



# National Transportation Safety Board Aviation Accident Final Report

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<b>Location:</b>	BIRMINGHAM, AL	<b>Accident Number:</b>	MIA98FA089
<b>Date &amp; Time:</b>	02/26/1998, 1729 CST	<b>Registration:</b>	N867US
<b>Aircraft:</b>	Fokker F28 MK 0100	<b>Aircraft Damage:</b>	Substantial
<b>Defining Event:</b>		<b>Injuries:</b>	92 None
<b>Flight Conducted Under:</b>	Part 121: Air Carrier - Scheduled		

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## Analysis

While flying in precipitation deviating within 10 miles from the edge of a level 5 thunderstorm associated with a squall line, the airplane was struck by lightning. Arching damage to the No. 1 elevator pressure and No. 2 elevator return hydraulic lines resulted in depletion of the hydraulic fluid from the Nos. 1 and 2 hydraulic system reservoirs. The airplane was landed on a wet runway and after touchdown, 2 of the 4 main landing gear tires ruptured. The airplane traveled off the left side of the runway, across grass, and came to rest with the nose landing gear separated. A loose canon plug at the parking brake shutoff valve was discovered which prevented the operation of the alternate antiskid system. That area was inspected 2 days earlier. The airplane was only equipped by design with 1 bonding strap located on the left side of the airplane for the horizontal and vertical stabilizer; which failed. Advisory Circular recommends that the area be designated for carrying substantial amounts of electrical current, but the airplane was not designed for such. The flight crew was not provided convective sigmets for the central U.S., which indicated severe thunderstorms over Birmingham. The destination airport was near the boundary of the east and central regions for convective sigmets. The airline does not conduct weather radar training in recurrent, upgrade, or requalification training. The dispatcher did not provide to the flight crew weather watches that were available 15 minutes before and after the flight departed.

## Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be: Were the 1) the inoperative alternate anti-skid control valve due to the disconnected electrical connector on the parking brake shut-off valve, the area was inspected 2 days earlier 2) the total loss of the hydraulic system resulting in the inability of the flight crew to maintain directional control. Factors in the accident were the 1) inadequate lightning protection design of the airplane by the manufacturer between the horizontal and vertical stabilizers which resulted in arching damage to hydraulic lines and depletion of the hydraulic fluid from the Nos. 1 and 2 hydraulic systems 2) inadequate weather information disseminated to the flight crew during the preflight briefing by the company dispatcher for failing to provide current up-to-date information of the intensity, and location of adverse weather 3) the failure of the company

dispatcher to relay pertinent weather information to the flight crew while en route which included convective sigmets, and the current extent and intensity of the squall line 4) the operation of the airplane by the flight crew within 10 miles from the northern edge of a ground based weather radar depicted level 5 thunderstorm resulting in a lightning strike 5) insufficient standards/requirements, operation/operator by the company management to require weather radar training in recurrent, upgrade, and requalification training, and 6) the limitations of the weather products provided to the flight crew by the airline for failure to include convective sigmets for the central U.S., based on the geographic location of the destination airport being east of the eastern/central boundary.

## Findings

Occurrence #1: IN FLIGHT ENCOUNTER WITH WEATHER

Phase of Operation: DESCENT - NORMAL

### Findings

1. (F) PREFLIGHT BRIEFING SERVICE - INADEQUATE - COMPANY/OPERATOR MANAGEMENT
  2. (F) INSUFF STANDARDS/REQUIREMENTS, OPERATION/OPERATOR - COMPANY/OPERATOR MGMT
  3. (F) IN-FLIGHT WEATHER ADVISORIES - INADEQUATE - DISPATCHER
  4. WEATHER CONDITION - LIGHTNING STRIKE
  5. (F) FLIGHT INTO ADVERSE WEATHER - PILOT IN COMMAND
  6. (F) INSUFF STANDARDS/REQUIREMENTS, OPERATION/OPERATOR - COMPANY/OPERATOR MGMT
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Occurrence #2: AIRFRAME/COMPONENT/SYSTEM FAILURE/MALFUNCTION

Phase of Operation: DESCENT - NORMAL

### Findings

7. HYDRAULIC SYSTEM, LINE - ARCING
  8. (F) ACFT/EQUIP, INADEQUATE DESIGN - MANUFACTURER
  9. (C) HYDRAULIC SYSTEM - LOSS, TOTAL
- 

Occurrence #3: LOSS OF CONTROL - ON GROUND/WATER

Phase of Operation: LANDING - ROLL

### Findings

10. (C) LANDING GEAR, ANTI-SKID BRAKE SYSTEM - INOPERATIVE
  11. REASON FOR OCCURRENCE UNDETERMINED
  12. LANDING GEAR, TIRE - FAILURE, TOTAL
  13. (C) DIRECTIONAL CONTROL - NOT POSSIBLE - PILOT IN COMMAND
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Occurrence #4: NOSE GEAR COLLAPSED

