received his flight instructor certificate.

During the next four years, he worked periodically as a charter pilot on Cessna 206 aircraft. [There are several variants of the single-engine Cessna 206, which is powered with a 300-horsepower or 285-horsepower reciprocating engine. The aircraft can be configured for cargo or for up to five passengers, and has a typical cruising speed of about 140 knots.]

[The captain] had 192 hours in the J-4101, of which approximately 151 hours were as pilot-in-command.

RTC instructors described the captain as an average student, who was hired in 1992 as a first officer on the Jetstream J-3201 by ACA. He failed his initial second-in-command (SIC) simulator check because of difficulties with instrument approaches and holding procedures. He received 3.0 hours additional training and successfully completed on May 7, 1992, a second simulator check.

In September 1993, the captain entered upgrade/transition training for the J-4101. The report said that this was the first time he had flown a glass-cockpit airplane, and he failed his initial type-rating checkride for the J-4101 "because of difficulties with instrument approaches, emergency procedures and judgment."

The report added: "The [FAA] examiner who administered the failed [checkride] reported that the captain entered a pilot-induced oscillation while conducting an ILS approach on standby instruments during which the stick shaker activated. He observed that the captain was 'unusually nervous' during the [checkride]."

The captain received about 2.5 hours additional training and successfully completed a second checkride administered by the same FAA examiner. He was assigned in October 1993 as a reserve captain after completing 21.2 hours and 11 landings during his initial operating experience (IOE), less than 90 days before the accident flight.

As a reserve captain on "B" status, he was required to report for duty within six hours of notification. He was notified at 0200 on January 7 that he was being elevated to "A" status, which required him to report for duty within 90 minutes of notification. He left by taxi early that morning from his home in Stamford, Connecticut, to connect with a flight from Stamford to Washington. No witnesses were located who could describe the pilot's activities while at the hotel or to confirm that he had had adequate rest on the night of January 6.

Investigators reviewed a list of all the flights made by the captain in the 90 days before the accident, and the time of day the flights were made. During that 90-day period, the report said,"The captain flew a total of 24 approaches to 10 airports. Columbus, Ohio, was not one of these airports. One approach was flown when frozen precipitation was reported with temperatures below freezing. None of the 24 approaches were performed during darkness, with frozen precipitation, in instrument meteorological conditions."

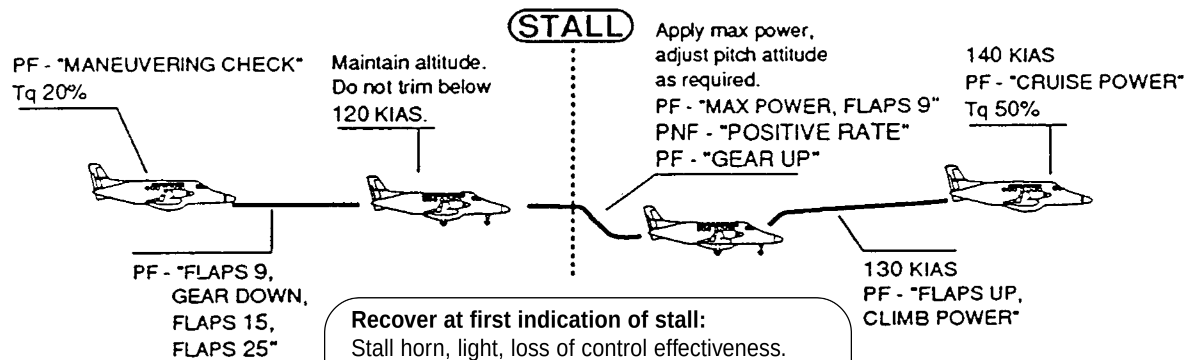
The first officer, age 29, held a commercial pilot certificate with ratings and limitations for airplane single- and multi-engine land and instrument airplane. He also held a flight instructor certificate with ratings and limitations for airplane single- and multi-engine and instrument airplane. At the time of the accident, his total flight time was 2,433 hours, of which 110 hours were in turboprop airplanes. He had 32 hours in the J-4101. The first officer held an FAA first-class medical certificate that was valid for second-class medical certificate privileges at the time of the accident. There were no limitations on the certificate.

