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March 16, 1999

Robert Benzon
Senior Air Safety Investigator
National Transportation Safety Board
490 L'Enfant Plaza East, S.W.
Washington, DC 20594

RE: DCA97MA055, Federal Express Submission

Dear Mr. Benzon,

Please find attached Federal Express's submission to the referenced accident. As requested, additional copies are provided for the NTSB Group Chairmen and Board Members. I have also forwarded copies to the other Parties to the investigation. If you have any questions, please contact me at the number below.

[redacted]

Michael C. Wales
Party Coordinator
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Enclosures

cc: Bill Steelhammer, Boeing Long Beach
Victoria Anderson, FAA
Shem Malmquist, FedEx Pilots Association
Frank DiMola, Port Authority of NY & NJ
Paul Mingler, GE Aircraft Engines

Federal Express Submission
MD-11, N611FE Accident
Newark, New Jersey
July 31, 1997
DCA97MA055

I. History of Flight

On July 31, 1997, Federal Express Flight 14, N611FE, was on a scheduled flight from Anchorage, AK to Newark NJ. At approximately 0131 EDT, FedEx 14 crashed on landing at Newark International Airport. The aircraft had a firm initial touch down, bounced, touched down again and began breaking apart as it continued to slide down the shoulder of Runway 22R. The aircraft overturned and came to rest beside Runway 22R, pointing in the direction of the approach end of the runway. The two member flight crew and three jumpseat passengers successfully evacuated the aircraft through the Captain's side window, without significant injuries. The aircraft was destroyed.

II. Federal Express's investigation focussed on the following areas: Aircraft design and certification, aircraft performance during the accident sequence, crew certification and training, and providing Aircraft Rescue and Fire Fighting (ARFF) personnel timely post accident information concerning onboard Dangerous Goods shipments.

III. Aircraft Design, Certification and Aircraft Performance during Accident Sequence.

A. Facts

1. Aircraft N611FE was involved in two previous incidents that resulted in structural damage prior to the accident flight on July 31, 1997. The first incident was a nose landing gear first landing that occurred in Memphis in January 1994. Damage was confined primarily to the forward fuselage. The aircraft was inspected and found to be acceptable for continued service until permanent repairs could be performed during a scheduled heavy maintenance visit. Prior to accomplishment of permanent repairs relating to the first incident, a second incident, a tail strike, occurred during landing in ANC in September 1994. The aircraft was ferried to LAX for repairs to the aft fuselage. Permanent repairs to the forward fuselage (first incident) were accomplished in summer 1995. Hard landing inspections were performed per the MD-11 maintenance manual after both incidents and again while accomplishing permanent repairs. All inspection results were documented and addressed per General Maintenance Manual (GMM) procedures.[1]

2. No pertinent aircraft discrepancies were noted in the maintenance records that may have affected the performance of the aircraft during the accident flight.[2]

3. The flight data recorder (FDR) recorded the following data related to the first touchdown at EWR on July 31, 1997:

   a. Maximum vertical acceleration was 1.67 g.

   b. Vertical descent rate at the CG of the aircraft was 7.6 feet/sec. (FPS).

   c. Roll attitude was 1 degree right wing down.[3]

4. After the first touchdown the aircraft bounced and became airborne. In the period following the first touchdown, the following occurred (based on FDR data):

   a. A nose down elevator (18 deg. max) and right wing down aileron deflection were recorded by the FDR along with a decrease in throttle resolver angle (TRA) as the aircraft pitched up and became airborne. TRA then increased and quickly decreased as the aircraft pitched nose down and rolled right wing down. The aircraft remained airborne for approximately 750 feet (about 3 seconds) after the first touchdown.

   b. The loss of lift caused by a decrease in pitch resulted in a vertical acceleration of 0.5 g just prior to the second touchdown (2^{nd} TD). This "negative g" condition coupled with the right wing down roll rate and attitude led to the conditions of the 2^{nd} TD.[3]

5. The FDR recorded the following data related to the 2^{nd} TD:

   a. Maximum vertical acceleration was 1.70 g.

