National Transportation Safety Board
Aviation Accident Final Report

Location:	ORLANDO, FL	**Accident Number:**	MIA96FA162
Date & Time:	06/23/1996, 1116 EDT	**Registration:**	N168CA
Aircraft:	Embraer 120	**Aircraft Damage:**	Substantial
Defining Event:		**Injuries:**	N/A
Flight Conducted Under:	Part 135: Air Taxi & Commuter - Scheduled		

Analysis

The airplane experienced a total loss of hydraulic pressure and hydraulic fluid while on descent to the destination airport. The flight crew conducted emergency procedures (hydraulic failure/landing gear failure) in accordance with the airplane flight manual (AFM)/quick reference handbook (QRH) with negative results. Subsequently, a wheels up landing was made. Examination of the airplane revealed a rupture of the No. 1 engine-driven hydraulic pump pressure hose. Review of the AFM and QRH emergency procedures revealed the manual did not discriminate between hydraulic or electrical failures. The procedures listed in the maintenance manual for lowering the landing gear by the free-fall mechanism were different from the AFM/QRH. Functional test of the landing gear system, using the AFM/QRH, resulted in the landing gear failing to extend due to hydraulic blockage in the landing gear solenoid valve. Functional test of the landing gear system, using the free-fall procedure contained in the maintenance manual, resulted in the extension of the landing gear.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be: the aircraft manufacture's inadequate written procedures in the airplane flight manual/quick reference handbook, which resulted in a failure of the landing gear to extend and a wheels up emergency landing, due to hydraulic blockage in the landing gear solenoid valve. Factors relating to the accident were: the chafed and ruptured hydraulic line and the subsequent hydraulic leak, which resulted in loss of hydraulic pressure and an inoperative normal landing gear extension system.

Factual Information

HISTORY OF FLIGHT

On June 23, 1996, about 1116 eastern daylight time, an Embraer EMB120, N168CA, registered to COMAIR Aircraft Inc., flight number 3599, operating as a 14 CFR Part 135 scheduled domestic passenger flight, experienced a landing gear failure on arrival at the Orlando International Airport, Orlando, Florida. The flightcrew completed emergency procedures with negative results, and an emergency landing was made. Visual meteorological conditions prevailed, and an IFR flight plan was filed. The airplane sustained substantial damage. The airline transport pilot-in-command, first officer, 1 flight attendant, and 29 passengers were not injured. The flight originated from Nassau, Bahamas, 2 hours 13 minutes before the accident.

The pilot-in-command stated on descent into the Orlando area the hydraulic master caution warning light illuminated, followed by the low level advisory light on the green hydraulic system. He instructed the first officer to review the loss of hydraulic pressure procedure in the quick reference handbook. The hydraulic master caution warning light illuminated again, followed by the low pressure advisory light on the green hydraulic system. The fluid level was pointing to the yellow, the hydraulic pressure was decreasing, and the light for the green system was flashing on and off. The flightcrew concluded that the green hydraulic system was empty and the green electric hydraulic pump was turned off. They discussed what systems would be lost in the event of a total failure of the green hydraulic system, and decided to lower the flaps and landing gear. The flaps were extended to 15 degrees; however the landing gear would not extend. They informed ATC of situation, and were placed in a box pattern east of Orlando International Airport. They performed the abnormal emergency landing gear instructions in the checklist and contacted the COMAIR maintenance facility for further instructions. Repeated attempts to lower the landing gear were unsuccessful, and a gear up landing was performed.

PERSONNEL INFORMATION

All pertinent aviation regulations, 14 CFR Part 135, airman competency and proficiency checks, had been recorded as conducted. The pilot stated, he had never conducted an abnormal landing gear extension in the EMB120, and he could not remember the last time he performed the procedure in the flight simulator. COMAIR training records reflects emergency training and emergency drills. The training records do not indicate what type of emergency training or drills were conducted. (For additional first pilot information, see page 3 of this report.)

All pertinent aviation regulations, 14 CFR Part 135, airman competency and proficiency checks had been recorded as conducted. The first officer stated he has never conducted an abnormal landing gear extension in the EMB120; however, he conducted one abnormal landing gear extension during his last simulator period in November 1995. COMAIR training records reflect emergency training and emergency training drills were conducted on November 11, 1995. (For additional second pilot information, see NTSB Form 6120.4 Supplement E.)

All pertinent aviation regulations, 14 CFR Part 135 and Part 121, competency and proficiency checks had been recorded as conducted. (For additional flight attendant information, see NTSB Form 6120.4 Supplement U.)

AIRCRAFT INFORMATION

Aircraft information is contained on page 2 of this report.

METEOROLOGICAL INFORMATION

Visual meteorological conditions prevailed at the time of the accident. (For additional weather information, see page 3 of this report.)