The first officer, a college graduate with a degree in aviation business, began his aviation career in 1983, then attended college and worked as a carpenter until 1990, when he began working as a flight instructor. For the next two years, he worked primarily as a flight instructor until he was hired as a customer service representative by ACA in 1993.

Four months after being hired, he entered training for the J-4101. He successfully completed the SIC flight check and the report said, "RTC's instructors described him as an above-average student." Less than one month before the accident, he completed 11 hours and 10 landings of IOE training, and was assigned as a reserve first officer on the J-4101.

Investigators reviewed the weather briefing provided to the crew of the accident flight. The report said that the briefing contained an AIRMET (see definition below) "for occasional: IFR [instrument flight rules] conditions in precipitation and/

Approach to Stall — Landing Configuration
(From Atlantic Coast Airlines Training Manual)



Recover at first indication of stall:
Stall horn, light, loss of control effectiveness.
Abandon maneuver if
- No horn/light 5 knots below calculated warning speed and/or
- No pusher 2 knots below calculated speed and/or
- No pusher 2 knots below illumination of stall light

KIAS = Knots indicated air speed
PF = Pilot flying
PNF = Pilot not flying
Tq = Engine torque

Source: U.S. National Transportation Safety Board

Figure 1

or fog; moderate turbulence between 8,000 and 20,000 feet [2,440 and 6,100 meters] with isolated severe turbulence; and light to moderate rime/mixed icing in clouds and precipitation between 2,000 and 19,000 feet [610 and 5,795 meters]. There were no SIGMETs [see definition below] in effect for the time and location of the accident."

[AIRMET (airman's meteorological information) — In-flight weather advisories issued only to amend the area forecast concerning weather phenomena that are of operational interest to all aircraft and potentially hazardous to aircraft having limited capability because of lack of equipment, instrumentation or pilot qualifications. AIRMETs concern weather of less severity than that covered by SIGMETs or Convective SIGMETs. AIRMETS cover moderate icing, moderate turbulence or visibility less than three miles (five kilometers), and extensive mountain obscurement.]

[SIGMET (significant meteorological information) — A weather advisory issued concerning weather significant to the safety of all aircraft. SIGMET advisories cover severe and extreme turbulence, severe icing and widespread dust or sandstorms that reduce visibility to less than three miles.]

The U.S. National Weather Service terminal weather forecast for CMH provided to the crew before departure was for a ceiling of 800 feet overcast, visibility more than six miles (9.6 kilometers), winds 330 degrees at eight knots; occasional ceiling 1,200 feet (366 meters) overcast, visibility four miles (6.4 kilometers) in light snow and fog. The crew was also provided with a pilot report of moderate rime icing at 4,000 feet (1,220 meters) in the Columbus area.

Before departing IAD on the accident flight, the captain discussed the weather with the first officer of an ACA flight that had just landed. "The first officer stated that the captain appeared normal in all respects, that his demeanor was calm and professional and that he was 'concerned' about the weather," said the report.

Investigators interviewed the pilot of a Hawker Siddeley HS-1000 business jet that had landed on Runway 28L at CMH approximately one minute before the crash of Flight 291. The report said that the Hawker Siddeley pilot "reported that during descent, the airplane entered clouds between 8,000 and 7,000 feet [2,440 and 2,135 meters]. He said that he encountered light freezing drizzle, light freezing rain and ice fog, and that the airplane accumulated rime ice during the approach. The airplane has a fluid anti-ice system. He estimated a rate of accumulation of 1/4 inch for every five minutes of flight time. Because of the ice, he added 10 knots to his [approach] airspeed. He said that there were no significant winds during the approach. The pilot stated that he broke out of the clouds at 500 feet [152 meters] and that the ILS approach was normal with no warning flags. He reported no ice accumulation on the leading edge surfaces of the wing; however, during a postflight inspection he noted 1/4 to 1/2 inch of ice on the nose of the airplane."

