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Pitch Oscillations, High Descent Rate Precede B-727 Runway Undershoot

The flight crew was conducting a Category II ILS approach in instrument meteorological conditions. The airplane pitched down after crossing the middle marker, and the autopilot disconnected. The captain increased power and pulled back the control column to arrest the sink rate. The airplane struck terrain, bounced onto the runway and then veered off the runway.

FSF Editorial Staff

About 0954 local time Feb. 9, 1998, a Boeing 727-223 operated by American Airlines touched down 314 feet (96 meters) from the runway displaced threshold (160 feet [49 meters] from runway pavement) during a Category II (CAT II) instrument landing system (ILS) approach to Runway 14R at Chicago (Illinois, U.S.) O'Hare International Airport (ORD). The main-landing gear separated during the touchdown. The airplane then became airborne, touched down on the runway, slid and veered off the side of the runway. Twenty-two passengers and one flight attendant received minor injuries during the accident and the subsequent emergency evacuation. The airplane was substantially damaged.

The U.S. National Transportation Safety Board (NTSB) said, in its final report, that the probable cause of the accident was "the failure of the flight crew to maintain a proper pitch attitude for a successful landing or go-around."

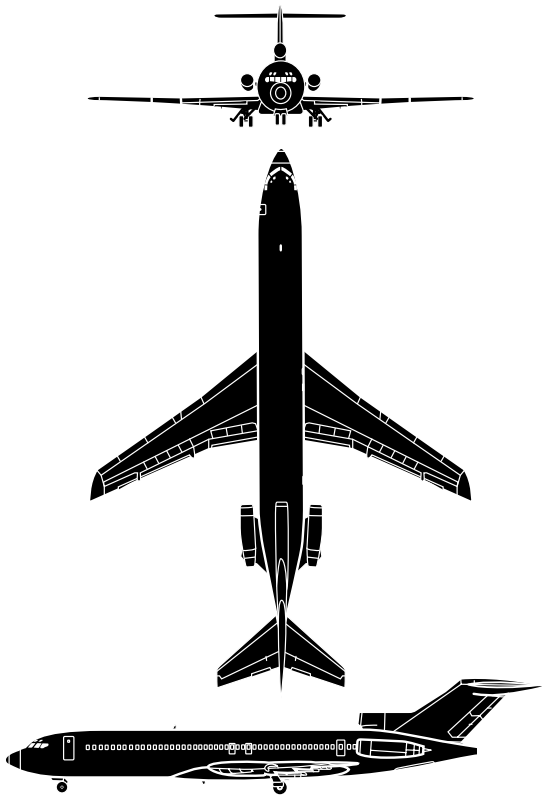
The report said, "Contributing to the accident were the divergent pitch oscillations of the airplane, which occurred during the final approach and were the result of an improper autopilot-desensitization rate."

The airplane, which was delivered new to American Airlines in 1975 and had accumulated 59,069 flight hours, was equipped with a Sperry Aerospace (now Honeywell) SP-50 autopilot roll computer and an SP-150 autopilot pitch computer. The autopilot computers had not been modified in accordance with two Sperry service bulletins: SB 21-1132-121, issued in 1982 and applicable to the SP-50; and SB 21-1132-122, issued in 1983 and applicable to the SP-150. The service bulletins recommended changes to the autopilot approach-mode desensitization schedules.

Approach-mode sensitivity (also called *gain*) refers to the magnitude of roll commands and pitch commands generated by the autopilot computers in response to flight-path deviations from the localizer and glideslope. Gain is reduced, consistent with the programmed desensitivity schedule, as the distance between the airplane and the runway decreases. The autopilot computers use distance estimates based on

either distance-measuring equipment (DME) information, radio altitude information or timing.

"Although the SP-150 was capable of scheduling the sensitivity based on radio altitude, the accident airplane's autopilot system was configured to start desensitizing over a 150-second period after passing through 1,500 feet radio altitude on the approach," the report said. "During the 150 seconds, the autopilot sensitivity, or gain, would be reduced from a value of 1.0 to a value of 0.22 (or about 78 percent).



Boeing 727-200

The three-engine, short/medium-range B-727 was introduced into service in 1960. The B-737-200, introduced in 1967, is a "stretched" version, with 10-foot (three-meter) fuselage extensions both forward and aft of the main-landing-gear wheel wells.

