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After Intentionally Stalling DC-8, Crew Uses Incorrect Recovery Technique, Resulting in Uncontrolled Descent and Collision with Terrain

Contributing factors included the pilots' unfamiliarity with an actual DC-8 stall, the test flight at night without a visual horizon and an engine-compressor stall that might have distracted the flight crew at a critical time.

FSF Editorial Staff

An Airborne Express (ABX Air Inc.) Douglas DC-8-63 collided with mountainous terrain while the crew was conducting a functional evaluation flight (FEF), following the completion of extensive modifications to the aircraft. (An FEF is a test flight following maintenance "that may have appreciably changed [the airplane's] flight characteristics or substantially affected its operation in flight," the final accident report of the U.S. National Transportation Safety Board [NTSB] said.)

The three flight crew members and three maintenance/avionics technicians who were on board the aircraft were killed in the Dec. 22, 1996, accident, which occurred at night in instrument meteorological conditions (IMC). The aircraft, valued at US$21 million, was destroyed.

The report said that the probable causes of the accident were "the inappropriate control inputs applied by the [pilot flying (PF)] during a stall-recovery attempt, the failure of the … pilot in command [the pilot not flying (PNF)] to recognize, address and correct these inappropriate control inputs and the failure of ABX to establish a formal functional evaluation flight program that included adequate program guidelines, requirements and pilot training for performance of these flights.

"Contributing to the causes of the accident were the inoperative stick shaker stall-warning system and the ABX DC-8 flight-training simulator's inadequate fidelity in reproducing the airplane's stall characteristics."

The aircraft had been purchased by ABX about six months before the accident flight and had undergone a major overhaul and modifications that were performed by the Triad International Maintenance Corporation (TIMCO) at the Piedmont Triad International Airport (GSO), Greensboro, North Carolina, U.S. Following the extensive maintenance, an FEF was required by U.S. Federal Aviation Regulations (FARs) Part 91 before the aircraft could be returned to service.

The day before the accident flight, the accident flight crew had begun an FEF on the aircraft, but the flight was terminated when a problem developed in the aircraft's hydraulic system. On the day of the accident, the FEF was scheduled to begin at 1320 hours local time, but the flight was delayed because of maintenance problems.

At 1740, the accident flight departed GSO on an instrument flight rules (IFR) flight plan. On board was an ABX flight

Douglas DC-8

The Douglas DC-8-63, which combines the stretched fuselage of the model 61 with aerodynamic and powerplant improvements, first flew in 1967. The model 63, equipped with four Pratt & Whitney JT3D-7 turbofan engines, has a maximum takeoff weight of 158,760 kilograms (350,000 pounds) and maximum cruising speed at 9,150 meters (30,000 feet) of 965 kilometers per hour (521 knots). The design range of the model 63 with maximum payload and normal reserves is 7,240 kilometers (4,500 miles).

Source: *Jane's All the World's Aircraft*

crew, comprising two pilots (both of whom were qualified as captains) and a flight engineer. In addition, three maintenance technicians (two ABX employees and one TIMCO employee) were on board to provide assistance during the FEF. The planned flight duration was two hours.

Following the DC-8's routine takeoff and climb-out, air traffic control (ATC) assigned the flight an altitude block from 3,965 meters (13,000 feet) to 4,575 meters (15,000 feet) mean sea level (MSL) in which to maneuver. Cloud tops along the airplane's route were slightly below 4,270 meters (14,000 feet). "Flight crew comments recorded on the cockpit voice recorder (CVR) indicated that the airplane flew briefly in and out of the clouds and that ice build-up was observed after they reached their assigned block altitude," the report said.

"At 1748:34, the [PF] in the left seat stated, 'We're gettin' a little bit of ice here,' followed by ' … probably get out of this' three seconds later,'" the report said. "At 1752:19, the PF said, 'We just flew out of it, let's stay here for a second.'" Following this exchange, the crew conducted several landing-gear, hydraulic-system and engine-system checks.

At 1805:37, the flight engineer said that the "next thing is our stall series."

The report said, "According to ABX, the purpose of this part of the FEF was to verify the airplane's flight characteristics following the removal, installation and rigging of flight control surfaces (flaps and ailerons) and to check the operation of the stall-warning and stick-shaker systems."

During this segment of the flight, the crew was required to "identify and record the speed at which the stick shaker activated and the speed of the stall indication," the report said. "At 1805:56, the [PNF] said, 'One eighty-four [knots (340 kilometers per hour [kph]), the reference for the crew to stop trimming the airplane], and … we should get uh, stall at uh, one twenty-two [knots (226 kph)]. I'm going to set that in my interior bug."

The flight engineer then told the pilots that the stick shaker would activate at 237 kph (128 knots). The PF asked the flight engineer if that airspeed was for both the stick shaker and the stall, to which the flight engineer replied, "Yeah, shaker and stall both."

The crew then slowed the aircraft at the rate of approximately 1.8 kph (one knot) per second. The PNF cautioned the PF not to allow the engine revolutions per minute (RPM) to decay (unspool) to flight idle. About one minute later, the PF asked the PNF about the procedure for setting the power during the stall. The PNF responded, "When you get close to the stall, you don't want to be unspooled." About 30 seconds later, "the CVR recorded sounds similar to the engines increasing in RPM," the report said.

"At 1808:06, the PF announced 'some buffet' (at [279 kph (151 knots)]), and the PNF noted 'yeah, that's pretty early,'" the report said. "At 1808:09, the sound of rattling was heard on the CVR and, at 1808:11, the flight engineer said, 'That's a stall right there … ain't no [stick] shaker' (at [269 kph (145 knots)])." The PF then said, "Set max power" at 1808:13.

