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Spatial Disorientation Linked to Fatal DC-8 Freighter Crash

After two missed approaches in instrument meteorological conditions at night, the captain took control of the aircraft from the first officer during climbout from the second missed approach. Seconds later, the airplane was out of control, and the first officer took the controls again. A U.S. National Transportation Safety Board accident investigation suggests that better, and more timely, communication between the captain and first officer might have prevented the accident.

Editorial Staff Report

The McDonnell Douglas DC-8-63 freighter was on its second missed approach to Toledo (Ohio) Express Airport when it entered a steep bank and pitched nose down. The aircraft crashed about 26 seconds later about three miles northwest of the airport.

The Feb. 15, 1992, crash, which killed the three-man flight crew and a passenger, occurred at 0326 Eastern Standard Time (EST) during instrument meteorological conditions.

Air Transport International (ATI) Flight 805 originated in Portland, Oregon, at 2145 EST bound for Seattle, Washington. The flight, operating under 14 Code of U.S. Federal Aviation Regulations (FAR) Part 121, unloaded and loaded freight and departed Seattle for Toledo at 2320 EST.

The airplane was vectored for an instrument landing system (ILS) approach to runway 07 and advised that Level 1 and Level 2 precipitation echoes were along the final approach course to Toledo. [Radar depiction of the intensity of precipitation is measured in six levels: Level 1 (weak), Level 2 (moderate), Level 3 (strong), Level 4 (very strong), Level 5 (intense), and Level 6 (extreme).]

The first officer was the pilot flying during the approaches and during the final moments of the flight.

A U.S. National Transportation Safety Board (NTSB) investigation report concluded that the probable cause of the accident was the "failure of the flight crew to properly recognize or recover in a timely manner from [an] unusual aircraft attitude." (Figure 1)

The NTSB said the unusual attitude could have resulted from spatial disorientation experienced by the captain [who took control of the aircraft during climbout from the second missed approach], caused by either physiological factors or a failed attitude director indicator. The NTSB said safety issues related to the crash included unusual attitude-recovery training for flight crews, crew fatigue and cockpit resource management (CRM).

"The captain assumed control of the airplane ... [but] apparently became spatially disoriented ... and he inadvertently allowed an unusual attitude to develop with bank angles up to 80 degrees and (downward) pitch angles to 25 degrees," the NTSB said.

The NTSB report added: "The captain transferred control of the airplane to the first officer when the airplane was nose low and in a left bank angle. However, there may have been a short period of time when neither pilot was in control.

"The first officer assumed control and began leveling the wings and raising the nose of the airplane, but impact with the ground occurred before the unusual attitude recovery was completed. The operability of the captain's attitude indicator at the time control was lost is uncertain. Witness marks on the one attitude director indicator ball that was found could have indicated an incorrect position at impact, [but] the evidence was inconclusive. Based on the performance of the airplane during the recovery, the first officer's attitude director indicator was operating properly [as was another independently-powered standby artificial horizon]."

At 0324:46, the first officer advised the air traffic controller at Toledo that the airplane was executing a second missed approach, and the flight was directed to climb and maintain 3,000 feet. At 0325, the captain called for climb power and a sound similar to that of a slight power reduction was recorded on the cockpit voice recorder (CVR). About 30 seconds later, the tower controller directed the flight crew to turn left to a heading of 300 degrees.

Flight simulation studies conducted by the NTSB indicated a rapid loss of altitude and an increase in airspeed "as the airplane dove to impact in about 26 seconds. The crash occurred at an airspeed in excess of 300 knots."

The captain, 59, was hired by ATI in October 1990. At the time of the accident, company records indicated that he had logged a total of 16,382 flying hours, of which 2,382 were in the DC-8.

"U.S. Federal Aviation Administration (FAA) records indicate that the captain failed his first attempt at a DC-8 type rating on Oct. 23, 1986. The unsatisfactory maneuvers were three-engine ILS, no flap approach, nondirectional beacon (NDB) approach and a 50-percent-power approach.

Cockpit Voice Recording of Flight 805's Intra-cockpit Communication

During the 30 seconds before impact, the CVR recorded the following:

0325:31.3	Sounds similar to simultaneous altitude and trim alert.
0325:38.9	Captain: *[expletives] ... what's the matter?*
0325:43.4	Captain: *what the [expletive]'s the matter here?*
0325:47.9	Unknown: *harry*.
0325:48.8	Captain: *you got it?*
0325:49.5	First Officer: *I got it.*
0325:52.0	Sound similar to altitude-alert warning.
0325:55.0	Sound similar to sink-rate warning.
0325:55.5	Flight Engineer: *pull up*.
0325:55.6	GPWS pull-up warning.
0325:57.3	Flight Engineer: *pull up*.
0325:57.7	GPWS pull-up warning.
0325:58.1	Captain: *up, up, up, up*.
0325:59.1	First Officer: *I can't*.
0325:59.7	GPWS pull-up warning.
0326:00.5	Captain: *up, up*.
0326:00.8	Sound of impact.