   b. Vertical descent rate at the CG of the aircraft was 11.5 FPS.

   c. Right wing down roll rate at the 2^{nd} TD was 7 deg./sec. This condition equated to an additional 2 FPS descent rate at the right main landing gear (RMLG). Thus, the RMLG experienced a maximum descent rate of 13.5 FPS at the 2^{nd} TD.

   d. Aircraft attitude was:
      1) 0.7 deg. nose down pitch.
      2) 9.5 deg. right wing down roll.
      3) 2.5 deg. nose left yaw.[3]

6. Three major events occurred at, or just subsequent to, the 2nd TD:
   a. RH wing failed.
   b. RMLG separated from the aircraft.
   c. RH inboard flap & vane assembly separated from the fuselage.[1]
7. Review of runway markings indicated that no part of the RH wing contacted the runway early in the accident sequence except for the RMLG wheels and #3 engine nacelle.[3] Detailed inspection of the #3 engine/nacelle/pylon combination brought to light that only the lower forward section of the nacelle contacted the runway during the initial period of the aircraft breakup. No damage was found on the #3 core cowling relating to runway contact[4]

B. Detailed Factual Research. The analysis described in paragraphs B and C below was performed by Boeing Long Beach (BLB), under the supervision of the NTSB and with the participation of party participants to the investigation.

1. Metallurgical analysis performed by Boeing Long Beach (BLB) indicated that all parts transported for detailed analysis conformed to original manufacturing specifications with the exception of the RH inboard flap lower half track (P/N ARB2502-501) which exhibited a yield strength of 2.4 ksi below the required 135 ksi.[1]
2. Metallurgical data from BLB indicated that all examined fracture surfaces failed due to ductile overload. There was no evidence of stress corrosion cracks, fatigue cracks, or manufacturing flaws detected by the BLB laboratory staff, on-site FedEx personnel (including FPA members), or NTSB metallurgist overseeing the BLB activity.[1]

C. Analysis

1. All data suggests that the MD-11 design, and N611FE specifically, complied with FAR 25 requirements relating to landing gear performance in effect at the time of certification.[5]
2. Calculations performed by BLB show that the total energy transmitted into the RMLG during the 2nd TD exceeded both certification requirements and MD-11 design specifications.
   a. Certification energy is based on maximum certified landing weight and 12 FPS descent rate drop test. Total demonstrated energy capacity was 494,500 ft-lb. for a single MLG.

b. The RMLG experienced a load of 1,574,000 ft-lb., or 318% of certification loads during the 2nd TD.[6]

3. Under the conditions of the 2nd TD, analysis by BLB determined that the weakest part of the wing is the rear spar section approximately half way between the trapezoidal panel and the MLG (certification data and ADAMS model). Additionally, BLB presented data showing that sufficient loads were present during the 2nd TD to fail the rear spar web.[6]

4. Aircraft structural failure most likely occurred in the following sequence:

   a. The aircraft pitch attitude, vertical acceleration, descent rate, and right wing down roll rate at the 2nd TD created a total energy load in the airframe far in excess of landing gear certification loads.

   b. The right wing down attitude at the second touchdown forced all landing energy through the RMLG, thus, increasing the loads into the RMLG to levels more than 300% of certification requirements. However, this extreme overload condition at the 2nd TD did not fail the RMLG.

   c. Excess energy not absorbed by the RMLG was transmitted to the rear spar of the right wing. This condition, in conjunction with the right wing down attitude, caused unusual loading into the rear spar of the RH wing. The upload into the wing at the RMLG, coupled with the down load of the LH wing and complete fuselage, induced a torsional load into the RH wing. The torsion translated to a shear overload condition in the RH wing rear spar (web) in the area between the RMLG and trapezoidal panel. The failure of the rear spar web then changed the bending stiffness and geometry of remaining intact wing. With the RH wing rear spar failing, the distance between the fuselage and wing increased. This condition overloaded the RH inboard flap track where the flap attaches to both the fuselage and wing. Correspondingly, the outboard movement of the wing caused an overload condition in the side brace fitting to trap panel (pillow block) joint, failing the connection of the RMLG to the fuselage.[7] As the wing continued to separate from the fuselage, the RMLG installation (i.e., the MLG wing attach fitting) began to fail, allowing the #3 engine nacelle to contact the runway. The RMLG then completely separated from the wing at a point further down the runway. With the possible exception of tire failures, all damage to the RMLG can be classified as secondary.[8]

