FLIGHT SAFETY FOUNDATION

Accident Prevention

Vol. 58 No. 1 *For Everyone Concerned With the Safety of Flight* January 2001

Destabilized Approach Results in MD-11 Bounced Landing, Structural Failure

The right wing separated from the fuselage during the second touchdown on the runway, and the airplane rolled and came to rest inverted. The five occupants received minor injuries during the impact and evacuation. The investigation generated a recommendation for pilot training on conducting stabilized approaches through the landing flare.

FSF Editorial Staff

About 0132 local time July 31, 1997, a McDonnell Douglas MD-11 operated by Federal Express (FedEx) was involved in an approach-and-landing accident at Newark (New Jersey, U.S.) International Airport. The airplane and cargo were destroyed by the impact and postaccident fire. The five occupants received minor injuries during the impact and while evacuating the airplane through a cockpit window.

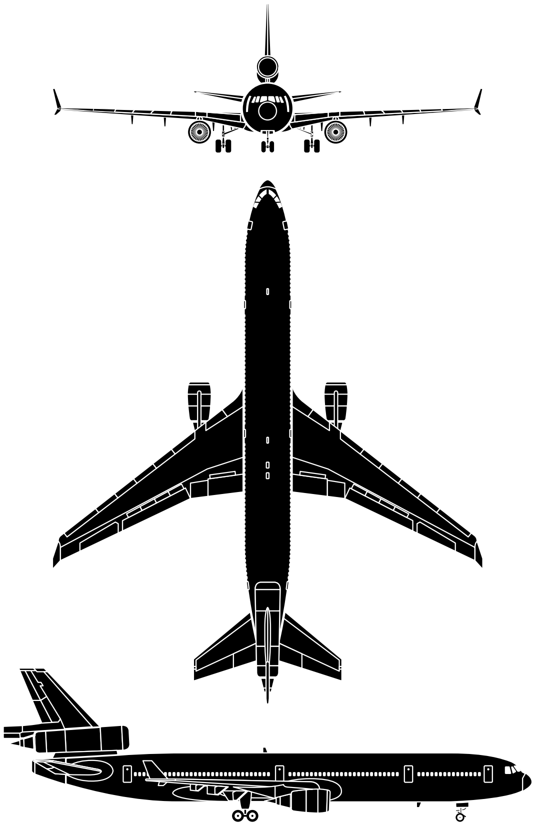
The U.S. National Transportation Safety Board (NTSB) said, in its final report, that the probable cause of the accident was "the captain's overcontrol of the airplane during the landing and his failure to execute a go-around from a destabilized flare."

The report said, "Contributing to the accident was the captain's concern with touching down early to ensure adequate stopping distance."

The airplane was being operated as Flight 14 on a regularly scheduled cargo flight from Singapore, with intermediate stops in Penang, Malaysia; Taipei, Taiwan; and Anchorage, Alaska. The accident captain and first officer conducted only the flight from Anchorage to Newark. Aboard the flight were a jump-seat passenger (a pilot for another airline) and two cabin passengers (both FedEx employees).

The captain, 59, held an airline transport pilot (ATP) certificate and an MD-11 type rating. He had 11,000 flight hours, including 1,253 flight hours in type and 318 flight hours as an MD-11 pilot-in-command. He was hired in 1979 by Flying Tigers, which merged with FedEx in 1989.

"A review of training records indicated that the captain had received an unsatisfactory evaluation on an upgrade proficiency check ride on Oct. 29, 1996," the report said. "The captain received additional training in V_1 cuts [simulated failure of an engine at takeoff decision speed] and multiple engine failures, and accomplished a successful recheck."



McDonnell Douglas MD-11

The McDonnell Douglas MD-11, a medium/long-range passenger/freight transport airplane, entered service in 1990. A derivative of the Douglas DC-10, the MD-11 has a two-pilot, all-digital flight deck; winglets above and below each wing tip; and a redesigned tail incorporating a 2,000-gallon (7,570-liter) fuel-trim tank.

The standard passenger version has accommodations for 323 passengers. The mixed passenger/cargo (combi) version has accommodations for 214 passengers.