Phase of Operation: LANDING - ROLL

### Findings

14. LANDING GEAR, NOSE GEAR ATTACH POINT - OVERLOAD

## Factual Information

### HISTORY OF FLIGHT

On February 26, 1998, about 1729 (all times central standard), a Fokker F28MK0100, N867US, registered to and operated by US Airways, Inc., as flight 861, experienced loss of directional control while landing at the Birmingham Municipal Airport, Birmingham, Alabama. Visual meteorological conditions prevailed at the time and an instrument flight rules flight plan was filed for the 14 CFR Part 121 scheduled, domestic, passenger flight from Charlotte, North Carolina, to Birmingham, Alabama. The airplane was substantially damaged and the airline transport-rated captain and first officer, 87 passengers, and 3 cabin crewmembers were not injured. The flight originated about 1612, from the Charlotte/Douglas International Airport.

At 1648, the flight dispatcher sent a message to the flightcrew via the ARINC Communicating Addressing and Reporting System (ACARS) that indicated thunderstorms were over the destination airport and north of the airport looked good on his radar. The message also stated that the thunderstorm should pass through within 10 minutes; Birmingham field should be "ok" after this line. This message was repeated twice. The dispatcher was sent a message by a flightcrew member 1 minute after the second message that they had received the previous message from the dispatcher. One minute after that message, the flightcrew advised the dispatcher that the flight was 90 miles east of the destination airport. The dispatcher acknowledged this then repeated the message that the thunderstorm passage should be in 10 minutes.

While en route and in contact with the Atlanta Air Route Traffic Control Center (ARTCC), at 1701:11, the cockpit voice recorder (CVR) recorded the captain to state "let's side step over a little bit" and at 1702:13, the CVR recorded the first officer to state "ok, it looks like it's building a little now", to which the captain replied that he advised the flight attendants to sit down earlier. At 1702:15, the first officer radioed the ARTCC controller and stated "uh center US 861, we'd like to come right uh about twenty degrees if we could for weather." The request was approved. Sound similar to thunder was recorded from the cockpit area microphone at 1701:41, 1702:44, and at 1704:24. At 1704:33, the CVR recorded the captain to state, "I bet we took that one on the nose, I felt it on the rudder pedals", which was confirmed by the first officer.

The captain reported after the accident that while deviating around adverse weather in clouds, about 20 miles from depicted adverse weather, he recognized that the airplane had been struck by lightning with no immediate affect to the airplane.

At 1705:14, the CVR recorded the first officer to state "lightning strike" to a flight attendant who reported seeing and hearing it. At 1705:36, the CVR recorded the captain to state "\*\*\*number 2" followed 5 seconds later by "we got low...\* lot lot of stuff goin' on. It's all right though." The captain then requested to "run that procedure" to which the first officer acknowledged and at 1706:24, the CVR recorded the first officer to state "ok, hydraulic system number two, low quantity" then 30 seconds later the captain stated "we lost the number one too chief." See legend of the CVR transcription which is an attachment to this report for explanation of the asterisks.

The CVR recorded the first officer to read the checklist for total hydraulic system failure and at 1711:53, while in contact with Birmingham Tower North Radar (NR) controller, the first

officer radioed the controller and stated "US 861, we had a lightning strike" then 6 seconds later, he requested the current weather conditions at the Birmingham airport. The controller provided the weather conditions and at 1713:01, the first officer radioed the controller and stated "...we've got a double hydraulic failure... so we'd like you to vector us right over the top of the airport at 2,500 feet..." which was acknowledged by the controller. At 1715:48, the first officer informed the controller "...we will need the equipment standing by on this approach and uh we'll not be able to clear the runway...." At 1718:00, the Birmingham Tower Flight Data/Clearance Delivery position controller notified the airport rescue and fire fighting of an Alert II, then at 1718:45, the first officer informed the controller, "we'll be declaring an emergency also we'd like the equipment as we previously stated...." At 1718:54, the NR controller transmitted "US Air 861 roger the equipment has been called and activated and they'll be standin by for ya." The airport fire rescue vehicles were positioned along predetermined locations adjacent to and along the length of the intended runway.

The captain reported after the accident that the landing gear and flaps were extended via the alternate method. At 1723:30, the NR controller transmitted "are you ready to come in" to which the first officer responded "we're ready." The flight was vectored then cleared for the Instrument Landing System approach to runway 23. While on final approach at 1725, the flight dispatcher sent a message via the ACARS system for the flight to divert to Charlotte. The approach was continued and the captain reported post accident that the touchdown was normal. After touchdown he applied the brakes with the knowledge that he would not have nose landing gear steering and he reported feeling a pronounced vibration. The airplane veered off the left side of the runway, across grass, and came to rest with the nose section of the airplane resting on a taxiway; the nose landing gear separated from the airplane. After the airplane came to rest, fire rescue personnel who responded to the airplane advised the captain who had his cockpit sliding window open that the airplane was "fire safe." The captain ordered that the passengers not be deplaned until transportation arrived. The passengers remained seated until transportation arrived then exited the airplane out the left forward door without using the escape slide, assisted by fire rescue personnel. A copy of air traffic control transcriptions are an attachment to this report.