D. Conclusions

1. N611FE was properly designed and certified in accordance with Federal Aviation Regulations.

2. The two prior hard landings experienced by N611FE had no impact on this accident.

3. Control inputs made after the bounce and just prior to the second landing resulted in the development of severe overload forces which were transmitted through the Right Main Landing Gear (RMLG) and into the Right Wing Rear Spar Web.

4. Landing overloads beyond design specifications caused the rear spar to begin to fail, resulting in the right inboard flap to depart the aircraft and subsequent failure of the RMLG.

5. Post accident laboratory analysis revealed all failure modes were due to ductile overload, the analyzed aircraft parts conformed to design specifications and there was no evidence of preexisting damage or failures.

IV. Pilot Flying (PF)[10] Certification, Training, and Human Factors

A. Facts

1. The PF was properly certified in accordance with the Federal Aviation Regulations.[9]

2. The PF was hired by the Flying Tiger Line on May 15, 1979. He was qualified as a DC-8 Flight Engineer on July 7, 1979. He transitioned to B-747 Flight Engineer on May 19, 1987, and then to B-747 First Officer on December 18, 1987. Federal Express Corporation purchased the Flying Tiger Line and merged flight operations on August 7, 1989, and the PF transitioned to DC-10 First Officer on August 4, 1992. All training and evaluations to date were satisfactory.

3. On July 5, 1994, the PF transitioned to MD-11 First Officer. Additionally, the PF received the following MD-11 First Officer Recurrent Training: a Proficiency Training (PT) on November 14, 1994, a Warm Up (WU) on June 3, 1995, a Proficiency Check (PC) on June 4, 1995, a Line Orientated Flight Training (LOFT) on January 12, 1996, Tailstrike Awareness Training and a WU on July 10, 1996, and a PC on July 11, 1996. The PF logged approximately 934 hours as a MD-11 First Officer and all training and evaluations to date were satisfactory.

4. On October 6, 1996, the PF began MD-11 Upgrade Training. On October 28, 1996, he received a progress evaluation and was subsequently recommended for an Upgrade PC. His instructor wrote the following remarks in the comment section of the Pilot Training Record:

   "Super prog ride!! No problems. Stays ahead of the a/c at all times. Hand flys great! Should do well on check ride. Signed off GPWS, CAT II/III check and VOR 27 KMEM"

5. On October 29, 1996, the PF received an unsatisfactory overall grade on his Upgrade PC. The FAA designated examiner wrote the following remarks on the Flight Officers Proficiency form (007):

   "1. V1 cut unsat wrong rudder pushed. 2. Loss of second eng aircraft control unsat"

6. On October 30, 1996, the PF received additional training and rechecked satisfactorily. On November 15, 1996, he received Tailstrike Awareness Training, and on December 21, 1996, after satisfactorily completing Initial Operating Experience, the PF was activated as a MD-11 Captain. Additionally, he received a line check on January 7, 1997, a PT on April 16, 1997, and a line check on July 11, 1997. The FDX 14 accident in Newark occurred on July 31, 1997. The PF had accumulated approximately 325 hours as Captain on the MD-11 at the time of the accident. With the exception of the Upgrade PC on October 29, 1996, all training and evaluations (since being hired by the Flying Tiger Line on May 15, 1979) were satisfactory.