The MD-11 is powered either by three Pratt & Whitney PW4460 turbofan engines, each rated at 60,000 pounds static thrust (267 kilonewtons), or by three General Electric CF6-80C2D1F turbofan engines, each rated at 61,500 pounds static thrust (274 kilonewtons).

Standard fuel capacities are 40,183 gallons (152,092 liters) for the passenger version and 38,650 gallons (146,290 liters) for the combi version and the freighter version.

Maximum takeoff weight is 625,500 pounds (283,727 kilograms) for all versions. Maximum landing weights are 430,000 pounds (195,048 kilograms) for the passenger version, 458,000 pounds (207,749 kilograms) for the combi and 471,500 pounds (213,872 kilograms) for the freighter.

Maximum operating Mach number is 0.945. Maximum level speed at 31,000 feet is Mach 0.87 (511 knots). Maximum design ranges with fuel reserves are 6,791 nautical miles (12,577 kilometers) for the passenger version, 6,273 nautical miles (11,618 kilometers) for the combi and 3,626 nautical miles (6,715 kilometers) for the freighter.

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

In the next 10 months, the captain completed satisfactorily a proficiency check and two line checks.

The captain had not flown during the seven days preceding the accident flight. He traveled from his home in Nevada, U.S., to Anchorage the evening before the flight.

"He reported routine activities and normal sleep in Anchorage, and feeling rested upon waking about 0830 local time the day of the accident," the report said. "The accident occurred approximately 14 hours later. The captain reported [that] he felt tired at the end of the accident flight but that his performance was not affected."

The first officer, 39, held an ATP certificate and an MD-11 type rating. He had 3,703 flight hours, including 95 flight hours in type. He was a pilot for the U.S. Navy and a flight engineer for another airline before being hired by FedEx as a ground-service employee in 1994. He transferred to FedEx air operations in 1995.

The first officer had flown six hours in the seven days preceding the accident flight. He was off duty in Anchorage for two days before the flight.

"He reported sleeping more than eight hours before the flight and waking about 1200 local time after being awake briefly from 0630 to 0830," the report said. "The first officer … told investigators that he did not feel fatigued during the accident flight and that he did not believe fatigue was an issue in the accident."

The captain and the first officer had no history of U.S. Federal Aviation Administration (FAA) enforcement actions, accidents, incidents or company disciplinary actions. The report said that both pilots were in good health and reported that they had stable personal lives and did not take medications or consume alcohol in the 24 hours before the accident.

Both pilots had completed the company's tail-strike awareness training program. The program was implemented in 1996 and was included in MD-11 pilot initial training, transition training and recurrent training.

"The program was designed to increase flight crew awareness of pilot-controlled factors that contributed to MD-11 tail strikes, including control inputs that affect pitching tendency after touchdown," the report said. "The program also focused on maintaining proper sink rates, bounce recovery and low-level go-around techniques."

The instructor's guide for the program said that thrust and a 7.5-degree nose-up pitch attitude should be used to recover from a high sink rate and bounced landing. The guide also provided the following information:

> "If a bounce occurs, a go-around should be initiated. Low-level go-arounds — i.e., less than 20 feet (radio

altitude) — are dramatically different than higher-altitude go-arounds. High-altitude go-arounds are initiated with pitch, while low-level go-arounds must be initiated with thrust. During low-level go-arounds, main-wheel touchdown may be unavoidable. The PF [pilot flying] must not exceed 10 degrees of pitch or retract the landing gear until passing 20 feet with a positive rate of climb.

"Some tail strikes have occurred as a result of the pilot attempting to arrest a high sink rate or bounce by quickly adding [nose-up] elevator. This technique immediately increases both the effective weight of the aircraft and the aircraft's vertical velocity. The resulting increased attitude rate will aggravate the pitching tendency after touchdown and drive the main wheels into the ground, thus compressing the main-wheel struts. The aft fuselage will contact the runway at approximately 10 degrees pitch attitude with the struts compressed."

Maintenance records showed that the accident airplane, which entered service in 1993, was damaged in two previous bounced landings. One bounced landing, in January 1994, resulted in minor damage during the second touchdown on the runway; the damage consisted of buckled external skin on the forward fuselage. The other bounced landing, in November 1994, resulted in a tail strike during the second touchdown on the runway; substantial damage was caused to the aft fuselage skin, a rear bulkhead and several floor supports.

