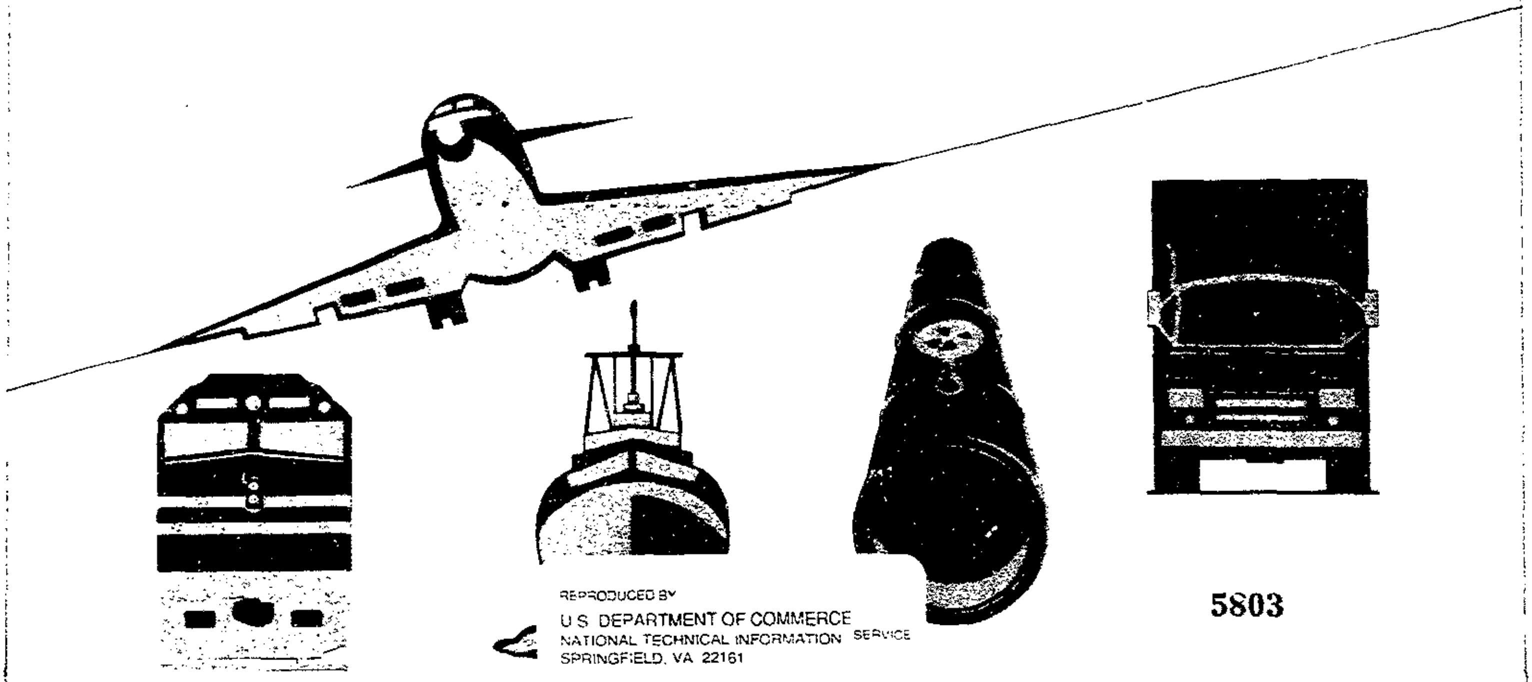
PB92-917007
NTSB/SIR-92/03

NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

SPECIAL INVESTIGATION REPORT

PIPER AIRCRAFT CORPORATION
PA-46 MALIBU/MIRAGE
ACCIDENTS/INCIDENT
MAY 31, 1989 TO MARCH 17, 1991



5803

Abstract: Between May 31, 1989, and March 17, 1991, five fatal accidents occurred in the United States involving Piper Aircraft Corporation model PA-46 airplanes. Twelve persons died in the accidents and the five airplanes were destroyed. The National Transportation Safety Board investigations and analyses of the accidents disclosed that one occurred because the pilot entered a very strong thunderstorm, lost control of the airplane, and overstressed critical structural components, which separated in flight. The causes of the other four accidents involved probable failure to use pitot heat during flight in freezing instrument meteorological conditions, possible misuse of integrated flight guidance and control systems, loss of control, and in-flight airframe failures due to loads and stresses that substantially exceeded design limits. The Safety Board issued six safety recommendations to the Federal Aviation Administration related to more stringent pilot training requirements for pilots of small pressurized airplanes, the addition of a pitot heat operating light in PA-46 and similar airplanes, revision of checklists in the pilot operating handbook and the airplane flight manual for PA-46 and similar airplanes, and improved training material for integrated flight guidance and control systems.

The National Transportation Safety Board is an independent Federal agency dedicated to promoting aviation, railroad, highway, marine, pipeline, and hazardous materials safety. Established in 1967, the agency is 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 Safety Board makes public its actions and decisions through accident reports, safety studies, special investigation reports, safety recommendations, and statistical reviews.

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Adopted: July 21, 1992
Notation 5803

CONTENTS

EXECUTIVE SUMMARY

Between May 31, 1989, and March 17, 1991, Piper PA-46 series Malibu and Mirage airplanes were involved in seven fatal accidents in the United States, Mexico, and Japan following departures from controlled flight. In addition to the seven accidents, another PA-46 airplane was involved in an incident that included substantial departures from controlled flight.

In July 1990, following the fourth U.S. fatal accident, the Safety Board initiated a special investigation of the facts, conditions, and circumstances that led to the loss of the four Malibu/Mirage airplanes in the U.S. As other accidents occurred, they were included in the special investigation. Two of the seven fatal accidents occurred in Japan and Mexico, and the available information on the accidents was included in the special investigation. The special investigation included a review of the relevant design features of the Malibu and Mirage airplanes, including structural integrity, flight control systems, and operating limitations. The investigation also focused on the flight experience and training of the pilots of the airplanes, particularly as these factors related to flying the Malibu/Mirage airplanes in instrument meteorological conditions (IMC) at and above the freezing level with relatively sophisticated integrated flight guidance and control systems.

Finally, as a consequence of the accidents, the Federal Aviation Administration, with the Safety Board's encouragement, conducted a special certification review of the airplanes, and the results are included in the report.

The probable causes of the five fatal accidents that occurred in the United States are included in the report. The investigation and analysis of the relevant data indicate that the causes of the accidents involved failure to use pitot heat in freezing IMC, possible misuse of the integrated flight guidance and control systems, loss of control, and in-flight airframe failures due to loads and stresses that substantially exceeded design limits. Factors related to the accidents included the lack of an appropriate checklist item for pitot heat in the pilot's operating handbook, and inadequate pilot training in the operation of the integrated flight guidance and control systems.

As a result of the special investigation, the Safety Board made safety recommendations concerning modifications to the PA-46 airplane flight manual, the pilot training needed to operate small pressurized airplanes, the addition of a pitot heat operating light, additional training requirements for the use of integrated flight guidance and control systems in small pressurized airplanes, and the provision of training supplements by manufacturers of integrated flight guidance and control systems.

INTRODUCTION

On May 31, 1989, a Piper PA-46-310P Malibu, U.S. Registration N9114B,[1] crashed near Bristol, Indiana. The pilot and two passengers were killed in the accident. The Safety Board determined that the probable cause of the accident was "continued flight by the pilot into known adverse weather and his exceeding the design stress limits of the aircraft which resulted in failure of the wing spars and separation of the right wing and empennage (stabilizers)." Contributing factors were "continued flight by the pilot above the maneuvering speed (V_a), his lack of familiarity with the make and model of aircraft, and thunderstorms."

During the 22 months following the above accident, four other fatal accidents occurred in the United States that involved PA-46 airplanes. Also, during this period, two fatal accidents occurred in PA-46 airplanes in foreign countries, and an incident occurred in the United States that involved substantial departures from controlled flight in a PA-46. The places and dates of the other six accidents and the incident are as follows:

Bakersfield, California
February 6, 1990; PA-46-350P Mirage, N8888M - - 2 deaths

Naylor, Missouri
May 27, 1990; PA-46-310P, Malibu, N22EK - - 2 deaths

Lakeville, Michigan
June 26, 1990; PA-46-310P, Malibu, N315RC - - 1 death

Hermosillo, Mexico
September 3, 1990; PA-46-310P, Mexican registry XB-EWP - - 4 deaths

Tottori, Japan
November 17, 1990; PA-46-310P Malibu, Japanese registry JA3990 - - 3 deaths

Ocala, Florida
March 16, 1991; PA-46-310P Malibu, N26033 - - an incident, 6 persons onboard, no injuries

Bronson, Florida
March 17, 1991; PA-46-310P, N9112k - - 4 deaths

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[1] Detailed information about each accident which occurred in the United States can be found in the factual reports prepared for each accident.

In July 1990, following the fourth U.S. fatal accident, the Safety Board initiated a special investigation of the Piper PA-46 airplane and the facts, conditions, and circumstances surrounding the fatal accidents. As other accidents and incidents occurred during the following 9-month period, they were investigated as a part of the special investigation. The available information on the two foreign accidents was included in the special investigation.

AIRPLANE BACKGROUND/HISTORY

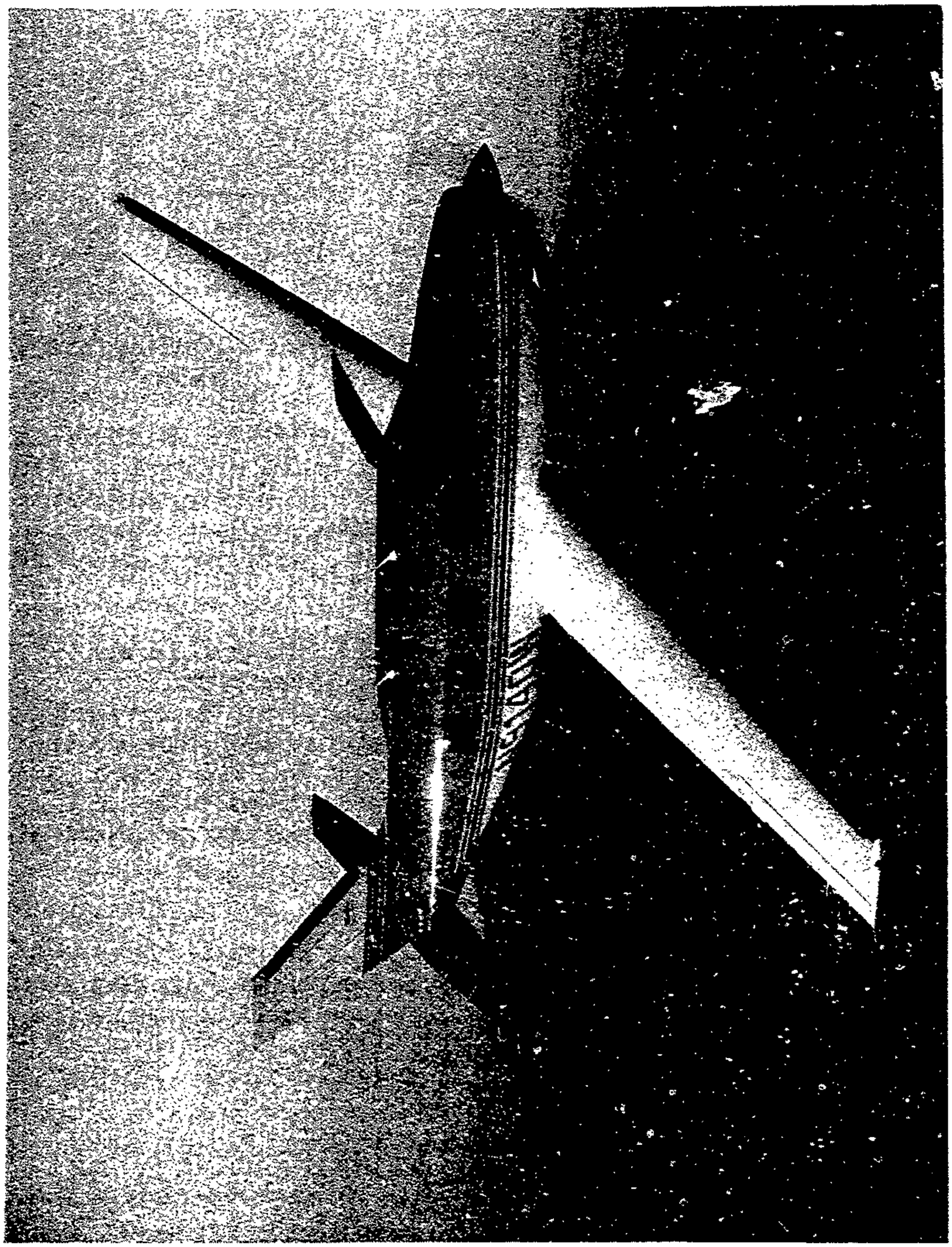
The Piper PA-46 series airplanes are single engine, metal, low-wing airplanes with retractable landing gear. The engines are turbocharged and are equipped with constant speed two-bladed propellers. The airplanes have pressurized cabins with seating for six, including two pilots. The airplanes are certificated for flight up to and including 25,000 feet and, if properly equipped, for flight into known icing conditions. (See Figure 1.)

The Piper Aircraft Corporation (PAC) designed and certificated the airplanes under the provisions of 14 Code of Federal Regulations (CFR) 23 effective February 1, 1965, through Amendment 23-25 effective March 6, 1980; 14 CFR 25.783(e) of Amendment 25-54 effective October 14, 1980; and 14 CFR 25.831(e) and (d) of Amendment 25-41 effective September 1, 1977. The PAC has certificated and produced two versions of the PA-46 -- the PA-46-310P Malibu that is equipped with a Teledyne Continental TS10-520-BE engine rated at 310 horsepower (hp), and the PA-46-350P Mirage that is equipped with a Textron Lycoming TS10-540-AE2A engine that is rated at 350 hp. The type certificate (normal category) for the Malibu was approved September 27, 1983, and the type certificate (normal category) for the Mirage was approved August 30, 1988.

Some of the operating limitations for the two models of the PA-46 are as follows:

	Malibu	Mirage
Maximum operating altitude	25,000 feet	25,000 feet
Maximum takeoff weight	4100 lbs	4300 lbs
Maximum Speed (V_{ne})	203 KIAS	198 KIAS
Max Structural Cruise Speed (V_{no})	173 KIAS	168 KIAS
Maneuvering Speed (V_A) @ 4,100 lbs	135 KIAS	133 KIAS
Maneuvering Speed (V_A) @ 2,450 lbs	103 KIAS	100 KIAS
Stall Speeds (Clean, Maximum weight)	69 KIAS	69 KIAS
Flight Load Factors -- Positive	3.8 G	3.8 G
-- Negative	No inverted maneuvers approved	

According to the PAC, as of June 25, 1992, it had manufactured 527 PA-46 airplanes of which 403 were Malibus and 124 were Mirages. The Malibu is no longer in production.



