FLIGHT SAFETY FOUNDATION

Accident Prevention

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Automatic Deployment of DC-9 Ground Spoilers During Final Approach Results in a Hard Landing Short of the Runway

According to the official U.S. accident report, failure of the cockpit voice recorder to retain conversations during the initial approach, landing and go-around impeded the investigation.

FSF Editorial Staff

The ValuJet Airlines Inc. McDonnell Douglas DC-9-32 was on short final landing approach to Runway 2R at the Nashville (Tennessee, U.S.) International Airport (BNA). As the DC-9 descended through 30.5 meters (100 feet) above ground level (AGL), the aircraft's ground spoilers automatically deployed, and the aircraft began to descend at an excessive rate. The first officer, who was the pilot flying, pulled back on the control column and added full power.

The excessive sink rate continued. The aircraft's tail struck the runway-approach system lights, and the landing gear contacted the ground. The flight crew executed a go-around, circled the airport and landed without further incident on Runway 31. The aircraft came to a stop on the runway. Because there was no fire or other emergency, the aircraft was not immediately evacuated; the passengers were transported to the airport terminal 20 minutes later.

One flight attendant and four passengers reported receiving minor injuries in the Jan. 7, 1996, accident. The aircraft received substantial damage to its tail section, nosegear, aft fuselage, slats, flaps and both engines. Two runway-approach system lights, two runway-threshold lights and the runway were damaged.

The accident occurred at dusk, in visual meteorological conditions (VMC).

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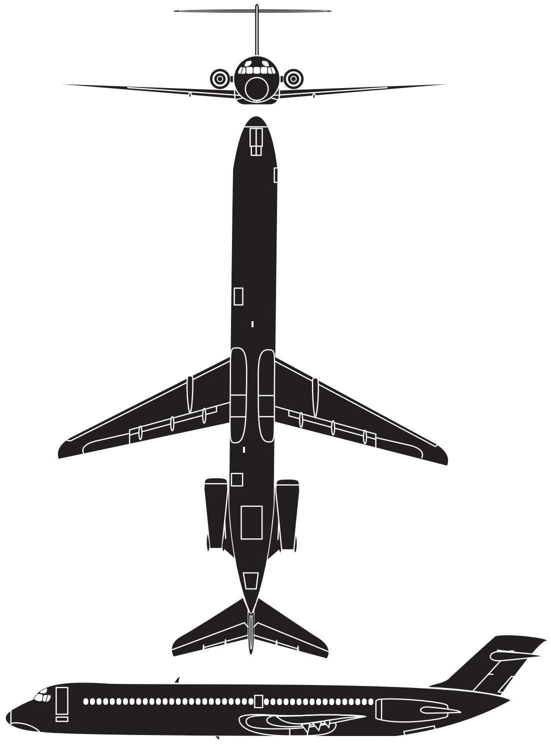
The final accident investigation report of the U.S. National Transportation Safety Board (NTSB) said that the probable cause of the accident was "the flight crew's improper procedures and actions (failing to contact system operations/dispatch, failing to use all available aircraft and company manuals, and prematurely resetting the ground-control relay circuit breakers) in response to an in-flight abnormality, which resulted in the inadvertent in-flight activation of the ground spoilers during the final approach to landing and the airplane's subsequent increased descent rate and excessively hard ground impact in the runway approach-light area.

"Contributing factors in the accident were ValuJet's failure to incorporate cold-weather nosegear-servicing procedures in its operations and maintenance manuals, the incomplete procedural guidance contained in the ValuJet quick reference handbook [QRH] and the flight crew's inadequate knowledge and understanding of the aircraft systems."

The accident flight was the third leg in the day flown by its pilots. The first two legs were flown from the William B. Hartsfield Atlanta (Georgia, U.S.) International Airport (ATL) to Indianapolis, Indiana, U.S., and return.