The report said that inspections conducted after these bounced landings showed no damage to the main landing gear, gear-attach points or wing structure. (Metallurgical examinations conducted on these components after the July 31, 1997, accident showed no preexisting structural damage or fatigue cracking.)

Before the accident flight, maintenance technicians in Anchorage found that a door on the no. 1 engine thrust reverser was delaminated. Under provisions of the airplane's minimum equipment list, the airplane was dispatched for the flight to Newark with the no. 1 engine thrust reverser inoperative.

The flight plan included an estimated time en route of five hours and 51 minutes. The flight crew said that the flight was routine and uneventful before reaching Newark.

At 0102, the flight crew began a descent from Flight Level (FL) 330 to FL 180.

The first officer used an airport performance laptop computer (APLC) to calculate the airplane's landing distance on Runway 22R, which was 8,200 feet (2,501 meters) long and 150 feet (46 meters) wide. (Runway 22L, which is 1,100 feet [336 meters] longer than Runway 22R, was closed at the time.) The first officer determined that, using the autobrake system in the medium-braking (MED) mode, the landing distance would be 6,080 feet (1,854 meters).

The crew then compared the computed landing distance with charted information showing that 6,860 feet (2,092 meters) of runway remained after the point at which the instrument landing system (ILS) glideslope intersected Runway 22R.

The first officer said, "So, if we go medium brakes landing on this runway, we'll have eight hundred and, eight hundred feet in front of us when we come to a stop?"

The captain said, "Yeah."

The first officer then asked the captain if he wanted to use maximum (MAX) autobraking.

"I don't know," the captain said. "We can probably … start MAX if it makes you feel better and then we'll, ah, come off … . We got a lot of stuff going against us here, so we'll … start off with MAX."

The crew then compared the MAX-autobraking landing distance shown by the APLC (5,030 feet [1,534 meters]) with the after-glideslope landing distance shown on the chart. and determined that 1,830 feet (558 meters) of runway would remain after stopping.

The report said that, although the crew had significant experience using the APLC, their calculations were not correct: The computed landing distance should have been compared with APLC data, which showed that runway distance was 7,760 feet (2,367 meters). This would have shown that after using MED autobraking to stop, 1,680 feet (512 meters) of runway would remain, and that after using MAX autobraking to stop, 2,730 feet (841 meters) of runway would remain.

"The flight crew's calculation error … influenced the captain's subsequent actions during final approach and landing by creating a sense of urgency to touch down early and initiate maximum braking immediately," said the report.

The report said that the crew's concerns about landing distance also were influenced by the inoperative no. 1 engine thrust reverser and recent malfunctions of the autobrake system. Although the effects of reverse thrust are not included in landing-distance calculations during performance certification, the crew knew that airplane deceleration would have been slightly reduced because reverse thrust could not be used from the no. 1 engine.

"The flight crew was aware of three recent events recorded in the airplane's maintenance log in which the airplane's autobrakes had failed to arm at takeoff or failed to work at landing," the report said. "Although maintenance personnel had checked the system after each reported failure and determined that it was functioning properly, the captain told [investigators] that he discussed the reliability of the autobrake system with the first officer before takeoff from [Anchorage and that he] kept the autobrake problem in mind when planning for the landing at [Newark], adding that he planned to land the airplane at the start of the runway and wanted to ensure that the airplane would not float during the landing flare."

At 0110, the crew began a descent from FL 180 to 7,000 feet. The captain told the first officer to advise the passengers to expect "a pretty abrupt stop because of those brakes and the thrust reversers and all that stuff."

The first officer said, over the intercom system, "To give you guys a heads up, we're gonna be landing pretty quick here. We've got about another 15 minutes to go to get on the ground. We got a short runway, so … the aircraft is going to be stopping pretty quick."

At 0115, the captain told the first officer to turn on the landing lights. The captain observed that the left landing light did not illuminate.

"Looks like we got one burned out," the captain said. "Just having all kinds of fun here."

"Left side's out, huh?" said the first officer.