#### PERSONNEL INFORMATION

The captain, age 42, was hired by USAir on December 12, 1982. He holds an airline transport pilot (ATP) certificate with type ratings in the CV-340, CV-A440, LR-Jet, B-737, and FK-100. His most recent proficiency check occurred on January 14, 1998, and his most recent line check occurred on July 8, 1997. The pilot's statement and records supplied by US Airways reveal that he had accumulated 16,759 hours total flying time at the time of the accident. He has accumulated while at US AIRWAYS, a total time of 10, 833 hours which included a total time of 2,283 hours as pilot-in-command in a Fokker F-100 type airplane. Review of all training records supplied by US Airways revealed no unusual or unsatisfactory training events from May 28, 1993, until the date of the accident. Prior to joining USAir, he had experience as a civilian pilot flying corporate and cargo operations. According to FAA documents, he had no prior accident, incident, or enforcement actions. Additional information pertaining to the captain is contained on page 2 of the Factual Report-Aviation and in the Operational Factors Group Chairman's Factual Report.

The first officer, age 47, was hired by Pacific Southwest Airlines (PSA) on June 20, 1986. In 1988, as a result of the merger between USAir and PSA he joined USAir. He holds an ATP

certificate with type ratings in the CE-500, IA-JET, SK-76, CL-600, HS-125, Fk-28, and B-767 aircraft. His most recent proficiency check occurred on January 9, 1998, and his most recent line check occurred on July 6, 1994. The pilot's statement and records supplied by US Airways reveal that he had accumulated 12,800 hours total flying time at the time of the accident. He has accumulated a total flight time of 6,045 hours with US AIRWAYS, which includes a total time of 2,057 hours in the Fokker F-100 type airplane. Review of all training records supplied by US Airways revealed no unusual or unsatisfactory training events from June 21, 1994, until the date of the accident. He had accumulated a total of 6518 hours total flying time when hired by PSA. Prior to joining PSA his experience was in corporate aviation. According to FAA documents, he had no prior accidents, incidents, or enforcement actions. Additional information pertaining to the first officer is contained in Supplement E, and in the Operational Factors Group Chairman's Factual Report. AIRCRAFT INFORMATION

The Fokker F28 Mark 0100 aircraft was issued type certificate number A20EU and certified in the transport category (14 CFR part 25) with a minimum flight crew of two pilots. The accident aircraft (N867US) was issued a Standard Airworthiness Certificate on July 31, 1990.

The last "A" check was accomplished on February 24, 1998, which included Card No. J5-55-3220A-1; this indicates a check for the left main landing gear/wheel bay hydraulic tubing, couplings, and components for signs of leakage, general condition, and security. The maintenance records indicate that the parking brake shutoff valve had been replaced on August 26, 1995, and operationally checked good. Testing of the parking brake shutoff valve last occurred on November 12, 1996, in accordance with a "C3" check and job card No. J5-50-3213C.

The airplane is equipped with two hydraulic systems with the normal brake system operated by the No.2 system. In the event of failure of the No. 2 system, the alternate brake system is automatically operated by the No. 1 system. In the event of failure of both the Nos. 1 and 2 systems, the alternate brake system is automatically operated by an accumulator which as indicated by the flight manual, allows for a specified number of brake applications. The anti-skid system schematic for the airplane indicates that the return of hydraulic pressure for the alternate brake system is routed through the alternate brake dual skid control valves then through the electrically energized "open" parking brake shut-off valve. With the shut-off valve in the "closed" position, the hydraulic pressure is prevented from being released from the brake assemblies, resulting in no anti-skid protection. Failure of the parking brake shut-off valve due to either a disconnected cannon plug or by an inoperative parking brake shut-off valve is not annunciated in the cockpit. At the time of the accident, there were no published procedures for the flight crew to determine the functionality or status of the parking brake shutoff valve.

The airplane was equipped by design, with only one bonding strap for the vertical to horizontal stabilizer, which is located on the left side of the airplane. That bonding strap is 5 inches long, AWG 12 tinned stranded soft copper wire, with seven groups of 37 AWG size 36 strands. According to the airplane manufacturer, that design was chosen for "Compliance of the requirements regarding the direct effects of lightning and static electricity." That requirement allowed compliance with the test requirement that voltages should be less than 500 volts to prevent arcing and a steady state current of 400 amps for 0.5 seconds, to be safely drained. Compliance demonstration was based on the accident make and model airplane and the similarities to the F28 make and model airplane, and by additional analysis and testing. With respect to the hydraulic system installation in the airplane, the manufacturer

determined that since the "tail section" is all metal; there is no exposure to indirect effects of lightning which was also applicable for electrical wiring, conducting lines, and hydraulic tubes.