7. Tailstrike Awareness Training

   a. Every MD-11 operator in the United States (American, Delta, FedEx, and World) has experienced MD-11 tailstrikes. As a comprehensive response to the FedEx MD-11 tailstrikes that occurred on November 4, 1994, April 24, 1996, and May 16, 1996, FedEx developed a MD-11 Tailstrike Awareness Training Program. The primary objective of the program is to reduce the frequency of MD-11 tailstrike events by increasing awareness of the pilot controlled factors that affect pitching tendency after touchdown and by reinforcing proper sink rate, bounce recovery, and low level go-around technique.

   b. FedEx was the first MD-11 operator to develop and implement a MD-11 Tailstrike Awareness Training Program. However, prior to commencing tailstrike awareness training, FedEx presented its program to the Douglas Aircraft Company (DAC) flight operations and flight training departments and to the FAA. In addition to receiving approval to proceed with its training program in June 1996, FedEx received an invitation to present its program to the airline industry at the DAC Tailstrike Symposium which was held in August 1996. The presentation was well received and FedEx was again invited to present its program at the DAC Flight Operations Seminar in October 1996. During this presentation, FedEx distributed Tailstrike Awareness Training materials to many of the MD-11 operators. FedEx has since presented its program to the Air Transport Association at their Operations and Safety Council forum.

c. Tailstrike awareness training consists of a comprehensive briefing and a full flight simulator session.

   1) The briefing covers; the scope and magnitude of the MD-11 tailstrike phenomena, proper takeoff rotation technique, factors that affect pitching tendency after touchdown, the chain of events found in most MD-11 landing tailstrikes, pilot actions that have resulted in excessive sink rates and subsequent MD-11 tailstrikes, stabilized approach procedures, the align maneuver, proper landing technique, auto throttle retard logic, high sink rate, bounce recovery and low level go-around technique, the dynamics of improper sink rate recovery technique, and a review of FedEx's comprehensive tailstrike avoidance strategy.

   2) The simulator training consists of six scenarios that graphically reinforce; proper takeoff rotation technique, proper crosswind landing technique, proper flare technique, auto throttle retard logic, proper sink rate and bounce recovery, the correlation between an increasing pitch attitude rate at touchdown and an increased pitch up tendency after touchdown, low level go-around technique, and the need for the Captain to make a positive and assertive transfer of control from the First Officer if the situation demands. All training scenarios (including the high sink rate and bounce recovery scenario) are repeated as needed until proficiency is achieved.

B. Analysis

1. The PF was trained in accordance with the FedEx Flight Operations Training Manual. He received Tailstrike Awareness Training on July 10, 1996, during First Officer recurrent training and again on November 15, 1996, during Captain Upgrade training. However, the flight control movements and subsequent flight path of the accident aircraft (FDX 14) are not consistent with the techniques and procedures taught in the FedEx MD-11 Tailstrike Awareness Training Program. Specifically;

FedEx recommends that the MD-11 be flown in stable path through the 50 and 40 foot callout (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. From 10 feet to touchdown, elevator back pressure should be relaxed and a constant pitch attitude maintained.

Based on FDR information, FDX 14 was on a nominal approach to runway 22R at Newark (flaps 50, pitch attitude 2-3 degrees nose up, airspeed 157-159 KIAS, and vertical speed 800 feet per minute). Surface winds were reported as 250 degrees at 5 knots (a 2 knot crosswind component). The PF was manually manipulating the flight controls with the auto throttle system engaged and electronic glide slope information displayed. At 36 feet Radio Altitude (RA), an abrupt flair was commenced. The aircraft achieved the landing attitude (4.9 degrees) at 25 feet RA. At 17 feet RA, nose down elevator deflection was initiated and pitch attitude began to decrease to 4.2 degrees. At 7 feet RA, a large nose up elevator deflection (26 of the available 35 degrees) was made. Additionally, nose left rudder deflection (5.5 degrees), right wing down aileron (4-5 degrees), and throttle advancement (to 74 degrees) throttle resolver angle (TRA) was recorded. FDX 14 touched down at 7.6 feet per second with an increasing pitch attitude rate. Shortly after touchdown, a large nose down elevator deflection (18 of the available 25 degrees) was recorded. The auto spoilers did not deploy due to the TRA (above 49 degrees). The lack of spoiler deployment combined with the high pitch attitude (8.44 degrees maximum), high thrust (65 percent N1 and accelerating), and increasing airspeed resulted in the aircraft becoming airborne.