The captain flew the first leg. "According to the captain, the first leg's departure from Atlanta was delayed for more than an



McDonnell Douglas DC-9

The twin-turbofan short/medium range McDonnell Douglas DC-9 was first flown in 1965 and has been stretched to increase passenger seating in several subsequent versions. It has a maximum takeoff weight of 44,450 kilograms (98,000 pounds) and a maximum cruising speed at 7,620 meters (25,000 feet) of 909 kilometers per hour (491 knots). The Series 30 has a range of 2,388 kilometers (1,120 miles) at an altitude of 9,150 meters (30,000 feet) with reserves for a 370-kilometer (174-mile) flight to an alternate and a 60-minute hold at 3,050 meters (10,000 feet).

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

hour because of maintenance on the auxiliary power unit (APU) generator and deicing operations," the report said. "The first officer performed pilot-flying duties for the second leg, which was the return flight from Indianapolis to Atlanta. The flight crew described the second leg of the trip sequence as routine."

When the flight crew arrived in Atlanta, the captain "went to ValuJet system operations to pick up the paperwork for the third leg of the trip sequence," the report said.

When the captain conducted the preflight inspection of the accident aircraft, he "observed that the nosegear shock strut appeared to have normal extension," the report said. "While the captain performed the exterior preflight inspection, the first officer, who performed pilot-flying duties for the third leg, completed the weight-and-balance paperwork and performed the interior preflight inspection of the airplane."

Flight 558, the accident flight, departed the gate at 1525 hours local time (one hour and 30 minutes behind schedule) with two flight crew members, three cabin crew members and 88 passengers. "The pilots reported that the engine start and taxi from the gate were normal," the report said. "Because of the amount of ice and snow they encountered as they taxied to Runway 26L, the pilots were concerned that the aircraft's surfaces/components would get contaminated during taxi."

The accident flight was cleared for takeoff at 1539. "The flight crew stated that the takeoff roll and rotation were normal," the report said. "The pilots reported that after the captain announced a positive rate-of-climb, the first officer requested ' … gear up.' The captain attempted to raise the landing-gear lever to the retract position, but the lever would not move beyond the uplock-check position."

The flight crew reviewed the ValuJet QRH for the DC-9, which contains procedures to be followed in the event that the landing gear cannot be routinely raised. After consulting the QRH, "the captain attempted to turn the nosewheel steering wheel located at his left side," the report said. "The nosewheel steering tiller did not turn, which confirmed that the nosewheel steering was centered and locked. According to the QRH, this indicated a malfunction of the landing-gear antiretraction mechanism. The pilots, in accordance with the QRH, pushed the landing-gear handle release button and raised the landing-gear lever again; this time the landing gear retracted."

The landing gear antiretraction mechanism "prevents moving the [landing-gear] lever more than [five centimeters (two inches)] out of the DOWN position until the nosegear strut extends, actuating the ground-shift mechanism," the report said. [The brackets around "landing-gear" appeared in the report.]

After the landing gear had been retracted, "the flight crew retracted the flaps and slats and adjusted the throttles for initial climb," the report said. "The captain assumed flying duties and requested that the first officer review the QRH to verify that all required procedures for raising the gear lever had been accomplished. The first officer confirmed that they had completed the procedures correctly."

The report continued: "As the DC-9 climbed through [1,220 meters (4,000 feet)] mean sea level (MSL), the captain advanced the throttles to normal climb power and called for the climb checklist. At this point, the takeoff warning horn sounded, and the first officer noted that the cabin was not pressurizing. The flight crew referred to the QRH again, and determined that in addition to the landing gear antiretract-mechanism malfunction, the ground-shift mechanism must have malfunctioned."

The QRH for the accident aircraft "indicated that if the ground-shift mechanism was still in the ground mode, there would be 'no autopressurization, and takeoff warning horn will sound when flaps/slats are retracted,'" the report said. "The QRH further stated, 'The ground-control relay electrical

Ground-shift Mechanism

"The DC-9 ground-shift mechanism [GSM], which is actuated by nosewheel shock strut extension/ compression, controls whether certain aircraft systems operate in the ground or flight mode," the report said. "When the plane is on the ground and the nosewheel strut is compressed by the weight of the aircraft, the GSM causes those aircraft systems to be operated in the ground mode. When the nosewheel shock strut is extended after takeoff, it triggers the ground shift mechanism, electronically shifting the aircraft systems to flight mode."