#### METEOROLOGICAL INFORMATION

About 3 hours 20 minutes before the flight departed, weather watch (WW) number 68 was issued by the National Weather Service Storm Prediction Center (SPC) which encompassed the area of the destination airport. The watch indicated a few severe thunderstorms with hail at the surface and aloft to 1inch, extreme turbulence and surface wind gusts to 70 knots, covering Alabama and Mississippi. The report discussed the squall line that was accelerating towards the Birmingham area with a well pronounced bowing of the line. Weather watch (WW) number 68 was in effect at the actual time of departure, and was not provided to the flight crew as part of the dispatch weather package.

About 2 hours 54 minutes before the flight departed, the Atlanta Center Weather Service Unit issued Meteorological Impact Statement (MIS) number 2. The advisory indicated almost the entire area of Alabama that contained scattered Digital Video Imaging Processor (DVIP) Level 3 to 5 thunderstorms and rain, with isolated severe thunderstorms with 60 knot wind gusts possible. The advisory indicates that the thunderstorms were moving from 240 degrees at 30 knots with tops to 40,000 feet. The MIS advisory was available to the US Airways dispatcher; the information was not contained in the weather package disseminated to the flightcrew by dispatch.

The crew received weather information as part of the flight plan and release (FP/R) paper work 1 hour 32 minutes before the flight departed which included departure, destination, alternate, and en route METAR observations, and terminal aerodrome forecasts (TAF). Review of the provided data revealed that the airmet data was only valid up until 1 hour 5 minutes before the estimated time of departure. Additionally, the destination TAF issued about 4 hours 37 minutes before the flight departed, with a valid time of 1300 local on the day of the occurrence, to 1300 local the following day, revealed that between 1400 to 1800 local, the forecast was for 4 miles visibility, thunderstorms, and light rain with a broken ceiling at 2,000 feet. The weather data provided to the flightcrew included the convective sigmets for the eastern United States, but did not include the convective sigmets for the central United States. The destination airport was approximately 15 minutes of longitude east of the line that separates the east and central regions. There were no convective sigmets issued for the eastern United States disseminated with the weather information provided to the flightcrew. A convective outlook that was contained in the eastern convective sigmets issued 2 hours 19 minutes before the flight departed, and disseminated to the flightcrew, valid for the flight, indicates a line of severe thunderstorms along and ahead of the cold front expected to move across southeastern Louisiana and southern and eastern Mississippi, into western Alabama. The outlook also referenced Severe Weather Watch bulletin number 67 and 68.

Convective sigmet 72C (central United States), issued about 1 hour 17 minutes before the flight departed (15 minutes after the captain received his weather information package from dispatch), and Convective sigmet 74C (central United States), issued about 17 minutes before the flight departed, to replace the previous convective sigmet, were not provided to the flightcrew. The sigmets indicated a line of severe thunderstorms 30 miles wide with tops to 45,000 feet. Also, about 1 hour 17 minutes before the flight departed, the SPC issued Severe Weather Forecast Alert (AWW) number 69 for the potential for tornadoes over Alabama, Mississippi, and adjacent waters valid from 42 minutes before the flight departed, until 2100

hours. This AWW was not provided to the flightcrew.

About 15 minutes before the flight departed, a status report on WW number 68 was issued by the SPC. The report confirmed reports of damaging winds that had been received over portions of west central and central Alabama. The report continued discussing the squall line that was accelerating towards the Birmingham area with a well pronounced bowing of the line. This status report was not provided to the flightcrew by the dispatcher.

About 15 minutes after the flight departed, the SPC issued WW number 70, which indicated severe thunderstorms over Alabama, from 48 minutes after the flight departed until 2100 local. The discussion of the watch referred to a line of severe thunderstorms moving eastward across central Alabama, with continued support for the next several hours for strong downdrafts. The WW 70 replaced WW 68 over Alabama and Mississippi, and covered the Birmingham area. This WW was not provided to the flightcrew by the dispatcher.

Additionally, Convective sigmet 75C (central United States) which was issued about 43 minutes after the flight departed, indicated that the thunderstorm activity was over Birmingham, with the activity described as severe thunderstorms moving from 260 degrees at 30 knots, with tops to 45,000 feet msl. This sigmet was also not provided to the flightcrew by dispatch while en route.

A surface weather observation taken at the accident airport about 52 minutes after the flight departed (approximately 3 minutes before the lightning strike) indicates a thunderstorm with light rain and mist and the remarks section indicates occasional lightning in cloud and cloud-to-cloud northeast through southeast, thunderstorms northeast through southeast.

The flightcrew did not request weather data while en route using the ACARS until after the lightning strike occurred; there was no report that the flightcrew obtained any of the convective sigmets, or severe weather watches on any FAA Flight Service Station frequency.