FLIGHT RECORDERS

N168CA was equipped with a Fairchild model A100A cockpit voice recorder. The recorder was forwarded to the NTSB Laboratory for analysis. The cockpit voice recorder was recorded clearly and the entire tape was transcribed. (For additional information, see NTSB Cockpit Voice Recorder Factual Report.)

N168CA was equipped with a Fairchild model F1000 flight data recorder. The flight data recorder was forwarded to the NTSB Laboratory for analysis. A transcription was accomplished using normal recovery procedures, which converted the raw data to engineering units, and is presented in tabular and graphic form. (For additional information, see NTSB Flight Data Recorder Factual Report.)

WRECKAGE AND IMPACT INFORMATION

COMAIR flight 3599, N168CA, was located just north of taxiway Juliet, on runway 36R at the Orlando International Airport, Orlando, Florida, on a heading of 351 degrees. Examination of the runway revealed N168CA touched down just north of taxiway Bravo, and slid 2,500 feet before the airplane came to a complete stop.

Examination of the airplane before recovery revealed the nose gear doors were partially open but were not releasing, and the nose gear was off the uplock position. Both main landing gear doors were observed in the uplock position. The airplane was lifted by airbags and placed on jacks. Normal attempts to lower the landing gear failed. The hydraulic manual selector valve was placed in the maintenance position. The nose gear doors opened and the nose gear extended to the full down position. The main landing gear doors sustained impact damage and had to be pried open before the landing gear could be lowered by activating the free fall mechanism. The airplane was lowered to the ground and towed to the COMAIR maintenance facility.

Examination of the airframe, flight controls, and engine assemblies revealed no evidence of a precrash mechanical failure or malfunction. Continuity of the flight control system was confirmed for pitch, roll, and yaw.

Examination of the green and blue hydraulic reservoirs revealed the green reservoir was empty, and the blue reservoir contained hydraulic fluid. Hydraulic fluid was added to the green reservoir. The engine-driven hydraulic pump pressure hose on the No. 1 engine was pressurized to over 2200 psi using a hydraulic cart. A rupture measuring 0.5 inch of diameter on the surface and 0.25 inch of diameter of metal braid was present in the vicinity of the forward left hand nacelle cowling hold-open rod. This was a result of chaffing/friction against the clip that secures the cowling support rod and stowaway clamp.

Functional ground test of the abnormal landing gear extension procedure were performed. The first and second attempt were successful. The third test and all subsequent tests failed due to a hydraulic blockage of the landing gear solenoid valve. Additional tests revealed that if the checklist procedures were not followed in sequence, the abnormal landing

gear extension procedure would fail. Electrical troubleshooting of the landing gear wiring, electric override switch, wiring to the landing gear door electrovalve, and the landing gear electrovalve revealed no deficiencies that could be attributed to the failure of the landing gear to extend. (For additional information, see Embraer NTSB Airplane Systems Group-Preliminary Factual Report, and FAA Accident Investigation Report dated June 23, 1996.)

The landing gear solenoid valve, hydraulic reservoir unit, and hydraulic pump were forwarded through the FAA Manufacturing Inspection District Office to the manufacturer for further analysis. The free-fall emergency selector valve, and the landing gear control box were examined at an authorized repair station. No deficiencies were noted that could be attributed to the failure of the landing gear to extend. (For additional information, see Test Report dated July 26, 1996, and August 27, 1996.)

MEDICAL AND PATHOLOGICAL INFORMATION

Toxicology testing of specimens obtained on June 23, 1996, from the pilot-in-command, first officer, and flight attendant, were performed by Phaneuf Associates Inc., Washington D.C. These tests were negative for marijuana, cocaine, phencyclidine, amphetamines, and opiates. Test for alcohol were negative for the pilot-in-command and first officer. The flight attendant was not tested for alcohol.

TEST AND RESEARCH

Examination of the landing gear solenoid valve, hydraulic reservoir unit, and hydraulic pump revealed no deficiencies that could be attributed to the failure of the landing gear to extend. (For additional information, see ITT Aerospace Controls letter dated August 23, 1996, Parker Engineering Report dated August 9, 1996, and Vickers Report dated July 22, 1996.)

Review of the EMB120 Airplane Flight Manual (AFM) and Quick Reference Handbook (QRH) for HYDRAULIC FAILURE (LOSS OF THE GREEN SYSTEM) and LANDING GEAR FAILURE (ABNORMAL LANDING GEAR EXTENSION) does not discriminate upon the cause of the failure being electrical or hydraulic. Review of the EMB120 Maintenance Manual revealed that the procedures listed for operation through the free-fall mechanism due to a total loss of the green hydraulic system, and or complete failure of the electrical control circuit of the landing gear is different from the procedures contained in the AFM or QRH. The maintenance manual is not maintained aboard the airplane, and flight crews do not have immediate access to the maintenance manual should an in-flight emergency occur.