When reviewing the CVR on Flight 291, the report said that investigators found that "the flight crew was aware they were accumulating ice during their descent for the approach and that they used the deice system to clear ice from the wings about seven minutes prior to impact. They discussed the accumulation of a small amount of rime ice on the wings before using the 'boots' to clear it off. About 35 seconds after boot activation, the first officer stated, '... little rime it never took nothing off this side here,' to which the captain agreed. The captain appropriately elected to conduct a 'flaps 25 ice AOA on' approach and landing. The [flight crew] should not have experienced any significant difficulties with the weather conditions during the approach and landing at CMH."

The NTSB reviewed the procedures of the flight crew during the approach. "The evidence indicates that the captain of Flight 291 followed company procedures until the point at which he initiated the ILS approach to Runway 28L at CMH," the report said. "However, he did not slow the airplane in sufficient time to be able to configure the airplane in a timely manner. After reducing power to flight idle to slow to approach speed, the pilots failed to monitor airspeed, and the captain failed to add power as the airspeed approached 130 knots. The airspeed decreased through the minimum of 130 knots for the approach until the stick shaker activated because the airplane was approaching stall speed. The captain failed to execute a proper stall recovery, and the airplane descended into the ground. Consequently, the investigation focused on why the flight crew failed to monitor the airspeed and why the stall recovery was not successful."

Investigators examined ACA company manuals and found that the manuals did not contain a definition for a stabilized approach. Nevertheless, said the report, "The ACA training manual did depict an approved ILS approach procedure for the J-4101. The procedure depicts the airplane with engine torque at 30 percent and airspeed at 180 knots before reaching the initial approach fix (IAF) and after the approach checklist is complete. It suggests a speed of 160 knots during the initial procedure with no flaps. … The procedure depicts the airplane as configured with the landing gear down and flaps set to 15 degrees before the final approach fix/point (FAF/FAP). At the FAF/FAP, the flaps should be lowered to 25 degrees with a minimum speed of 130 knots and engine torque at 30 percent."

The report noted: "The accident flight attained neither the configuration nor the other guidelines specified in the chart. … The airplane crossed [the outer marker] at 178 knots with the airplane in a clean (flaps retracted and gear up) configuration. The high speed prevented the crew from lowering the flaps to nine degrees upon intercepting the glideslope and lowering the landing gear at the LOM [the locator outer marker]. This was contrary to ACA procedures and constituted an unstabilized approach."

The report continued: "In addition, power was reduced to flight idle in a belated attempt to lower the airspeed while descending on the glideslope. The low power setting resulted in a rapid deceleration, and without adequate monitoring by the crew, the airspeed decreased below the 130 knots minimum required speed and below the 112 knots reference speed. Those speeds were based on the assumption that the flaps would have been lowered to 25 degrees, rather than the 15 degrees of flaps that was actually achieved."

The NTSB tried to determine why the captain commanded the flaps to be fully retracted when the airplane stalled.

Investigators also found that the ACA training manual did not have an approved high-speed approach profile for the J-4101. "However, the training manual does contain a [high-speed] ILS/VFR approach published for the J-3201," the report said. "It states that the airplane should be slowed to 160 knots approximately three nautical miles from the point where the descent is initiated, as opposed to 130 knots for the standard ILS approach. … The captain's flying experience during the preceding year was on the J-3201 as a first officer. As such, the [NTSB] believes that the captain would have been familiar with [high-speed] approaches to the FAF. Although it was not an approved procedure on the J-4101, it is possible that the captain reverted to a modified J-3201 procedure to penetrate the icing layers. The investigation determined that J-4101 pilots do fly [high-speed] approaches for air traffic control considerations. However, this procedure is neither published nor approved."

The report added: "The ILS profile depicted in the flight manual also contained a caution that, 'If approach not stabilized by 1,000 feet [3,050 meters] HAA [height above airport] IMC or 500 feet HAA VMC [visual meteorological conditions] — go around.' Other than being established on the localizer and glideslope, none of the depicted stabilized approach criteria regarding airspeed and configuration were met when the airplane passed through 1,000 feet HAA in IMC. The captain did not begin to configure the airplane for landing until 48 seconds after crossing the ... outer marker. At that time, the position of the airplane was about three miles from the approach end of Runway 28L. The final landing checklist was not completed until the airplane was about 600 feet [183 meters] HAA, and the airplane was not configured for landing until that time."