Piper PA-46-310P (Malibu)

FIGURE 1

PA-46 ACCIDENTS AND INCIDENT

Bristol, Indiana

History of the Flight

On May 31, 1989, the pilot of a Piper PA-46-310P Malibu, N9114B, departed Tullahoma, Tennessee, on an instrument flight rules (IFR) flight plan, for Kalamazoo, Michigan. About 1518 central standard time while at 16,000 feet[2], the pilot queried the Indianapolis air route traffic control center (ARTCC) regarding weather conditions, and the controller advised that there was convective weather about 70 miles directly ahead of his position. About 1521, the pilot requested a deviation left of course to pass behind the weather. The deviation was approved, and about 1527, the pilot was cleared to climb to 17,000 feet. At 1539, the pilot advised the Chicago air route traffic control center (ARTCC) that he was going to make a turn to get out of some weather; the turn was approved. At 1540, the pilot advised that he was going to proceed westbound for a ways and that "he was having a little point control[3] problem and did not want to get into bad weather."

About 1556, the pilot was cleared to descend to 13,000 feet, and about 3 minutes later the pilot requested a continuation of the descent for landing at Kalamazoo. The controller was unable to provide clearance below 13,000 feet, and at 1604, the pilot again asked for a lower altitude. The controller indicated that the pilot would have a clearance for a lower altitude in about 10 miles. The pilot responded "okay, we're never gonna be able to get down."

At 1604:19, the controller stated: "turn left, fly heading three five zero, be a vector for your descent." Shortly thereafter, the pilot stated "Present heading is three five zero and we're getting in a big cell and we've got to get out of here." The controller then advised: "Deviation left of course out of weather is approved as needed, maintain one two thousand." Sixteen seconds later the pilot reported "...four bravo...I can't hold it...hold on." The airplane crashed about 1608 central standard time near Bristol, Indiana, about 20 miles east-northeast of South Bend, Indiana. The pilot and two passengers aboard the airplane were killed, and the airplane was destroyed.

Weather

Weather radar data disclosed that N9114B had entered an area of very strong radar echoes containing thunderstorms with heavy rain showers. Witnesses near the crash site

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[2] All altitudes are in feet above mean sea level (msl) unless otherwise indicated.

[3] According to the airplane owner, point control probably was a reference to the stormscope that shows discharges of lightning as points of light on the cockpit display.

stated that it was not raining at the time of the crash, but that thunderstorms and lightning were visible in the area.

At 1546, the reported weather at South Bend, Indiana, was as follows:

> estimated ceiling -- 2,500 feet broken, 5,500 feet broken, 25,000 feet overcast; visibility -- 7 miles; temperature -- 83°F; dew point -- 73°F; winds -- 240° at 15 knots; Remarks --small breaks in overcast, hazy. The freezing level was near 14,000 feet in northern Indiana.

Pilot

The pilot of N9114, age 54, had a private pilot certificate with airplane single-engine and multi-engine land and instrument ratings. According to his pilot log books, he had a total of 1,619 flight hours, which included about 441 hours in instrument flight conditions. He had a total of 17 hours in the PA-46 airplane. He also had flown 7 and 18 hours, respectively, during the preceding 30-day and 90-day periods which included 2.5 hours and 9.3 hours, respectively, of instrument flight time (see Appendix A for further information on pilot experience).

The pilot had a Class III medical certificate that was issued on July 23, 1987, without any waivers or limitations. He had completed a biennial flight review about 20 months before the accident. Postaccident toxicological tests disclosed no intoxicants or licit or illicit drugs in the pilot's body.

The pilot and both passengers were restrained in their seats by seatbelts and shoulder harnesses. They had received fatal blunt trauma injuries.

Airplane

N9114B, Serial no. 46-08046, was owned by Stout Leasing, Inc., Flushing, Michigan. The pilot had leased the airplane from Stout Leasing for a business trip to Tennessee and return. The airplane had a total service time of 705 hours, and the engine had a total time of 499 hours. An annual inspection was completed on the airplane on August 29, 1988; the airplane and engine had accumulated 79 hours since the inspection. The airplane was not equipped with weather radar but was equipped with a 3M (Ryan) WX-10A stormscope. An estimated 130 gallons of fuel were aboard the airplane on departure from Tullahoma. The airplane's gross weight and center of gravity were within limits throughout the flight.

According to the pilot's operating handbook (POH) for the airplane, the WX-10A stormscope signal displays are not intended for the purpose of penetrating thunderstorm areas. Also, a placard located on top of the throttle quadrant near the stormscope reads: STORMSCOPE NOT TO BE USED FOR THUNDERSTORM AREA PENETRATION.

Wreckage

The main crash site (latitude 41° 43' 53"N, longitude 85° 47' 31"W) is located near Bristol, Indiana. The wreckage debris path extended from the main site in a northeasterly direction about 4 miles. The fuselage was at the main site where it came to rest inverted on a southeasterly heading; it was flattened to about one-half of its original height.

The outboard section of the right wing was about 0.8 mile northeast of the main wreckage site; it had separated outboard of the main gear well at the spar splice. The upper cap of the main spar was buckled; the lower cap was straight with a 45-degree scarf at the separation.

The left wing was at the main wreckage site; the outboard section had separated at the spar splice but remained attached to the inboard section by a 3-inch piece of skin at the leading edge. The upper cap of the main spar was buckled, and the lower cap was straight at the point of separation. The stringers along the upper surface of the wing were buckled, and the lower stringers were straight.

Portions of the empennage were located in the debris path, including the upper portion of the rudder with the balance weight attached (about 2.8 miles northeast), about one-half of the left elevator (about 3 miles northeast), and the upper and lower skins of the right and left horizontal stabilizers (about 3 miles northeast).

The landing gears were retracted, but the main gears doors had separated in flight. The engine was in the forward fuselage and damaged by impact with the ground. The propeller was attached, and both blades were bent aft. The interior of the right turbocharger housing had scrape marks from its impeller. The left turbocharger housing was covered by bent cowling and was not inspected. Both engine-driven vacuum pumps were removed and inspected; no scoring was present on the interiors of the chambers.

Metallurgical examination of critical fracture surfaces disclosed no evidence of corrosion or fatigue; the surfaces showed typical overload fractures. Control cable fractures were typical tensile overload failures. The primary gyro instruments disclosed evidence of internal rotational scoring. The cockpit instruments and control panels were extensively damaged, and no useful information was obtained from related switches, controls, and displays.

Flightpath Study

A flightpath study of recorded air traffic control (ATC) radar data (See Figures 2 and 3) was conducted for the accident by a Safety Board airplane performance engineer. Airplane performance calculations derived from recorded radar data indicate

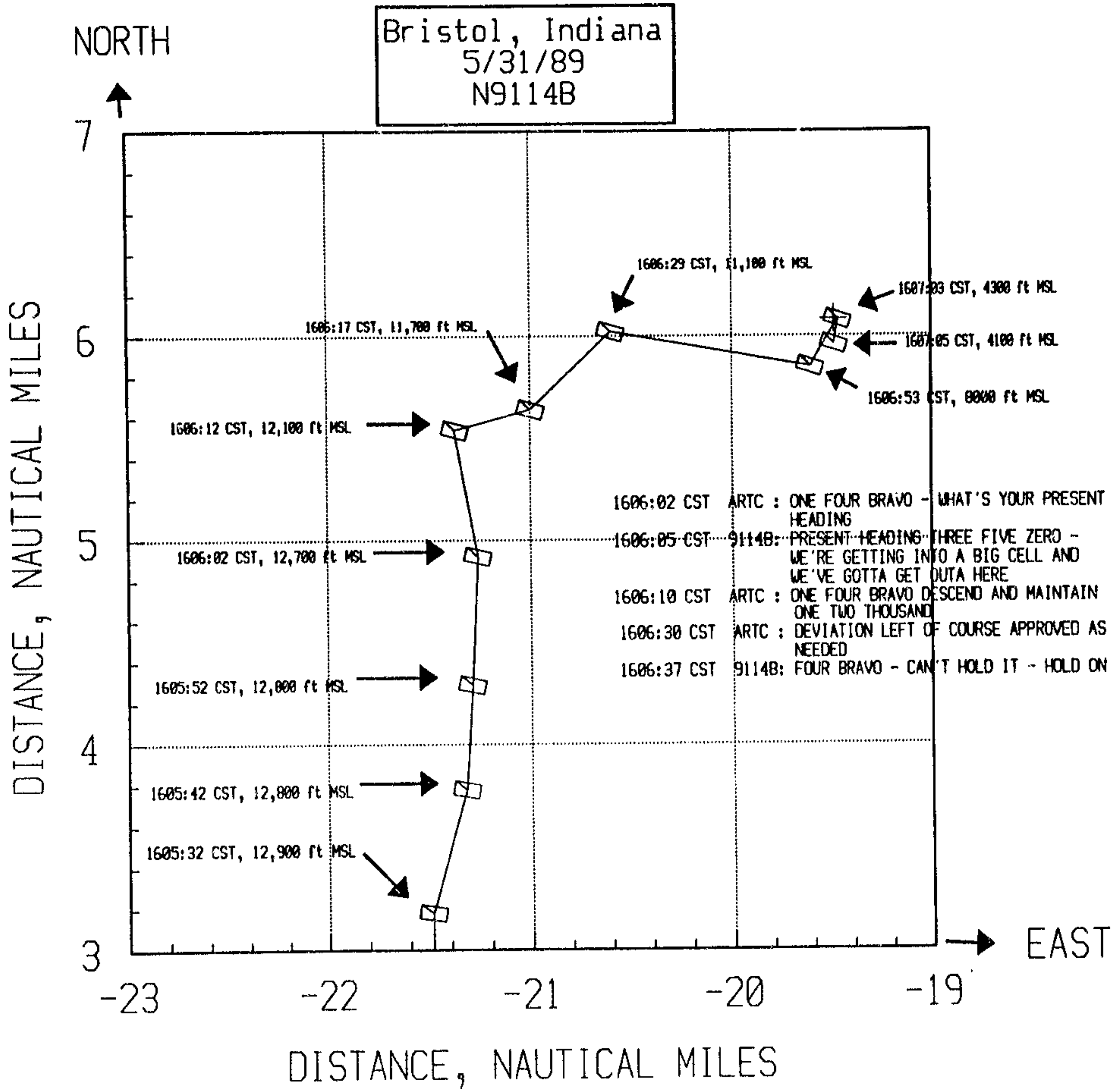

Bristol, Indiana
5/31/89
N9114B
NORTH
EAST
DISTANCE, NAUTICAL MILES
DISTANCE, NAUTICAL MILES
7
6
5
4
3
-23
-22
-21
-20
-19
1606:29 CST, 11,100 ft MSL
1607:03 CST, 4300 ft MSL
1607:05 CST, 4100 ft MSL
1606:53 CST, 8000 ft MSL
1606:17 CST, 11,700 ft MSL
1606:12 CST, 12,100 ft MSL
1606:02 CST, 12,700 ft MSL
1605:52 CST, 12,800 ft MSL
1605:42 CST, 12,800 ft MSL
1605:32 CST, 12,900 ft MSL
1606:02 CST ARTC : ONE FOUR BRAVO - WHAT'S YOUR PRESENT HEADING
1606:05 CST 9114B: PRESENT HEADING THREE FIVE ZERO - WE'RE GETTING INTO A BIG CELL AND WE'VE GOTTA GET OUTA HERE
1606:10 CST ARTC : ONE FOUR BRAVO DESCEND AND MAINTAIN ONE TWO THOUSAND
1606:30 CST ARTC : DEVIATION LEFT OF COURSE APPROVED AS NEEDED
1606:37 CST 9114B: FOUR BRAVO - CAN'T HOLD IT - HOLD ON

FIGURE 2

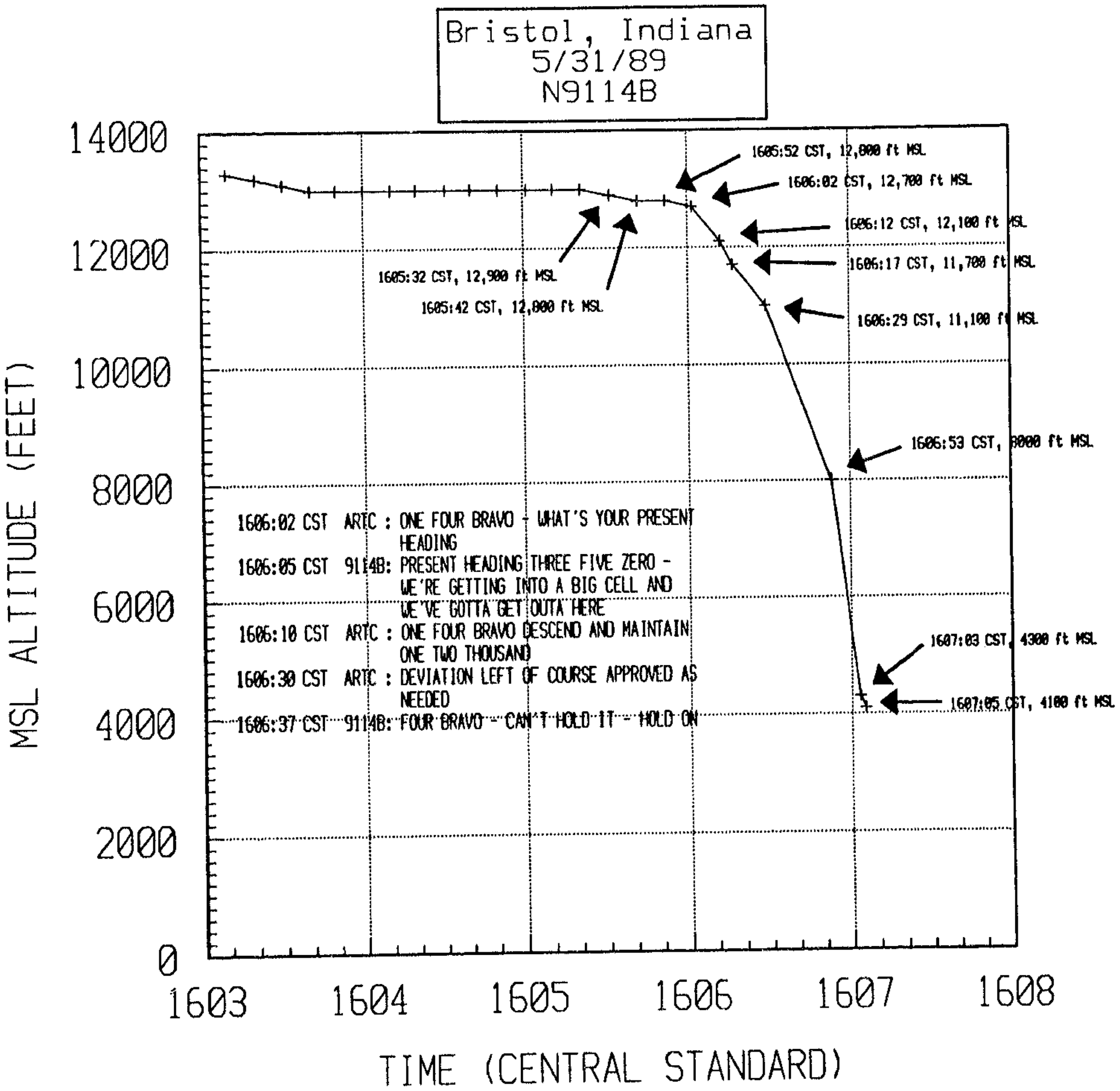

Bristol, Indiana
5/31/89
N9114B
14000
12000
10000
8000
6000
4000
2000
0
MSL ALTITUDE (FEET)
1603
1604
1605
1606
1607
1608
TIME (CENTRAL STANDARD)
1605:32 CST, 12,900 ft MSL
1605:42 CST, 12,800 ft MSL
1605:52 CST, 12,800 ft MSL
1606:02 CST, 12,700 ft MSL
1606:12 CST, 12,100 ft MSL
1606:17 CST, 11,700 ft MSL
1606:29 CST, 11,100 ft MSL
1606:53 CST, 8000 ft MSL
1607:03 CST, 4300 ft MSL
1607:05 CST, 4100 ft MSL
1606:02 CST ARTC : ONE FOUR BRAVO - WHAT'S YOUR PRESENT HEADING
1606:05 CST 9114B: PRESENT HEADING THREE FIVE ZERO - WE'RE GETTING INTO A BIG CELL AND WE'VE GOTTA GET OUTA HERE
1606:10 CST ARTC : ONE FOUR BRAVO DESCEND AND MAINTAIN ONE TWO THOUSAND
1606:30 CST ARTC : DEVIATION LEFT OF COURSE APPROVED AS NEEDED
1606:37 CST 9114B: FOUR BRAVO - CAN'T HOLD IT - HOLD ON