When the GSM is in the ground mode:

1. Cabin pressurization, airfoil ice protection, cargo compartment heating and certain other aircraft functions cannot be operated in the flight mode;
2. The landing gear antiretraction mechanism is engaged, preventing the cockpit landing gear handle from moving more than five centimeters (two inches) out of the down position; and,
3. A takeoff-warning horn will sound intermittently if the throttles are advanced 5.4 centimeters (2.125 inches) or more forward of the idle stops, and the flaps are not set at five degrees or 15 degrees.

When the aircraft is airborne and the nosewheel strut extends normally, the GSM shifts aircraft systems to flight mode. If the nosewheel strut does not extend far enough to trigger the GSM, aircraft systems will remain in the ground mode.

The landing gear antiretraction mechanism is mechanical and can be overridden by a landing-gear lever release pushbutton in the cockpit. Depressing this button bypasses the landing gear antiretraction mechanism, allowing the landing gear to be raised even though the GSM is still in the ground mode.

To put the GSM in flight mode with the nosewheel strut not fully extended, it is necessary to pull the two ground-control relay circuit breakers (H20 and J20).

On landing, the armed ground spoilers will deploy automatically on main-wheel spinup or compression of the nosewheel strut. The GSM thus acts as a safety feature, to ensure ground spoiler deployment when a slippery runway surface or other cause prevents the main wheels from spinning fast enough.

circuits can be placed in the flight mode by pulling the ground-control relay circuit breakers … .'"

After the ground-control relay circuit breakers were pulled, "the takeoff warning horn silenced, and the cabin began to pressurize. The flight crew completed the climb checklist without further incident," the report said.

"As the DC-9 climbed through [3,050 meters (10,000 feet)] MSL, the captain engaged the autopilot and transferred control of the airplane back to the first officer," the report said. "According to the pilots, they discussed the problems they had encountered and considered their options as they continued the climb-out after departure.

"ValuJet's company operating manual (COM) states that pilots shall report all incidents and/or irregularities to company system operations/dispatch at the earliest opportunity. The pilots indicated that they did not contact ValuJet system operations/dispatch about the events that occurred during their departure from Atlanta because they believed that the ice and snow on the ground in Atlanta might have contaminated the ground-shift mechanism."

The pilots elected to continue the flight to Nashville because the aircraft appeared to be operating normally, and they "planned to have the contract maintenance personnel at Nashville examine the airplane after landing," the report said.

As they proceeded to Nashville, the flight crew "discussed the procedures they should use during the approach and landing in Nashville," the report said. After consulting the QRH, "the pilots decided to depressurize the cabin during the descent with the automatic pressurization system."

Although the automatic pressurization system appeared to be functioning normally, the pilots "were concerned that there might be a slight 'bump' in pressurization after landing, caused by the venting of cabin pressure after touchdown," the report said. "The pilots decided that they could preclude such a loss of cabin pressurization after landing by resetting the ground-control relay circuit breakers just before touchdown. They believed that resetting the circuit breakers on short final approach would also satisfactorily accomplish the third QRH approach-and-landing checklist item."

As they approached Nashville, the flight crew "performed the normal descent-and-approach checklist and obtained the current automatic terminal information service (ATIS) for Nashville," the report said.

The BNA weather observation reported a ceiling at 732 meters (2,400 feet), with a visibility of eight kilometers (five miles) in light, blowing snow. The temperature was -6 degrees C (21 degrees F), dew point -9 degrees C (15 degrees F) and the surface winds were out of the northwest at 22.2 kilometers per hour (kph [12 knots]), with gusts to 37 kph (20 knots).

Following company procedures, "the first officer elected to fly the instrument landing system (ILS)/transition to visual approach to Runway 2R at an airspeed about [18.5 kph (10 knots)] higher than the calculated approach airspeed to compensate for the gusty crosswind during the approach and landing," the report said.

As they proceeded inbound on the ILS approach, "the flight crew performed the normal before-landing checklist, which

Spoilers

"The DC-9-32 has four spoiler panels located on the upper surface of the wings, forward of the trailing-edge flaps," the report said. "During airborne operations, the spoiler panels work with the ailerons automatically, through an aileron/flight-spoiler mixer assembly, to help lower the up-aileron wing. Additionally, when the speed-brake/ground-spoiler control lever is pulled aft during flight, the four spoiler panels extend to function as speed brakes.