The lightning strike occurred at approximately 1704:33, while flying at 12,400 feet, approximately 28 miles northeast of the Birmingham airport. Review of weather radar taken from the Birmingham Weather surveillance radar correlated with the data from the Digital Flight Data Recorder (DFDR), and the Atlanta Air Route Traffic Control Center National Track Analysis Program (NTAP), revealed that at the time of the lightning strike, the airplane was flying through level 1 returns as depicted by the Digital Video Integrated Processor (DVIP), and level 3 returns as depicted by the DVIP was below the flight path of the airplane. Additionally, the airplane was within 10 miles north of the northern edge of level 5 returns at the same altitude, and within 22 miles from the northern edge of level 6 returns as depicted by the DVIP, associated with a squall line.

The graphic flight following (GFF) screen, that is available to all US AIRWAYS dispatchers in Operational Control Center, was used by the accident flight's dispatcher to track the progress of the flight. This screen was able to overlay the position of the flight [provided by a link with ATC] on a graphic of the weather in the area where the flight was located. The flight's dispatcher was alerted of the weather the flight was approaching by use of the GFF screen and sent a message to the accident flight regarding the weather conditions developing around Birmingham airport. This information was sent to the flight twice with a request for the flight's location. The dispatcher stated that the request for location was necessary because the flight had dropped from the GFF screen twice; he did not receive any weather inquiries from the flightcrew but did send them weather updates. He also stated that he was aware of the Severe

Weather Watch issued by the NWS for severe thunderstorms in the area but did not send the full text or messages to the crew via the ARINC Communication and Reporting System (ACARS). He sent the actual weather observation for Birmingham and the text message described above summarizing the weather in the area based on his radar display.

According to a report prepared for the National Transportation Safety Board by Global Atmospherics, Inc., dated March 16, 1998, revealed that 27 lightning strikes were detected within a 20-mile radius of a point which was located 10 miles north-northeast of the Birmingham Airport for the period between 1700 to 1720.

The flightcrew reported that during the flight they were utilizing the on-board weather avoidance radar with ranges selected from 120 down to 15 nautical miles, and a tilt from plus 5 to minus 3 degrees. They reported seeing no red returns within 30 miles and only green returns around the airplane about the time of the lightning strike, a line extended to the left 20 to 120 miles. They did not see any lightning until the lightning strike. The airplane was in precipitation for approximately 40 miles before the lightning strike. Additional information pertaining to weather is contained in the Meteorological Factual Report which is an attachment to this report.

#### COMMUNICATIONS

There were no reported communications difficulties.

#### AERODROME INFORMATION

Birmingham International Airport (BHM) is a publicly owned airport and is operated by the Birmingham Airport Authority. The airport is certified under 14 CFR Part 139 and currently receives scheduled Part 121 air carrier service. It is located 4 miles northeast of the city of Birmingham, Alabama. BHM handles about 156,277 operations a year, including commercial, air taxi, general aviation, and military aircraft.

Runway 23 is 10,000 feet long and 150 feet wide. The surface is grooved asphalt and in good condition. The runway is equipped with centerline lights, high intensity runway lights (HIRL), medium intensity approach light system with runway alignment indicator lights (MALSR) and a 4 light precision approach path indicator (PAPI) located on the left side of the runway. The runway has precision instrument markings applied to the surface.

Runway 23 is served by an instrument landing system with distance measuring equipment (ILS/DME). The localizer operates on a frequency of 109.5 MHz. The glide slope is standard with a 3.000 angle. The outer marker is a locator/beacon and there are no middle or inner markers.

A review of Birmingham International Airport notices to airmen (NOTAMS) did not reveal any components of the landing aids to be inoperative at the time of the accident.

The airport fire rescue station was notified of the inbound airplane at 1718, of an Alert II, and advised that the airplane was about 4 minutes from landing. The fire rescue vehicles were placed in their predetermined locations; one near the approach end of the runway selected, one near the midpoint of the runway selected, and another near the departure end of the runway selected. About 1715, or 14 minutes before the airplane was landed, the airport operations section was notified of the inbound airplane by the Air Traffic Control Tower.

#### FLIGHT RECORDERS

The airplane was equipped with a Fairchild model A-100A cockpit voice recorder (CVR) that was removed from the airplane and sent to the Recorders Laboratory of the NTSB located in Washington, D.C. A transcript of communications starting at 1658:31, and ending at 1729:41, is included in the Specialist's Factual Report of Investigation and is an attachment to this report

The airplane was equipped with a Fairchild F800 Digital Flight Data Recorder (DFDR) which was removed and sent to the NTSB Vehicle Recorder Laboratory located in Washington, D.C. The DFDR does not record brake application or anti-skid information. A successful readout was performed. Review of the Group Chairman's Report revealed that the DFDR data recorded the "Master Caution" about 1 minute 7 seconds after the estimated time of the lightning strike as recorded by the CVR. During that time the vertical acceleration was noted to be plus 1.3 G's, and the pressure altitude was 12,000 feet. About 2 minutes 23 seconds later, the DFDR recorded the switch from "OK" to "Low" of the Hydraulic Oil Pressure 1 and 2 Status. About 10 seconds after the DFDR recorded the "Air'Ground" event, the data showed large oscillations. A copy of the DFDR readout is included in the Specialist's Factual Report of Investigation and is an attachment to this report.