FIGURE 3

that as the airplane descended from 17,000 feet, it was heading north; it then was leveled at 13,000 feet. At that time, the airplane's indicated airspeed was about 190 knots (KIAS). The speed decreased to about 150 KIAS over the next 40 seconds. During the following 60 seconds, the airspeed increased to 180 KIAS and then decreased again to 150 KIAS. A descent from 13,000 feet was then begun and the speed increased to 170 KIAS by the time the pilot reported, "...we're getting into a big cell and we've gotta get outa here." At an altitude of 12,100 feet, the airplane entered a steeply banked turn to the right, its speed increased from about 170 KIAS to more than 200 KIAS as the altitude decreased to 11,100 feet in about 17 seconds, and its heading changed from north to east. From the original northerly ground track, the airplane traveled about 1.5 miles to the east where it broke apart in flight. A trajectory study of various parts of the airplane wreckage disclosed that the breakup occurred above 10,000 feet.

Bakersfield, California

History of the Flight

On February 6, 1990, the pilot of a Piper PA-46-350P Mirage, N8888M, en route from Porterville to Redlands, California, on an IFR flight plan at 9,000 feet, entered a very rapid descent and crashed near Bakersfield, California, about 1548 pacific standard time. The pilot and one other person aboard the airplane were killed, and the airplane was destroyed.

The pilot received a weather briefing from the Fresno Flight Service Station (FSS) beginning about 1418, after which he filed an IFR flight plan. The weather briefing indicated flight precautions for the Tehachapi area (a mountainous area 25-30 miles east-southeast of Bakersfield) for occasional moderate rime mixed icing from the freezing level to 18,000 feet. The forecast freezing levels were at 3,000 feet to 6,000 feet in central California and 6,000 feet to 9,000 feet in southern California.

The radar approach controllers at the Bakersfield air traffic control tower were providing IFR services; they reported observing the radar data block for N8888M on course as the ascent to 9,000 feet was completed. The altitude then increased to 9,400 feet before the airplane suddenly entered a very rapid descent. The airplane's transponder return disappeared from the radar screen when the airplane reached 5,400 feet.

Weather

At 1550, the reported weather at Bakersfield was as follows:

clouds --3,700 feet scattered, 6,000 feet overcast; visibility -- 15 miles; temperature -- 49°F; dewpoint -- 43°F; wind -- 310 degrees at 10 knots; altimeter -- 30.14 inches Hg.

Infrared data from the Geostationary Operational Environmental Satellite (GOES) indicated that at 1535 in the area of the accident site, clouds were present with tops above 18,000 feet with a possibility of imbedded convective showers. Other GOES data indicated the probable presence of mixed icing of light to moderate intensity between 8,000 feet and 10,000 feet and freezing temperatures above 6,500 feet.

Pilot

The pilot, age 74, held a private pilot certificate with airplane ratings for single-engine land and instruments. His most recent third class medical certificate was issued January 15, 1988, with a limitation that he wear corrective lenses while exercising the privileges of his airman certificate. According to the pilot's personal physician (an aviation medical examiner), the pilot was examined on January 12, 1990, for renewal of his medical certificate, and the pilot was eligible for a third class certificate pending receipt of a statement from the pilot's treating physician concerning the pilot's postoperative status from prostate surgery. The statement had not been received by the time the accident occurred.

According to the autopsy, the pilot died from blunt force trauma. An anatomic diagnosis of his heart indicated extensive atherosclerosis of the aorta, calcific coronary artery occlusion, and slight left ventricular hypertrophy. According to the pathologist, "microscopic findings certainly document prior myocardial infarction but are not suggestive or supportive of acute infarction." Other incapacitating cardiac events were not excluded. Toxicological tests were negative for alcohol, and licit and illicit drugs.

A review of the pilot's flight log indicated that he had logged about 8,155 flight hours, including 1,348 hours of actual instrument time. He had flown 51 hours in the PA-46-350P, including 8 hours of actual instrument time. During the preceding 90-day and 30-day periods, he had flown 12 hours and 5 hours of instrument time, respectively.

The pilot had purchased N8888M in September 1989 while the airplane was in production. He took delivery of the airplane in Florida in December 1989, and he attended the PAC school for PA-46 owners and pilots while in Florida. He flew 3.5 hours in simulator training and received 10.2 hours of flight instruction in N8888M from December 13 through 16. According to written comments by his PAC instructor on December 15, the pilot needed to familiarize himself with instrument locations on the panel and to intensively work on the flight director and instrument procedures. On December 16, another instructor indicated that the pilot needed continued work on instrument procedures and an additional 10 hours of instrument instruction to fly in instrument meteorological conditions (IMC). After returning to California, the pilot flew seven flights, and 9.4 hours in N8888M with a local instructor. According to the instructor, after completion of these flights, which included extensive instruction on the autopilot and flight director systems, the pilot possessed adequate skills to fly the airplane in IMC. The pilot had completed a biennial flight review about 19 months before the accident.

Airplane

N8888M, Serial No. 46-22081, was issued an airworthiness certificate on December 8, 1989. It had accumulated about 62 hours in service when the accident occurred. It was equipped with a King Radio Corporation KFC 150 flight control system and a KAS 297B vertical speed and altitude selector system. It had dual vacuum pumps, a stormscope, and windshield, airframe, and propeller deice equipment. On February 5, 1990, it was fueled with 97 gallons of 100 low lead aviation gas which, according to the refueler, filled the tanks. The airplane's gross weight and center of gravity were within limits throughout the flight.

Wreckage

The fuselage was inverted at the main wreckage site, latitude 35° 43'N and longitude 118° 56'W, at an elevation of about 890 feet. A path of wreckage extended east of the main wreckage site on a magnetic bearing of about 95° for a distance of about 4,100 feet. The major components scattered along the wreckage path from the main site included the outboard panel of the right wing (about 1,200 feet), the outboard portion of the right flap (1,900 feet), skin from the left side of the horizontal stabilizer (1,700 feet), the upper and lower portions of the vertical stabilizer (about 2,000 feet), the right outboard portion of the elevator (2,400 feet), portions of skin from the right side of the horizontal stabilizer (2,700 feet), portions of structure from the right side of the horizontal stabilizer (2,900 and 3,500 feet), and the stub spar from the right side of the horizontal stabilizer (3,350 feet).

The outboard section of the right wing had separated at the spar splice which exhibited deformation by bending in a wing-tip-downward direction. The outboard section of the left wing had separated at the spar splice but was attached to the inboard section by a portion of leading edge skin; the main spar exhibited deformation by bending in a wing-tip-upward direction.

The elevator was separated into five major pieces; the left half remained attached to the rear spar of the horizontal stabilizer, which remained attached to the tail cone fuselage bulkhead. The left side of the main spar of the horizontal stabilizer was bent aft about 40 degrees and was twisted leading edge down about 85 degrees. The right side of the main spar was bent aft about 60 degrees and was twisted leading edge up about 60 degrees. The right half of the elevator was located in the wreckage in four pieces.

The upper skin of the right horizontal stabilizer was separated from the rivets that attached it to the ribs and main spar. The lower skin of the left horizontal stabilizer was separated in a similar manner. The stub forward spars on both sides of the horizontal stabilizer had separated from their fuselage attachment points in a lateral (outward) direction.

The vertical stabilizer had separated from the fuselage in two major pieces which were found in the wreckage path. The upper section had a chordwise buckle and a contour that matched the leading edge of the right wing outer panel.

Examination of the engine and propeller revealed no evidence of preexisting abnormalities. Examination of the induction air box revealed that the flapper valve was in the alternate air position.

The cabin entry door was secured within its frame and the backing pins were properly extended. The forward baggage compartment door was secured. Documentation of cockpit controls and switches indicated that all anti-ice switches were off, including the pitot heat. The electrical master, battery, alternator, invertor, avionics master, and cabin heat switches were on. Also, the rotating beacon, strobe, and instrument panel light switches were on.

All autopilot components were removed for examination. The KC 192 flight computer and the KAS 297B vertical speed/altitude selector had internal damage and could not be tested. The autopilot servo clutch torques were within prescribed limits, and the servos for pitch, yaw, and trim operated within prescribed tolerances. The roll servo had impact damage, but the mechanical elements functioned correctly, and the correct electrical signals were supplied by the internal circuitry. The landing gear and flaps actuators were in the retracted position. The elevator trim jack screw had 2.5 threads exposed that corresponded to a trim tab trailing edge up (airplane nose down) position of 30 percent or about 5.7 degrees of the 19 degrees of travel.

The right attitude gyro was disassembled and examined. The exterior case was damaged. The internal rotor was heavily scored. The left side turn coordinator gyro was examined; its rotor had minor scoring.

Flightpath Study

A flightpath study was performed for this accident by Safety Board aircraft performance engineers from recorded ATC radar data (See Figures 4 and 5). Airplane performance derived from the data indicate that the airplane initially was ascending at a rate of about 1,500 feet per minute (fpm) at an indicated airspeed of 100 KIAS. Near 8,000 feet, the vertical speed decreased to about 1300 fpm and the airspeed decreased from about 100 KIAS to about 90 KIAS over the next 35 seconds. Near 9000 feet, the vertical speed decreased to near zero while the airspeed was near 100 KIAS. Over the next 25 seconds, the airplane reached 9,200 feet, and the airspeed increased to 135 KIAS. The airplane then started a turn to the left, climbed 200 feet to 9,400 feet in about 15 seconds during the initial part of the left turn, and the airspeed increased to about 140 KIAS. Within the next 20 seconds, the airplane started a turn to the right and descended rapidly with the airspeed increasing to about 190 KIAS. Within the next 10 to 15 seconds, the rate of descent increased, the airspeed increased to over 220 KIAS, and the rate of turn to the right