The NTSB tried to determine why the captain commanded the flaps to be fully retracted when the airplane stalled. The report said, “The initial response of the J-4101 flying pilot for missed approaches, [go-arounds] and all approaches to stall in cruise, takeoff or landing configuration is maximum power, flaps nine degrees. In contrast to the approved procedure, about one second after stick pusher activation, the captain called for ‘flaps up.’ … The investigation revealed no procedure in either the J-3201 or the J-4101 in which stall recoveries or go-around procedures would require a flaps-up response. … The delayed and insufficient power application revealed by the FDR is inconsistent with the stall recovery procedure.”

Investigators considered the possibility that the captain could have believed he was experiencing a tailplane stall from icing. “Such confusion and possible misidentification of the problem,” the report said, “could have prevented the captain from accomplishing the proper stall recovery procedure. However, the [NTSB] discounted tailplane stall due to ice accretion, and the captain’s actions as being related to an attempt to recover from tailplane stall … .”

“Although it is difficult to explain how an air transport pilot could not respond appropriately to a stick shaker, it is apparent that at that point in flight, both the captain and the first officer were unaware of fundamental parameters and unable to anticipate the airplane’s flightpath.”

In reviewing the actions of the first officer during the approach, the report said: “The first officer was confronted with an increased workload for several reasons: the delay by the captain to configure the airplane for landing; tasks associated with checklist completion; and interaction with the captain. These activities sufficiently distracted the inexperienced first officer and prevented him from maintaining awareness of the deteriorating progress of the flight. The [NTSB] believes that the first officer raised the flaps as a direct response to the captain’s command, without considering the appropriateness of such an action.”

The report said that investigators examined the operation of the stall warning system on the accident airplane, and found that the stick shaker “activated at the proper wing AOA, but at a speed that was about seven knots higher (104.5 knots) than the stall speed obtained from the AFM [aircraft flight manual] (97.5 knots) for the existing conditions. The comparison of flight test data to accident data showed that the accident airplane’s performance was consistent with reduced aerodynamic lift of the wing due to ice accretion and to deceleration greater than that used to determine the certification stall speeds. The [NTSB] believes that the stall warning system operated correctly and gave an appropriate warning of impending stall. … Prompt application of power and a small aircraft-nose-down elevator deflection would have resulted in a timely recovery from the [low-speed] situation, without activation of the stick pusher.”

In assessing the skills of the flight crew, the report concluded: “The evidence suggests that each crewmember possessed unique deficiencies that affected his performance during the flight. The [NTSB] believes that these deficiencies, alone or in combination, likely contributed to the errors noted. These include the captain’s documented history of poor execution of precision instrument approaches; inexperience in nighttime, icing and restricted visibility conditions in the J-4100; inexperience with [autopilot-coupled] approaches and inexperience as a PIC. The first officer, who was considered an [above-average] pilot, nevertheless, was inexperienced as a first officer in ... Part 135 operations and inexperienced in the J-4100.”

Investigators reviewed the training received by both the captain and the first officer. The report said, “At the time of the accident, there was no J-4101 simulator available for training anywhere in the world. … [All flight] training, at the time of the accident, was accomplished in the airplane. Pilots interviewed stated that the flight training was excellent. The company check airmen interviewed stated that the transition during IOE was easier, since pilots had actually flown the airplane. None of the pilots interviewed indicated that abnormal or emergency procedures that were simulated in the airplane resulted in a poor learning situation or lack of knowledge transfer. Nevertheless, the [NTSB] believes that the lack of a simulator, specifically designed for the J-4101 airplane, limits a pilot’s training and subsequent ability to perform certain procedures that can only be safely practiced in a simulator. For example, stick shaker activation during instrument approaches would not be a safe practice during training flights in the actual airplane.”