"Maximum spoiler deployment in flight is approximately 30 degrees. During ground operation [when the ground-shift mechanism is in the ground mode], the four spoiler panels can be extended to 60 degrees to perform the ground-spoiler function. Ground-spoiler actuation can be accomplished automatically or manually.

"According to the McDonnell Douglas DC-9 [flight crew operations manual], automatic ground-spoiler extension requires [either] main-wheel spin-up or the ground-shift mechanism to be in the ground mode."

included arming the spoilers, extending the flaps/slats and extending the landing gear," the report said. "The flight crew stated that the landing gear extended normally, and flaps were set at 50 degrees (fully extended) for landing.

"The first officer told investigators that when the DC-9 was about [30.5 meters (100 feet)] above ground level (AGL), the captain verified a zero PSI [pounds per square inch] differential on the cabin differential pressure gauge and reset the ground-control relay circuit breakers."

The first officer "noted that the cabin outflow valve began to move to the full open position, and then he heard the sound of the ground spoilers deploying as the airplane began to descend at an excessive rate," the report said. "The first officer reported that he shouted 'ground spoilers!' and attempted to arrest the excessive sink rate with back pressure on the control column and the addition of full power."

Moments later, "the DC-9 struck the runway approach-light area tail-first, followed by main landing gear and nosegear, with engine thrust increasing," the report said. "The nosewheel tires and rims separated after ground impact, and then the airplane became airborne again." Ground scars in the approach-light area indicated that the aircraft first touched down about [(27 meters (90 feet)] before the runway-threshold lights.

The aircraft's flight data recorder (FDR) indicated that "the airplane's sink rate was between [12 meters and 14 meters (39 feet and 47 feet)] per second just before runway impact, whereas over the previous 10 seconds, the descent rates were between zero and [seven meters (23 feet)] per second," the report said. "About four seconds before impact, pitch-attitude values increased from about zero to a maximum value of 22.8 degrees nose-up about the time of impact. During the two seconds before impact, vertical acceleration values increased from 0.677 Gs to the final recorded value of 2.854 Gs."

After the aircraft had contacted the ground, the flight crew executed a go-around. "The captain assumed control of the airplane as it became airborne and established a climb on runway heading," the report said. "The first officer raised the flaps to 15 degrees, which positioned the flaps for the climb. Because of possible impact damage, the flight crew decided not to retract the flaps/slats any further, and to leave the landing gear extended during the go-around."

During the go-around, "the first officer noticed that the no. 2 (first officer's) navigation and communication radios were unusable," the report said. "The captain then attempted to contact air traffic control (ATC) using the no. 1 (captain's) communication radio, but was unsuccessful."

Because of the problems with the navigation radio, the flight crew decided to stay in visual contact with the airfield instead of executing the published missed-approach procedure on the instrument approach chart for the ILS. The pilots agreed that they should "return to land at Nashville as soon as possible," the report said. "They planned to land on Runway 31, because it was closest to their position and because they knew it was operational from the ATIS broadcast they had received during their first approach."

Because they could not communicate with Nashville tower, the flight crew followed U.S. Federal Aviation Administration (FAA) recommended procedures for lost communications and set the aircraft transponder to 7700/7600 (the emergency and lost-communications transponder codes, respectively).

Air traffic controllers in Nashville tower said that they "observed debris from the DC-9 at the approach end of Runway 2R after the airplane struck the ground during the first landing attempt, and they were aware that the airplane nosegear was damaged from the impact," the report said. "Although the air traffic controllers attempted to advise flight crew of the damage, they were unable to re-establish radio communication with Flight 558.

"At approximately 1623, ATC personnel contacted the aircraft rescue and fire fighting (ARFF) facility to advise it that they were unable to communicate with a DC-9 that would probably be returning to land with landing gear problems."