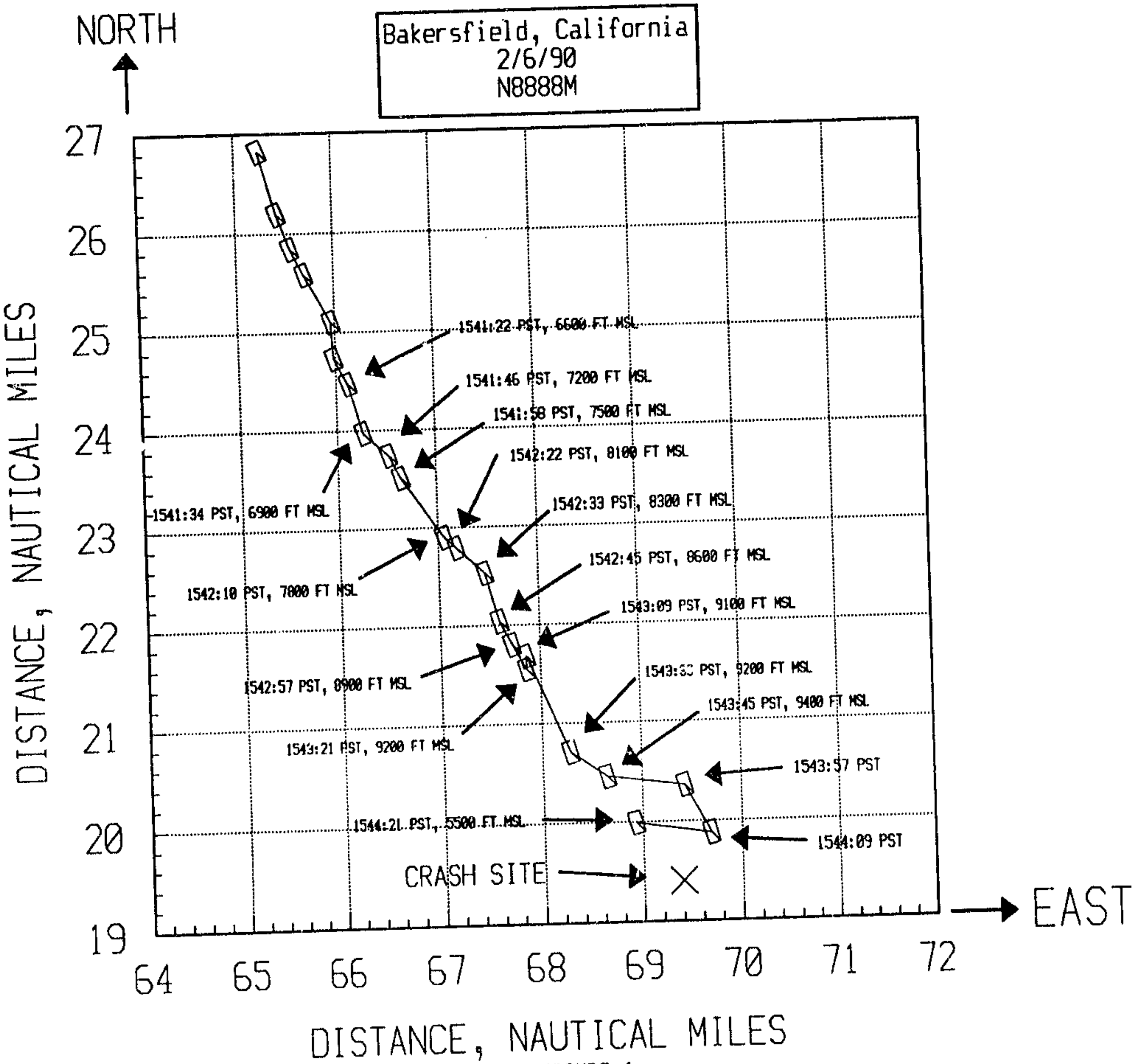
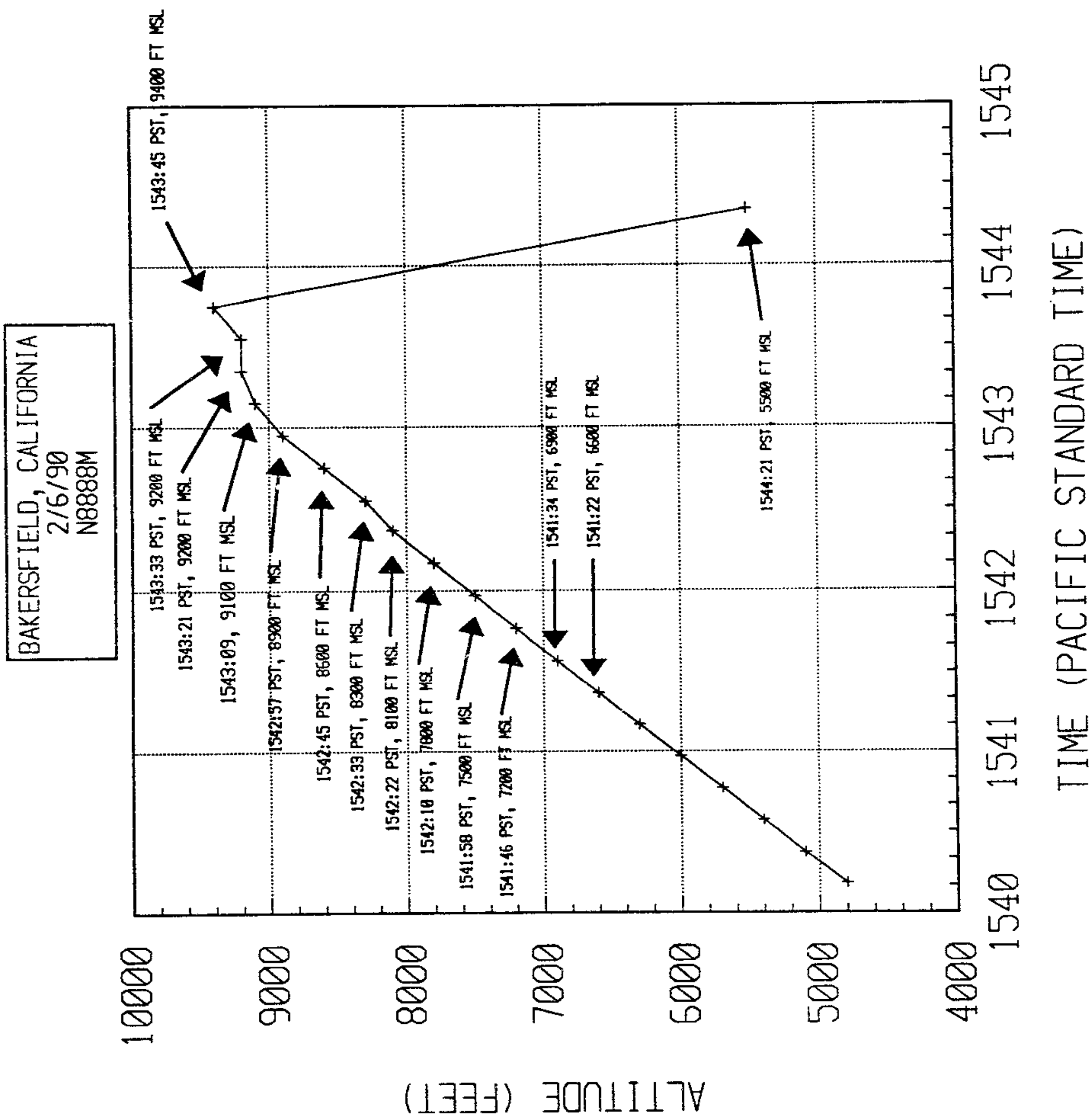

Bakersfield, California
2/6/90
N8888M
NORTH
EAST
DISTANCE, NAUTICAL MILES
DISTANCE, NAUTICAL MILES
27
26
25
24
23
22
21
20
19
64
65
66
67
68
69
70
71
72
1541:22 PST, 6600 FT MSL
1541:34 PST, 6900 FT MSL
1541:46 PST, 7200 FT MSL
1541:58 PST, 7500 FT MSL
1542:10 PST, 7800 FT MSL
1542:22 PST, 8100 FT MSL
1542:33 PST, 8300 FT MSL
1542:45 PST, 8600 FT MSL
1542:57 PST, 8900 FT MSL
1543:09 PST, 9100 FT MSL
1543:21 PST, 9200 FT MSL
1543:33 PST, 9200 FT MSL
1543:45 PST, 9400 FT MSL
1543:57 PST
1544:09 PST
1544:21 PST, 5500 FT MSL
CRASH SITE

FIGURE 4


BAKERSFIELD, CALIFORNIA
2/6/90
N888M
1543:45 PST, 9400 FT MSL
1543:33 PST, 9200 FT MSL
1543:21 PST, 9200 FT MSL
1543:09, 9100 FT MSL
1542:57 PST, 8900 FT MSL
1542:45 PST, 8600 FT MSL
1542:33 PST, 8300 FT MSL
1542:22 PST, 8100 FT MSL
1542:10 PST, 7800 FT MSL
1541:58 PST, 7500 FT MSL
1541:46 PST, 7200 FT MSL
1541:34 PST, 6900 FT MSL
1541:22 PST, 6600 FT MSL
1544:21 PST, 5500 FT MSL
ALTITUDE (FEET)
10000
9000
8000
7000
6000
5000
4000
1540
1541
1542
1543
1544
1545
TIME (PACIFIC STANDARD TIME)
FIGURE 5

increased significantly. Trajectory studies of airplane wreckage and the derived flight path are consistent with an in-flight breakup that occurred between 4,500 feet and 6,500 feet while in a descent angle of 50 degrees with an airspeed in excess of 265 KIAS.

Naylor, Missouri (About 140 miles South of St. Louis)

History of the Flight

On May 27, 1990, the pilot of a Piper PA-46-310P Malibu, N22EK, en route from Sewanee, Tennessee, to Springfield, Missouri, on an IFR flight plan at flight level (FL) 200 indicated control problems with the airplane, after which the airplane entered a rapid high-speed descent and crashed near Naylor, Missouri, about 1134 central daylight time. The pilot and a passenger were killed in the accident, and the airplane was destroyed.

About 0637 central daylight time, the pilot of N22EK called the Nashville, Tennessee, Flight Service Station (FSS) to file an IFR flight plan from Sewanee, Tennessee (UOS), to Springfield, Missouri, (SGF) and from SGF to Colorado Springs, Colorado (COS). He filed for an altitude of FL200, a time en route of 3 hours to SGF, and a departure time of 1000. The pilot asked for weather along the route. He was given the latest report from SGF and a forecast for clouds -- 600 feet scattered, 4,500 feet overcast, and occasional 600 feet overcast until 1200. The freezing level was about 13,100 feet. After 1200, the forecast for SGF was as follows: 4,500 feet overcast and a chance of rainshowers and thunderstorms.

According to the weather briefing, a frontal system existed from about the Tulsa, Oklahoma, area to just south of SGF and eastward to a point just north of Nashville, Tennessee; and the front was drifting slowly southward. The briefer indicated that the pilot could expect some rainshowers and thunderstorms along the route from the Nashville area through Kansas, and that the better weather was to the north of the route, particularly from the Nashville area to Cape Girardeau, Missouri, area. Some moderate convective activity was in the Columbia, Missouri, area to the SGF area moving southeast. The pilot was provided with forecast winds aloft at 18,000 and 24,000 feet -- they were generally from the west at 20 to 30 knots.

Current weather radar information was provided to the pilot. The radar summaries showed thunderstorm activity from about 80 miles north to 180 miles northwest of Memphis, Tennessee, with an absence of activity on a line from Jonesboro to Harrison, Arkansas, and heavy activity to the south of the line. The pilot confirmed that the freezing level was near 13,000 feet along the route.

At 1000:48 central daylight time, the pilot of N22EK called Memphis Center, reported his departure from UOS and requested his IFR clearance to SGF. The Memphis Center controller provided the clearance and radar vectors to avoid traffic. At 1007:35, the pilot asked to fly a more northerly course because he had a "small cell about 30 miles out." At 1018:40, the pilot was cleared direct to SGF.

After receiving progressively higher altitude clearances, at 1044:41, the pilot of N22EK reported to Memphis Center (McKeller Sector) that he was at FL200. At 1125:23, the pilot requested clearance to FL220, which was provided. At 1127:50, the controller cleared the pilot to contact Memphis center on frequency 127.4 MHz and asked the pilot about the tops of the clouds. At 1128:13, the pilot responded "...I was in the clouds, I'm in a layer right now at ... flight level 200 to 210, I was going to try to get over it..."

At 1128:40, the pilot reported to Memphis Center (Jonesboro Sector) on 127.4 MHz "...Malibu Two Two Echo Kilo with you at flight level two one three going to two two zero." At 1128:49, the controller acknowledged the pilot's transmission. At 1132:02, the Jonesboro controller told the McKeller controller, "Two Two Echo Kilo, I don't think he meant to do that, I'm going to ask him what he's doing there." At 1133:39, and for several minutes after, the Jonesboro controller called N22EK repeatedly with no response. At 1136:39, the controller transmitted "Malibu Two Two Echo Kilo, Memphis, radio contact lost, do you hear center?" There was no response from the pilot of N22EK.

The air traffic control portion of the investigation disclosed that at 1129:10, the pilot of N22EK contacted the Columbia, Missouri, FSS flight watch service on 122.0 MHz, and, at 1129:22, reported "...I'm at ... going to flight level two two zero ah en route to Springfield, Missouri... could you give me ah Topeka weather ... for about an hour from now?" At 1129:49, the flight watch specialist provided the current and forecast Topeka weather. At 1131:00, the pilot asked for the SGF weather which was provided as: clouds -- 500 feet overcast, and visibility -- 5 miles in fog. At 1131:34, the pilot indicated that he would go to Topeka.

At 1133:39, the pilot of N22EK transmitted on 122.0 MHz "Two Echo Kilo, I'm having a bit of trouble, I'm trying to level out at flight level two zero zero (tone)." At 1134:15, the pilot transmitted, "Two Echo Kilo, I've lost my ah ... cho Kilo, Mayday, Mayday, Mayday." This was the last known transmission from the pilot of N22EK.

Two witnesses in a rural residential area near Naylor, Missouri, saw N22EK descend out of an overcast sky at a 15 to 20 degree nose-down angle with its wings level and landing gear extended. One witness estimated the base of the overcast at 2,000 feet above ground level (agl). Their attention was attracted to the airplane by a loud engine sound, "like a large truck going down the road." One witness indicated that within a few seconds of seeing the airplane, the wings of the airplane broke off simultaneously, accompanied by what he described as an explosion. He saw many small parts flying through the air, and the fuselage passing in front of him and crashing into the woods behind his house. He said that the wings floated over his head about 90 degrees to the direction of the fuselage and landed in a neighbor's yard.

The accident site was at latitude 36° 31' 50"N and longitude 80° 29' 06"W at an elevation of about 300 feet. The accident occurred about 1137 during daylight hours.

Weather

An 1137 special observation at Jonesboro, Arkansas (about 43 miles south of the accident site), was as follows:

> clouds -- indefinite ceiling at 300 feet, sky obscured; visibility -- ½ mile, moderate rain; fog; winds -- 250 at 7 knots. An 1151 observation at Cape Girardeau, Missouri (about 58 miles northeast of the accident site), was as follows: clouds -- 1,200 feet scattered, estimated ceiling 2,100 feet; visibility -- 5 miles, haze; temperature -- 71°F; dewpoint -- 64°F; winds -- 020° at 8 knots.

A review of weather radar data and GOES data showed that about 1133, N22EK was within about 5 miles of a moderate (level 2) convective weather echo. At 1131, GOES visible images confirmed an area of bright clouds within 5 miles of the accident site. Also, the images showed a large area of other clouds surrounding the accident site. GOES infrared data showed cloud tops near 33,000 feet with possible light to moderate mixed icing in clouds above a freezing level of about 13,000 feet. Also, the 1101 GOES visible data showed widely scattered clouds over northwest Tennessee and the boot heel of Missouri with the beginning of clouds on the western border of the boot heel, the areas that N22EK traversed between 1101 and 1132. The 1131 GOES visible images showed a thickening cloud mass over the Missouri boot heel. N22EK crashed about 2 miles north of the Arkansas-Missouri border and about 30 miles west of the border where it curves south to form the western boundary of the boot heel.

Pilot

The pilot of N22EK, age 64, held a private pilot certificate with airplane single-engine land and instrument ratings. According to available records, the pilot had about 1,603 hours of flight time which included about 365 hours of instrument flight time. The pilot had acquired about 182 hours in the PA-46, which included about 54 hours of instrument time. He had attended the PAC training school in Florida in February 1989 where he flew 3.6 hours in the PA-46 with a PAC instructor and received a biennial flight review. The pilot had a third class medical issued July 18, 1988, with a limitation that the pilot wear corrective lenses while exercising the privileges of his airman certificate. An autopsy of the pilot disclosed death by massive blunt trauma with no other remarkable findings. Toxicological tests were negative for alcohol and licit and illicit drugs.

According to the vice president of a Piper Aircraft dealership that had flown with the pilot of N22EK several times, the pilot was very cautious and conservative about flying in low IMC. On one occasion, the accident pilot had asked the vice president to fly the instrument approach needed to land in IMC.

Airplane

N22EK, Serial No. 46-8508524, was owned by the pilot. According to records related to its last annual inspection on May 3, 1990, the airplane had a total time in service of 420 hours, and the engine had 59.4 hours time in service. N22EK was equipped with color weather radar and a stormscope.