The airplane accommodates 163 passengers to 189 passengers (compared with 103 passengers in the B-737-100) and has a three-pilot flight deck. Maximum takeoff weight is 190,500 pounds (86,411 kilograms). Maximum landing weight is 160,000 pounds (72,576 kilograms).

Pratt & Whitney JT8D-9 turbofan engines, each flat-rated at 14,500 pounds (6,577 kilograms) thrust, were standard. JT8D-11 engines, flat-rated at 15,000 pounds (6,804 kilograms) thrust, and JT8D-15 engines, flat-rated at 15,500 pounds (7,031 kilograms) thrust, were options.♦

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

"After receiving the signal from the middle marker (located about 0.5 nautical mile [0.9 kilometer] from the runway threshold), the gain further reduced to a value of 0.055 over 30 seconds (or another 75 percent)."

The programmed desensitivity schedule is based, in part, on typical approach airspeeds. The changes recommended in the service bulletins were intended to accommodate higher approach airspeeds than the roll computer and the pitch computer originally were designed to accommodate; the original schedule was based on B-727 approach airspeeds with flaps extended 40 degrees.

"However, in the early 1980s, operators began using a 30-degree flap setting and correspondingly higher airspeeds to improve the maneuverability of the airplane during the approach," the report said. "The changes outlined by [the service bulletins] were designed to reduce the time required for autopilot desensitization from 150 seconds to 105 seconds."

The American Airlines *727 Operating Manual* requires CAT II ILS approaches to be conducted with the autopilot coupled to the ILS.

"Both pilots monitor the autopilot and instruments, but the first officer is the flying pilot until the captain is ready to take the controls and complete the approach visually," the report said. "The first officer remains on instruments throughout the approach and landing. … The captain directs primary attention outside the airplane to seek visual reference at not less than 100 feet above DH [decision height].

"When the captain is ready to take the controls and complete the approach visually, the captain will push the first officer's hand from the throttles and call out 'I've got it,' indicating intention to land. In the event that visual contact is lost or a go-around is required, the captain will execute a missed approach procedure."

The captain, 42, had about 11,000 flight hours, including 424 flight hours as a B-727 pilot-in-command and 895 flight hours as a B-727 second-in-command. He had accumulated about 4,000 flight hours as a Fokker 100 captain before transitioning as a B-727 captain in April 1997.

"According to the captain, he had flown about 10 CAT II approaches in his flying career (or about 'once or twice a year')," the report said. "He stated that the accident flight was his first nonsimulated CAT II approach in a 727."

The first officer, 40, had 5,638 flight hours, including 3,731 flight hours as a B-727 second-in-command. The flight engineer, 40, had about 3,000 flight hours, including 1,550 as an American Airlines flight engineer.

The airplane was being operated as Flight 1340, en route to ORD from Kansas City (Missouri, U.S.) International Airport.

The airplane had departed from Kansas City at 0843. The airplane was in cruise flight at Flight Level 330 (33,000 feet) at 0923 when the captain conducted an approach briefing.

"The briefing included the ORD Runway 14R navigation radio frequencies, approach fixes, altimeter settings, crew call-outs and the missed approach procedure," the report said. "According to the cockpit voice recorder (CVR) transcript, at 0925.22, the captain stated that, after 100 feet, he would 'keep it on autopilot just a few seconds and then … disconnect.'" [The DH for the approach was 100 feet.]

At 0929, the crew received automatic terminal information service (ATIS) information X-ray, which said that the wind was calm, visibility was less than one-quarter statute mile (0.4 kilometer) with freezing fog, vertical visibility was 100 feet, and temperature and dew point both were minus 3 degrees Celsius (27 degrees Fahrenheit).

At 0936, Chicago Center told the crew to maintain 250 knots and to contact Chicago Approach.

The captain (the pilot not flying) told Chicago Approach that the airplane was at 11,000 feet and that they had received information X-ray.

The approach controller told the flight crew to expect the Runway 14R ILS approach and said that the current runway visual range (RVR) was 1,600 feet. (Minimum RVR for a CAT II approach is 1,200 feet.)

The approach controller vectored the crew onto a right downwind for Runway 14R and then onto a course to intercept the localizer. At 0948, the controller told the crew to intercept the localizer at 5,000 feet and cleared the crew to conduct the ILS approach.

"[The first officer said] that the autopilot system was tracking the localizer and glideslope normally, and that the airplane was configured at 170 knots [with landing gear extended and] with flaps set at 15 degrees until [crossing the outer marker], when flaps were extended to 30 degrees and the airplane was slowed to 143 knots," the report said. (Landing reference speed [V_{REF}] was 130 knots.)