As the crew of the accident aircraft continued their approach to Runway 31, the captain flew the airplane while the first officer briefed the approach. "The pilots completed the before-landing checklist, and the first officer extended flaps and slats for landing," the report said. "The pilots decided not to arm the spoilers for landing because they planned to manually deploy the ground spoilers during the landing roll. As they approached the runway, the pilots observed emergency equipment with flashing lights moving into position near Runways 2R and 31."

During the postaccident investigation, the pilots said that they did not have time to brief the flight attendants or the passengers about the emergency before the second landing.

During the landing, “the airplane touched down on its main landing gear on the centerline of Runway 31,” the report said. “The first officer deployed the ground spoilers manually, and the captain applied the thrust reversers. Both pilots stated that they heard a loud grinding noise when the nosegear touched down on the runway centerline. The noise continued throughout the landing roll, and the airplane began to drift to the left of the runway centerline. The captain corrected for the left drift with brakes … .”

The airplane came to a stop, “approximately [three meters (10 feet)] left of the centerline and about [1,769 meters (5,800 feet)] from the approach end of the runway,” the report said. There were scrape marks that “started on the runway centerline, approximately [839 meters (2,750 feet)] from the approach end of the runway … . The scrape marks stopped where the airplane’s nosegear strut rested on the pavement.”

After the airplane had come to a stop, “the flight crew performed the after-landing checklist and shut down the engines normally,” the report said. “The captain informed the flight attendants and passengers via the public address (PA) system that a flight-control malfunction had occurred, that the airplane was safely stopped with emergency equipment standing by and that the pilots were requesting ground transportation from the airplane to the terminal. He instructed the passengers to remain seated until further advised.”

ARFF personnel arrived on the scene. “The first officer opened the right-side cockpit window and asked the ARFF personnel if any risk was involved in remaining onboard the airplane,” the report said. “ARFF personnel advised the pilots that there was no evidence of fuel leaks, smoke or fire, and the airplane appeared to be safe for continued occupancy.” The flight crew decided not to order an immediate evacuation of the aircraft; about 20 minutes after the DC-9 stopped, the passengers were transported by bus to the terminal and the pilots were taken to the terminal in an emergency-response vehicle.

The captain, 43, held an airline transport pilot (ATP) certificate, with airplane single- and multi-engine ratings, a DC-9 type rating and a valid FAA first-class medical certificate with no restrictions or limitations. He had 4,381 hours of flight time, with 1,061 hours in the DC-9 and 26 hours as a DC-9 captain. He was hired by ValuJet in 1994 as a first officer on the DC-9. “The captain’s most recent proficiency check was completed on Dec. 6, 1995, in the DC-9 airplane in conjunction with his upgrade to captain,” the report said.

The first officer, 42, held an ATP certificate with airplane multi-engine land ratings, and DC-9, Gulfstream G-1159, Cessna 500, Falcon 10, Falcon 20 and Falcon 50 type ratings. He also held commercial pilot privileges for airplane single-engine land and sea, and an instrument rating. The first officer held a valid FAA first-class medical certificate with the limitation that he wear corrective lenses while flying. He had 7,707 hours of flight time, with 205 hours (all as first officer) in the DC-9.

The first officer was hired by ValuJet in 1995. His last proficiency check was completed on Oct. 11, 1995, in the DC-9. “The first officer reported that he had more than 20 years flight experience, of which more than 17 years and 5,500 flight hours were in multi-engine turbojet aircraft,” the report said.

Investigators reviewed the maintenance logs for the accident aircraft and found no discrepancies relevant to the accident flight.

The accident aircraft was moved to a heated hangar, where investigators simulated the accident approach/landing sequence by pulling the two ground-control relay circuit breakers (as the accident flight crew had done), which put the airplane in the “flight” mode. “Investigators then performed the before-landing checklist, which included extending the landing gear and arming the spoilers,” the report said.

When investigators reset one of the two circuit breakers, “they observed that the cabin pressurization went to the open position,” the report said. When the second circuit breaker was reset, “the ground spoilers deployed,” the report said. This was the sequence that occurred on the accident flight as reported by the flight crew.