Wreckage

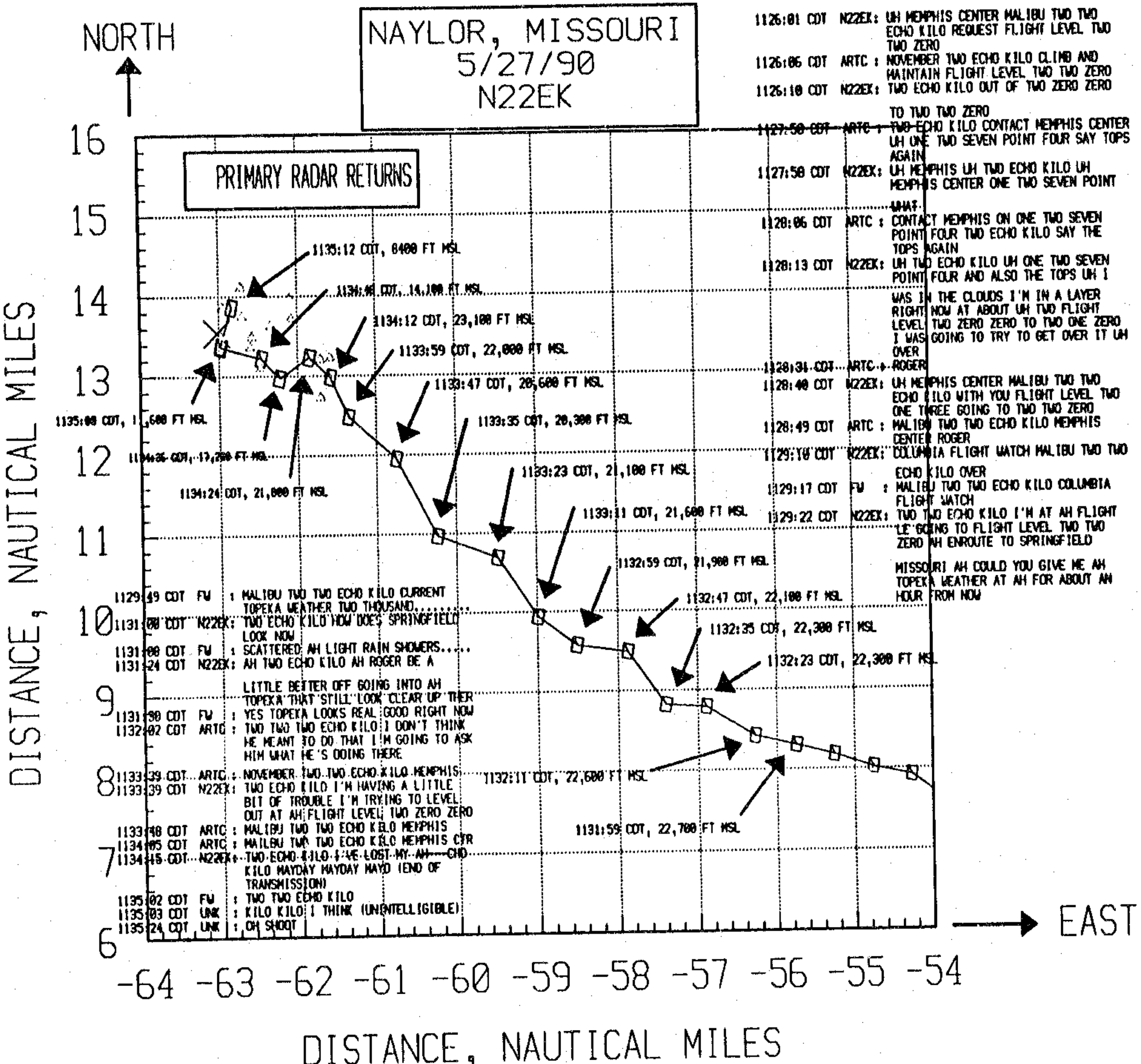
The fuselage came to rest in a tree-covered area. The left wing had separated at the wing root and was located about 0.2 mile south of the fuselage. The outboard panel of the right wing was separated; it was located about 0.6 mile south of the fuselage. The inboard portion of the right wing was partially attached to the fuselage by its aft attachment point on the rear spar. The main spar had separated at the wing root.

The lower portion of the rudder was about 300 feet from the fuselage, and the vertical stabilizer was near the rudder. The main spar of the horizontal stabilizer was attached to its bulkhead; its outboard ends were buckled along its upper and lower caps for about 1 foot. The left and right stabilizer skins had separated and were found about ½ mile southwest of the fuselage.

The main and nose gear actuators were in the extended position. The engine was examined; there was no evidence of an in-flight malfunction or failure. The cockpit was badly damaged and very little could be documented about the position of various controls and switches. The pitot heat switch was off and the induction air selector was in the primary position.

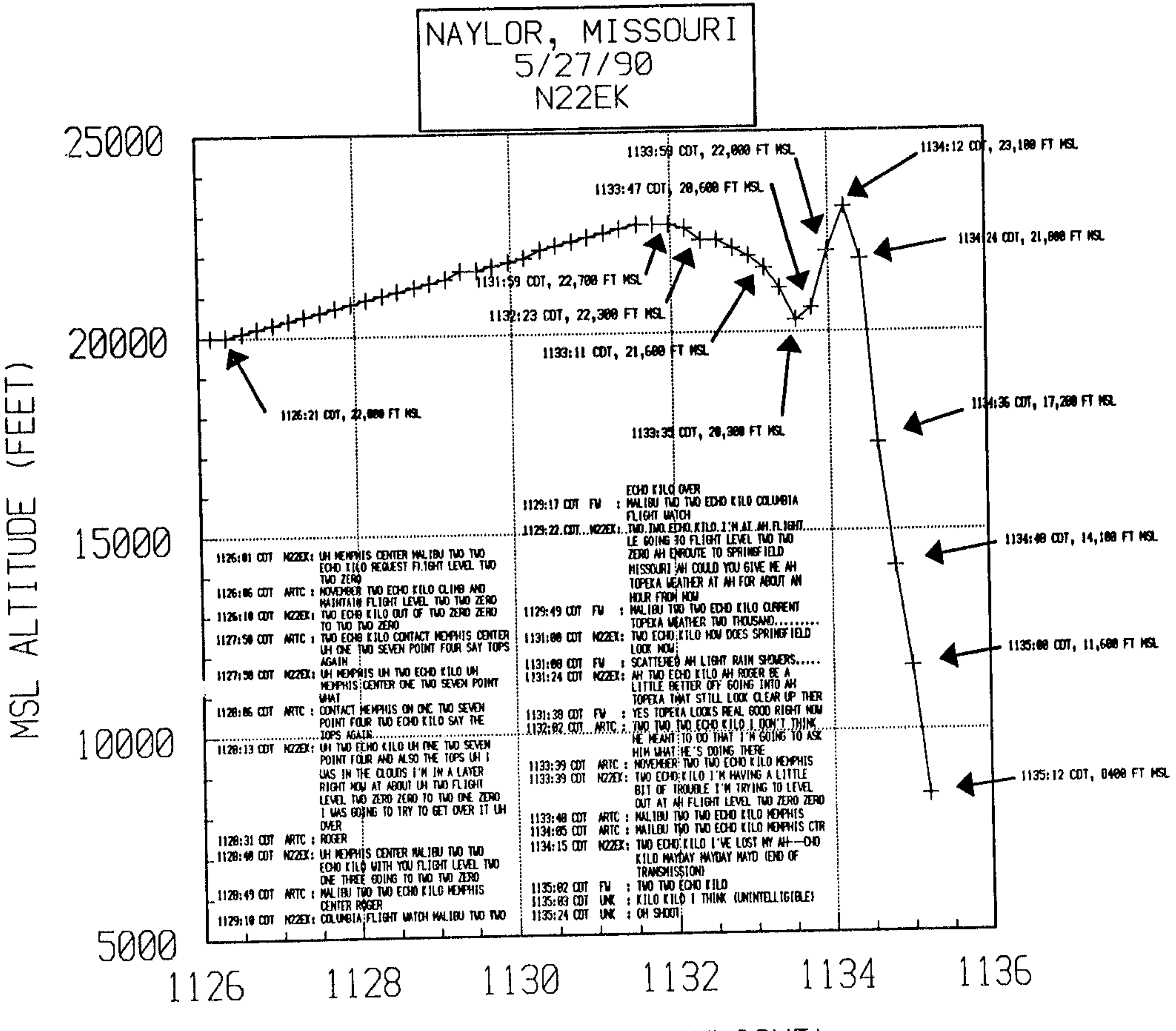
Flightpath Study

The flightpath study conducted from ATC radar data (See Figures 6 and 7) for this accident by Safety Board airplane performance engineers showed that as it ascended from FL200 to FL227, the airplane was climbing at a rate of about 500 feet per minute and was slowing from about 130 KIAS to about 110 KIAS. The airplane stopped ascending about FL227 and then began to descend for 90 seconds. The airplane descended about 2,300 feet to about FL204, reached a vertical speed of about 3,200 feet per minute during the descent, and the airspeed increased from about 110 KIAS to 198 KIAS. The airplane's descent stopped at FL204, and a climb to FL231 feet began. During the ascent to FL231, the airspeed decreased to well within the range of stall while the airplane achieved a climb angle of about 25 degrees.



NAYLOR, MISSOURI
5/27/90
N22EK
NORTH
EAST
PRIMARY RADAR RETURNS
DISTANCE, NAUTICAL MILES
DISTANCE, NAUTICAL MILES
16
15
14
13
12
11
10
9
8
7
6
-64 -63 -62 -61 -60 -59 -58 -57 -56 -55 -54
1135:12 CDT, 8400 FT MSL
1134:48 CDT, 14,100 FT MSL
1134:12 CDT, 23,100 FT MSL
1133:59 CDT, 22,000 FT MSL
1133:47 CDT, 20,600 FT MSL
1133:35 CDT, 20,300 FT MSL
1133:23 CDT, 21,100 FT MSL
1133:11 CDT, 21,600 FT MSL
1132:59 CDT, 21,900 FT MSL
1132:47 CDT, 22,100 FT MSL
1132:35 CDT, 22,300 FT MSL
1132:23 CDT, 22,300 FT MSL
1132:11 CDT, 22,600 FT MSL
1131:59 CDT, 22,700 FT MSL
1135:00 CDT, 1,600 FT MSL
1134:36 CDT, 17,200 FT MSL
1134:24 CDT, 21,000 FT MSL
1126:01 CDT N22EK: UH MEMPHIS CENTER MALIBU TWO TWO ECHO KILO REQUEST FLIGHT LEVEL TWO TWO ZERO
1126:06 CDT ARTC : NOVEMBER TWO ECHO KILO CLIMB AND MAINTAIN FLIGHT LEVEL TWO TWO ZERO
1126:10 CDT N22EK: TWO ECHO KILO OUT OF TWO ZERO ZERO TO TWO TWO ZERO
1127:50 CDT ARTC : TWO ECHO KILO CONTACT MEMPHIS CENTER UH ONE TWO SEVEN POINT FOUR SAY TOPS AGAIN
1127:58 CDT N22EK: UH MEMPHIS UH TWO ECHO KILO UH MEMPHIS CENTER ONE TWO SEVEN POINT WHAT
1128:06 CDT ARTC : CONTACT MEMPHIS ON ONE TWO SEVEN POINT FOUR TWO ECHO KILO SAY THE TOPS AGAIN
1128:13 CDT N22EK: UH TWO ECHO KILO UH ONE TWO SEVEN POINT FOUR AND ALSO THE TOPS UH I WAS IN THE CLOUDS I'M IN A LAYER RIGHT NOW AT ABOUT UH TWO FLIGHT LEVEL TWO ZERO ZERO TO TWO ONE ZERO I WAS GOING TO TRY TO GET OVER IT UH OVER
1128:34 CDT ARTC : ROGER
1128:40 CDT N22EK: UH MEMPHIS CENTER MALIBU TWO TWO ECHO KILO WITH YOU FLIGHT LEVEL TWO ONE THREE GOING TO TWO TWO ZERO
1128:49 CDT ARTC : MALIBU TWO TWO ECHO KILO MEMPHIS CENTER ROGER
1129:10 CDT N22EK: COLUMBIA FLIGHT WATCH MALIBU TWO TWO ECHO KILO OVER
1129:17 CDT FW : MALIBU TWO TWO ECHO KILO COLUMBIA FLIGHT WATCH
1129:22 CDT N22EK: TWO TWO ECHO KILO I'M AT AH FLIGHT LE GOING TO FLIGHT LEVEL TWO TWO ZERO AH ENROUTE TO SPRINGFIELD MISSOURI AH COULD YOU GIVE ME AH TOPEKA WEATHER AT AH FOR ABOUT AN HOUR FROM NOW
1129:49 CDT FW : MALIBU TWO TWO ECHO KILO CURRENT TOPEKA WEATHER TWO THOUSAND........
1131:00 CDT N22EK: TWO ECHO KILO HOW DOES SPRINGFIELD LOOK NOW
1131:08 CDT FW : SCATTERED AH LIGHT RAIN SHOWERS.....
1131:24 CDT N22EK: AH TWO ECHO KILO AH ROGER BE A LITTLE BETTER OFF GOING INTO AH TOPEKA THAT STILL LOOK CLEAR UP THER
1131:30 CDT FW : YES TOPEKA LOOKS REAL GOOD RIGHT NOW
1132:02 CDT ARTC : TWO TWO TWO ECHO KILO I DON'T THINK HE MEANT TO DO THAT I'M GOING TO ASK HIM WHAT HE'S DOING THERE
1133:39 CDT ARTC : NOVEMBER TWO TWO ECHO KILO MEMPHIS
1133:39 CDT N22EK: TWO ECHO KILO I'M HAVING A LITTLE BIT OF TROUBLE I'M TRYING TO LEVEL OUT AT AH FLIGHT LEVEL TWO ZERO ZERO
1133:48 CDT ARTC : MALIBU TWO TWO ECHO KILO MEMPHIS
1134:05 CDT ARTC : MAILBU TWO TWO ECHO KILO MEMPHIS CTR
1134:15 CDT N22EK: TWO ECHO KILO I'VE LOST MY AH ECHO KILO MAYDAY MAYDAY MAYD (END OF TRANSMISSION)
1135:02 CDT FW : TWO TWO ECHO KILO
1135:03 CDT UNK : KILO KILO I THINK (UNINTELLIGIBLE)
1135:24 CDT UNK : OH SHOOT