At 0951, the captain told Chicago Tower that the airplane was at the outer marker (ROAMY) and inbound on final approach (see "Cockpit Voice Recorder Transcript, American Airlines Flight 1340, Feb. 9, 1998," page 7). The outer marker was 5.2 nautical miles (9.6 kilometers) from the runway threshold.

The tower controller cleared the crew to land and said that the winds were calm and that RVR was 1,600 feet. The captain's acknowledgement of the clearance was the last radio transmission received from the accident airplane by air traffic control.

The flight crew selected the engine-heat system and the wing-heat system before the airplane entered clouds at about 500 feet above ground level (AGL).

"The captain told [investigators] that at an altitude of 200 feet, the glideslope and localizer were 'wired' [i.e., tracked precisely by the autopilot] and that after an instrument scan, he concluded that 'everything appeared solid,'" the report said.

Flight data recorder (FDR) data indicated that the approach was stabilized until two seconds after the airplane crossed the middle marker at about 170 feet AGL.

The airplane descended one-half dot below the glideslope, as shown on the glideslope indicator, before the autopilot corrected the deviation.

"While flying inside the middle marker during the most critical phase of the approach, … the flight crew did not react in a proper and timely manner to excessive pitch deviations and descent rates by either initiating a go-around or adjusting the pitch attitude and thrust to ensure a successful landing, as required by the CAT II procedures outlined in the *American Airlines 727 Operating Manual*," the report said.

Within three seconds of crossing the middle marker, the airplane's pitch attitude increased from one degree nose-up to about 3.5 degrees nose-up. During this time, the captain observed the lead-in lights.

"The captain stated that the lead-in lights were faint but that he could see that the airplane was lined up on the runway centerline," the report said. "He also stated that when he took control of the airplane, he 'wriggled up' in his seat to see the lights better." The captain said that he did not believe that he pushed on the control column when he adjusted his seating position.

The report said, "The captain … left his sunglasses on during the approach and landing, increasing the potential for visual illusions as the result of reduced visibility." (The first officer had removed his sunglasses before the airplane entered clouds.)

The airplane was at about 140 feet AGL when the captain took control at 0953:49 (five seconds before impact). At this time, the airplane pitched two degrees nose-down and descended about one-half dot below the glideslope.

During the next two seconds, the airplane pitched six degrees nose-down and descended "well below the glideslope," the report said.

The report said, "The captain stated that in a 'heartbeat,' the lead-in lights went from normal to 'all around us.'"

The first officer, who had been concentrating his instrument scan on the radio altimeter, looked up and observed the "nose pointed short of the runway."

The captain said that he was holding "lightly" the control column, with one finger next to the autopilot-disconnect button.

"He stated that he did not think he pushed the control column forward and that he thought the autopilot 'pushed the airplane over,'" the report said.

The airplane was at about 80 feet AGL at 0953:51 when the flight engineer said, "Oooh, nose, uh." The CVR then recorded a click, which the report said was consistent with the sound of the autopilot disconnecting.

"The captain stated that he did not recall disengaging the autopilot and, that if it was disengaged, it was not done intentionally," the report said.

Two seconds before impact, the ground-proximity warning system (GPWS) generated a "sink rate" aural alert and the flight engineer said, "Nose up, nose up."

The airplane's descent rate had increased rapidly to about 1,900 feet per minute. The captain pitched the airplane to about six degrees nose-up and increased power substantially. The report said that these actions were not sufficient to arrest the descent rate.

"[The flight engineer said that] he thought that the captain's actions brought the airplane out of the nose-down attitude and prevented a 'solid nose-first strike,'" the report said.

The airplane was in a five-degree nose-up and five-degree right-wing-down attitude when it touched down at 133 knots and with a descent rate of 1,350 feet per minute.

"The first officer stated that the airplane 'hit harder than a hard landing,' bounced and hit again," the report said. "The captain stated that after the first impact, he thought, 'Keep what you got, let's see if she'll fly.' He stated that he then felt the airplane bounce, realized that the airplane was on the right side of the runway and briefly applied left rudder as the airplane skidded down the runway."

The airplane slid about 2,350 feet (717 meters), veered off the right side of the runway and came to rest in mud about 250 feet (76 meters) from the runway.