The report said that, according to the ValuJet aircraft operating manual (AOM), “during the exterior inspection of the airplane, the flight crew should check the nosegear strut for inflation and leaks and [the AOM] includes a note indicating that ‘normal strut extension is [five centimeters to 15 centimeters (two inches to six inches)].’”

McDonnell Douglas representatives told investigators that “when the nosegear shock strut is underserviced/underinflated, strut extension after liftoff may not be sufficient to activate the ground-shift mechanism to shift the aircraft systems into the flight mode and release the gear-lever antiretraction mechanism,” the report said. “[McDonnell Douglas] representatives indicated that this is a commonly reported occurrence during cold-weather operations.” Numerous service bulletins and all-operator letters had been issued by McDonnell Douglas to address this problem.

The report noted that “ValuJet’s maintenance manual had not been revised or amended in accordance with the manufacturer’s recommended cold-weather nosegear servicing procedures.”

The NTSB noted that the accident flight crew did not adhere to ValuJet COM guidance, and cited three instances during the accident flight in which ValuJet company procedures were not followed. “The first instance occurred when the first officer flew the second leg and planned to fly the third leg of the trip," the report said. "Although according to the COM, a captain may allow the first officer to fly the airplane when the captain has at least 100 hours as PIC [pilot-in-command] in jet transport aircraft under [U.S. Federal Aviation Regulations (FARs)] Part 121, at the time of the accident, the captain of Flight 558 had only 26 hours as PIC.

"Therefore, the captain was not authorized under the COM to allow the first officer to fly the airplane," the report said. "The captain told investigators that he was not familiar with the section of the COM that indicated that he was not supposed to share flying duties with the first officer.

"The second instance during which company procedures were not followed was when the pilots did not notify ValuJet system operations/dispatch that they were unable to raise the landing gear without pushing the landing gear–handle release button," the report said. "Also, they did not report that they needed to disengage the ground-control relay circuit breakers to put the airplane in flight mode."

The third instance of the accident flight crew's failure to follow company procedures occurred when the crew "used only the QRH, without referring to the AOM, to determine how to address the anomalies that arose," the report said. "Thus, had the pilots consulted the AOM for more detailed guidance, they might have recognized that they should not reset the ground-control relay circuit breakers until after the airplane was on the ground, and the accident might not have occurred."

The pilots of the accident flight had completed a two-day course in cockpit resource management (CRM) within the 12 months preceding the accident. When the NTSB reviewed ValuJet's CRM course, the issue was raised that the course "may have only provided an overview of *cockpit* resource management, without thoroughly teaching the concept of total, integrated *crew resource* management," the report said.

In reviewing the flight crew's use of CRM during the accident flight, the report noted that "although the pilots did not brief the flight attendants about the irregularity and its possible ramifications during the go-around, the pilots indicated that the omission was the result of the limited time available to them during the go-around."

The report continued: "Records indicate that the pilots had approximately six minutes between the hard landing on Runway 2R and their touchdown on Runway 31. According to the CVR [cockpit voice recorder] transcript, approximately 15 seconds before the airplane touched down on Runway 31, the first officer stated, ' … [We] should've braced them in the back' [i.e., the cabin crew and passengers should have been instructed to take the "brace" position]. The flight crew's failure to discuss the irregularity and its possible ramifications with the flight attendants is further evidence of insufficient adherence to the accepted principles of crew resource management training."

Investigators reviewed ValuJet's crew pay and bonus schedule to determine if this could have influenced the accident flight crew's decision making. According to ValuJet's pay and bonus schedule, "pilots were paid based upon the number of flight segments flown, and received bonus pay at the end of the year based on a share of the annual company profits," the report said.

The FAA principal operations inspector (POI) responsible for the oversight of ValuJet told investigators that he did not believe that, under ValuJet's pay schedule at the time of the accident, "the pilots would have been compensated for the accident leg of the flight if they had returned to Atlanta, rather than completing the trip to Nashville," the report said. "However, according to ValuJet's director of operations and ValuJet's chief pilot, the pilots would have received 'segment 2' pay for the accident leg of the trip sequence, whether they returned to Atlanta or continued the flight to Nashville."