The report added: “When the stick shaker alerted, the CVR established that neither [pilot] recognized that the airplane was about to stall. They failed to focus on airspeed, after the stick shaker alerted, and neither commented on nor displayed a recognition of the airplane’s precarious airspeed situation. The captain’s vacillating calls for flap retraction further illustrate his unawareness of the airspeed and the meaning of the stick shaker. Although it is difficult to explain how an air transport pilot could not respond appropriately to a stick shaker, it is apparent that at that point in flight, both the captain and the first officer were unaware of fundamental parameters and unable to anticipate the airplane’s flightpath. Thus, they were ‘behind the airplane’ ... .”

The cockpit of the J-4101 incorporates an electronic flight instrument system (EFIS), which required ACA pilots transitioning to this airplane to learn a new concept of instrumentation.

"The investigation revealed no pilot comments regarding difficulty in flying or interpreting the EFIS system installed on the J-4101 airplane, and no comments that the captain or the first officer involved in the accident were deficient in instrument skills using the EFIS system," the report said. "However, both pilots were inexperienced in the new airplane and failed to scan the instruments properly during the high workload of the accident flight."

The report said that the investigation was unable to eliminate the crew's inexperience with EFIS as a "potentially adverse influence on their performance." It noted that they had considerably more experience with electromechanical instrumentation, and their lack of experience with a digital format might have hindered their ability to anticpate trends in the airspeed.

Investigators also examined the captain's use of the autopilot. The report concluded: "An interview with another ACA [co-pilot], who had flown with the captain for 15 days in December 1993, indicated that the captain frequently liked to couple the airplane to the autopilot, on approach, rather than fly the airplane manually. A review of the captain's records indicated that the two failed checkrides (SIC on the J-3201 and PIC on the J-4101) were, in part, due to unsatisfactory performance on approaches. On subsequent rechecks, he demonstrated satisfactory proficiency after retraining. The [NTSB] believes that the captain was inexperienced and lacked confidence in his ability to fly the J-4101, but that he was aware of his weaknesses. As a result, he may have relied on the autopilot to supplement his flying abilities and enhance the approach stability of the airplane in less than optimum weather conditions."

The report said that the captain's failure to monitor airspeed after the aircraft was established on the approach was believed caused by "attentional narrowing as a reaction to the stress the captain experienced during the approach."

Evidence indicated that the captain had difficulty performing certain actions simultaneously, including:

- Slowing the airplane and establishing proper airspeed;
- Maintaining a precise flightpath in restricted visual conditions;
- Maintaining a vigilance for ice accretion; and,
- Closely observing the first officer and managing his actions.

The report said that the circumstances of the flight "should not have been especially anxiety provoking" for an air transport pilot, but the "captain's own failure to stabilize the aircraft on final approach ... likely exacerbated" his anxiety.

The captain apparently used the autopilot to compensate for his deficiencies in accomplishing instrument approaches, without concomitant monitoring of the instruments, a situation made worse when he was in high-performance aircraft during restricted visual conditions.

The report said that the captain's failure to monitor airspeed after the aircraft was established on the approach was believed caused by "attentional narrowing as a reaction to the stress the captain experienced during the approach."

In reviewing the role of cockpit resource management (CRM) in the crash of Flight 291, the report said: "The events of this accident reflect a total breakdown in crew coordination, an essential element of conducting successful instrument approaches. CRM training is not currently required under [Part] 135; nonetheless, ACA did include a one-hour class during its J-4101 ground school that included previous accidents/incidents, human factor considerations and the NASA [ASRS]. The training did not provide for interaction of the crewmembers or feedback and continued reinforcement regarding their performance, as described in [FAA] Advisory Circular (AC) 120-51A, 'Crew Resource Management Training.'"

The investigation examined ACA's management and oversight of its operations. The report concluded: "Although the company met or exceeded the ground and flight training requirements and regulations, the operational oversight and monitoring of the pilots by company managers appeared to have been reduced. The lack of adequate supervision and guidance may have led flight crews to develop poor flight procedures and habits. An example was the procedure of flying [high-speed] approaches to assist air traffic control. The nonstandardization of operations between airplanes was recognized by management and was being addressed by the company through the development of a flight standards manual. At the time of the accident, the manual had not been approved by the FAA."

The report added: "While the captain had more flight experience than the first officer, he had been recently promoted from a first officer on a J-3101 to a captain of a J-4101 on a scheduled air carrier. If standardization of approach procedures between airplanes had been established, the captain might have been better prepared to carry out proper approach procedures, and the first officer might have been more knowledgeable and trained for the event."