#### WRECKAGE AND IMPACT

Examination of the runway revealed that the airplane touched down approximately 2,000 past the displaced threshold of runway 23 with evidenced of hydroplaning noted from Nos. 1,2, and 4, main landing gear tires, beginning about 3,000 feet past the point of touchdown. The airplane departed the left side of the runway about 25 feet past the intersection of the left edge of runway 23 and taxiway A3, then rolled onto grass where marks from the landing gear were noted. The marks in the grass continue 379 feet to taxiway A2, then continue on the opposite side of taxiway A2, and continue in grass with the airplane coming to rest on a magnetic heading of 205 degrees resting on the main landing gear with the nose section of the airplane resting on taxiway A, just before taxiway A1. The nose landing gear which had separated was located on grass between taxiway A2, about 540 feet aft of where the airplane had come to rest. The airplane was towed to a ramp for further examination. Airport personnel reported finding pieces of main landing gear tires on the runway between taxiways A3 and A4. Additionally, the left main landing gear shimmy damper reservoir was found on the left side of the runway before taxiway A3.

Examination of the two hydraulic system reservoirs of the airplane revealed both were empty and hydraulic fluid was noted on the vertical stabilizer. Both hydraulic systems were pressurized with low pressure and leakage was noted from a hole in the No. 1 elevator pressure line approximately 3/4 up the vertical stabilizer, and leakage was noted from a second hole in the No. 2 elevator return line; the hole was located behind the rudder flutter damper approximately 1/2 way up the vertical stabilizer. Both lines were removed for further examination (see Tests and Research section of this report). Additionally, examination of the parking brake shutoff valve which is located in the left wheel well area revealed that the electrical connector for the parking brake shutoff valve was 11 clicks of the ratchet from being fully engaged. By design the connector takes 18 clicks for full engagement. Testing of the circuit in the as found position revealed that the shutoff valve was not electrically connected. The valve requires electrical power to be energized "open." Examination of the alternate brake accumulator revealed that it was in a "fully precharged" to 1,000 psi.

Examination of the main landing gear tires revealed that tire Nos. 1 and 2 exhibited evidence

of flat spots, and were failed; remnants were found along the runway. Tire No. 3 exhibited no evidence of flat spotting, it remained inflated and secured to the wheel. Tire No. 4 exhibited evidence of flat spotting but remained attached to its wheel.

Examination of the airframe revealed that the right exterior fuselage skin from station 6650, which is about 10 feet aft of the R1 door, to station 26426, which is near the tailcone, exhibited approximately 103 burn marks which ranged in size from 1/16 inch to 5/8 inch in diameter. Additionally, the right stabilizer exhibited evidence of scorching at the outboard corner of the upper surface at the trailing edge. The outboard static wick on the right stabilizer was noted to be missing the static wick with evidence of heat at the base of the static wick. Additionally, a bonding strap that provides an electrical connection between the horizontal and vertical stabilizer was failed, and the strap was discolored. Additional information pertaining to wreckage and impact is contained in the Systems/Structures Group Chairman's Report which is an attachment to this report.

#### MEDICAL AND PATHOLOGICAL INFORMATION

On the day of the accident about 2222 and 2217 hours central standard time, breath alcohol screening was performed on the captain and first officer, respectively. The results of both were negative. A drug screen was performed to detect marijuana, PCP, Amphetamines, Cocaine metabolites, and Opiate metabolites of urine specimens obtained from the captain and first officer on the day of the accident about 2200 and 2145, respectively. The results for both for all tested drugs was negative.

#### TESTS AND RESEARCH

The airplane was equipped with Collins WXR-100 airborne weather radar (X-band) which has a 3.3 cm wavelength, 3-degree beam width. As discussed in the meteorological information section, the airplane was in precipitation for approximately 40 miles before the lightning strike. Attenuation is caused by the absorption and scattering of the electromagnetic energy by the medium between the radar and the target. The weather radar would have experienced a 15.63 dBZ loss of signal due to attenuation while flying through the precipitation. This loss of signal approximately translates to a one-color shift on the typical three-color aircraft display. As a result, an area of precipitation would be depicted as yellow, instead of red.