"Well, let's see here," the captain said. "Yeah, just the right's working. Well, I guess we got another thing we'll write up."

The first officer asked the captain if he should use the radio to inform maintenance technicians at Newark about the landing-light problem. The captain said, "No, I don't think it's a big issue. They'll defer it if they have to."

The captain later told investigators that the inoperative left landing light did not significantly affect his ability to judge sink rate and land the airplane. The report said that other external lights were available during the landing, including the right landing light, turn-off lights mounted at the wing roots (which the company required flight crews to use below FL 180); and taxi lights and landing lights mounted on the nose gear.

"Therefore, the area normally covered by the left landing light would have been darker than normal but not without illumination because of the overlapping areas of illumination from the other lights," the report said.

At 0122, the crew began a descent to 3,000 feet. During the descent, the crew conducted the approach checklist and listened to the automatic terminal information service (ATIS) broadcast for Newark. The ATIS broadcast included surface winds from 250 degrees at five knots, 10 statute miles (16 kilometers) visibility and scattered clouds at 8,000 feet.

At 0128, the crew began a descent to 2,000 feet. The first officer reported the airport in sight, and air traffic control (ATC) cleared the crew to conduct a visual approach to Runway 22R.

At 0129, ATC cleared the crew to land.

The captain announced that the autopilot had captured the ILS glideslope and told the first officer to extend the landing gear and begin the before-landing checklist. The crew confirmed that MAX autobraking was selected, extended the flaps to 35 degrees, armed the ground spoilers, confirmed that the landing gear was extended and extended the flaps to 50 degrees.

The airplane was at 1,200 feet at 0130 when the captain said that he was "coming off the autopilot." The crew then engaged the autothrottle system. (At the time, the company's MD-11 flight manual required use of autothrottles during all landings; the flight manual was revised in June 1998 to rescind this requirement.)

The first officer said, "Flaps are 50. Before-landing checklist is complete."

The captain then told the first officer to remind him to use only the no. 2 thrust reverser and the no. 3 thrust reverser.

"Two and three on the reverse, just in case I forget," the captain said.

The company MD-11 flight manual said that a normal landing should be conducted as follows:

> "Aim to touch down 1,500 [feet (458 meters)] from the runway threshold. The runway threshold should disappear under the nose at about the same time CAWS [central aural warning system] announces "100" [feet]. Maintain a stabilized flight path through the ["50" (feet) and "40" (feet)] CAWS call-outs (unless sink rate is high). At 30 [feet], a smooth 2.5-degree flare should be initiated so as to arrive below 10 [feet] in the landing attitude. Do not trim in the flare. Elevator back pressure should be relaxed, and a constant pitch attitude should be maintained from 10 [feet] radio altitude to touchdown."

The report said that the approach was stabilized until the flare was begun.

"According to information from the airplane's flight data recorder (FDR), the approach was flown on the glideslope and localizer until touchdown, and the airplane's approach airspeed was about 158 knots until the flare," the report said. "According to the CVR [cockpit voice recorder], the pilots had selected an approach reference speed of 157 knots, or V_{REF} [reference landing speed] plus five knots."

The average pitch attitude was three degrees nose-up, which was consistent with flight manual data for descending on a three-degree ILS glideslope. The descent rate remained stable at 800 feet per minute.

At 0132, the first officer called "minimums" (indicating that the airplane was at the published decision height for the ILS approach).

At 50 feet radio altitude, the autothrottle system began to move the throttles to the flight-idle stop, and thrust began to decrease. At about 37 feet, the captain began to flare the airplane for landing. The pitch attitude reached five degrees nose up at 17 feet radio altitude, two seconds before the first touchdown.

"This portion of the flare maneuver was consistent with FedEx MD-11 flight manual guidance, which called for a 'smooth 2.5-degree flare' to be initiated between 30 [feet] and 40 feet radio altitude," the report said. "Thus, the … captain's execution of the beginning of the flare maneuver was normal and [was] not a factor in the accident."

The captain then applied a nose-down elevator input, and pitch attitude began to decrease.

"When the captain rapidly moved the elevators to near neutral instead of maintaining nose-up elevator and continuing the flare (two seconds before first touchdown), he destabilized the flare and established a greater sink rate," the report said.