The NTSB also examined the seatbelts in the accident airplane, after the surviving passengers reported that they had experienced difficulty with the release buckle. The report said, "Two of the surviving passengers [a married couple] had difficulty removing their seatbelts after the airplane came to rest (the third, the five-year-old daughter of the couple, slid under her belt to get out). The surviving male passenger stated that the plastic release lever on the safety belt's release buckle was difficult to open because it had to be pulled farther back than other metal-type release levers."

The report said that as a result of this experience, investigators examined the safety belts in three of ACA's J-4101 airplanes and found "that when the safety belts were tightened firmly around an occupant's waist, the seat buckles would not release consistently. Also, when the release levers were pulled to their full open positions, the safety belts would not release."

Investigators examined the seat belt release buckles at the manufacturer's facility. "During this examination, the manufacturer demonstrated that the safety belts and release buckles met the requirements contained in the FAA's TSO [technical standard order]-C22f," the report said. "Once it was demonstrated that the safety belt complied with the TSO, a one-inch piece of dense foam was placed between the body block and the safety belt to represent the seat occupant's soft abdominal tissue. It was found that with the foam pad in place and with the belt loaded to the requirements of the TSO, the buckle would not release when its lever was opened."

As a result of its findings on the safety belts, the NTSB issued three recommendations to the FAA before the accident investigation was complete:

- "Immediately notify all operators of the [NTSB's] finding, including the U.S. Department of Defense and foreign governments, and require all operators whose aircraft have the affected Pacific Scientific safety belt buckles to inform passengers and crewmembers about the need to align the buckle insert to [ensure] easy release of the safety belts;

- "Issue an airworthiness directive [AD] to require the removal and replacement of all safety belts manufactured by Pacific Scientific for [the affected] buckles, with 45-degree lift levers, and [the affected] buckles with 90-degree lift levers, with belts having buckles of a different design as expeditiously as possible, consistent with the availability of replacement buckles; [and,]

- "Amend TSO-C22f to incorporate procedures which would place material representative of soft abdominal tissue between the test apparatus and the release buckle to ensure that safety belts can be released when subjected to loads specified in the TSO."

In its response to the NTSB's recommendations, the FAA said: "Pacific Scientific has issued a service bulletin that was sent to appropriate operators and is providing redesigned replace-

Final Minutes of Flight 291*

2311:18	Captain (Capt.): You ever get 'em? [Referring to first officer's attempt to reach the company dispatcher by radio.]
2311:19	First officer (FO): No, no.
2311:21	Capt.: Okay, screw 'em.
2311:26	Capt.: Okay, we're going down to 10,000. D and A's been completed, ah ... the only thing we have left is reach company.
2311:45	Capt.: Depending upon what we go through I might have you pop the boots at the outer marker, we'll see.
2311:49	FO: Okay ... all I'd have to do is hit auto-cycle light up right up here?
2311:55	Capt.: Yeah, just hit auto-cycle.
2311:56	FO: Right, okay.
2312:12	FO: You got six miles in eleven hundred, so typical —
2312:18	Capt.: Oh yeah, not worried about that.
2312:35	Capt.: Down to four. [Clearance from CMH to descend and maintain 4,000 feet received by FO.]
2312:35	FO: That's what I said to him.
2312:41	Capt.: Yeah, I'm just repeating it, I heard you.
2313:29	Capt.: What's the winds, the surface winds down there ... again?
2313:32	FO: Ah, three three zero at four knots.
2313:35	Capt.: Thanks.
2314:12	Capt.: Tell you what.
2314:13	FO: Yeah.
2314:15	Capt.: Bust the boots.
2314:28	FO: You only got a little rime.
2314:44	Capt.: Yeah, I got a little bit.
2314:52	FO: Seems to be a little rime, it never took nothing off [unintelligible] this side here.
2314:56	Capt.: Yeah, it didn't take that much off ... that's cool.
2315:56	Capt.: Hello.
2315:59	FO: So now it's two and a half with 800. [CMH reported the weather at the airport.]
2316:20	Capt.: What's the ice AOA [angle of attack], ah —
2316:26	Capt.: What's the V speed?
2316:43	[Sound of single chime]
2316:46	Capt.: We're gonna do flaps 25 ice AOA on so what's the ref speed for that ... at this weight?
2317:19	Capt.: Thousand.
2317:20	FO: Ref's gonna be —
2317:20	[Sound similar to that of altitude or gear warning alert.]
2317:21	FO: One to go ... ref is gonna be one twelve.