The Federal Aviation Administration approved US Airways Flight Operations Training Manual (FOTM) specifically describes the amount, kind, and hours of training that each pilot will receive prior to flying the line. This training will vary with position in the new aircraft and the previous aircraft assignment. Both crewmembers were trained in accordance with the US Airways FOTM. With respect to weather radar operation and interpretation, the US AIRWAYS FOTM lists training in "weather radar" only in Initial New Hire, Initial Equipment, and Transition Ground Training. The FOTM does not require weather radar training during Recurrent, Upgrade, or Requalification training. The Captain stated that he had not received any formal training on the use of radar during F-100 school. The F/O stated that he had received specific training on radar usage in ground school and during his initial operating experience (IOE) training. Both pilots stated that they had seen the Archie Trammell course on weather radar but did not remember where or when.

The US Airways Fokker 100 Pilots Handbook contains no information on the operation of or suggested techniques for the use of radar in day-to-day operation.

According to US AIRWAYS non-aircraft specific training information material pertaining to weather radar, "Avoid intense or extreme level echoes by at least 20 miles; that is, such echoes should be separated by at least 40 miles before you fly between them." That same page indicates that a level 5 reflectivity of the Video Integrated Processor (VIP) scale is noted to be "intense."

The tail of the airplane was designated by the airplane manufacturer as a "swept stroke area" lightning zone 2B, and the interface between the horizontal and vertical stabilizer was designated as zone 3. Review of Advisory Circular AC 20-53A, revealed that the trailing edges should be designated Zone 1B and "surfaces of the vehicle for which there is a low possibility of direct contact with the lightning arc channel that are not within any of the above zones, but which lie between them, should be considered as within zone 3. Zone 3 areas must carry substantial amounts of electrical current, but only by conduction between some pair of attachment points." Further information pertaining to determination of lightning strike zones is contained in Advisory Circular AC No 20-53A, and is an attachment to this report.

Examination of the airplane was also performed by a National Resource Specialist on Lightning and Electromagnetic Interference with the Federal Aviation Administration. The examination revealed that with the horizontal stabilator positioned to a plus 1 range, the bonding jumper for the horizontal stabilizer and the vertical stabilizer would be positioned near hydraulic tubes that are located on the left side of the vertical stabilizer. Further examination showed that there was no evidence of lightning marks on the vertical stabilizer, and as previously mentioned, lightning marks were noted on the tip of the right horizontal stabilizer. The National Resource Specialist stated that, "The horizontal stabilizer hinge bonding strap specified in the Fokker [Illustrated Parts Catalog] IPC pages has a possibility of failing when subjected to lightning currents at or below the AC 20-53A Zone 3 current specifications." A copy of his report is an attachment to the Systems/Structures Group Chairman Factual Report.

Examination of the hydraulic system No. 2 elevator pressure line, the failed two-piece bonding strap from the horizontal stabilizer to the vertical stabilizer, the insulated bonding strap from the vicinity of the rudder flutter damper, the No. 2 elevator return line, and the No. 1 elevator pressure line was performed by the NTSB Materials Laboratory located in Washington, D.C. The results of examination of the No. 2 elevator pressure line revealed evidence of fretting which did not penetrate through the wall. The results of examination of the two pieces of the bonding strap revealed fusing of the individual wires which is associated with intense heat. The examination of the insulated bonding strap revealed a hole in the insulation with evidence of melting of the wires. The hole found in the No. 2 elevator return line was noted to be discolored with evidence of resolidification, and electrical arcing. The No. 1 elevator pressure line also exhibited evidence of electrical arcing and fused material adhering to the exterior portion of the line. A copy of the Materials Laboratory Factual Report is included in the Systems/Structures Group Chairman's Factual Report.

Review of the airplane manufacturer's Aircraft Operating Manual "Total System Failure" section, revealed it states to avoid anti-skid brake activation. That statement is not included in the US AIRWAYS Pilot's Handbook.

Examination of the brake from the No. 3 position was performed which revealed no evidence of failure or malfunction. A copy of the report is included in the Systems/Structures Group Chairman's Factual Report.

## ADDITIONAL DATA/INFORMATION

Additional parties to the investigation is E.G. Pate, of US Airways.

The airplane minus the retained components was released to Mr. Roy Weatherbee, Director/Inspection for US AIRWAYS, on March 2, 1998. The retained cockpit voice recorder was delivered to Mr. E.G. Pate, on March 4, 1998. The retained DFDR was delivered to Mr. Jerry Caler, the US AIRWAYS station manager of the Washington National Airport, on December 17, 1998. The remainder of the retained components were released to Mr. Jeffrey S. Campbell, Senior Engineer-Fokker Engineering, U.S. Airways, on April 11, 2000.