Both pilots felt the airplane's sink rate increase.

"With just more than one second remaining before touchdown, the captain had the following options: accept the sink rate and subsequent hard landing, attempt to salvage the landing with last-second thrust and pitch adjustments, or execute a go-around," the report said. "FDR data and postaccident interviews show that the captain chose to try to salvage the landing."

The airplane was descending through seven feet radio altitude when the captain applied a nose-up elevator input and increased power from near-flight-idle thrust to near-takeoff thrust. A right-wing-down aileron input of four degrees to five degrees also was made.

"The large nose-up elevator and thrust inputs that the captain made with only one second remaining before touchdown were his reaction to the sink rate and an attempt to prevent a hard landing," the report said.

The airplane's pitch attitude had just begun to increase and vertical acceleration had just begun to decrease when the airplane touched down on the runway. Vertical speed was about 7.6 feet per second (fps), and vertical acceleration was 1.67 G [gravity force].

"From that moment on, evidence indicates that all of the captain's control inputs were too late and too large to achieve the desired effect," the report said.

The captain applied a rapid nose-down elevator input —from about 70 percent of maximum nose-up elevator travel to about 67 percent of maximum nose-down elevator travel in less than one second.

"[The] large nose-down elevator input [was] consistent with an effort to keep the airplane on the runway and ensure an early touchdown of the nose gear with maximum available stopping distance," the report said. "Although [the captain] began these nose-down inputs at about the time of the first touchdown, the airplane had bounced back into the air by the time he had pushed almost all the way forward on the control column."

"With just more than one second remaining before touchdown, the captain had the following options: accept the sink rate and subsequent hard landing, attempt to salvage the landing with last-second thrust and pitch adjustments, or execute a go-around," the report said.

The report said that the large and rapid elevator-control reversals were consistent with a "classic" pilot-inducted oscillation (PIO).

"Essentially, the captain made each increasingly larger elevator input in an attempt to compensate for the input he had made in the opposite direction about one second earlier," the report said. "PIO in the pitch axis can occur when pilots make large, rapid control inputs in an attempt to quickly achieve desired pitch attitude changes.

"The airplane reacts to each large pitch control input; but, by the time the pilot recognizes this and removes the input, it is too late to avoid an overshoot of the pilot's pitch target. This, in turn, signals the pilot to reverse and enlarge the control input, and a PIO with increasing divergence may result."

The airplane was airborne for about two seconds after the first touchdown and reached a maximum height of five feet.

"Given the nose-down elevator position at that point in the bounce [i.e., at five feet], there were probably no additional crew actions that could have been taken to prevent a hard impact with the runway," the report said.

The airplane was in a 0.7-degree nose-down and 9.5-degree right-wing-down attitude when it struck the runway. The right-main landing gear had a vertical speed of approximately 13.5 fps upon impact.

"The energy transmitted into the right-main landing gear during the second touchdown was 3.2 times greater than the MD-11's maximum certificated landing energy and was sufficient to fully compress ('bottom') the right-main landing-gear strut and cause structural failure of the right-wing rear spar," the report said.

The right wing separated from the fuselage, and a fuel-fed fire erupted.

The captain and first officer said that the airplane slowly rolled right after the second touchdown. The captain said that the airplane "remained on its side for a time as it slid down the runway. Both pilots said that they saw orange flames. The first officer believed that the fuselage and window structure were going to fail; he unfastened his seat belt and shoulder harness, and got out of his seat. He held onto his seat back and stood on the overhead console as the airplane continued to roll.

The airplane came to rest inverted, heading 95 degrees, about 5,126 feet (1,563 meters) beyond the runway threshold and 580 feet (177 meters) right of the runway centerline.

The first officer went to the forward cabin area to check on the two cabin passengers, who appeared to be uninjured. He was unable to open either of the two forward cabin doors and shouted to the cockpit that the cockpit windows would have to be used for evacuation.

The captain, who had fallen on his head and hand after unfastening his seat belt and shoulder harness, opened the cockpit window, exited the airplane and shouted, "This window is open." The jump-seat passenger, the two cabin passengers and the first officer exited through the cockpit window. The first officer saw aircraft rescue and fire fighting vehicles approaching as he exited the airplane.