The door on a ceiling stowage compartment formerly used to stow life rafts opened during impact and blocked the aisle leading to the forward cabin door. The 116 passengers and six crewmembers evacuated the airplane through three other cabin doors and four overwing exits.

The report said that two passenger-seat-belt attachments became unhooked during impact, causing minor injuries to one passenger.

The report said that the tower controller did not monitor the progress of the airplane after he cleared the crew to land. After the accident occurred, the controller cleared the crews of two United Airlines B-737s to land on Runway 14R. One B-737, which had crossed the outer marker when the accident airplane was one mile (1.9 kilometers) from the runway, was landed uneventfully.

Five minutes after the accident occurred, the driver of a ground vehicle radioed tower personnel that there was "a plane down" and that there was debris on the runway. The controller then told the crew of the other B-737 to go around; the airplane touched down on the runway during the go-around.

The captain of the accident airplane told investigators that three problems might have contributed to the accident: vertical-velocity-indicator lag that delayed the first officer's detection of the flight-path deviation; weather conditions that obscured horizontal cues that the captain could use to judge the airplane's attitude; and runway lights set to low intensity. (The report said that the runway lights were at high intensity.)

The report said that calculations based on FDR data indicated that 100 seconds elapsed from the time the airplane descended through 1,500 feet until it reached the middle marker.

"As a result, during the approach, the autopilot sensitivity was consistently higher than its intended design value," the report said. "Engineering simulator studies revealed that at the approach speeds of the accident flight, the autopilot (with the 150-second desensitization period) commanded oscillatory pitch changes that increased over time and resulted in significant deviations from the desired flight path.

"The investigation revealed that the accident airplane's autopilot was functioning within its design tolerances; however, the autopilot's 150-second desensitization rate was too slow for the accident airplane's approach speed, resulting in divergent pitch deviations at a low altitude at a critical time during the approach."

Several reports of Runway 14R glideslope anomalies were examined during the investigation. In one report, an American Airlines B-727 captain said that, on Nov. 29, 1997, his airplane was slightly below the glideslope at 250 feet AGL and pitched up slightly; the glideslope indication then moved down rapidly, and the airplane pitched nose-down "fairly severe[ly]" to capture the glideslope. The captain conducted a go-around and another ILS approach to Runway 14R. He said that after experiencing a "similar bump" at the same altitude, he conducted a go-around and flew the airplane to an alternate airport.

"Additional pilot reports of problems (both before and after the accident) with Runway 14R's ILS system were received and reviewed," the report said. "Most of the reports stated that after the aircraft was established on the glideslope, some sort of disturbance was observed in an otherwise stable glideslope. The disturbances were noticed at various places along the

glideslope. … Some of the reported occurrences could be attributed to aircraft or vehicles moving around the ILS critical area; however, several of the incidents could not be attributed to any known aircraft or vehicle movement. No pattern to any of the unexplained occurrences was found."

The report said that pilots who conducted the Runway 14R ILS approach before and after each reported occurrence of glideslope anomalies observed normal ILS indications.

The U.S. Federal Aviation Administration (FAA) conducted several routine checks and several special flight checks of the ILS.

"In all of the normal and special flight checks, the ILS system was found to be within normal limits; therefore, the FAA concluded that the pilot-reported incidents were transient events," the report said.

Postaccident FAA flight tests of the Runway 14R ILS navigational components (i.e., glideslope, localizer and lighting system) indicated that they were functioning normally.

The accident report included a submission by American Airlines. In the submission, the airline said, "The aircraft's abrupt nose-down pitch [at about 150 feet AGL] appears to have been the result of the autopilot's response to a distortion in the glideslope signal for Runway 14R. The flight crew reacted to the aircraft's abrupt nose-down pitch quickly to restore the aircraft to a nose-up pitch attitude prior to touchdown.

"Possible causes for the distortion in the glideslope signal were electromagnetic interference (EMI) from onboard portable electronic devices (PEDs), EMI from ground-based equipment and penetration of the ILS glideslope critical [area] or sensitive area."

American Airlines said that NTSB should recommend that the FAA conduct a study of the potential effects on aviation safety and aviation operations of EMI from PEDs and ground-based equipment, and issue guidance to ensure that aviation systems are not adversely affected by EMI.