FIGURE 6



NAYLOR, MISSOURI
5/27/90
N22EK
MSL ALTITUDE (FEET)
25000
20000
15000
10000
5000
1126
1128
1130
1132
1134
1136
TIME (CENTRAL DAYLIGHT)
1126:21 CDT, 22,000 FT MSL
1131:59 CDT, 22,700 FT MSL
1132:23 CDT, 22,300 FT MSL
1133:11 CDT, 21,600 FT MSL
1133:35 CDT, 20,300 FT MSL
1133:47 CDT, 20,600 FT MSL
1133:59 CDT, 22,000 FT MSL
1134:12 CDT, 23,100 FT MSL
1134:24 CDT, 21,000 FT MSL
1134:36 CDT, 17,200 FT MSL
1134:48 CDT, 14,100 FT MSL
1135:00 CDT, 11,600 FT MSL
1135:12 CDT, 0400 FT MSL
1126:01 CDT N22EK: UH MEMPHIS CENTER MALIBU TWO TWO ECHO KILO REQUEST FLIGHT LEVEL TWO TWO ZERO
1126:06 CDT ARTC : NOVEMBER TWO ECHO KILO CLIMB AND MAINTAIN FLIGHT LEVEL TWO TWO ZERO
1126:10 CDT N22EK: TWO ECHO KILO OUT OF TWO ZERO ZERO TO TWO TWO ZERO
1127:50 CDT ARTC : TWO ECHO KILO CONTACT MEMPHIS CENTER UH ONE TWO SEVEN POINT FOUR SAY TOPS AGAIN
1127:58 CDT N22EK: UH MEMPHIS UH TWO ECHO KILO UH MEMPHIS CENTER ONE TWO SEVEN POINT WHAT
1128:06 CDT ARTC : CONTACT MEMPHIS ON ONE TWO SEVEN POINT FOUR TWO ECHO KILO SAY THE TOPS AGAIN
1128:13 CDT N22EK: UH TWO ECHO KILO UH ONE TWO SEVEN POINT FOUR AND ALSO THE TOPS UH I WAS IN THE CLOUDS I'M IN A LAYER RIGHT NOW AT ABOUT UH TWO FLIGHT LEVEL TWO ZERO ZERO TO TWO ONE ZERO I WAS GOING TO TRY TO GET OVER IT UH OVER
1128:31 CDT ARTC : ROGER
1128:40 CDT N22EK: UH MEMPHIS CENTER MALIBU TWO TWO ECHO KILO WITH YOU FLIGHT LEVEL TWO ONE THREE GOING TO TWO TWO ZERO
1128:49 CDT ARTC : MALIBU TWO TWO ECHO KILO MEMPHIS CENTER ROGER
1129:10 CDT N22EK: COLUMBIA FLIGHT WATCH MALIBU TWO TWO ECHO KILO OVER
1129:17 CDT FW : MALIBU TWO TWO ECHO KILO COLUMBIA FLIGHT WATCH
1129:22 CDT N22EK: TWO TWO ECHO KILO I'M AT AH FLIGHT LE GOING TO FLIGHT LEVEL TWO TWO ZERO AH ENROUTE TO SPRINGFIELD MISSOURI AH COULD YOU GIVE ME AH TOPEKA WEATHER AT AH FOR ABOUT AN HOUR FROM NOW
1129:49 CDT FW : MALIBU TWO TWO ECHO KILO CURRENT TOPEKA WEATHER TWO THOUSAND.........
1131:00 CDT N22EK: TWO ECHO KILO HOW DOES SPRINGFIELD LOOK NOW
1131:08 CDT FW : SCATTERED AH LIGHT RAIN SHOWERS.....
1131:24 CDT N22EK: AH TWO ECHO KILO AH ROGER BE A LITTLE BETTER OFF GOING INTO AH TOPEKA THAT STILL LOOK CLEAR UP THER
1131:38 CDT FW : YES TOPEKA LOOKS REAL GOOD RIGHT NOW
1132:02 CDT ARTC : TWO TWO TWO ECHO KILO I DON'T THINK HE MEANT TO DO THAT I'M GOING TO ASK HIM WHAT HE'S DOING THERE
1133:39 CDT ARTC : NOVEMBER TWO TWO ECHO KILO MEMPHIS
1133:39 CDT N22EK: TWO ECHO KILO I'M HAVING A LITTLE BIT OF TROUBLE I'M TRYING TO LEVEL OUT AT AH FLIGHT LEVEL TWO ZERO ZERO
1133:48 CDT ARTC : MALIBU TWO TWO ECHO KILO MEMPHIS
1134:05 CDT ARTC : MAILBU TWO TWO ECHO KILO MEMPHIS CTR
1134:15 CDT N22EK: TWO ECHO KILO I'VE LOST MY AH--CHO KILO MAYDAY MAYDAY MAYD (END OF TRANSMISSION)
1135:02 CDT FW : TWO TWO ECHO KILO
1135:03 CDT UNK : KILO KILO I THINK (UNINTELLIGIBLE)
1135:24 CDT UNK : OH SHOOT

FIGURE 7

Correlation of the communications transcripts with the flightpath study revealed that near FL204 where the airplane began to climb to FL 231, the pilot remarked on the radio to the Columbia FSS that he was "...having a little bit of trouble, I'm trying to level out at ah flight level two zero zero." In addition, near the point where the airplane apparently stalled at FL231, the pilot transmitted "I've lost my..." Shortly thereafter, the pilot transmitted a "Mayday."

Lakeville, Michigan (About 30 miles Southeast of Flint, Michigan)

History of the Flight

On June 26, 1990, a Piper PA-46-310P Malibu, N315RC, en route from Flint, Michigan, to Akron, Ohio, entered a high-speed descent from about 13,900 feet and crashed near Lakeville, Michigan, about 1617 eastern daylight time. The pilot and sole occupant was killed, and the airplane was destroyed.

The pilot received a weather briefing from the Lansing FSS about 1542 after which he filed an IFR flight plan to Akron. The route forecast for Flint through southern Michigan was as follows: clouds -- 3,500 feet scattered to broken, 6,000 feet scattered to broken, 20,000 feet broken; visibility -- unrestricted; winds -- 220° at 14 with gusts to 24 knots; and a chance of 2,000 feet overcast and 2 miles in thunderstorms or rainshowers. The pilot filed for an en route altitude of 12,000 feet. According to meteorological soundings at Flint at 0800 and 2000, the freezing level was at 12,507 feet and 12,854 feet, respectively.

At 1605:27, the pilot of N315RC contacted the Cleveland Center and indicated that he was climbing out of 6,000 feet for 8,000 feet. The Cleveland controller (Flint Sector) responded and cleared the pilot to climb to 15,000 feet. At 1607:23, the controller asked for a good rate of climb through 14,000 feet after which the pilot could fly direct to Windsor. The pilot acknowledged the request and clearance. At 1613:36, the Flint Sector controller said "Five Romeo Charlie, direct to Windsor now, and contact Cleveland Center on one two five point six, good day." At 1613:43, the pilot responded "one two five point six, thank you." That was the last known transmission from the pilot of N315RC.

At 1616:32, the Flint Sector controller called the Windsor Sector controller and asked the latter if he was talking to N315RC. The Windsor Sector controller responded negatively. At 1616:44, the Flint Sector controller stated, "I just lost radar with him."

Weather

The 1626 weather radar observation from the Detroit Metropolitan/Wayne County Airport showed the accident site within an area of 2/10 moderate rain showers and 3/10 light rain. The 1555 weather observation at Pontiac, Michigan, in part was as follows:

ceiling -- estimated 6,000 feet broken, 10,000 feet overcast; visibility -- 7 miles; temperature--76°F. The 1645 observation in part was as follows: ceiling -- measured 1,600 feet broken, 5,000 feet overcast; visibility -- 8 miles; temperature 73°F.

Pilot

The pilot, age 57, had a private pilot certificate with airplane single-engine land and instrument ratings. According to his personal flight log, he had a total of about 983 flight hours which included about 116 actual instrument hours and 50 hours of simulated instrument time. He had flown about 197 hours in the PA-46. He had flown about 17 hours and 45 hours in the PA-46 during the preceding 30-day and 90-day periods, respectively, which included 4.1 hours and 18.0 hours of instrument flight, respectively. He had completed a biennial flight review about 10 months before the accident.

The pilot attended the PAC training school for the PA-46 in August 1989, and he received his instrument rating in September 1989. He had failed his first flight check for the instrument rating but, according to his flight instructor, after additional training, he successfully passed his next flight check.

The pilot had a third class medical certificate which was issued on January 23, 1990, with limitations that corrective lenses be worn during flight. An autopsy revealed no significant medical problems, and toxicological tests were negative for alcohol and illicit and licit drugs. The pilot died of multiple injuries related to the crash.

According to representatives of the company that sold N315RC to the pilot, they declined to sell the airplane to the pilot until he agreed to obtain 25 hours of instruction from an approved instructor, to obtain an instrument rating, and to attend the PAC training course. The pilot complied with this agreement and purchased the airplane in July 1989. The airplane was released to the pilot with his instructor designated as the pilot-in-command (PIC).

According to his flight instructor, the pilot of N315RC probably would have used the airplane's autopilot routinely for all phases of flight except takeoff and landing. This included the use of the altitude preselect and vertical speed select features of the KAS 297B that was in the airplane.

Airplane

N315RC, Serial No. 46-8508044, was owned by the D & M Express Co. of Akron, Ohio. The accident pilot was the president of D&M Express Co. The airplane had accumulated a total of about 710 flight hours and about 7 hours since its last annual inspection, which was completed on June 1, 1990. The Continental model TS10-520BE engine had a total of about 358 hours. The airplane had an estimated 92 gallons of fuel onboard, and its weight and balance were within prescribed limits. N315RC was equipped with a color weather radar and a stormscope.

Wreckage

The main wreckage site was in a pond at latitude 42° 50' 51" North and longitude 83° 07' 48" West. The elevation of the site was about 1,000 feet msl. A wreckage path extended east-northeast of the main site for about 2 miles. The fuselage was inverted in about 4 feet of water at the main site. All major components of the airplane were accounted for except the outboard portions of the left wing and left aileron, portions of the vertical stabilizer, and the outboard portion of the left elevator, including the balance weight.

The outboard panel of the right wing was located about 0.7 miles east-northeast of the main wreckage site; the panel had separated near the production splice in the spars. The upper cap of the main spar was fractured with upward deformation near both faces of the fracture. On the inboard section of the right wing, the web of the main spar was separated from its lower cap for about 2 feet inboard of the fracture face of the main spar.

The inboard section of the left wing was attached to the fuselage. The outboard section had separated slightly outboard of the production splice; it was not recovered. The fractures and associated deformations indicated downward loading of the outboard panel during separation.

The right horizontal stabilizer was located about 0.3 mile east-northeast of the main wreckage; the right portion of the elevator was attached to the main spar of the horizontal stabilizer by the outboard hinge. The stabilizer was twisted nose down about 140 degrees, and the front stub spar was bent aft about 60 degrees. The attached portion of the right portion of the elevator was twisted trailing edge down over the length of the right main spar. The elevator trim tab fittings and actuator rods were attached to the trim tab.

The outboard portion of the left side of the elevator was not located. The main spar of the left horizontal stabilizer was bent aft and twisted leading edge down. The skin from the left horizontal stabilizer had separated; it was located about 1.5 miles east-northeast of the main wreckage site. The vertical stabilizer was missing and was not located.

The fuselage was flattened to about one-half of its normal height. The cabin door handle was in the closed and locked position; the door was essentially intact.

The cockpit area was extensively damaged, and the instrument panel was destroyed. The position of switches and controls could not be determined except that the pitot heat switch was off and the induction air selector was in the primary position. Primary gyro instruments were disassembled, and internal rotational scoring was evident.

The landing gear was retracted. Examination of the engine disclosed no evidence of preimpact damage or malfunction. Continuity between the vacuum pump shaft and the propeller shaft was established -- the latter could be rotated about 10 degrees. One blade of the propeller was bent aft about 10 degrees. The other blade had no significant bend or twist. The leading edges of the blades were clear and free of gouges.

Flightpath Study

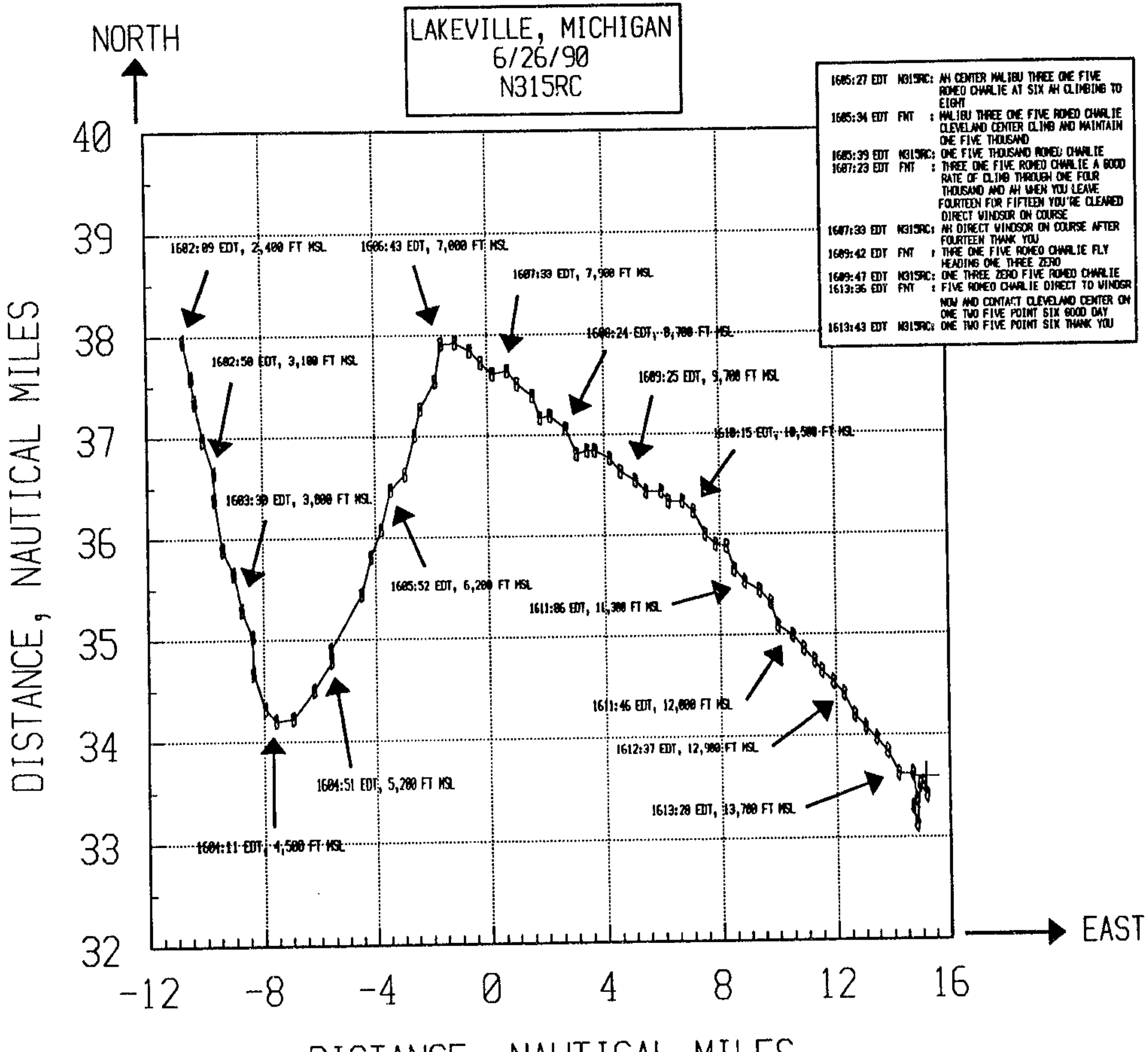
A flightpath study of ATC radar data (See Figures 8, 9 and 10) was conducted for the accident by Safety Board airplane performance engineers. The study revealed that the airplane climbed at a steady rate of about 1,000 fpm during the climb phase of the flight, and the indicated airspeed decreased from about 120 KIAS to 110 KIAS near 13,300 feet. Near 13,900 feet, the airspeed decreased to less than 80 KIAS, and the airplane made a shallow turn to the left followed by a steeper turn to the right. The airplane then entered a rapid descent with some maneuvering as the airspeed rapidly increased. According to the airplane flight manual for the PA-46-310P, the maximum rate of climb expected at 14,000 feet with an indicated airspeed of 110 knots, and at the assumed weight of the accident airplane, was about 1,200 fpm if the engine was operated at normal climb power. A trajectory study based on the radar data and wreckage scatter indicates that the airplane broke apart in a rapid descent between 9,000 feet and 6,000 feet.