Source: *U.S. National Transportation Safety Board*

Figure 1

The FAA inspector noted on the forms 'not with the aircraft' and 'train to proficiency.'"

After receiving additional training, the captain passed the rating check ride on Nov. 5, 1986. "Interviews revealed that his peers regarded him as a very good pilot," the NTSB said.

The first officer, 37, joined the company in 1989. Records indicated that he had accumulated about 5,082 flying hours, of which 1,143 were in the DC-8 as first officer and 1,992 as flight engineer.

"Company records indicate that the first officer was an average pilot and that he had no difficulty with either training or proficiency checks. Fellow pilots described him as professional, adaptable and eager," the NTSB said.

The flight engineer, 57, was also hired in 1989. Records indicate that he had logged a total of 21,697 flying hours, of which 7,697 were in the DC-8.

The passenger was a nonrevenue crew member from another cargo airline.

ATI records indicated that the captain and first officer had been paired on 23 previous trip sequences. The captain and flight engineer had been paired on 20 previous trip sequences.

The DC-8-63 involved in the crash had logged a total of 70,430 hours and had 22,982 cycles on the airframe. The airplane was equipped with four Pratt & Whitney JT3D-7 engines.

Surface weather conditions at the time of the crash were reported as measured ceiling 400 feet overcast, visibility two miles, moderate rain, fog and winds of 090 degrees at 13 knots.

[On the second missed approach, Toledo tower reported winds of 100 degrees at 10 knots. The crew of Flight 805 told the tower that they were experiencing 35-knot winds of 180 degrees on the final approach course, requiring a significant crab angle to stay on course.]

The wreckage site measured more than 2,000 feet in length along a heading of about 295 degrees true. Parts of the wreckage were destroyed by post-impact fires. The NTSB said that the largest pieces of wreckage included portions of the left and right wings and fuselage, the landing gear and the engines.

"Based on the tree strikes, ground scars and airplane dimensions, the flight path angle was estimated at 17-degrees down, and the airplane roll was approximately 15-degrees left wing down," the NTSB report concluded.

The NTSB said everyone aboard the airplane died instantly during the impact sequence.

The NTSB said that although low ceilings and visibilities were present at the time of the crash, existing conditions "did not preclude a successful approach."

It added: "Therefore, weather cannot be considered causal in this accident, although the adverse crosswind was probably the precipitating event that caused the two missed approaches."

The events during the first missed approach, the NTSB said, suggested "poor airmanship on the part of the first officer ..."

A low-level wind-shear alert system (LLWAS) was operating at Toledo at the time of the accident. No LLWAS alarms were recorded from 0300 to 0340, the NTSB said.

The report reviewed in detail the crew's performance during the two missed approaches.

During the initial descent into the Toledo area, the captain was "coaching" the first officer on when to start down to the initial approach fix crossing altitude and when to increase the flap setting, the report said.

"The CVR indicates that on the first approach attempt, the first officer slowed the airplane too much for its ... configuration. He never achieved the flap/speed combination desired by the captain, and he should have been capable of maintaining the appropriate speed. He also failed to intercept either the localizer or the glideslope on the first attempted approach."

There was no evidence suggesting that the air traffic control (ATC) vector affected the intercept on the first approach, the NTSB said.

"According to the controller, the attempt to capture and maintain the localizer began 23 miles from the outer marker. The airplane was about 15 miles from the marker when the captain prompted the first officer with 'there's the glideslope.' During the next two minutes, they ran the landing checklist, but the nearly constant comments from the captain about airspeed, configuration and the glideslope (which the first officer apparently never captured) failed to achieve the desired results, and they performed the first missed approach."