The accident report also included a joint submission by the Allied Pilots Association (APA) and the Association of Professional Flight Attendants (APFA). In the submission, APA and APFA said, "The [probable] cause of this accident was the abrupt nose-down pitch of this aircraft while connected to the autopilot. The causal factors for the pitching moment could not be positively determined due to the limited parameters recorded by the [FDR]. Circumstantial evidence points toward two possible causes for the pitching moment:

- "Overcorrections applied by the autopilot due to improper desensitization of the autopilot pitch output. Normal autopilot pitch desensitization requires an adequate signal from the middle marker and radar altimeter input to begin the desensitizing process; [and,]

- "An improper glideslope signal received by the aircraft's ILS receiver due to [EMI] from onboard electronic devices or ground-based equipment."

[On April 30, 2001, American Airlines and APA filed an addendum to their submissions to the accident report. The addendum said, "The probable cause of the accident was a nose-down pitch excursion of the aircraft, while the autopilot was engaged, at approximately 150 feet [AGL], an altitude insufficient for a complete recovery. The aircraft's nose-down pitch deviation appears to have been the result of the autopilot's response to a distortion in the glideslope signal for Runway 14R."[1]]

The accident report said, "FAA flight checks flown on the ILS 14R, analyses of pilot-debrief records and [FAA's] long-term monitoring of the ILS and surrounding radio-frequency transmissions did not reveal any evidence of radio-frequency interference (RFI) to aircraft glideslope receivers using the accident runway. [NTSB] also conducted a dedicated study of the 14R ILS and found no evidence of RFI or other system anomalies that would have significantly affected the glideslope receiver and autopilot."

Based on the findings of the accident investigation, NTSB made the following recommendations to FAA:

- "Identify all airplanes operated under [U.S. Federal Aviation Regulations] Part 121 with life raft ceiling stowage compartments or compartments that formerly held life rafts that open downward and issue an airworthiness directive to limit the distance that those compartments can open. (A-99-10);

- "Reexamine the design of seat belts installed on passenger seats on air carrier, air taxi and commercial airplanes to determine the reason some have become unhooked from their seat attachments during turbulence or a hard landing and establish a suitable means of ensuring that the seat belts remain attached to their shackles during all modes of flight. (A-99-11);

- "Require operators of Boeing 727 aircraft equipped with Sperry Aerospace SP-50 and SP-150 autopilots to perform the modifications described in [the Sperry service bulletins] if these 727 aircraft are used for coupled [ILS CAT II] approaches at flap settings less than 40 degrees. (A-00-41);

- "Develop sets of operating limitations for Sperry Aerospace SP-50 and SP-150 autopilots on coupled [ILS] approaches that are appropriate for the desensitization schedules used by these autopilots so that every possible desensitization schedule has a

corresponding set of operating limitations. The limitations should address approach flap settings and airspeeds specifically, and should also consider tolerances on winds, capture altitudes, glideslope angles and/or other parameters that could adversely affect autopilot performance and safety of flight. (A-00-42);

- "Advise all operators of Boeing 727 aircraft equipped with Sperry Aerospace SP-50 and SP-150 autopilots to inform their pilots, maintenance [personnel] and engineering personnel of the dangers of conducting coupled [ILS] approaches at airspeeds that are not consistent with the desensitization schedule of the autopilots, and notify the operators that [FAA] has been asked to develop operating limitations for the use of these autopilots on coupled approaches that will ensure that the approaches are conducted in a manner consistent with the autopilot design. (A-00-43);

- "Review the certification of all autopilot systems that use time-based desensitization schedules and develop operating limitations, as necessary, for the use of these autopilots on coupled [ILS] approaches. The limitations should address approach flap settings and airspeeds specifically, and should also consider tolerances on winds, capture altitudes, glideslope angles and/or other parameters that could adversely affect autopilot performance and safety of flight. (A-00-44); [and,]

- "Advise all operators of aircraft equipped with autopilot systems that use time-based desensitization schedules to inform their pilots, maintenance [personnel] and engineering personnel of the dangers of conducting coupled [ILS] approaches at airspeeds that are not consistent with the autopilot desensitization schedule, and notify the operators that [FAA] has been asked to develop operating limitations for the use of these autopilots on coupled approaches that will ensure that the approaches are conducted in a manner consistent with the design of the autopilot. (A-00-45)."