"Seven seconds later, popping sounds began and continued for nine seconds," the report said. The PNF then said to the PF, "You can take a little altitude down. Take it down." Twelve seconds later, the PNF said, "Start bringing the nose back up."

At 1809:10, the report said, "ATC asked the crew if they were in an emergency descent and the PNF replied, 'Yes sir.' ATC then asked the crew, 'Can you hold [2,135 meters (7,000 feet)]?' There was no reply, and there were no further radio communications from the accident airplane with ATC."

Following ATC's query, the two pilots discussed adding engine power and the use of the left rudder. The PNF said, "Okay now, easy bring it back." The ground-proximity warning system (GPWS) then activated. Three seconds after the GPWS aural warning, "the sound of impact was recorded on the CVR at 1809:38," the report said.

"Three ground witnesses told accident investigators that the airplane was generating loud 'skipping or missing' noises," the report said. "Two of the witnesses reported seeing the airplane descending out of the clouds at a steep angle, with bright lights shining downward. The witnesses described weather conditions at the time of the accident as cloudy with precipitation that was freezing at the surface."

The aircraft collided with a 1,281-meter (4,200-foot) mountain at 976 meters (3,200 feet), one minute and 32 seconds after the PF had said "some buffet." The aircraft struck the terrain in a left wing–low and 26-degree, nose-down attitude. The airplane was destroyed by impact forces and a postaccident fire. All crew members and technicians were killed on impact.

The wreckage path was 214 meters (700 feet) long. "The location of the ground scars and separated airframe and engine components indicated that the left wing tip made initial ground contact, and the ground impact crater became deeper and wider as the left wing continued to penetrate the ground," the report said. "The impact of the no. 1 engine followed. All four engines were found at the accident site, similarly damaged and broken into three or four sections. ...

"The alignment of the impact craters for the outboard left wing, the no. 1 engine and the aft fuselage is consistent with FDR [flight data recorder] data showing high vertical G forces and a steep left-bank angle at the time of ground impact. The initial ground impact scar was [19.8 meters (65 feet)] long … . The distance between the initial tree impacts and the first ground impact was about [22.9 meters (75 feet)]. Several pieces of leading-edge structure were found in the area between the trees and the initial ground impact.

"A section of the vertical stabilizer (the lower [5.8 meters (19 feet)]) was found on its left side in a third ground-scar area along with the tail cone. Fuselage pieces were scattered throughout a debris field that expanded in a fan-shaped pattern beyond the empennage area. Parts of the cockpit were found in this debris field, and several small pieces of wing skin were found well beyond the empennage and down the hill to the right of the main wreckage area."

The PF, 37, held an airline transport pilot (ATP) certificate with an airplane multi-engine land rating and type ratings in the DC-8, British Aerospace Jetstream 31 and Saab 340. He also held a commercial certificate, airplane single-engine land rating, a flight engineer certificate and an airframe and powerplant (A&P) certificate. The PF held a valid FAA first-class medical certificate with the limitation to wear corrective lenses for distant vision. He had 8,426 hours of flight time, with 1,509 hours in the DC-8 and 434 hours as DC-8 pilot-in-command (PIC).

The PF was hired by ABX in 1991 as a DC-8 first officer. In 1993, "he was promoted to DC-8 equipment chief pilot and was assigned as a DC-8 standards pilot in May 1996," the report said. "He was promoted to manager of DC-8 flight standards in June 1996, replacing the accident PNF in that position. He had also been selected to become an FAA-designated DC-8 examiner. His most recent proficiency check was on July 11, 1996, and his most recent line check was on Dec. 5, 1995. … ABX performance evaluations [of the PF] were complimentary."

Before he was hired by ABX, the PF was employed by Trans World Airlines (TWA) as a flight engineer on the Boeing 727 and a first officer on the McDonnell Douglas DC-9/MD-80.

The PNF, 48, held an ATP certificate with an airplane multi-engine land rating and type ratings in the Cessna CE-500, DC-8 and DC-9, and commercial privileges, single-engine land. He also held a flight engineer certificate with a turbojet-powered rating. The PNF held a valid FAA first-class medical certificate with no limitations. He had 8,087 hours of flight time, with 869 hours in the DC-8 and 462 hours as a DC-8 captain.

The PNF was hired by ABX in 1988 as a DC-8 first officer. "He later was promoted to DC-8 simulator instructor and, in 1990, to DC-9 flight standards pilot," the report said. "After a brief period as a DC-9 line captain, he was promoted in 1994 to DC-8 flight standards manager and to [Boeing 767] flight manager in July 1996, in anticipation of the planned delivery of … B-767 airplanes to the ABX fleet. He was also an FAA-designated DC-8 examiner. … His most recent proficiency check was July 12, 1996, and his most recent line check was on Sept. 5, 1996."

"The PNF's personnel records at ABX contained complimentary performance evaluations," the report said. "A June 1991 company evaluation noted that the PNF was a 'little laid back … may want to do his own thing, doesn't want to upset or rock boat.'"

Before being hired by ABX, the PNF was employed by several air carriers as a B-727/DC-8 flight engineer and a DC-9/MD-80 captain. His flying career began in the U.S. Air Force as a Lockheed C-141 pilot and instructor.

Investigators reviewed the FEF experience of the accident pilots. "According to ABX records, the PNF on the accident flight had a total of 1.1 hours of flying experience as PIC (logged the previous day) of a DC-8 postmodification FEF," the report said. "The PNF had 12.6 hours of experience as a nonflying second-in-command (SIC) on postmodification DC-8 FEFs and had conducted other, less extensive FEFs in the DC-8 that did not involve a stall series.