FedEx recommends that if a high sink rate or low bounce occurs, the pilot flying should establish a 7 1/2 degree pitch attitude and increase thrust until the sink rate has been arrested and or a normal landing accomplished. If a high bounce occurs, a low level go-around should be initiated.

FDX 14 became airborne following the first touchdown (climbing to approximately 7 feet RA). As the aircraft climbed, it pitched nose down (consistent with the nose down elevator deflection) and rolled right wing down (consistent with the right wing down aileron deflection). Prior to the second touchdown, another large nose up elevator deflection (24 of the available 35 degrees) was made and additional nose left rudder, and right wing down aileron were recorded. The aircraft touched down at 13.5 feet per second, 9.5 degrees right wing down, and pitch attitude at – 0.7 degrees. The resulting loads overstressed the right wing structure and the right main landing gear.

C. Human Factors

1. Facts

a. Prior to the accident flight, the auto brake system had three prior write-ups for the system not arming. Each time, maintenance had checked the system and could not duplicate the problem. Departing ANC, the auto brakes had "armed" without problem.[9]

b. The number three engine reverser was deferred as inoperative.[9]

c. The crew misunderstood the landing data provided by the Airport Performance Laptop Computer. They thought the landing distance data provided by the computer was the distance required to stop after the glide slope touchdown.[11]

2. Analysis

a. The PF discussed with the F/O landing on the shorter runway at EWR because of concern about the inoperative reverser and auto brake history. He indicated he "wasn't going to grease it…but try to put it on the end of the runway and try to make sure he would not get any floating out of it."[9]

b. Runway 22R total runway available at EWR was 7760 feet. Runway available beyond glide slop touchdown was 6860 feet. When the crew computed the landing data for medium brakes, the APLC indicated stopping distance was 6080 feet.[9] The crew thought the APLC data indicated the distance required to stop after glide slope touchdown, that only approximately 800 feet of runway would be remaining, and elected to use maximum braking. The crew discussed the abrupt stop using maximum brakes and alerted the jump seat passengers to expect this.[11] They didn't understand that the APLC landing distance included a nominal 1500 feet of ground distance flown down the runway to glide slop touchdown; and therefore, actual runway remaining with medium brakes would have been approximately 1700 feet.

c. The combination of the anomalies associated with the auto brakes, the inoperative thrust reverser, and apparent short runway may have put the PF in a mindset that he needed to keep the aircraft on the runway after the first touchdown and subsequent bounce. This subconscious decision may account for the control inputs following the first touchdown.

d. Pilots generally attempt to salvage poorly flown landings rather than going around to attempt another. They are trained and prepared for a go around when the approach/landing is adversely affect by environmental factors (wind shear, etc.); however, when the poor landing results from pilot inputs, the tendency is to continue the landing. Programs such as the Federal Express Tailstike Awareness Training are designed to instill within the pilot an awareness and appreciation that if an unstabalized approach or landing is flown to conclusion, the potential outcome could be catastrophic. The training emphasizes that going around is an accepted and approved procedure. It attempts to "train out" the innate pilot desire to complete a poorly flown approach and landing.

D. Conclusions

1. The PF was properly trained in the MD-11, to include Tailstike Awareness Training.

2. Aircraft discrepancies and misunderstanding of the APLC data may have led the PF to believe he had to keep the aircraft on the runway.

3. Control inputs after the first touchdown are inconsistent with the Tailstike Awareness Training.

4. Had the procedures taught in the Tailstrike Awareness Training been followed and the aircraft taken around after the first touchdown, this accident would not have occurred.

V. Dangerous Goods

A. Fact

Timely, accurate reporting of Dangerous Goods (DG) onboard accident aircraft to ARFF response remains an industry wide limiting factor.

B. Analysis

1. The Federal Express 390 Part B provides detailed information concerning each DG shipment. Copies of the 390 Part B are maintained at the originating station and are also placed in the onboard document pouch.