[As of Sept. 19, 2001, NTSB received from FAA the following responses to the recommendations:

- In response to A-99-10 and A-99-11, FAA said that it planned to issue by December 2001 a notice of proposed rule making (NPRM) to require operators of B-727s to modify life raft ceiling stowage compartments[2] and to require replacement of D-ring-type seat-belt-attachment fittings[3];

- In response to A-00-41 and A-00-42, FAA said that it planned to issue by December 2001 an NPRM to require operators of the affected B-727s to perform the modifications described in the Sperry service bulletins[4] and to revise airplane flight manuals to limit the approach-flap setting to 30 degrees, to prohibit CAT II autopilot-coupled approaches if the middle marker is inoperative and to require autopilot disconnection at or before 80 feet on a CAT II autopilot-coupled approach[5];

- In response to A-00-43 and A-00-45, FAA on June 13, 2001, issued flight standards bulletins for air transportation (FSAT 01-04), general aviation (FSGA 01-01) and airworthiness (FSAW 01-05). The bulletins, all titled *Autopilots on Boeing 727 Aircraft and Other Aircraft*, direct FAA principal operations inspectors to request that affected air carriers inform their pilots, maintenance personnel and engineering personnel of the dangers of conducting coupled ILS approaches at airspeeds that are not consistent with the autopilot desensitization schedule.[6] The bulletins also said that FAA will develop operating limitations for the use of SP-50 and SP-150 autopilots on coupled approaches.[7] The bulletins include guidance to ensure that proper airspeeds are flown in accordance with time-based desensitization schedules; and,

- In response to A-00-44, FAA said that it is working with The Boeing Co. on analyses of the design, operational limitations and certification of autopilots with time-based desensitization schedules.[8]]

[On Sept. 25, 2001, APA and APFA requested that NTSB reconsider the findings and statement of probable cause in the final accident report. The 20-page submission for reconsideration said, "The probable cause of this accident was an autopilot-induced nose-down pitch excursion of the aircraft at approximately 140 feet, an altitude insufficient for complete recovery. The aircraft's nose-down deviation was the result of the autopilot's response to a distortion in the glideslope signal. Contributing to the pitch excursion was the FAA's failure to mandate two optional Sperry service bulletins … which called for safety-of-flight modifications to the autopilot's desensitization rate."[9]]♦

[FSF editorial note: This article, except where specifically noted, is based on U.S. National Transportation Safety Board (NTSB) *Aircraft Accident Brief*, accident no. DCA98MA023 (26 pages); NTSB factual report no. DCA98MA023 (1,257 pages); NTSB *Safety Recommendation*, Feb. 19, 1999, A-99-10 and A-99-11 (five pages); and NTSB *Safety Recommendation*, June 1, 2000, A-00-41 through A-00-45 (eight pages). The factual report contains photographs, diagrams and attachments.]

References

1. American Airlines; Allied Pilots Association. *Addendum to Technical Submissions*, DCA98MA023. April 30, 2001.

2. U.S. Federal Aviation Administration (FAA). *NTSB Recommendations to FAA and FAA Responses*

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3. FAA. *NTSB Recommendations to FAA and FAA Responses Report*. Report no. A-99-11. nasdac.faa.gov/asp/asy_searchus.asp. June 12, 2001.

4. FAA. *NTSB Recommendations to FAA and FAA Responses Report*. Report no. A-00-41. nasdac.faa.gov/asp/asy_searchus.asp. Nov. 24, 2000.

5. FAA. *NTSB Recommendations to FAA and FAA Responses Report*. Report no. A-00-42. nasdac.faa.gov/asp/asy_searchus.asp. June 12, 2001.

6. FAA. *NTSB Recommendations to FAA and FAA Responses Report*. Report no. A-00-43. nasdac.faa.gov/asp/asy_searchus.asp. July 30, 2001.

7. FAA. *NTSB Recommendations to FAA and FAA Responses Report*. Report no. A-00-45. nasdac.faa.gov/asp/asy_searchus.asp. July 30, 2001.

8. FAA. *NTSB Recommendations to FAA and FAA Responses Report*. Report no. A-00-44. nasdac.faa.gov/asp/asy_searchus.asp. Nov. 24, 2000.

9. Allied Pilots Association; Association of Professional Flight Attendants. *Submission for Reconsideration*, NTSB Accident Investigation no. DCA98MA023. Aug. 23, 2001.

Appendix

Cockpit Voice Recorder Transcript, American Airlines Flight 1340, Feb. 9, 1998

[FSF editorial note: The following transcript begins when the airplane, a Boeing 727-200, intercepts the glideslope during a Category II instrument landing system (ILS) approach to Runway 14R at Chicago (Illinois, U.S.) O'Hare International Airport. The transcript is as it appears in the U.S. National Transportation Safety Board (NTSB) report, except for minor column rearrangement and minor editing for consistency and style. All times are local.]