"Between 1991 and 1993, the accident PNF had flown 15 FEFs as PIC in DC-9s, according to ABX records. Some of these

Cockpit Voice Recorder Transcript, ABX Air, DC-8, Dec. 22, 1996

Time	Source	Content
1805:37	**CAM-3**:	next thing is our stall series.
1805:40	**CAM-1**:	... K.
1805:47	**CAM-?**:	** stall.
1805:49	**CAM-2**:	** that's uuuuuh.
1805:51	**CAM-1**:	we got two oh. what's our uh … one eighty-eight or one eighty-four.
1805:56	**CAM-2**:	one eighty-four, and … we should get uh, stall at uh, one twenty-two. I'm gonna set that in my, interior bug.
1806:07	**CAM-1**:	mine's set *.
1806:08	**CAM**:	[sound similar to stabilizer-in-motion warning horn]
1806:10	**CAM-3**:	shaker one twenty-eight if you just hall out call out your numbers, I'll record 'em.
1806:14	**CAM-1**:	that's shaker and the stall?
1806:15	**CAM-3**:	yeah, shaker and stall both.
1806:17	**CAM-1**:	all right.
1806:18	**CAM-2**:	the only trick to this is just don't unspool.
1806:25	**CAM-2**:	I just swapped the igniters. I'll leave 'em on the for the stall.
1806:34	**CAM-3**:	standby rudder pump back on.
1806:36	**CAM-1**:	OK.
1807:08	**CAM**:	[sound similar to stabilizer-in-motion warning horn]
1807:21	**CAM-1**:	looks like, are you saying you don't want to pull all the way back to it and then spool back or just wait.
1807:23	**CAM**:	[sound similar to stabilizer-in-motion warning horn]
1807:25	**CAM-2**:	aw you can do that, just when you get close to the stall you don't want to be unspooled.
1807:28	**CAM-1**:	unspool and then I'll respool.
1807:29	**CAM-2**:	that's fine.
1807:31	**CAM-1**:	speed it up.
1807:41	**CAM**:	[sound similar to stabilizer-in-motion warning horn]
1807:43	**CAM-1**:	guess I better not trim below * two *.
1807:51	**CAM-1**:	yeah, I'm gonna spool now.
1807:52	**CAM-2**:	all right.

DC-9 flights may have involved approach to stall. The accident flight PF had no experience as a pilot on the DC-8 postmodification FEF before the abbreviated Dec. 21 FEF."

Investigators reviewed the history of the accident aircraft. After being purchased by ABX in June 1996, the aircraft underwent modifications at TIMCO. "In addition to extensive overhaul work, ABX ordered many equipment modifications to standardize [the accident aircraft] with 14 other company DC-8s," the report said. "Many avionics, cockpit and airplane systems were modified, including the flight directors, color radar, air data instruments, communications and navigation receivers and transmitters. A new cargo-handling installation and a dual electronic flight instrument system (EFIS) were also part of ABX's order."

Because the accident airplane contained more corrosion than anticipated, the proposed four-month modification and overhaul project was extended to six months.

The day before the accident flight, the first FEF was terminated "because of an indication of hydraulic quantity loss," the report said. "No major leak was found, but a minor leak was located at the nose landing-gear actuator. TIMCO maintenance personnel said [that] they suspected that trapped air in the lines may have caused the low hydraulic-quantity indication. The nose-gear actuator was replaced, and the system was reserviced after the arrival of replacement parts at 1630 on [the day of the accident]. The airplane had no open maintenance items before the second FEF."

The only mechanical malfunction during the accident flight was a failure of the stall-warning stick shaker to activate.

The investigation focused on "flight crew performance during the accident sequence, and whether the cues presented to the flight crew, their prior experience, the fidelity of the ABX DC-8 flight training simulator, the organizational structure and function of ABX or oversight by the FAA may have affected the flight crew's performance," the report said.

Investigators found that the flight crew "prepared for the stall maneuver generally in accordance with ABX procedures, with the exception of their use of pitch trim," the report said. "The PF reduced the airspeed into the stall region at approximately the desired rate of one knot per second, and he increased engine EPR [engine pressure ratio] (spooled up the engines) prior to the onset of buffet to provide adequate engine acceleration during the recovery."

Investigators believed that the flight crew "recognized the incipient stall and initiated the stall recovery in accordance with ABX's procedures," the report said. "Based on the thrust application and the 'set max power' statement of the PF, the [NTSB] concludes that the PF made a timely decision to terminate the clean stall and begin the stall recovery."

1807:55	**CAM**:	[sound similar to engine increasing in RPM]
1808:06	**CAM-1**:	some buffet.
1808:07	**CAM-2**:	yeah, that's pretty early. *
1808:09	**CAM**:	[sound of rattling]
1808:11	**CAM-3**:	that's a stall right there. * ain't no shaker.
1808:13	**CAM**:	[sound similar to increase in engine RPM]
1808:13	**CAM-1**:	set max power.
1808:14	**CAM-2**:	one thirty-three.
1808:17	**CAM-3**:	* power.
1808:19	**CAM-1**:	one forty's about where I'm at.
1808:20	**CAM**:	[sound of irregular popping similar to engine compressor stall starts]
1808:23	**CAM-2**:	that's number two engine.
1808:25	**CAM**:	[sound similar to altitude alert signal]
1808:25	**CAM-3**:	** pull her back.
1808:26	**CAM-2**:	you got it.
1808:29	**CAM**:	[sound of irregular popping similar to engine compressor stall stops]
1808:30	**CAM-2**:	you can take a little altitude down. take it down.
1808:32	**CAM-1**:	** control. [spoken with buffeting voice]
1808:36	**CAM**:	[sound similar to engine decreasing in RPM]
1808:38	**CAM-2**:	a little rudder.
1808:39	**CAM-1**:	all right.
1808:40	**CAM-2**:	OK.
1808:42	**CAM-2**:	start bringing the nose back up.
1808:43	**CAM-1**:	got it.
1808:45	**RDO-2**:	center, ABX uh, eight two seven is in a descent.
1808:48	**CAM-2**:	now a little back pressure.
1808:49	**CAM-1**:	got it.
1808:50	**CTR**:	… X eight two seven, change to Indianapolis one two eight point four.
1808:52	**CAM-2**:	easy on the rudder.
1808:53	**CAM-1**:	yaw damper on?
1808:54	**CAM-2**:	yaw damper's on.
1808:56	**CAM**:	[sound of rattling increases]
1808:58	**CTR**:	ABX eight twenty seven, Indianapolis one two eight point four.