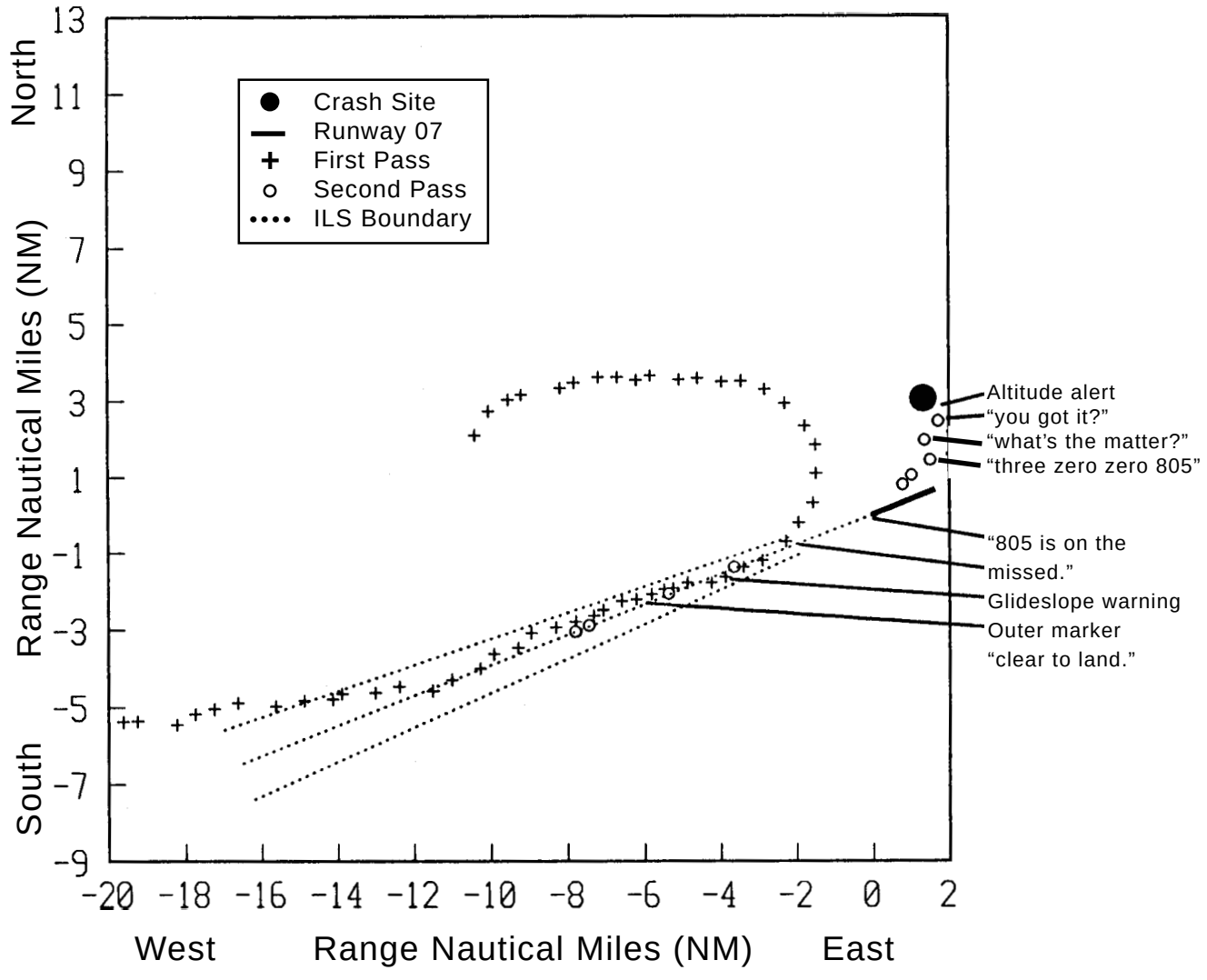
The events during the first missed approach, the NTSB said, suggested "poor airmanship on the part of the first officer ... that he was overloaded by the sequence of events and was not achieving proper control of the airplane.

"It is obvious that the captain was frustrated with the first officer's performance when he commented '... still don't have enough flaps for this speed ... add power ... you're not on the glidepath ... bring it up to the glidepath.' He then added, 'you're not even on the (expletive) localizer at all.' Finally, he had to remind the first officer to raise the landing gear during the go-around." (Figure 2)

The NTSB noted that on the second approach, the first officer's performance should have improved because he was aware of the approach conditions and could better prepare for the strong crosswinds.

"Once again, however, he was unable to complete the approach. [The captain] talked the first officer through the amount of crab required. With increased coaching, the first officer apparently intercepted the localizer and the glideslope. Despite specific admonitions, '... don't get slow because you got plenty of wind down here to help you,' they began receiving GPWS, glideslope and sink-rate warnings. After six GPWS warnings, the captain stated, 'push the power and get back up to the glidepath.' Four seconds later he advised, 'okay now take it back off ... stay with it.' The first officer responded by reducing power about three seconds later, but two sec-

Flight 805 Ground Track Based on Radar Data



Source: U.S. National Transportation Safety Board

Figure 2

onds later the captain announced, 'Oh (expletive) I got it' in a frustrated or disgusted tone of voice. The first officer was unable to properly fly the airplane in an operation ... for which he was trained."

Crew fatigue, the NTSB said, was one possible explanation for the first officer's substandard performance.