Additional testing of the abnormal landing gear extension (without green hydraulic pump pressure) was conducted by COMAIR in the presence of the FAA utilizing the procedures listed in the AFM and QRH. All landing gear hung on the gear doors and would not extend. The landing gear was lowered by the activation of the maintenance selector valve. The procedures listed in the maintenance manual for operation through the free-fall mechanism were initiated. All landing gear extended and locked. The results were provided to the NTSB investigator-in-charge and Embraer. Embraer attempted to duplicate the test with negative results. A subsequent test was conducted with all parties to the investigation present. The procedures utilized by the FAA and COMAIR were duplicated in the same airplane with the same results. It was determined that in the event of a loss of green hydraulic system, that the flight crew must not place the landing gear lever in the down position nor operate the gear electrical override switch, but instead, lower the landing gear by using only the free-fall extension system, without trying to extend it by any other means. If the green hydraulic system is lost and

the landing gear lever is moved to the down position or the gear electrical override switch is actuated, the landing doors may not open because hydraulic blockage can develop in the doors solenoid valve. It was concluded that this can occur during abnormal landing gear extension when three other conditions occur:

* The door solenoid valve is energized, and * A restriction downstream of the doors solenoid valve cause a back pressure in the line which commands the spool of the doors solenoid valve to an intermediary position creating a hydraulic blockage, or * Free-fall deployment procedure is performed out of sequence provided.

(For additional information, see FAA letter dated August 27, 1996, and Embraer NTSB Airplane Systems Group-Preliminary Factual Report.) ADDITIONAL INFORMATION

The airplane was released to Mr. Frank Morse, COMAIR Manager of Maintenance, on June 26, 1996. The flight data recorder was released to Mr. Morse, on August 6, 1996. The cockpit voice recorder was released to Mr. John McGann, COMAIR Chief Pilot, on August 7, 1996. Additional components retained for further analysis were released to Mr. Morse, on September 10, 1996.

Aircraft and Owner/Operator Information

Aircraft Make:	Embraer	**Registration:**	N168CA
Model/Series:	120 120	**Aircraft Category:**	Airplane
Year of Manufacture:		**Amateur Built:**	No
Airworthiness Certificate:	Transport	**Serial Number:**	168
Landing Gear Type:	Retractable - Tricycle	**Seats:**	33
Date/Type of Last Inspection:	06/22/1996, Continuous Airworthiness	**Certified Max Gross Wt.:**	25353 lbs
Time Since Last Inspection:	3 Hours	**Engines:**	2 Turbo Prop
Airframe Total Time:	16775 Hours	**Engine Manufacturer:**	P&W
ELT:	Installed, not activated	**Engine Model/Series:**	PW118
Registered Owner:	COMAIR	**Rated Power:**	1800 hp
Operator:	COMAIR	**Operating Certificate(s) Held:**	Commuter Air Carrier (135)
Operator Does Business As:	COMAIR	**Operator Designator Code:**	COMA

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual Conditions	**Condition of Light:**	Day
Observation Facility, Elevation:	MCO, 96 ft msl	**Distance from Accident Site:**	0 Nautical Miles
Observation Time:	1114 EDT	**Direction from Accident Site:**	0°
Lowest Cloud Condition:	Scattered / 2000 ft agl	**Visibility**	8 Miles
Lowest Ceiling:	Overcast / 25000 ft agl	**Visibility (RVR):**	0 ft
Wind Speed/Gusts:	7 knots /	**Turbulence Type Forecast/Actual:**	/
Wind Direction:	290°	**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:	30 inches Hg	**Temperature/Dew Point:**	32°C / 26°C
Precipitation and Obscuration:			
Departure Point:	NASSAU, OF (NAS)	**Type of Flight Plan Filed:**	IFR
Destination:	(MCO)	**Type of Clearance:**	IFR
Departure Time:	0903 EDT	**Type of Airspace:**	Class D

Airport Information

Airport:	ORLANDO INTERNATIONAL (MCO)	**Runway Surface Type:**	Asphalt
Airport Elevation:	96 ft	**Runway Surface Condition:**	Dry
Runway Used:	36R	**IFR Approach:**	None
Runway Length/Width:	10953 ft / 200 ft	**VFR Approach/Landing:**	Forced Landing; Traffic Pattern

Wreckage and Impact Information

Crew Injuries:	N/A	**Aircraft Damage:**	Substantial
Passenger Injuries:	N/A	**Aircraft Fire:**	None
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	N/A	**Latitude, Longitude:**	

Administrative Information

Investigator In Charge (IIC):	CARROL A SMITH	**Report Date:**	04/03/1997
Additional Participating Persons:			
Publish Date:			
Investigation Docket:	NTSB accident and incident dockets serve as permanent archival information for the NTSB's investigations. Dockets released prior to June 1, 2009 are publicly available from the NTSB's Record Management Division at pubinq@ntsb.gov, or at 800-877-6799. Dockets released after this date are available at http://dms.ntsb.gov/pubdms/.		