Hermosillo, Mexico

On September 3, 1990, a Piper PA-46-310P, Mexican registry XB-EWP, en route from Los Noaches, Mexico, to Tijuana, Mexico, on a visual flight rules (VFR) flight plan crashed near Hermosillo, Mexico. The pilot and three passengers were killed, and the airplane was destroyed. Information supplied by the Mexican civil aviation authorities indicates that witnesses saw the airplane fly into a large storm cloud and pieces of the airplane fall to the ground.

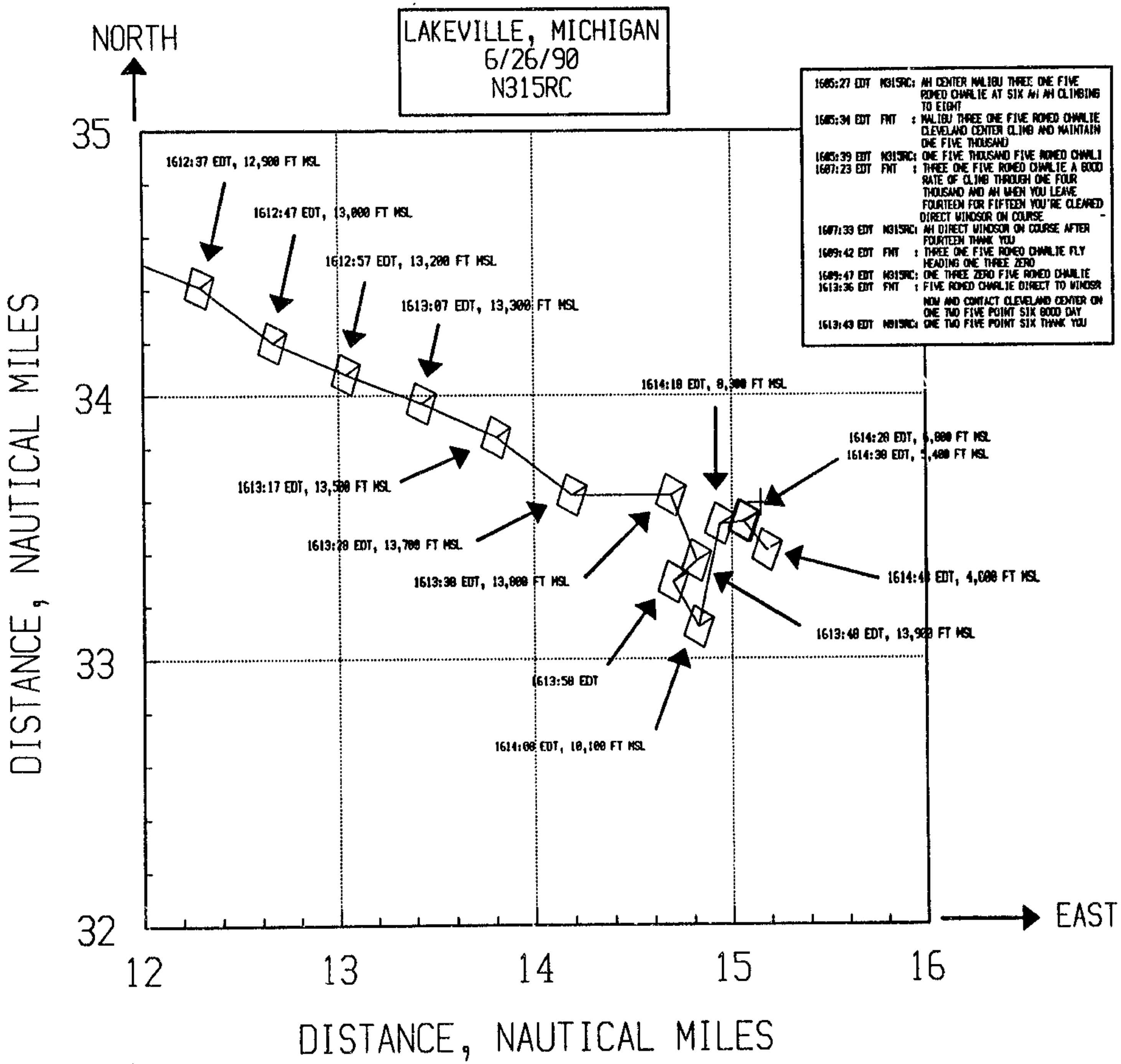
Tottori, Japan

On November 17, 1990, a Piper PA-46-310P, Japanese registry JA3990, en route from Tottori, Japan, to Yao, Japan, on a night visual flight rules (VFR) flight plan crashed near the Tottori Airport. The pilot and two passengers were killed. Information provided by the Japanese Aircraft Accident Investigation Commission (AAIC) indicates that after departure from the Tottori Airport, the pilot orbited above the field while climbing to cruise altitude in order to cross a coastal mountain range. The AAIC investigation estimated that the airplane achieved an altitude of 5,500 feet msl when it suddenly entered an uncontrolled descent and crashed about 2.5 kilometers south-southeast of the airport. The accident occurred during the hours of darkness. Weather conditions in the area consisted of scattered to broken clouds based near 5,000 feet msl.



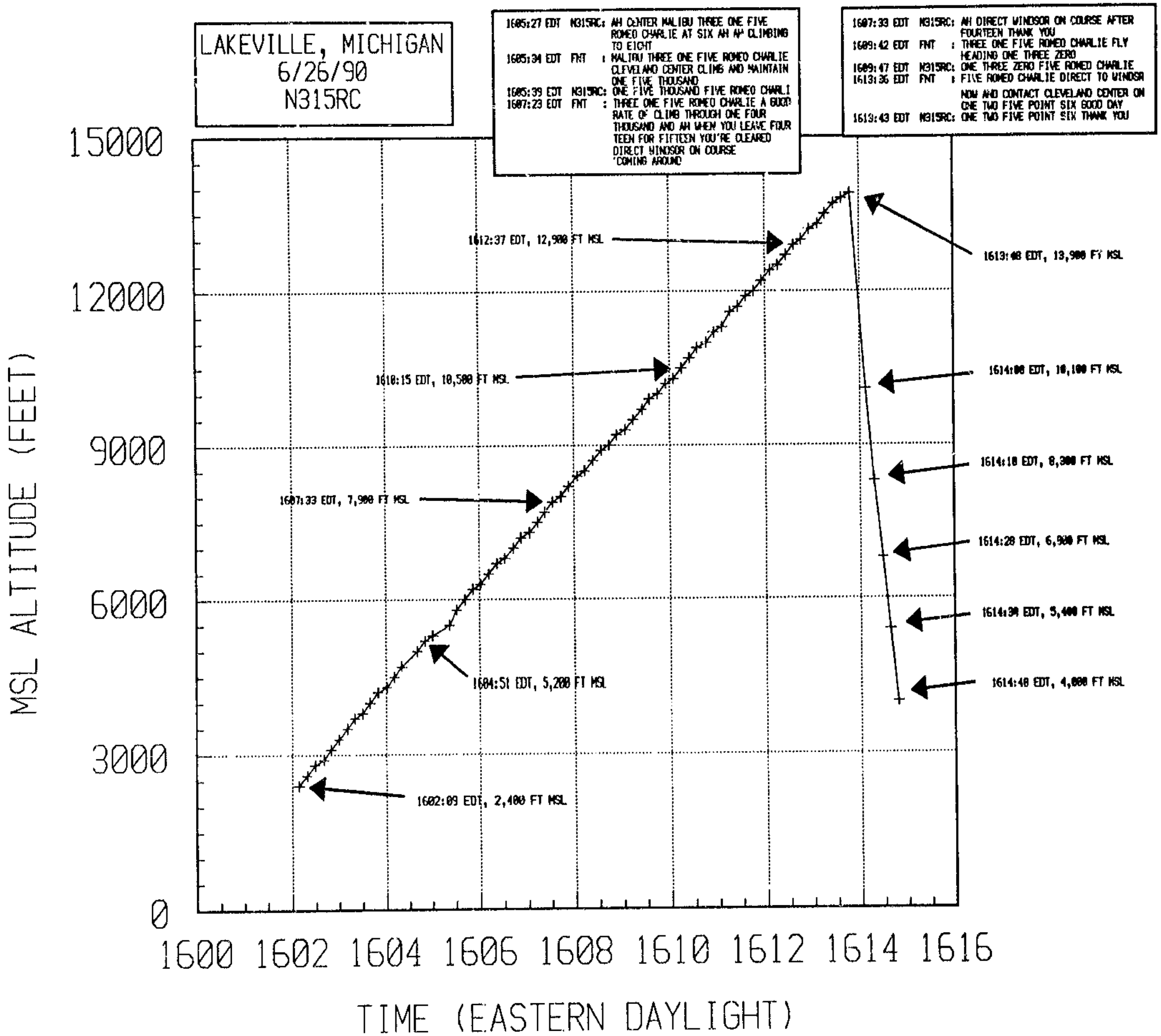
LAKEVILLE, MICHIGAN
6/26/90
N315RC
NORTH
EAST
40
39
38
37
36
35
34
33
32
-12
-8
-4
0
4
8
12
16
DISTANCE, NAUTICAL MILES
DISTANCE, NAUTICAL MILES
1602:09 EDT, 2,400 FT MSL
1602:50 EDT, 3,100 FT MSL
1603:30 EDT, 3,800 FT MSL
1604:11 EDT, 4,500 FT MSL
1604:51 EDT, 5,200 FT MSL
1605:52 EDT, 6,200 FT MSL
1606:43 EDT, 7,000 FT MSL
1607:33 EDT, 7,900 FT MSL
1608:24 EDT, 8,700 FT MSL
1609:25 EDT, 9,700 FT MSL
1610:15 EDT, 10,500 FT MSL
1611:06 EDT, 11,300 FT MSL
1611:46 EDT, 12,000 FT MSL
1612:37 EDT, 12,900 FT MSL
1613:28 EDT, 13,700 FT MSL
1605:27 EDT N315RC: AH CENTER MALIBU THREE ONE FIVE ROMEO CHARLIE AT SIX AH CLIMBING TO EIGHT
1605:34 EDT FNT : MALIBU THREE ONE FIVE ROMEO CHARLIE CLEVELAND CENTER CLIMB AND MAINTAIN ONE FIVE THOUSAND
1605:39 EDT N315RC: ONE FIVE THOUSAND ROMEO CHARLIE
1607:23 EDT FNT : THREE ONE FIVE ROMEO CHARLIE A GOOD RATE OF CLIMB THROUGH ONE FOUR THOUSAND AND AH WHEN YOU LEAVE FOURTEEN FOR FIFTEEN YOU'RE CLEARED DIRECT WINDSOR ON COURSE
1607:33 EDT N315RC: AH DIRECT WINDSOR ON COURSE AFTER FOURTEEN THANK YOU
1609:42 EDT FNT : THRE ONE FIVE ROMEO CHARLIE FLY HEADING ONE THREE ZERO
1609:47 EDT N315RC: ONE THREE ZERO FIVE ROMEO CHARLIE
1613:36 EDT FNT : FIVE ROMEO CHARLIE DIRECT TO WINDSR NOW AND CONTACT CLEVELAND CENTER ON ONE TWO FIVE POINT SIX GOOD DAY
1613:43 EDT N315RC: ONE TWO FIVE POINT SIX THANK YOU

FIGURE 8



LAKEVILLE, MICHIGAN
6/26/90
N315RC
NORTH
EAST
1605:27 EDT N315RC: AH CENTER MALIBU THREE ONE FIVE ROMEO CHARLIE AT SIX AH AH CLIMBING TO EIGHT
1605:34 EDT FNT : MALIBU THREE ONE FIVE ROMEO CHARLIE CLEVELAND CENTER CLIMB AND MAINTAIN ONE FIVE THOUSAND
1605:39 EDT N315RC: ONE FIVE THOUSAND FIVE ROMEO CHARLI
1607:23 EDT FNT : THREE ONE FIVE ROMEO CHARLIE A GOOD RATE OF CLIMB THROUGH ONE FOUR THOUSAND AND AH WHEN YOU LEAVE FOURTEEN FOR FIFTEEN YOU'RE CLEARED DIRECT WINDSOR ON COURSE
1607:33 EDT N315RC: AH DIRECT WINDSOR ON COURSE AFTER FOURTEEN THANK YOU
1609:42 EDT FNT : THREE ONE FIVE ROMEO CHARLIE FLY HEADING ONE THREE ZERO
1609:47 EDT N315RC: ONE THREE ZERO FIVE ROMEO CHARLIE
1613:36 EDT FNT : FIVE ROMEO CHARLIE DIRECT TO WINDSR NOW AND CONTACT CLEVELAND CENTER ON ONE TWO FIVE POINT SIX GOOD DAY
1613:43 EDT N315RC: ONE TWO FIVE POINT SIX THANK YOU
1612:37 EDT, 12,900 FT MSL
1612:47 EDT, 13,000 FT MSL
1612:57 EDT, 13,200 FT MSL
1613:07 EDT, 13,300 FT MSL
1613:17 EDT, 13,500 FT MSL
1613:20 EDT, 13,700 FT MSL
1613:30 EDT, 13,800 FT MSL
1613:40 EDT, 13,9 0 FT MSL
1613:50 EDT
1614:00 EDT, 10,100 FT MSL
1614:10 EDT, 8,300 FT MSL
1614:20 EDT, ,000 FT MSL
1614:30 EDT, ,400 FT MSL
1614:4 EDT, 4,000 FT MSL
35
34
33
32
12
13
14
15
16
DISTANCE, NAUTICAL MILES
DISTANCE, NAUTICAL MILES

FIGURE 9



LAKEVILLE, MICHIGAN
6/26/90
N315RC
1605:27 EDT N315RC: AH CENTER MALIBU THREE ONE FIVE ROMEO CHARLIE AT SIX AH AH CLIMBING TO EIGHT
1605:34 EDT FNT : MALIBU THREE ONE FIVE ROMEO CHARLIE CLEVELAND CENTER CLIMB AND MAINTAIN ONE FIVE THOUSAND
1605:39 EDT N315RC: ONE FIVE THOUSAND FIVE ROMEO CHARLI
1607:23 EDT FNT : THREE ONE FIVE ROMEO CHARLIE A GOOD RATE OF CLIMB THROUGH ONE FOUR THOUSAND AND AH WHEN YOU LEAVE FOUR TEEN FOR FIFTEEN YOU'RE CLEARED DIRECT WINDSOR ON COURSE
'COMING AROUND
1607:33 EDT N315RC: AH DIRECT WINDSOR ON COURSE AFTER FOURTEEN THANK YOU
1609:42 EDT FNT : THREE ONE FIVE ROMEO CHARLIE FLY HEADING ONE THREE ZERO
1609:47 EDT N315RC: ONE THREE ZERO FIVE ROMEO CHARLIE
1613:36 EDT FNT : FIVE ROMEO CHARLIE DIRECT TO WINDSR NOW AND CONTACT CLEVELAND CENTER ON ONE TWO FIVE POINT SIX GOOD DAY
1613:43 EDT N315RC: ONE TWO FIVE POINT SIX THANK YOU
1612:37 EDT, 12,900 FT MSL
1613:48 EDT, 13,900 FT MSL
1610:15 EDT, 10,500 FT MSL
1614:08 EDT, 10,100 FT MSL
1614:18 EDT, 8,300 FT MSL
1607:33 EDT, 7,900 FT MSL
1614:28 EDT, 6,900 FT MSL
1614:38 EDT, 5,400 FT MSL
1604:51 EDT, 5,200 FT MSL
1614:48 EDT, 4,000 FT MSL
1602:09 EDT, 2,400 FT MSL
15000
12000
9000
6000
3000
0
MSL ALTITUDE (FEET)
1600 1602 1604 1606 1608 1610 1612 1614 1616
TIME (EASTERN DAYLIGHT)

FIGURE 10

Based on interviews with the pilot's associates and his flight instructor, the AAIC concluded that the noninstrument rated pilot was using the autopilot during the climb phase of the flight. Examination of the wreckage disclosed in-flight structural failures from excessive loads and stresses on the airframe.