The accident flight was the second leg of a two-trip sequence from Portland to Seattle to Toledo. The crew was scheduled to fly the reverse route the next day. The first leg began with a duty time of 0300 (local time in Portland) after a week of rest. Nevertheless, the NTSB said it was "unable to determine conclusively that the crew was 'well rested' in the traditional sense.

"If their week off duty was spent in normal awake-sleep cycles, they could have been adversely affected by fatigue at the time of the accident because their return to duty placed them in abnormal, reversed sleep-wake cycles. Moreover, the accident occurred on the second day of this disrupted sleep cycle during the early morning hours, a time of day associated with diminished capacity to function effectively because of circadian rhythms."

Aeromedical studies show that deceleration while turning can produce the sensation of turning in the opposite direction.

But the NTSB also noted that analysis of the CVR transcript revealed no obvious symptoms of fatigue. While acknowledging that conditions were conducive to producing fatigue and increasing susceptibility to disorientation, the NTSB said evidence was not sufficient to conclude that crew fatigue "adversely affected pilot performance in this accident."

The report devoted considerable attention to examining the potential role of spatial disorientation in the crash.

"There is no question that the captain became gravely concerned about something one minute and 22 seconds after assuming airplane control (probably for the first time since landing in Portland the previous day) on the second missed approach," stated the NTSB.

The report said that the CVR transcript suggested that the captain's comments ["what's the matter?"] reflected a state of perplexity or confusion rather than recognition of a mechanical problem.

The flight data recorder (FDR) indicated that the pilot began a slow, sustained left turn about 0324:50. Beginning about 0325:00, the sound of a power reduction was heard on the CVR, and the airplane was approaching its assigned altitude.

"However, at 0325:10, the FDR still showed the airplane ascending through 2,800 feet at a rate of 2,400 feet per minute. At 0325:31, the FDR showed that the airplane's altitude peaked at 211 feet above the assigned altitude of 3,000 feet. It is probable that the captain then realized he had overshot his assigned altitude and proceeded to push the nose over during the decelerating turn to regain 3,000 feet."

About five seconds later, shortly after the first officer acknowledged the turn to 300 degrees, the FDR showed that the turn rate increased dramatically. Simulations, the NTSB said, showed that the bank angle then steepened to about 25 degrees when the captain said the words "what's the matter?" A flight-path study indicated that eight seconds after exceeding 30-degrees bank angle, the airplane was passing through about 60-degrees left bank at a 14-degree descent angle, the report said.

"This combination of steady, sustained turning, acceleration-to-deceleration changeover, and abrupt ascent to descent transition, at night with no visible horizon or outside references, is especially conducive to spatial disorientation," the NTSB said.

Aeromedical studies show that deceleration while turning can produce the sensation of turning in the opposite direction. "Had the captain ... incorrectly believed that he was rolling out of his turn to the left (the opposite direction), he might have increased the bank angle to the left to compensate."

The NTSB concluded that the first officer's response to the captain's release of control was immediate and correct in execution. However, it said the accident underscored the need for further improvement in unusual attitude recovery and CRM training.

"Airline pilots are not periodically trained to recover from unusual attitudes as are military pilots or civilian acrobatic pilots," the NTSB said. "The presumption is that an airline pilot should avoid an unusual attitude and will never have a need to recover from one."

The report said the accident highlighted the need for "active crew coordination and interaction to avoid having the flying pilot exceed flight limitations such as airspeed, pitch and bank angles. The circumstances further emphasize the importance of timely action in challenging or correcting fellow crew members."

The first officer could have been more aggressive in challenging the captain as the bank angles increased, the NTSB said.

"Because 30 degrees is the steepest bank angle used in normal transport flying, the captain's continued roll into a steeper bank should have alerted the first officer that he needed to challenge the captain's performance," the report said. "The accident might have been prevented if the first officer had corrected or challenged the captain's overbank in the 10 seconds between the first signal of trouble and the captain's transfer of control statement."

But the report noted that the first officer's poor performance during the preceding approaches may have made him hesitant to speak up and alert the captain to a deviation or to intervene to correct it.

The first officer may also have been affected by the CRM environment in the cockpit just prior to the accident, the NTSB said.

"The last 30 minutes of the flight were more representative of an instructor/student than a teamwork situation. Cockpit conversation and interaction were one-sided, in that the captain was dominating the conversation and making all the decisions concerning the flight until the first officer assumed control of the airplane after the loss of control."

The NTSB said that a more aggressive control input may also have averted disaster.

"A larger, more rapid aileron input would have leveled the wings faster; and a more aggressive pullout could have been within the operating envelope of the aircraft. Even if he had exceeded the approved g-load for the DC-8, a large safety margin existed to preclude structural failure. Obviously, this situation called for extremely quick and aggressive control inputs." ♦

ACCIDENT PREVENTION

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