The accident flight crew told investigators that "they were not certain whether they would have been compensated if they had returned to Atlanta, but they indicated that pay was not a factor in their decision-making process," the report said. "According to the first officer, he had experienced pay discrepancies on some occasions since he was hired by ValuJet, and had successfully negotiated with the company to receive back pay."

Investigators reviewed ValuJet's COM and could not find a description of the company's pay policy for a situation when a scheduled flight did not reach its intended destination. The report expressed concern that "the individuals interviewed about the pay schedule held dissimilar views about how the ValuJet pay schedule would have been applied had the flight crew elected to return to Atlanta after the irregularity."

The NTSB investigated why neither the captain's nor the first officer's communication and navigation radios were functional during the go-around. "Postaccident examination of the aircraft revealed that the no. 1 communication radio was unusable because the no. 1 communication radio on/off switch was positioned in an intermediate (unpowered) position," the report said. "The pilots stated that they did not intentionally place the no. 1 communication radio switch in the intermediate (unpowered) position, nor did they recall bumping the no. 1 communication radio switch."

The report noted that "the no. 1 communication radio switch, which is located on the left (captain's) side of the control pedestal between the two pilots, might have been inadvertently and unknowingly bumped by either flight crew member during the initial ground impact at Nashville, or during their performance of subsequent go-around procedures."

Postaccident examination of the accident aircraft also revealed that "the right DC [direct current] bus reverse-current relay, which provides power to the no. 2 communication and navigation radios, was 'open,'" the report said. "The right DC reverse-current relay is mounted on the inside of the aft wall of the nosewheel well, and is not accessible from the cockpit during flight."

The report said that "during the initial ground impact, the nose landing gear struck the ground with enough force to separate the nosewheel assemblies from the nosegear strut. It is likely that either the force of the initial ground impact or an impact of the nosewheel assembly/debris against portions of the nosewheel well resulted in the 'opening' of the right DC reverse-current relay."

The report also said that "the investigation of this accident was complicated by the fact that the 30-minute closed-loop CVR tape did not include documentation of the initial approach to Runway 2R, the hard landing event or the go-around. Although the flight crew's statements and recollections were detailed and clear, information pertinent to the investigation was unrecoverable because of the 30-minute tape duration."

Investigators reviewed the FAA's oversight of ValuJet's training programs. "The [NTSB] notes that there was no indication that the POI recognized that the manner in which FlightSafety International (FSI) [the aircraft-specific training provider] and ValuJet used manuals and handbooks during pilot training was potentially confusing to the pilots," the report said. "Although documentation indicates that the POI occasionally sat in on portions of the FSI/ValuJet ground school, there is no evidence that he ever audited the entire training class."

In the month following the Flight 558 accident, the POI "sent a letter to ValuJet's senior vice president of operations, expressing his concern about recent accidents and incidents involving ValuJet flights," the report said. "The POI wrote that recent incidents involved flight crews who were either new to the air carrier and/or had very little Part 121 experience, and several involved bad weather. He reported that during his observation of a recent initial training class at FSI in Miami, he noted that only one pilot in the class had prior Part 121 experience."

The POI's report also indicated that "FAA inspectors conducting en route surveillance had found it necessary to counsel captains during flights to keep them from operating contrary to [the] FARs," the report said.

The FAA's surveillance also indicated that "due to the rapid expansion of ValuJet Airlines, many of the new captains have a minimal amount of Part 121 experience," the report said. "It appears that the captains are allowing the first officer to make the takeoff and/or landing out of response to an unwritten practice of alternating that function, rather than considering the weather and/or their own need for experience."

In February 1996, the FAA's maintenance division reported on an audit of ValuJet conducted by the U.S. Department of Transportation that "indicated that ValuJet had a total of 46 violations since 1993, of which 20 remained open at the time the report was written," the report said. "The [FAA] report concluded that the data "clearly show[ed] some weaknesses" in the FAA's overall surveillance of ValuJet's operations, particularly in the following areas: "Manuals and Procedures"; "Shops and Facilities"; and "Structural Inspection."