The report said, "For eight seconds following the initiation of the stall recovery, … the PF maintained the airplane's pitch attitude at between 10 degrees and 14 degrees ANU [aircraft nose up]. During this eight-second period, the airspeed continued to decrease and the airplane entered a fully developed stall.

"The failure of the airplane to recover before entering the full stall resulted from the control column inputs the PF was making to maintain pitch attitude. The control column was moved aft by the PF, from five degrees aft (at 1808:11, just prior to initiating the recovery) to 20 degrees aft (14 seconds later). An increasingly downward flight-path angle coupled with a relatively constant pitch angle resulted in an increasing angle-of-attack. The increase in angle-of-attack, which placed the airplane [further] into the stalled condition, may not have been perceived by the flight crew unless they were closely monitoring the airspeed indicator. In addition, the vertical speed indicator and altimeter should have provided evidence of a developing sink rate and stall."

At this point in the flight, "the airplane began a series of roll reversals, and the airplane remained in an aerodynamic stall condition because the PF held significant back pressure on the control column all the way to impact," the report said. "Each time the airplane developed a large nose-down pitch rate (combined with reductions in airspeed at 1808:25 and 1809:22), the PF responded with additional back pressure, according to FDR data on control column movement. In contrast, the appropriate pilot response to an uncommanded decrease in pitch attitude (which is, itself, an indication that the airplane is in a stall) would have been forward movement of the control column."

The objective of ABX's stall-recovery procedures was to train flight crews "to recognize an impending stall and perform a recovery with a minimum loss of altitude," the report said. " … Evaluation criteria for the performance of this maneuver by line flight crews during proficiency checks include minimum altitude loss and avoidance of a secondary stall (which can be recognized by reactivation of the stick shaker or aerodynamic buffet)."

The accident flight crew initiated the stall maneuver at 4,118 meters (13,500 feet). "Their use of the lowest [153 meters (500 feet)] of the block altitude indicated that the flight crew anticipated recovering from the stall with a minimum altitude loss, just as they were accustomed to performing and instructing the standard ABX stall maneuvers in the simulator," the report said. "Further, their execution of the clean stall only slightly above the cloud tops suggests that the flight crew did not anticipate the possibility of greater altitude loss."

The report said, "Although the PF attempted to establish his desired pitch attitude and power setting, he failed to recognize that these initial pitch and power inputs were inadequate for the stall recovery he was executing, and he failed to take further action to correct for the decreasing airspeed and developing

1809:02	**RDO-2**:	ABX eight two seven, we're going to stay on this frequency a minute, we're descending through eight thousand call you right back.
1809:07	**CAM-2**:	nose down.
1809:08	**CAM-2**:	* power in, your gonna get * ….
1809:10	**CAM-?**:	*
1809:10	**CTR**:	ABX eight twenty seven, you emergency descent?
1809:12	**RDO-2**:	yes sir.
1809:14	**CTR**:	OK uh, can you hold seven thousand?
1809:17	**CAM-2**:	now, need some power in, 'n you can use just your outboards if number two is giving you some problems.
1809:19	**CAM**:	[sound similar to engine increasing in RPM]
1809:22	**CAM-1**:	OK.
1809:24	**CAM-2**:	uh, bring two back.
1809:26	**CAM**:	[sound of click]
1809:27	**CAM**:	[sound similar to engine decreasing in RPM]
1809:28	**CAM-2**:	rudder, rudder.
1809:28	**CAM-1**:	I got it.
1809:29	**CAM-2**:	left rudder.
1809:30	**CAM-1**:	left rudder's buried.
1809:32	**CAM-2**:	OK, easy, don't. OK now, easy bring it back.
1809:35	**CAM-7**:	terrain, terrain, whoop, whoop, pull up.
1809:36	**CAM-?**:	(really, really)
1809:38	**CAM**:	[sound of impact]
1809:39	End of recording	

RDO	=	Radio transmission from accident aircraft
CAM	=	Cockpit area microphone voice or sound source
CTR	=	Radio transmission from Atlanta Center
-1	=	Voice identified as co-pilot
-2	=	Voice identified as pilot-in-command (PIC)
-3	=	Voice identified as flight engineer
-7	=	Aircraft mechanical voice
-?	=	Voice unidentified
*	=	Unintelligible word
( )	=	Questionable insertion
[ ]	=	Editorial insertion
….	=	Pause

Source: U.S. National Transportation Safety Board

sink rate. Allowing the control column to move forward would have stopped the airspeed loss, and the airplane would have recovered from the stall. However, he failed to do so."

The report concluded that "the PF applied inappropriate control column back-pressure during the stall-recovery attempt in an inadequate performance of the stall-recovery procedure established in ABX's operations manual, and these control inputs were causal to the accident."

Investigators reviewed the flight crew's surprise by the stall buffet that occurred at 276 kph (149 knots), which was higher than they had anticipated. "DC-8-63 performance certification test data provided by Douglas indicate that an aerodynamic stall is typically preceded by aerodynamic buffet about [28 kph (15 knots)] above the stall speed," the report said. "Therefore, the nominal airspeed for the buffet to have begun on the accident flight would have been [254 kph (137 knots)]; based on these data, the buffet apparently began about [22 kph (12 knots)] early.