2. During an accident when this detailed, time critical information is required, the originating ramp must gather this information and Fax it to the requesting agency. The 390 Part B forms are composed of flimsy paper and are completed by hand. Attempts to copy and Fax the Part Bs are

normally unsuccessful due to deterioration of the print, and sometimes the handwriting is illegible.

3. The aircraft onboard documentation pouch containing the 390 Part A with enclosed Part B have been mounted in different areas of the cockpit or foyer leading to the cockpit and are sometimes not easily accessible to the crew during an emergency evacuation.

C. Conclusion

A mechanism needs to be developed to ensure ARFF personnel responding to an aircraft accident receive timely and accurate DG information.

VI. FINDINGS

A. FINDING 1: MD-11, N611FE, was properly designed and certified in accordance with the Federal Aviation Regulations.

B. FINDING 2: N611FE had two prior hard landing events. Damage resulting from these events was properly repaired, with no impact on the aircraft's airworthiness.

C. FINDING 3: The PF was properly certified, trained, and current in the MD-11.

D. FINDING 4: N611FE's had a recent history of inoperative auto brakes and on the accident flight, the number three engine thrust reverser was deferred.

E. FINDING 5: The crew misunderstood the data provided by the Aircraft Performance Laptop Computer and thought they had less runway available to stop the aircraft than actually available.

F. FINDING 6: During the initial landing, the aircraft's touchdown was firmer than normal and the aircraft became airborne.

G. FINDING 7: (Cause) The Federal Express, MD-11 Tail Strike Avoidance procedures and techniques were not used to recover from the bounce.

H. FINDING 8: (Cause) Inappropriate control inputs made after the bounce and just prior to the second touchdown resulted in the development of severe overload forces which were transmitted through the Right Main Landing Gear (RMLG) and into the Right Wing Rear Spar Web.

I. FINDING 9: Landing overloads caused the right rear spar, the right inboard flap and the RMLG to fail.

J. FINDING 10: The aircraft settled onto the number three engine and lift provided by the left wing and flap, coupled by thrust from the number one engine, resulted in the fuselage rotating clockwise over the failing right wing, causing it to separate from the aircraft.

K. FINDING 11: The aircraft skidded to a stop on its back, pointing toward the approach end of the runway. The jump seat passengers and crew escaped the burning aircraft without significant injuries.

L. FINDING 12: (Cause) Fire fighting was delayed when fire fighters chose not to attack the fire without additional detailed information concerning Dangerous Goods.

M. FINDING 13: Post accident laboratory analysis revealed all failure modes were due to ductile overload, the analyzed aircraft parts conformed to design specifications, and there was no evidence of preexisting damage or failures.

VII. RECOMMENDATIONS

A. Incorporate into airline pilot training, industry wide, the effects of aerodynamics and the outcome of inappropriate control inputs prior to landing.

ACTIONS TAKEN:

1. The accident investigation revealed a general lack of knowledge on the part of most airline pilots regarding landing gear certification. Therefore, the FedEx MD-11 Tailstrike Awareness Training Program has been amended to include; landing gear certification requirements, the effects of acceleration on the weight bearing capability of the main landing gear, and the effects of pitch and or roll rate on the total sink rate at the main landing gear. Additionally, in an attempt to increase airline industry awareness of these issues, FedEx has requested landing gear certification be an agenda item at the next Boeing Flight Operations Symposium.
2. Federal Express Flight Training is developing a Basic Aerodynamics course to be taught in all fleet type initial, upgrade or transition training.

B. Air Carriers develop a means to provide Aircraft Rescue and Fire Fighting personnel timely, detailed information concerning on board Dangerous Goods.

ACTIONS TAKEN:

1. *Federal Express is currently* developing electronic tracking of specific Dangerous Goods data. This data would be made available to fire

fighters within minutes of an accident. Development and implementation of this system will take 18-24 months.

2. As an interim measure, FedEx now manually inputs Dangerous Goods data as part of a flight's Flight Dispatch Report. The information includes Dangerous Goods Class Number and Name, aircraft loading position, weight, and Unit Load Device number. This system provides emergency responders with essential Dangerous Goods information without the necessity of faxing data from the origin ramp.