RDO = Radio transmission from accident aircraft
CAM = Cockpit area microphone voice or sound source
TWR = Radio transmission from O'Hare tower controller
GPWS = Mechanical voice or sound source from the ground-proximity warning system
-1 = Voice identified as captain
-2 = Voice identified as first officer
-3 = Voice identified as second officer (flight engineer)
-? = Voice unidentified
* = Unintelligible word
[ ] = NTSB editorial insertion
… = Pause

Time	Source	Content
0950:12	**CAM-1**	OK, I got four green lights, glideslope intercept.
0950:15	**CAM-2**	check.
0950:21	**CAM**	[sound of click]
0950:33	**CAM**	[sound similar to altitude-alert warning]
0951:31	**CAM-2**	* go with the landing gear down.
0951:33	**CAM-1**	all right
0951:34	**CAM**	[sound similar to landing gear being extended]
0951:36	**CAM**	[sound similar to trim wheel moving at slow rotation]
0951:43	**CAM-3**	gear?
0951:44	**CAM**	[sound similar to trim wheel moving at slow rotation]
0951:45	**CAM**	[sound similar to outer marker beacon identifier]
0951:46	**CAM-?**	* *.
0951:46	**CAM-1**	three green.
0951:47	**CAM-2**	flaps twenty-five.
0951:48	**CAM**	[sound similar to trim wheel moving at slow rotation]
0951:48	**CAM-1**	three green, no red.
0951:48	**CAM-?**	there's ROAMY.
0951:51	**CAM**	[sound similar to trim wheel moving at slow rotation]
0951:55	**RDO-1**	American, uh, thirteen forty is ROAMY.
0951:55	**CAM-2**	give me thirty.
0951:56	**CAM**	[sound similar to flap handle being moved]
0951:57	**CAM**	[sound similar to trim wheel moving at slow rotation]
0951:58	**TWR**	American thirteen forty, O'Hare runway one four right, cleared to land. seven thirty-seven short final. wind is calm. touchdown RVR is one thousand six hundred. midpoint three thousand, rollout forty-five hundred.
0952:06	**CAM**	[sound of eight clicks]
0952.08	**RDO-1**	fourteen right. cleared to land, American thirteen forty.

0952:12	**CAM-1**	OK, flaps are thirty.
0952:13	**CAM**	[sound similar to trim wheel moving at slow rotation]
0952:26	**CAM**	[sound similar to trim wheel moving at slow rotation]
0952:34	**CAM-1**	OK, put the heat on. out of a thousand.
0952:36	**CAM-2**	out of a thousand. we have thirty thirty.
0952:37	**CAM-1**	you got it.
0952:38	**CAM-2**	green light, cleared to land, one four right.
0952:42	**CAM-1**	thank you.
0952:43	**CAM-3**	autopilot to go.
0952:51	**CAM**	[sound similar to trim wheel moving at slow rotation]
0953:22	**CAM-2**	there's five, we're sinking seven, plus twelve.
0953:28	**CAM-2**	four hundred.
0953:33	**CAM-2**	three hundred.
0953:41	**CAM**	[sound similar to middle marker beacon identifier]
0953:42	**CAM-2**	two hundred.
0953:44	**CAM**	[sound similar to trim wheel moving at slow rotation for three seconds]
0953:48	**CAM**	[sound similar to trim wheel moving at slow rotation for four seconds]
0953:49	**CAM-1**	I got it.
0953:50	**CAM-2**	you got it.
0953:50	**CAM**	[sound similar to inner marker beacon identifier]
0953:51	**CAM-3**	ooh nose uh.
0953:52	**CAM**	[sound of click]
0953:52	**CAM-2**	one hundred.
0953:52	**GPWS**	sink rate.
0953:52	**CAM-3**	nose up, nose up.
0953:54	**GPWS**	thirty.
0953:54	**CAM**	[sound of impact]
0953:55	**CAM**	[sound of unidentified horn starts and continues to end of recording]
0953:55	**GPWS**	bank angle, bank angle.
0953:56	**CAM**	[sound of second impact]
0953:57	**CAM**	[sound of third impact followed by rustling sound]
0954:00	**End of Recording, End of Transcript**	

Accident Prevention

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