"Because the prestall buffet began at an airspeed greater than the flight crew expected, the [NTSB] evaluated three factors that could have affected the airspeeds for both prestall buffet and stall during the accident flight: the weight of the airplane, airframe icing and flight-control surface rigging."

The NTSB determined that the weight-and-balance for the accident flight were within approved limits and, therefore, were not a factor in the greater-than-expected prestall buffet.

The aircraft had been operating intermittently in the cloud tops, in conditions "conducive to light-to-moderate icing for a brief period before the attempted stall maneuver," the report said. The CVR revealed that the crew noticed that some ice had accumulated on the airplane, and that the airplane was out of the icing conditions shortly thereafter. "The [NTSB] was unable to determine the amount of airframe ice that the airplane would have accumulated during this period," the report said. "However, airframe icing could have caused the airplane to buffet at a greater airspeed than the flight crew expected."

Investigators also reviewed how the rigging of the airplane's flaps and ailerons could have affected the buffet and stall speeds. "One of the purposes of performing the stall series during the postmodification FEF was to verify that control-surface rigging was proper by comparing calculated stick-shaker activation and stall speeds to the airspeeds at which the airplane actually encountered these events," the report said.

The NTSB was not able to determine whether variations in flap and aileron rigging contributed to the prestall buffet, but concluded that "some combination of airframe icing, flight-control rigging or other factors resulted in the greater-than-expected buffet-onset speed," the report said.

The report also said, “FDR parameters indicated that the actual stall occurred at [233 kph (126 knots)], only [7.4 kph (four knots)] greater than the stall speed calculated by the flight crew. Therefore, despite the early onset of aerodynamic buffet, the [NTSB] concludes that any effects of airframe icing or flight-control rigging upon the stall speed of the accident airplane were minimal, and did not contribute to the accident.”

The investigation revealed that the flight crew set the horizontal stabilizer trim at the incorrect airspeed for the stall maneuver. The trim speed set by the PF was 324 kph (175 knots), and the correct trim speed for the accident flight was 340 kph (184 knots). “The effect on the stall recovery of trimming the airplane to a slower airspeed than desired would have been to require more forward control-column movement to achieve the desired nose-down pitch rate and recover from the stall,” the report said. “However, because the airplane’s 175-knot trim speed was significantly greater than the 126-knot stall speed, additional control-column back pressure was required from the PF to slow the airplane to the stall speed, and the airplane would have rapidly recovered from the stall if the PF had relaxed his back pressure on the control column. Therefore, the [NTSB] concludes that although the PF trimmed the airplane below the recommended minimum trim speed for the clean stall, this action did not contribute to the accident.”

Both pilots on the accident flight were qualified as captains on the DC-8. Investigators attempted to determine “whether the PNF was serving as the pilot-in-command [PIC] of the accident flight and instructing the PF from the right seat,” the report said.

The day before the accident, on the incomplete FEF, the ABX aircraft log for that flight revealed that the PF’s name had been entered in the “Captain” block. “However, that log page was ambiguous as to who had been the PIC of the … flight because the PNF signed for the airplane in the ‘Captain’s signature’ block,” the report said. “The aircraft log page for the accident flight was not recovered.”

CVR comments during the accident flight “revealed that the PNF directed the PF, while the PF expressed uncertainty and asked questions,” the report said. “Further, several of the communications from the PNF to the PF were instructional in nature.

“Based on these communications and the PF’s lack of any prior experience with a complete DC-8 postmodification FEF, the [NTSB] concludes that the PNF, in the right seat, was serving as the [PIC] of the accident flight and was conducting instruction in FEF procedures; and that the PF, in the left seat, was serving as the [SIC] and was receiving instruction in FEF maneuvers, including the clean-stall maneuver.”

“In this kind of crew pairing, it may be difficult for one captain to challenge the actions of the other because of a lack of overt command authority.”

Because the PNF was PIC during the accident flight, the NTSB attempted to determine why the PNF “did not take control of the airplane or otherwise intervene effectively as the PF held the airplane in a stalled condition all the way to impact,” the report said. “In this accident, both pilots were captains, both were managers and both had similar backgrounds at ABX. In this kind of crew pairing, it may be difficult for one captain to challenge the actions of the other because of a lack of overt command authority.”

Early during the accident sequence, the PNF commented to the PF about the stall recovery. “However, when the PF did not respond adequately, the PNF did not escalate his verbal interventions or take over the controls,” the report said. “During the uncontrolled descent, the PNF continued to provide suggested control inputs to the PF, but the PNF never told the PF to move the control column forward.

“It is possible that the PNF’s priorities changed after the extreme rolling moments developed. The PNF may have become less concerned about angle-of-attack, and the reduction of pitch attitude may have become a secondary priority to roll-attitude control. Throughout the recovery sequence, the PNF made several statements to the PF to help direct him out of the roll situation (but not out of the stall condition), and he remained in an instructional role up to the time of impact.

“During this period, the PNF also took time to respond to a query from ATC pertaining to the airplane’s rapid descent below its assigned block altitude floor. Based on the PNF’s lack of urgency in correcting the PF’s control inputs and the PNF’s radio transmissions with ATC, [the PNF] apparently lost awareness of the flight’s descent rate and proximity to the ground. The [NTSB] concludes that the PNF’s failure, as the [PIC], to recognize, address and correct the PF’s inappropriate control inputs were causal to this accident.”