3. FedEx is working towards placing the Dangerous Goods document pouch in an accessible location inside cockpit. This will be standard for all aircraft. The new pouch is a bright red and is attached with Velcro. The intent is that when the crew is faced with an emergency evacuation and based on the urgency of the situation, will detach the pouch and either throw it out a window or door, or carry it with them and once on the ground, give the pouch to the nearest ARFF member. This will be included in the next FedEx Flight Operations Manual revision. It stipulates that the retrieval of the pouch will only be accomplished if the situation allows and will not interfere in any manner with crew safety.

VIII. ADDITIONAL RECOMMENDATIONS

A. Current and future air carriers using the APLC ensure pilots receive periodic refresher training on the computer and provided data.

ACTIONS TAKEN:

1. A comprehensive APLC multimedia presentation has been incorporated into Federal Express MD-11 Initial, Transition, Upgrade, and Recurrent training to ensure that all FedEx MD-11 pilots fully understand APLC takeoff and landing performance data output.

2. Federal Express Flight Training is developing APLC refresher training to be included in other fleet type initial, transition, recurrent and upgrade training.

B. FAA and Boeing Products, Long Beach study the feasibility of developing a MD-11 (DC-10) postproduction landing gear vertical fuse that would cause the gear to fail before the wing, but not create "early fusing" in otherwise hard landings.

C. Revise Maintenance Manuals to reflect that vertical speed is not the only factor that needs to be analyzed during hard landings inspections. Maintenance and groups studying Flight Data Recorder information need to be trained on the influence of vertical accelerations prior to landing.

END NOTES

[1] Refer to NTSB systems group draft factual report.

[2] Refer to NTSB systems group draft factual report. It should be noted that the aircraft maintenance log shows the #3 thrust reverser (TR) placarded inoperative in ANC prior to departure of the accident flight. However, CVR transcripts suggest that the crew thought the #1 TR was inoperative. In addition, extensive discussions about servicing of the RMLG fluid level did not yield any evidence that it was improperly serviced following a seal change that was accomplished one week prior to the accident. BLB stated in their March 1998 presentation that an improperly serviced RMLG would not have had a measurable impact on its load absorbing capacity.

[3] Refer to NTSB performance group factual report.

[4] Photos not contained in the NTSB structures group factual show core cowling prior to recovery damage. Additionally, extensive discussion and research about pylon fusing supported the position that the pylon did not fuse during the initial seconds of the aircraft structural breakup as BLB suggested in the March 1998 meeting. Runway markings and engine nacelle damage are inconsistent with pylon fusing early in the breakup sequence.

[5] The FAA presented data at the March 1998 meeting outlining gear certification data (FAR's 25.473, 25.479, 25.483, and 25.723). Participants at the NTSB meeting in January 1999 seemed to agree on this subject.

[6] Refer to BLB presentation from January 1999 technical review meeting.

[7] Supplemental discussions with BLB engineering members involved in the analysis revealed that the MD-11 design was based on NASA research data showing that aircraft that land "hard" generally have minimal roll angle at touchdown. Conversely, aircraft that have high roll angles at touchdown have low descent rates. Basically, the DC-10/MD-11 is designed to withstand a hard landing or a high roll angle landing, but not both as N611FE experienced. It is the feeling of BLB engineering involved in the accident that the aircraft would have remained intact and upright had the roll angle been less at the 2nd TD, thus distributing the landing loads more evenly between both MLG's and throughout the entire airframe structure. Data from previous DC-10 and MD-11 hard landings (including N611FE's prior two events) would support this position.

[8] Although not clearly stated in the NTSB systems group factual report, it was concluded by all parties involved in disassembly and inspection of both MLG's, that failure of the RMLG bogie beam was caused by contact with the trim cylinder rod end. This condition only could occur at geometric angles possible after the RMLG separated from the wing. Refer to BLB metallurgical report and supplemental photos illustrating MLG relative angles.

[9] Refer to NTSB Operations Group Factual Report

[10] Pilot Flying refers to the Flight 14 Captain

[11] Refer to NTSB CVR Group Factual Report