Based on its investigation, the NTSB developed a number of findings, the most significant of which were:

- "The nosegear shock-strut extension during the initial climb-out was insufficient to actuate the ground-shift mechanism, shift the airplane systems to the flight mode and release the gear-lever antiretraction mechanism;
- "Preflight visual inspections by flight crews cannot be relied upon to detect underserviced/underinflated DC-9 nosegear struts, and more frequent and detailed maintenance inspections of the DC-9 nosegear shock strut should be included in cold-weather maintenance procedures;
- "ValuJet Airlines and the [FAA] should have recognized the possibility of airplanes being exposed to cold-weather conditions and the potential nosegear problems from such exposure, and ValuJet should have developed cold-weather nosegear servicing procedures similar to those in the DC-9 maintenance manual to address these problems;
- "Had the pilots adhered to ValuJet's [COM] procedures and notified system operations/dispatch of the landing gear irregularity during their departure from Atlanta, they would probably have received sufficient maintenance advice and guidance from technical specialists to land uneventfully at either Atlanta or Nashville;
- "The pilots' actions and statements illustrate that their knowledge and understanding of the aircraft systems and the effects those systems have on each other were inadequate;
- "The pilots' failure to communicate with and utilize some of the other resources available to them (such as the more detailed written procedural guidance located in the [AOM], or in-flight maintenance advice through ValuJet system operations/dispatch in Atlanta or from contract maintenance personnel in Nashville) raises questions about the effectiveness of the crew resource management training provided;
- "There were no pre-existing (preimpact) communication/navigation radio anomalies; rather, the radio difficulties that the flight crew encountered during the go-around were, directly or indirectly, the result of the airplane's impact with the ground in the approach-light area short of Runway 2R;
- "Had the flight crew turned off power to the [CVR] after the airplane was safely stopped on the ground, investigators would have had access to valuable documentation of the hard landing, and the events leading up to it;

- "The 30-minute closed-loop [CVR] tape on board the accident airplane was of inadequate duration to be helpful in the investigation of this accident, because pertinent impact-related audio information and conversation had been recorded over and was unrecoverable; [and,]
- "The FAA's oversight of ValuJet's procedures and operations was inadequate."

The NTSB addressed the following recommendations to the FAA:

- "Require all airlines to review their operations and maintenance manuals and, if necessary, adjust or expand these manuals to reflect the manufacturer's recommended cold-weather nosegear servicing procedures (A-96-166);
- "Stress the importance of adherence to the rules, structure and guidelines within the revised ValuJet [COM] to ValuJet management and its employees, to [FSI] (or other contracted training organizations used by ValuJet) and to the individuals responsible for the oversight of ValuJet (A-96-167);
- "Re-evaluate ValuJet's flight operations training manual and the ValuJet training syllabus used by [FSI], and require ValuJet to revise or expand these documents to include more detailed descriptions and explanation of the [McDonnell Douglas] DC-9 systems and procedures (A-96-168);
- "Require ValuJet to revise its [CRM] training curriculum to more clearly reflect modern integrated (flight crew, cabin crew, company, etc.) CRM practices (including line operational simulation training) and to combine academic/classroom training with integrated practical crew simulations (A-96-169);
- "Require all airlines to revise their procedures to stipulate that flight crews turn off power to the [CVR] as part of the engine-shutdown procedure in the event of a reportable incident/accident (A-96-170); [and,]
- "Require that all newly manufactured [CVRs] intended for use on airplanes have a minimum recording duration of two hours (A-96-171)."

The NTSB recommended to ValuJet that it:

- "Develop, immediately, a more extensive and accurate winter-operations manual, with corresponding adjustments to maintenance procedures, to reflect the manufacturer's cold-weather nosegear servicing procedures (A-96-172); [and,]
- "Clarify for all flight crews the importance of referencing all available crew reference documents and consulting with company maintenance personnel (time permitting) to resolve in-flight abnormalities before committing a flight to landing (A-96-173)."♦

Editorial note: This report was adapted from *Ground Spoiler Activation in Flight/Hard Landing, ValuJet Airlines Flight 558, Douglas DC-9-32, N922VV, Nashville, Tennessee, January 7, 1996*. Report no. NTSB/AAR-96/07, December 1996. The 174-page report contains figures and appendices.

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