The NTSB evaluated the cues available to the flight crew and how distractions could have contributed to the failure to recover from the stall. Investigators were told by ABX pilots that “the stick shaker activated inconsistently relative to the onset of prestall buffet during the clean-stall maneuver, sometimes activating prior to buffet, but in some cases activating simultaneously with buffet or after the buffet had begun,” the report said. “According to the ABX director of flight technical programs, FEF flight crews were told that they should be prepared for the stick shaker not to activate before the stall during the clean-stall maneuver.

“Further, the CVR transcript indicates that the flight crew had clearly identified a stall buffet and that they initiated a recovery in a timely manner. Consequently, the [NTSB] concludes that the absence of the stick shaker prior to the stall did not affect the flight crew's recognition of the initial entry into the stall."

The stall-warning components on the accident aircraft were destroyed at impact, and "the recovered components provided no evidence about the system's status and function," the report said. "Consequently, the [NTSB] was unable to identify the failure mode of the stall-warning system."

The report said, "It is even possible that, in the absence of the stick-shaker warning, the flight crew may have gradually lost the perception that the airplane was stalled (especially in the latter stages of the accident sequence when the airplane was descending in an accelerated stall condition at high airspeed and positive G-load) and may have been attempting to perform a high-airspeed, nose-low unusual-attitude recovery.

"The unusual-attitude recovery procedure calls for engine thrust to be reduced to idle and primary attention to be focused on leveling the wings; FDR engine-thrust parameters and the flight crew's statements about lateral control recorded by the CVR were consistent with this procedure.

" … The inoperative stall warning system contributed to the accident by failing to reinforce to the flight crew the indications that the airplane was in a full stall during the recovery attempt. Further, based on the circumstances of this accident, the [NTSB] is concerned that existing air carrier maintenance programs may not ensure that stall-warning systems are adequately checked during scheduled maintenance."

The report said, "A flight deck display of angle-of-attack would have maintained the flight crew's awareness of the stall condition, and it would have provided a direct indication of the pitch attitudes required for recovery throughout the attempted stall-recovery sequence in this accident." The FAA, in response to an NTSB recommendation in early 1996 regarding the use of angle-of-attack displays, "is currently evaluating the operational requirements for angle-of-attack instrumentation on transport-category aircraft," the report said. " … This accident might have been prevented if the flight crew had been provided a clear, direct indication of the airplane's angle-of-attack."

From 1808:30 until impact, the airplane rolled at angles from 70 degrees left to 115 degrees right. "It is possible that the pilots perceived the roll reversals to be caused by pilot-induced oscillations from rudder inputs out of phase with the airplane's roll/yaw moments," the report said. "If so, the PF may have been devoting a great deal of attention to the increasing mismatch between his rudder-control inputs and the airplane's roll attitude."

The NTSB reviewed the role of distractions in the flight crew's failure to recover from the stall. The high angle-of-attack during the stall caused an airflow disruption through the no. 2 engine, which resulted in engine compressor surges. The surges "were loud and potentially distracting during this critical period (the airplane stalled one second later, according to FDR data)," the report said.

" … The engine compressor surges in the no. 2 engine (caused by airflow disruption) may have distracted the flight crew during the critical early period of the stall recovery, when sufficient lateral control was available for the recovery.

"The flight crew responded to the surges by reducing power on all four engines, but to differing degrees: … EPR levels on the no. 1 and no. 2 engines decreased to 1.39 and 1.04, respectively. EPR levels on the no. 3 and no. 4 engines were reduced to 1.66 and 1.73, respectively, with resultant asymmetrical thrust. At this time, the airspeed had dropped below the stall speed of 126 knots with the airplane still in a 10-degree nose-up attitude."

"In the absence of the stick-shaker warning, the flight crew may have gradually lost the perception that the airplane was stalled … and may have been attempting to perform a high-airspeed, nose-low unusual-attitude recovery."

Investigators were unable to determine whether the asymmetric power condition resulted in the rolling moments. "The airplane's lateral stability would have been reduced, and its sensitivity to rudder-induced sideslip would have been increased," the report said. "In the stall condition that prevailed on the accident flight, both of these factors (engine surges and rudder inputs) could also have been responsible for the rolling moments."

The weather conditions in which the accident flight was operating were evaluated for visual cues during the stall maneuver. "Although IMC prevailed for parts of the night flight, the accident airplane was in VMC [visual meteorological conditions] above a cloud layer when the flight crew began the stall series," the report said. "However, based on weather satellite data and almanac information, the [NTSB] concludes that the flight crew did not have a clearly visible natural horizon because of darkness and clouds above and below the airplane, and that the airplane most likely encountered IMC soon after descending through 13,500 feet and remained in IMC until just before impacting terrain."

The report also said that "by conducting these maneuvers without a visible natural horizon, the flight crew was deprived of an important flight attitude reference that would have aided in their recovery from a full stall."

Investigators evaluated the ABX DC-8 simulator and found that “the simulator did not reproduce the stall characteristics of the DC-8 with fidelity,” the report said. “For example, when slowed to below the airspeed of stick-shaker activation, the simulator developed a stable, nose-high, wings-level descent, with no tendency to pitch down in a stall break (abrupt nose-down pitch or roll).

“In contrast, according to Douglas and ABX manuals and the FDR data from the accident flight, the actual DC-8 airplane’s stall characteristics include a pronounced stall break. Further, after slowing well below stall speed, the simulator entered a mode in which the aerodynamic buffet stopped and the airspeed did not continue to decrease.”

The report said, “ … Because the PF and PNF were exposed during extensive simulator experience to what they presumed was the stall behavior of the DC-8, the stall break that occurred in the airplane most likely surprised them. The [NTSB] concludes that the flight crew’s exposure to a low-fidelity reproduction of the DC-8’s stall characteristics in the ABX DC-8 flight training simulator was a factor in the PF holding aft (stall-inducing) control-column inputs when the airplane began to pitch down and roll, which contributed to this accident.”