(continued on page 10)

(Continued from page 9)

2317:25	Capt.: What, that's with the ice AOA, right?
2317:28	FO: That's affirm.
2317:29	Capt.: Okay, that's what we're gonna do … that's what we're gonna do.
2317:46	[Sound of single chime.]
2317:58	[Sound similar to reduction in prop/engine noise amplitude.]
2318:26	Capt.: Two ninety-one. [Referring to FO's use of 391 rather than 291 to identify the flight during radio communication.]
2318:36	FO: What did I say?
2318:38	Capt.: Three ninety-one.
2318:39	FO: Oh.
2318:40	Capt.: Okay, if you got all the speeds don't worry about them anymore.
2318:44	FO: Ref is 112, I gotta plug that (too).
2318:46	Capt.: I did it for you.
2318:53	FO: Here comes glideslope. ((Sound similar to altitude or gear warning alert.))
2319:30	Capt.: And we're marker inbound.
2319:36.8	Capt.: Don't forget to give me my calls, 1,014 is DH [decision height].
2320:01.3	FO: A thousand above.
2320:02.3	Capt.: Okay, flaps nine.
2320:08.5	Capt.: Gear down.
2320:25.6	FO: Flaps fifteen, landing gear down, three green.
2320:31.6	FO: Condition levers a hund- … condition levers a hundred percent.
2320:36.1	Capt.: Okay, give me a hundred percent, please.
2320:38.1	FO: A hundred percent, flows at three.
2320:39.8	((Sound of increase in propeller/engine rpm.))
2320.41.1	Capt.: Three.
2320:41.6	FO: Yaw damper.
2320:42.7	Capt.: And autopilot to go, don't touch.
2320:44.5	FO: Don't touch.
2320:46.2	FO: Holding on the yaw damper.
2320:46.6	((Sound similar to that of a stick shaker start.))
2320:47.2	((Sound of seven tones similar to that of autopilot disconnect alert.))
2320:48.1	Capt.: Tony.
2320:49.5	((Sound similar to that of a stick shaker stops.))
2320:50.2	Capt.: What did you do?
2320:50.8	FO: I didn't do nothing.
2320:51	((Sound similar to that of stick shaker starts.))
2320:52.3	((Sound similar to that of an increase in prop/engine noise amplitude.))
2320:52.5	Capt.: Gimme flaps up.
2320:53.7	((Sound similar to that of a stick shaker stops.))
2320:53.7	Capt.: No, no, hold it.
2320:54.0	((The GPWS transmits "Pull."))
2320:54.3	((Sound similar to that of a stick shaker starts again and continues to the end of recording.))
2320:55.3	Capt.: Gimme flaps up.
2320:57.5	((Sound similar to that of change in or addition to stick shaker.))
2320:58.7	Capt.: Whoa.
2321:00.2	((Sound of impact.))

( ) = Questionable Insertion
(( )) = Editorial Insertion
[ ] = FSF or NTSB clarifications
* Transcript from aircraft's cockpit voice recorder.
Source: U.S. National Transportation Safety Board

ment buckles to operators with the affected equipment. The design changes to the safety belt buckles were developed by the manufacturer, in cooperation with [FAA] engineers and the [FAA] Civil Aeromedical Institute. The manufacturer is aggressively pursuing the replacement of these safety belts. The FAA is considering the issuance of an airworthiness directive to require mandatory replacement of the buckles within 90 days. If the FAA issues an airworthiness directive it will be sent to all operators of affected aircraft. In the meantime, the FAA believes the [manufacturer's] notification to all operators is sufficient interim action."