### Pilot Information

<b>Certificate:</b>	Airline Transport; Flight Instructor; Commercial; Flight Engineer	<b>Age:</b>	42, Male
<b>Airplane Rating(s):</b>	Multi-engine Land; Single-engine Land	<b>Seat Occupied:</b>	Left
<b>Other Aircraft Rating(s):</b>	None	<b>Restraint Used:</b>	Seatbelt, Shoulder harness
<b>Instrument Rating(s):</b>	Airplane	<b>Second Pilot Present:</b>	Yes
<b>Instructor Rating(s):</b>	Airplane Multi-engine; Airplane Single-engine; Instrument Airplane	<b>Toxicology Performed:</b>	Yes
<b>Medical Certification:</b>	Class 1 Valid Medical--no waivers/lim.	<b>Last Medical Exam:</b>	11/17/1997
<b>Occupational Pilot:</b>		<b>Last Flight Review or Equivalent:</b>	
<b>Flight Time:</b>	16758 hours (Total, all aircraft), 2810 hours (Total, this make and model), 160 hours (Last 90 days, all aircraft), 54 hours (Last 30 days, all aircraft), 1 hours (Last 24 hours, all aircraft)		

## Aircraft and Owner/Operator Information

Aircraft Manufacturer:	Fokker	Registration:	N867US
Model/Series:	F28 MK 0100 F28 MK 010	Aircraft Category:	Airplane
Year of Manufacture:		Amateur Built:	No
Airworthiness Certificate:	Transport	Serial Number:	11312
Landing Gear Type:	Retractable - Tricycle	Seats:	97
Date/Type of Last Inspection:	02/24/1998, Continuous Airworthiness	Certified Max Gross Wt.:	94400 lbs
Time Since Last Inspection:	21 Hours	Engines:	2 Turbo Jet
Airframe Total Time:	17724 Hours	Engine Manufacturer:	Rolls-Royce
ELT:		Engine Model/Series:	TAY-650-15
Registered Owner:	US AIRWAYS, INC.	Rated Power:	15100 lbs
Operator:	US AIRWAYS, INC.	Air Carrier Operating Certificate:	Flag carrier (121)
Operator Does Business As:		Operator Designator Code:	USAA

## Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual Conditions	Condition of Light:	Night/Dark
Observation Facility, Elevation:	BHM, 644 ft msl	Observation Time:	1738 CST
Distance from Accident Site:	0 Nautical Miles	Direction from Accident Site:	0°
Lowest Cloud Condition:	Unknown / 0 ft agl	Temperature/Dew Point:	59° C / 59° C
Lowest Ceiling:	Broken / 3700 ft agl	Visibility	4 Miles
Wind Speed/Gusts, Direction:	5 knots, 60°	Visibility (RVR):	0 ft
Altimeter Setting:	29 inches Hg	Visibility (RVV):	0 Miles
Precipitation and Obscuration:			
Departure Point:	CHARLOTTE, NC (CLT)	Type of Flight Plan Filed:	IFR
Destination:	(BHM)	Type of Clearance:	IFR
Departure Time:	1712 EST	Type of Airspace:	Class C

## Airport Information

Airport:	BIRMINGHAM INTERNATIONAL (BHM)	Runway Surface Type:	Asphalt
Airport Elevation:	644 ft	Runway Surface Condition:	Wet
Runway Used:	23	IFR Approach:	Visual
Runway Length/Width:	10000 ft / 150 ft	VFR Approach/Landing:	Full Stop; Traffic Pattern

## Wreckage and Impact Information

<b>Crew Injuries:</b>	6 None	<b>Aircraft Damage:</b>	Substantial
<b>Passenger Injuries:</b>	86 None	<b>Aircraft Fire:</b>	None
<b>Ground Injuries:</b>	N/A	<b>Aircraft Explosion:</b>	None
<b>Total Injuries:</b>	92 None	<b>Latitude, Longitude:</b>	

## Administrative Information

<b>Investigator In Charge (IIC):</b>	TIMOTHY W MONVILLE	<b>Adopted Date:</b>	02/16/2001
<b>Additional Participating Persons:</b>	THOMAS L MILLER; BIRMINGHAM, AL GEORGE H SNYDER; PITTSBURG, PA DANIEL SICCHIO; PENNELLVILLE, NY FRANSVAN DE POL; SCHIPOL, OF		
<b>Publish Date:</b>			
<b>Investigation Docket:</b>	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 <a href="mailto:pubinq@ntsb.gov">pubinq@ntsb.gov</a> , or at 800-877-6799. Dockets released after this date are available at <a href="http://dms.nts.gov/pubdms/">http://dms.nts.gov/pubdms/</a> .		

The National Transportation Safety Board (NTSB), established in 1967, is an independent federal agency mandated by Congress through the Independent Safety Board Act of 1974 to investigate transportation accidents, determine the probable causes of the accidents, issue safety recommendations, study transportation safety issues, and evaluate the safety effectiveness of government agencies involved in transportation. The NTSB makes public its actions and decisions through accident reports, safety studies, special investigation reports, safety recommendations, and statistical reviews.

The Independent Safety Board Act, as codified at 49 U.S.C. Section 1154(b), precludes the admission into evidence or use of any part of an NTSB report related to an incident or accident in a civil action for damages resulting from a matter mentioned in the report.