“The accident could have been prevented if ABX had institutionalized and the flight crew had used the revised FEF stall-recovery procedure agreed upon by ABX in 1991.”

In 1991, an ABX DC-8 experienced a loss-of-control incident following a postmodification FEF. As a result of this incident, the FEF stall-recovery procedure was revised and agreed to by both ABX and the FAA. “The revised FEF stall-recovery procedure stressed a positive reduction of pitch attitude to rapidly decrease the angle-of-attack below the critical stall angle before the application of engine power,” the report said. “In calling for a more positive reduction of pitch attitude, the revised procedure eliminated the emphasis of the standard ABX stall-recovery procedure on minimum altitude loss.”

The report said, “After the DC-8 flight standards manager, who had adopted the revised FEF procedure, returned to line flying in 1994 and was replaced by the accident PNF, the director of flight technical programs trained the accident PNF using the original stall-recovery procedure. The accident PNF, in turn, trained the accident PF.”

During the accident flight, the report said, “Some provisions of the revised procedure were implemented and used during the accident flight, although the manner in which they were used confirmed that the flight crew was attempting the original, minimum-altitude-loss stall recovery ... .

“Despite [ABX’s] partial implementation of the revised procedure, the statements of the director of flight technical programs and the actions of the accident flight crew show that ABX ultimately did not institutionalize the technique of exchanging altitude for a more rapid stall recovery, and thus failed to take advantage of the valid lessons of the 1991 DC-8 FEF loss-of-control incident ... .

“The accident could have been prevented if ABX had institutionalized and the flight crew had used the revised FEF stall-recovery procedure agreed upon by ABX in 1991.”

The investigation reviewed the guidance provided by ABX to its flight crews for conducting an FEF. “ABX had no specific prohibition against conducting an FEF at night,” the report said. “In addition, the pilots’ direct supervisor, the director of training and standards, stated that he had conducted FEFs at night and that he would have approved the operation of the accident flight at night had he been asked by the flight crew.”

The report said, “In contrast to this practice at ABX, procedures established by a major U.S. airplane manufacturer for the first flight after a major modification stated, ‘If a flight cannot depart on time to be completed by nightfall, then it should be rescheduled for the next morning.’”

The report said, “ABX’s failure to require completion of an FEF by sundown or to establish adequate limitations on ambient lighting and weather conditions led the flight crew to attempt the stall series in the absence of a natural horizon, and contributed to the accident. Further, based on its review of the provisions of selected air carrier and manufacturer manuals, the [NTSB] concludes that there is a lack of consistency across the industry in the conditions and limitations for conducting FEFs and associated approach-to-stall maneuvers. ...

“The clean-stall maneuver was performed by ABX pilots in the airplane only during postmodification FEFs. Therefore, neither pilot involved in the accident had performed the clean-stall maneuver in a DC-8 airplane before the accident flight.” In addition, the report said, “Training for FEFs was informal and undocumented, and ABX had established no specific training or proficiency requirements for pilots conducting FEFs.

“The informality of its FEF training program led ABX to fail to recognize that a postmodification FEF was a nonroutine operation with special characteristics, including further entry into the stall than was provided in regular line pilot training and for which the simulator did not provide adequate fidelity. … The [NTSB] concludes that the informality of the ABX FEF training program contributed to the accident by permitting the inappropriate pairing of two pilots for an FEF, neither of whom had handled the flight controls during an actual stall in the DC-8.”

Investigators evaluated "whether the flight crew's decision to undertake the FEF at night was prompted by supervisory or self-imposed pressure," the report said. The completion of the work on the accident aircraft had been delayed for several months. This situation delayed the availability of the aircraft for revenue operations and, the report said, "had caused the company to inform a freight charter customer that its charters were subject to cancellation on short notice (because [the accident aircraft] would not be available in case another airplane needed repairs) and subsequently to cancel one of these charters. ...

"The [NTSB] was unable to identify the accident flight crew's state of awareness of these specific plans for [the accident aircraft]; however, according to ABX's director of flight training and standards, the accident PNF was aware of the company's desire to place the airplane in revenue service. The flight crew, as ABX managers, would most likely have responded to the urgency to place the airplane in service with a strong effort to get the job done."

Investigators found "no evidence of direct pressure on the flight crew from higher level ABX managers to complete the flight," the report said. "The [NTSB] concludes that the flight crew's decision to conduct the flight at night was influenced by the succession of delays they had experienced earlier in the day."

The NTSB reviewed the FAA's oversight of ABX, including an FAA inspection of ABX in 1991, and "found evidence that ABX had problems ensuring that company manuals and other documentation of operations procedures kept pace with the company's growth," the report said, and that "FEF program deficiencies were consistent with the general problems identified by the 1991 FAA inspection."

The FAA principal operations inspector (POI) assigned to ABX "successfully identified the safety issues raised in the 1991 DC-8 loss-of-control incident, as shown by his efforts to cause ABX to revise its FEF stall-recovery procedures and the air carrier's implementation of this revision," the report said. "The response of the FAA [POI] to the 1991 ABX DC-8 loss-of-control incident was timely and appropriate, but it was not formally incorporated into ABX procedures."