Commenting on the NTSB's recommendation that TSO-C22f should be revised, the FAA said that the TSO "was revised over a year ago to address the concerns expressed in this recommendation."

The NTSB concurred with the FAA's actions to issue an airworthiness directive to require the removal and replacement of the affected safety belts. Nevertheless, the NTSB said that the FAA had failed to address "the need for operators to warn passengers of the possibility of in-service buckles not operating properly [and] … the actions taken by the FAA have not incorporated procedures which would place material representative of soft abdominal tissue between the test apparatus and the release buckle."

The NTSB developed 15 findings as a result of its investigation. The most significant findings in the report were:

- "Light to moderate icing conditions existed during the approach to Columbus; however, airframe icing was not a factor in the cause of the accident;

- “Air traffic services were not totally in accordance with established procedures but did not contribute to the cause of the accident;

- “The J-4101 was a new airplane placed into service in the United States by ACA in May 1993. Both pilots had low flight time and experience in the airplane and in any airplane equipped with an ... EFIS. Additionally, the captain had low time and experience as a captain;

- “[High-speed] approaches to the final approach fix were often flown by J-4101 crews, although the procedure was neither published in the company operations and training manuals nor approved by the FAA;

- “The captain initiated the ILS approach at a high speed and crossed the final approach fix at a high speed without first having the airplane properly configured for a stabilized approach;

- “The landing checklist was initiated late in the approach, and the delay caused distractions to both pilots because the approach was unstabilized;

- “The airplane’s autopilot maintained the airplane on the glideslope and localizer; however, airspeed was not monitored nor maintained by the flight crew;

- “The first officer failed to alert the captain of the deteriorating airspeed, which was below the minimum specified for the approach. The airline had no specified callouts for airspeed deviations during instrument approaches;

- “The captain failed to apply full power and correctly configure the airplane in a timely manner; [and,]

- “Inadequate consideration was given to the possible consequences of pairing a newly upgraded captain, on a new airplane, with a first officer who had no airline experience in air carrier operations, nor do current FAA regulations address this issue.”

Based on its findings, the NTSB made four recommendations to the FAA:

- “Ensure that the training programs for ... Part 135 pilots place an increased emphasis on stall warning recognition and recovery techniques, to include stick shaker and stick pusher during training;

- “Ensure that all Part 135 operators that incorporate both a [high-speed] approach profile and a coupled approach profile in the training manual for all airplanes train pilots to proficiency for those approach profiles;

- “Ensure that Atlantic Coast Airlines trains its [flight crews] in approved [high-speed] approach techniques, similar to [those in] the manufacturer’s airplane flight manual. The present procedures show a normal stabilized approach procedure, but the pilots typically fly faster to keep up with jet traffic and therefore do not follow their own procedures; [and,]

- “*Immediately* [emphasis in original] issue an emergency airworthiness directive informing all operators and affected parties, including the U.S. Department of Defense and foreign governments, of the NTSB’s findings, and require all operators whose aircraft have the affected Pacific Scientific safety belt buckles to inform passengers and crewmembers before each flight about the need to align the buckle insert when lifting the buckle release lever to ensure easy release of the safety belts.”

The NTSB also reiterated two previous recommendations to the FAA:

- “Require that scheduled air carriers operating under ... Part 135 develop, and include in their flight operation manuals and training programs, stabilized approach criteria. The criteria should include specific limits of localizer, glideslope and VOR [very high frequency omnidirectional radio range] needle deflections, and rates of descent, etc., near the airport, beyond which initiation of an immediate missed approach would be required; [and,]

- “Amend TSO-C22f to incorporate procedures which would place material representative of soft abdominal tissue between the test apparatus and the release buckle to ensure that safety belts can be released when subjected to loads specified in the TSO.” ♦

Editorial note: This article was adapted from *Aircraft Accident Report: Stall and Loss of Control on Final Approach, Atlantic Coast Airlines, Inc./United Express Flight 6291, Jetstream 4101, N304UE, Columbus, Ohio, January 7, 1994, Report No. NTSB/AAR-94/07*, prepared by the U.S. National Transportation Safety Board. The 118-page report includes figures and appendices.

ACCIDENT PREVENTION

ISSN 1057-5561

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