"The fire was extinguished (except for sporadic hot spots) about 0700," the report said.

The report discussed the known tendency of the MD-11 to pitch up after ground spoiler deployment. Partial deployment of the ground spoilers occurs automatically when the main wheels begin rotating on landing; full deployment occurs when the nose-gear strut is compressed.

"The captain told [investigators] that he was expecting the nose-up pitching moment associated with initial spoiler deployment at [main-landing-gear] spin-up," the report said. "He stated that he remembered compensating with forward-control-column input and that he thought the spoilers had deployed at touchdown.

"Although a portion of the captain's nose-down elevator input at the time of the first touchdown may have been in response to the pitch-up tendency, the input greatly exceeded that required to control this tendency."

The report said that, although the airplane's tendency to pitch up when the ground spoilers deploy did not contribute to the accident, "reduction or elimination of the pitch-up tendency would simplify MD-11 landing techniques and may help prevent future MD-11 landing incidents and accidents."

In May 2000, The Boeing Co. [which merged with McDonnell Douglas under the Boeing name in 1997] received FAA certification of an MD-11 flight control computer (FCC) software upgrade called "FCC-908." The software upgrade modifies longitudinal-stability-augmentation-system (LSAS) functions; the results are reduced pitch sensitivity during landing and handling qualities that are similar to those of the DC-10 (precursor of the MD-11).

"The handling changes incorporated in the MD-11 FCC-908 software upgrade will provide valuable improvements in safety during MD-11 landings," the report said.

The report said, however, that an FCC-908 software upgrade should be accompanied by an FDR modification that will enable differentiation between pilot-induced elevator control movements and LSAS-induced elevator control movements.

The report discussed the MD-11 "ground-spoiler-knockdown feature," which prevents the spoilers from deploying or retracts the spoilers when the no. 2 throttle is above the flight-idle stop. The feature is designed to ensure that ground spoilers are not extended during go-arounds.

The captain's application of power before the first touchdown prevented the ground spoilers from deploying. The report said that, although activation of the spoilers would have decreased lift and lessened the airplane's bounce after touchdown, the ground-spoiler-knockdown system did not contribute to the accident.

The report said, however, that the threshold at which the ground-spoiler-knockdown feature activates "may be too low to allow for power applications to accommodate moderate sink rate [control techniques] and airspeed control techniques near the ground without disarming the AGS [automatic ground spoiler] system."

The report said that existing MD-11 and DC-10 AGS systems can be modified to allow greater throttle movement before the ground-spoiler-knockdown feature is activated.

"Delaying the knockdown feature would allow pilots to make larger thrust increases just before landing without preventing ground spoiler deployment at touchdown, which may help prevent or minimize some bounces," the report said. "In the event of a go-around, the higher knockdown [threshold] would slightly delay the retraction of ground spoilers; therefore, a study to determine an optimum [threshold] for activation of the knockdown feature would be necessary."

The report said that the accident prompted NTSB to review certification standards for transport airplane handling qualities during landing operations.

"The review indicated that, besides basic stability criteria, few objective standards exist for the assessment and acceptance of these handling qualities, including the interactions of airplane and pilot responses, and the effects of adverse environmental conditions," the report said. "Certain complex system interactions, pilot input characteristics and other factors, such as [center of gravity] position and atmospheric conditions, may occasionally combine during the landing phase in undesirable ways that were not identified during the original certification of transport airplanes."

The report also discussed two landing-gear design techniques: fusing and overdesigning. Fuse pins are used to ensure that the landing gear breaks from the wing when loads exceed the design limit, rather than to transfer loads to the wing. Overdesigning ensures that the landing gear can withstand loads greater than those required for certification.

The MD-11 main landing gear was fused for a drag-overload condition and overdesigned for a vertical-overload condition.

"Boeing has stated that this design was implemented because data indicated that the most likely landing gear overload condition would occur as a result of striking an obstruction," the report said.

The report said that current certification standards require landing gear to withstand a 1.0-G vertical acceleration, small roll angles and sink rates up to 12 fps.