Based on its investigation, the NTSB developed a number of findings:

- "The [PF] made a timely decision to terminate the clean stall and begin the stall recovery;
- "The [PF] applied inappropriate control column back pressure during the stall-recovery attempt in an inadequate performance of the stall-recovery procedure established in ABX's operations manual;
- "Aircraft weight-and-balance were not a factor in the greater-than-expected buffet-onset speed; and the airplane was loaded within its approved weight-and-balance limits during the accident flight;
- "Some combination of airframe icing, flight-control rigging or other factors resulted in the greater-than-expected buffet-onset speed; however, any effects of airframe icing or flight-control rigging upon the stall speed of the accident airplane were minimal;
- "Although the [PF] trimmed the airplane below the recommended minimum trim speed for the clean stall, this action did not contribute to the accident;
- "The [PNF], in the right seat, was serving as the [PIC] of the accident flight and was conducting instruction in [FEF] procedures; and the [PF], in the left seat, was serving as the [SIC] and was receiving instruction in [FEF] maneuvers, including the clean-stall maneuver;
- "The [PNF], as the pilot-in-command, failed to recognize, address and correct the [PF's] inappropriate control inputs;
- "The absence of the stick shaker prior to the stall did not affect the flight crew's recognition of the initial entry into the stall;
- "The inoperative stall-warning system failed to reinforce to the flight crew the indications that the airplane was in a full stall during the recovery attempt;
- "This accident might have been prevented if the flight crew had been provided a clear, direct indication of the airplane's angle-of-attack;
- "The engine compressor surges in the no. 2 engine (caused by airflow disruption) may have distracted the flight crew during the critical early period of the stall recovery, when sufficient lateral control was available for the recovery;
- "The flight crew did not have a clearly visible natural horizon because of darkness and clouds above and below the airplane, and the airplane most likely encountered [IMC] soon after descending through 13,500 feet and remained in [IMC] until just before impacting terrain;
- "By conducting these maneuvers without a visible natural horizon, the flight crew was deprived of an important flight-attitude reference that would have aided in their recovery from a full stall;
- "The flight crew's exposure to low-fidelity reproduction of the DC-8's stall characteristics in the ABX DC-8 flight training simulator was a factor in the [PF] holding aft

(stall-inducing) control column inputs when the airplane began to pitch down and roll;

- "The accident could have been prevented if ABX had institutionalized and the flight crew had used the revised [FEF] stall-recovery procedure agreed upon by ABX in 1991;

- "ABX's failure to require completion of [an FEF] by sundown or to establish adequate limitations on ambient lighting and weather conditions led the flight crew to attempt the stall series in the absence of a natural horizon;

- "There is a lack of consistency across the industry in the conditions and limitations for conducting [FEFs] and associated approach-to-stall maneuvers;

- "The informality of the ABX [FEF] training program permitted the inappropriate pairing of two pilots for [an FEF], neither of whom had handled the flight controls during an actual stall in the DC-8;

- "The occurrence of fatal accidents during two different nonroutine operations ([an FEF] and a three-engine ferry [flight of a four-engine aircraft]) by air carriers indicates a need to identify other nonroutine operations conducted by air carriers that may require additional procedural definition and training measures;

- "The flight crew's decision to conduct the flight at night was influenced by the succession of delays they had experienced earlier in the day;

- "The deficiencies of the ABX [FEF] program remained latent after general organizational problems were identified by the 1991 [FAA] National Aviation Safety Inspection Program in the other company functions;

- "The response of the FAA [POI] to the 1991 ABX DC-8 loss-of-control incident was timely and appropriate, but it was not formally incorporated into ABX procedures; [and,]

- "The currently established FAA airworthiness and operating procedural requirements for conducting [FEFs] on large transport aircraft provide inadequate guidance to air carrier operators, maintenance repair stations, FAA principal operations and maintenance inspectors, and other affected parties."

As a result of its findings, the NTSB made the following recommendations to the FAA:

- "Require Douglas Aircraft Co. to review and amend the stall-warning test procedures in the DC-8 maintenance manual and maintenance-planning document to include regular calibration and functional checks of the complete stall-warning system;

- "Evaluate the data available on the stall characteristics of airplanes used in air carrier service and, if appropriate, require the manufacturers and operators of flight simulators used in air carrier pilot training to improve the fidelity of these simulators in reproducing the stall characteristics of the airplanes they represent to the maximum extent that is practical; then add training in recovery from stalls with pitch attitudes at or below the horizon to the special-events training programs of air carriers;

- "Ensure that ABX explicitly incorporates the revised [FEF] stall-recovery procedure (that was agreed upon in 1991 by ABX and the FAA), or an equivalent procedure, in its DC-8 [FEF] program;

- "Develop an advisory circular that provides guidance to air carriers on the appropriate conditions, limitations and tolerances for the performance of [FEFs] and the specific maneuvers performed during these flights, including approaches to stall;

- "Identify the set of operations conducted by air carriers that require special consideration, including [FEFs] and other nonroutine operations that have similar needs for training and operational guidance; then amend air carrier operations specifications to include appropriate guidelines and limitations for these nonroutine operations and amend [FARs] Part 121 to require air carriers to establish appropriate flight crew training and qualification requirements in their training manuals;

- "Undertake an appropriate level of surveillance of the [FEF] programs of all air carriers, following implementation of the [NTSB's] suggested changes to [FEF] and other nonroutine operations; [and,]

- "Modify the operating and airworthiness regulations … or issue appropriate guidance material to clarify airworthiness and operational procedural requirements for conducting [FEFs] in transport-category aircraft."

In addition, the NTSB reiterated a previous recommendation to the FAA that resulted from a previous accident: "Require that all transport-category aircraft present pilots with angle-of-attack information in a visual format, and that all air carriers train their pilots to use the information to obtain maximum possible climb performance."♦

Editorial note: This report was adapted from *Uncontrolled Flight into Terrain, ABX Air (Airborne Express), Douglas DC-8-63, N827AX, Narrows, Virginia, December 22, 1996*. Report no. NTSB/AAR-97/05. July 1997. The 107-page report contains figures and appendices.

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