"Several major landing accidents have now occurred as a result of pilots allowing their airplanes to land with more adverse combinations of lift, roll angle and sink rate than those specified in the regulations," the report said. "In each accident, a wing broke and a fuel fire erupted. Each of these accidents involved aircraft whose landing gear were not fused for upward (vertical)-acting loads."

The report also said that some airplane manufacturers recommend that operators use peak vertical acceleration data recorded by the FDR during landing to identify hard landings that might have caused structural damage.

"Data from the Newark accident indicate that initial vertical acceleration, pitch [rates] and roll rates, and attitudes should also be considered during FDR readout and evaluation of a potential hard-landing event," the report said.

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

- "Convene a joint government-industry task force composed, at a minimum, of representatives of manufacturers, operators, pilot labor organizations and [FAA] to develop, within one year, a pilot training tool to do the following:
  - "Include information about factors that can contribute to structural failures involving the landing gear, wings and fuselage, such as design sink-rate limits, roll-angle limits, control inputs' roll rate, pitch rate, single-gear landings, the effect of decreased lift, and structural loading consequences of bottoming landing-gear struts and tires;
  - "Provide a syllabus for simulator training on the execution of stabilized approaches to the landing flare, the identification of unstabilized landing flares and recovery from these situations, including proper high-sink-rate recovery techniques during flare to landing, techniques for avoiding and recovering from overcontrol in pitch before touchdown, and techniques for avoiding overcontrol and premature derotation during a bounced landing; [and,]
  - "Promote an orientation toward a proactive go-around;
- "Require principal operations inspectors assigned to [U.S. Federal Aviation Regulations (FARs)] Part 121 carriers that use auxiliary performance computers to review and ensure the adequacy of training and procedures regarding the use of this equipment and the interpretation of the data generated, including landing-distance data;
- "Require the installation, within one year, of the MD-11 [FCC-908] software upgrade on all MD-11 airplanes;
- "Require, on all MD-11s equipped with the [FCC-908] software, the retrofit of digital flight data recovery systems with all additional parameters required to precisely identify and differentiate between pilot and [LSAS] elevator control activity, including control column force, inertial reference unit pitch rate, LSAS command signals, elevator positions and automatic ground spoiler command signals;
- "Review and, if appropriate, revise the DC-10 and MD-11 [ground-spoiler-knockdown] feature to ensure that it does not prevent ground spoiler deployment at moderate [throttle settings] that could be associated with sink rate and airspeed corrections during the landing phase;
- "Require DC-10 and MD-11 operators to provide their pilots with information and training regarding the ground-spoiler-knockdown feature and its effects on landing characteristics and performance;

- “Sponsor a National Aeronautics and Space Administration (NASA) study of the stability-and-control characteristics of widely used, large transport category airplanes to:

  – “Identify undesirable characteristics that may develop during the landing phase in the presence of adverse combinations of pilot control inputs, airplane center of gravity position, atmospheric conditions and other factors; and,

  – “Compare overall qualitative and quantitative stability-and-control characteristics on an objective basis;

  “The study should include analyses of DC-10 and MD-11 landing accidents and any other landing incidents and accidents deemed pertinent by NASA;

- “Based on the results of the [NASA] study, implement improved certification criteria for transport category airplane designs that will reduce the incidence of landing accidents;

- “Conduct a study to determine if landing gear vertical overload fusing offers a higher level of safety than when the gear is overdesigned. If fusing offers a higher level of safety, revise [FARs] Part 25 to require vertical overload fusing of landing gear; [and,]

- “Require manufacturers of [FARs] Part 23 and Part 25 airplanes, and Part 121 operators to revise their hard landing inspection-and-reporting criteria to account for all factors that can contribute to structural damage; instruct principal maintenance and operations inspectors assigned to Part 121 operators to ensure that these changes have been made to operator maintenance manuals and [flight operational quality assurance (FOQA)] programs.”♦

[This article, except where specifically noted, is based on U.S. National Transportation Safety Board *Aircraft Accident Report: Crash During Landing, Federal Express, Inc., McDonnell Douglas MD-11, N611FE, Newark International Airport, Newark, New Jersey, July 31, 1997*. The 141-page report includes photos, diagrams and appendixes.]