The pilot of JA3990, age 46, held a Japanese private pilot certificate with an airplane single-engine land rating; he had no instrument rating. His second class medical certificate was issued on October 3, 1990. He had about 440 flight hours of which 150 were in the PA-46.

Ocala, Florida

History of the Flight

On March 16, 1991, the pilot of a Piper PA-46-310P Malibu, N26033, en route from Naples, Florida, to Charlotte, North Carolina, on an IFR flight plan, descended out of control from about FL183 to about 3,000 msl feet near Ocala, Florida. The pilot and his five passengers were not injured, but the airplane was damaged. Numerous rivets in the structure were loosened, the elevator trim tab was bent, and the right wheel well door was missing.

According to the pilot's postincident statement, he was level at FL180 when he noticed some cumulus buildups about 5 miles ahead of the airplane. He requested a clearance for a higher altitude and was cleared by Jacksonville Center to climb to and maintain FL200. The pilot said that he selected 20,000 feet on the altitude preselect unit and programmed the autopilot for a 500 fpm climb rate. The pilot stated that as soon as the autopilot was engaged in the climb mode, the airplane suddenly pitched up to a very nose-high attitude. He first noticed something was wrong as the airplane pitched higher than he expected. He then disengaged the autopilot as the indicated airspeed reached zero and the airplane stalled. At that point, the pilot remembered having observed the manual pitch trim wheel complete its movement to the full nose-up position. He said that he attempted to push forward on the controls and that the airplane then entered a left spin or spiral into the clouds. The pilot said that the uncontrolled descent in a spin or spiral continued until he was able to recover the airplane when it exited the clouds near 3,000 feet. The pilot said that he thought that he might have effected a recovery near 7,000 feet; however, the airplane reentered the spin or spiral.

Correlations of ATC radar data to the radio communications transcripts showed that during a sharp right turn to the northeast and a descent from FL181 to 16,700 feet, the pilot reported that "we caught a down draft - gonna go to 16 thousand." The airplane reached 16,700 feet and then climbed to FL181 and started down again. About 12 seconds later, as the airplane descended through 17,400 feet, the pilot reported "we're trying to get the plane under control right now..."

As the airplane passed 15,000 feet, the pilot reported "I don't know what's happening --- we seem to be diving -- we're not getting any airspeed." Prompted by a comment from a pilot of a commercial airline flight, which was repeated by the Jacksonville controller to the pilot of N26033 to turn on the pitot heat, the pilot, at 1232:03, reported "we just turned it on now -- we got it on now." Sixteen seconds later, the pilot reported "we're not getting any -- we're not getting any indication -- we're not getting any indi." A few seconds later the pilot reported "we can't seem to get the ___ under control." At 1233:35,, the pilot transmitted "we're in VFR - but - the pla___ will not respond to - in - any power setting." Later, ATC asked "can you fly the airplane at all?" and the pilot responded "we're trying to keep it - but - it keeps diving on us." At 1237:06, the pilot reported "Okay sir, we're at three thousand feet_ flying level."

The pilot of N26033 was then provided with radar vectors to the Ocala Airport where an uneventful landing was accomplished.

Weather

According to the 1240 surface weather observation at Gainesville, Florida, the clouds were broken at 1,000 feet agl and overcast at 4,000 feet agl; the visibility was 5 miles in fog. The 1250 observation at Orlando was as follows: clouds--700 feet scattered, 1,600 feet broken, and 4,000 feet overcast; the visibility was 2 miles in light rain and fog. The surface temperature was 58°F and the dew point was 57°F.

Ocala is about 22 miles south-southeast of Gainesville and about 40 miles northwest of Orlando.

Pilot

The pilot, age 43, held a private pilot certificate with airplane single-engine land and instrument ratings. His third class medical certificate was issued on January 16, 1990, with no limitations. He estimated that he had a total time of about 650 flight hours which included about 20 hours of instrument flight time; the latter included 5 to 6 hours in IMC. The pilot had attended the PAC PA-46 school for owners and pilots in 1990, and he had flown the PA-46 about 70 hours.

Flightpath Study

Safety Board airplane performance engineers again used ATC recorded radar data (See Figures 11, 12 and 13) to reconstruct the flightpath of the airplane. The flightpath study revealed that before significant flightpath deviations began, the airplane was at FL181 and heading north at approximately 150 KIAS. At 1228:07, while in a turn to the northwest, the airplane began to descend; it descended about 300 feet and then returned to FL180, at 1228:32, while in a sharp right turn that began about 1228:26. While in the right turn, the

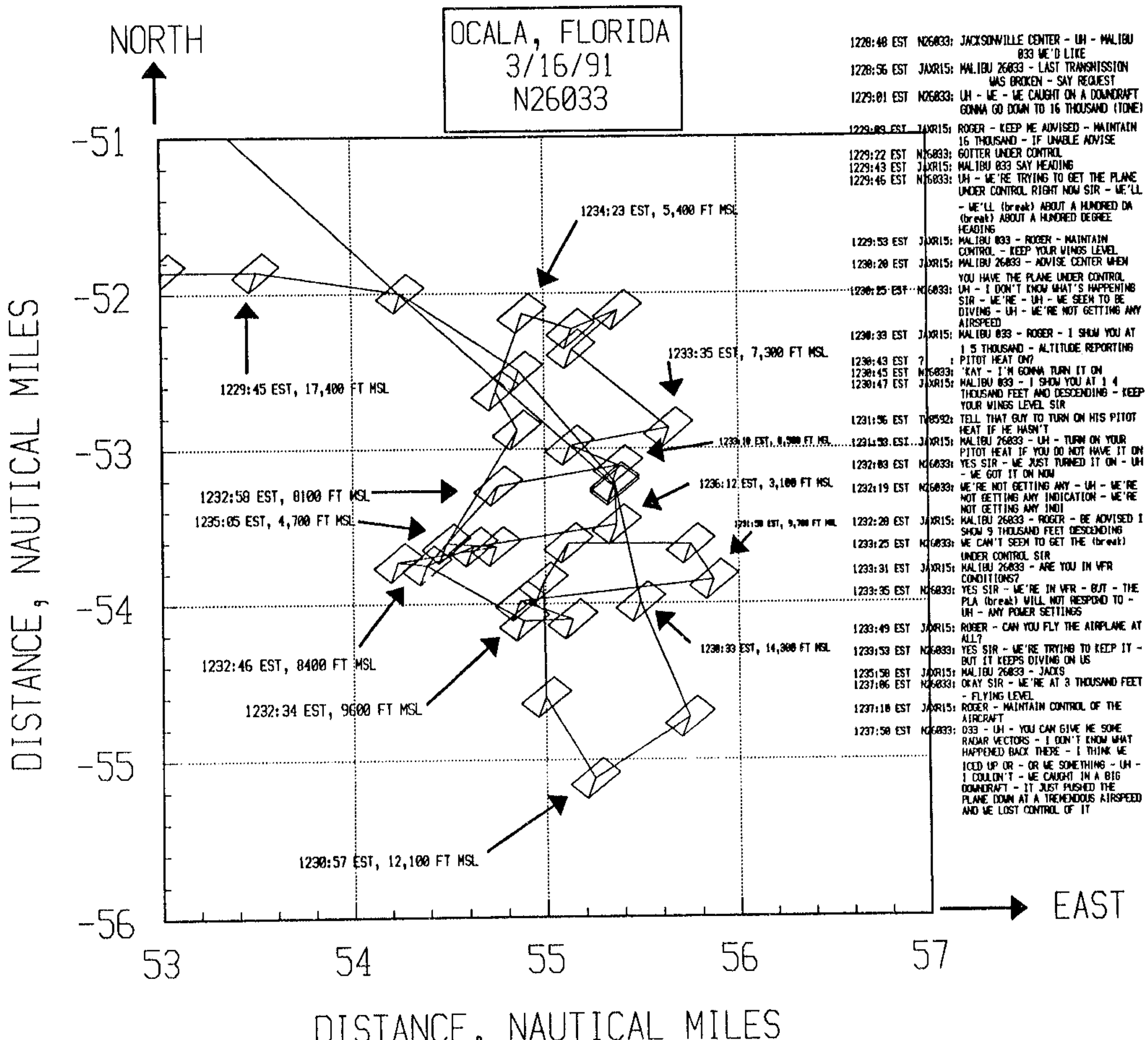

OCALA, FLORIDA
3/16/91
N26033
NORTH
EAST
DISTANCE, NAUTICAL MILES
DISTANCE, NAUTICAL MILES
-51
-52
-53
-54
-55
-56
53
54
55
56
57
1229:45 EST, 17,400 FT MSL
1234:23 EST, 5,400 FT MSL
1233:35 EST, 7,300 FT MSL
1236:12 EST, 3,100 FT MSL
1232:58 EST, 8100 FT MSL
1235:05 EST, 4,700 FT MSL
1232:46 EST, 8400 FT MSL
1232:34 EST, 9600 FT MSL
1230:33 EST, 14,300 FT MSL
1230:57 EST, 12,100 FT MSL
1228:40 EST N26033: JACKSONVILLE CENTER - UH - MALIBU 033 WE'D LIKE
1228:56 EST JAXR15: MALIBU 26033 - LAST TRANSMISSION WAS BROKEN - SAY REQUEST
1229:01 EST N26033: UH - WE - WE CAUGHT ON A DOWNDRAFT GONNA GO DOWN TO 16 THOUSAND (TONE)
1229:09 EST JAXR15: ROGER - KEEP ME ADVISED - MAINTAIN 16 THOUSAND - IF UNABLE ADVISE
1229:22 EST N26033: GOTTER UNDER CONTROL
1229:43 EST JAXR15: MALIBU 033 SAY HEADING
1229:46 EST N26033: UH - WE'RE TRYING TO GET THE PLANE UNDER CONTROL RIGHT NOW SIR - WE'LL - WE'LL (break) ABOUT A HUNDRED DA (break) ABOUT A HUNDRED DEGREE HEADING
1229:53 EST JAXR15: MALIBU 033 - ROGER - MAINTAIN CONTROL - KEEP YOUR WINGS LEVEL
1230:20 EST JAXR15: MALIBU 26033 - ADVISE CENTER WHEN YOU HAVE THE PLANE UNDER CONTROL
1230:25 EST N26033: UH - I DON'T KNOW WHAT'S HAPPENING SIR - WE'RE - UH - WE SEEM TO BE DIVING - UH - WE'RE NOT GETTING ANY AIRSPEED
1230:39 EST JAXR15: MALIBU 033 - ROGER - I SHOW YOU AT 1 5 THOUSAND - ALTITUDE REPORTING
1230:43 EST ? : PITOT HEAT ON?
1230:45 EST N26033: 'KAY - I'M GONNA TURN IT ON
1230:47 EST JAXR15: MALIBU 033 - I SHOW YOU AT 1 4 THOUSAND FEET AND DESCENDING - KEEP YOUR WINGS LEVEL SIR
1231:56 EST TW8592: TELL THAT GUY TO TURN ON HIS PITOT HEAT IF HE HASN'T
1231:58 EST JAXR15: MALIBU 26033 - UH - TURN ON YOUR PITOT HEAT IF YOU DO NOT HAVE IT ON
1232:03 EST N26033: YES SIR - WE JUST TURNED IT ON - UH - WE GOT IT ON NOW
1232:19 EST N26033: WE'RE NOT GETTING ANY - UH - WE'RE NOT GETTING ANY INDICATION - WE'RE NOT GETTING ANY INDI
1232:28 EST JAXR15: MALIBU 26033 - ROGER - BE ADVISED I SHOW 9 THOUSAND FEET DESCENDING
1233:25 EST N26033: WE CAN'T SEEM TO GET THE (break) UNDER CONTROL SIR
1233:31 EST JAXR15: MALIBU 26033 - ARE YOU IN VFR CONDITIONS?
1233:35 EST N26033: YES SIR - WE'RE IN VFR - BUT - THE PLA (break) WILL NOT RESPOND TO - UH - ANY POWER SETTINGS
1233:49 EST JAXR15: ROGER - CAN YOU FLY THE AIRPLANE AT ALL?
1233:53 EST N26033: YES SIR - WE'RE TRYING TO KEEP IT - BUT IT KEEPS DIVING ON US
1235:58 EST JAXR15: MALIBU 26033 - JACKS
1237:06 EST N26033: OKAY SIR - WE'RE AT 3 THOUSAND FEET - FLYING LEVEL
1237:10 EST JAXR15: ROGER - MAINTAIN CONTROL OF THE AIRCRAFT
1237:50 EST N26033: 033 - UH - YOU CAN GIVE ME SOME RADAR VECTORS - I DON'T KNOW WHAT HAPPENED BACK THERE - I THINK WE ICED UP OR - OR WE SOMETHING - UH - I COULDN'T - WE CAUGHT IN A BIG DOWNDRAFT - IT JUST PUSHED THE PLANE DOWN AT A TREMENDOUS AIRSPEED AND WE LOST CONTROL OF IT

FIGURE 11

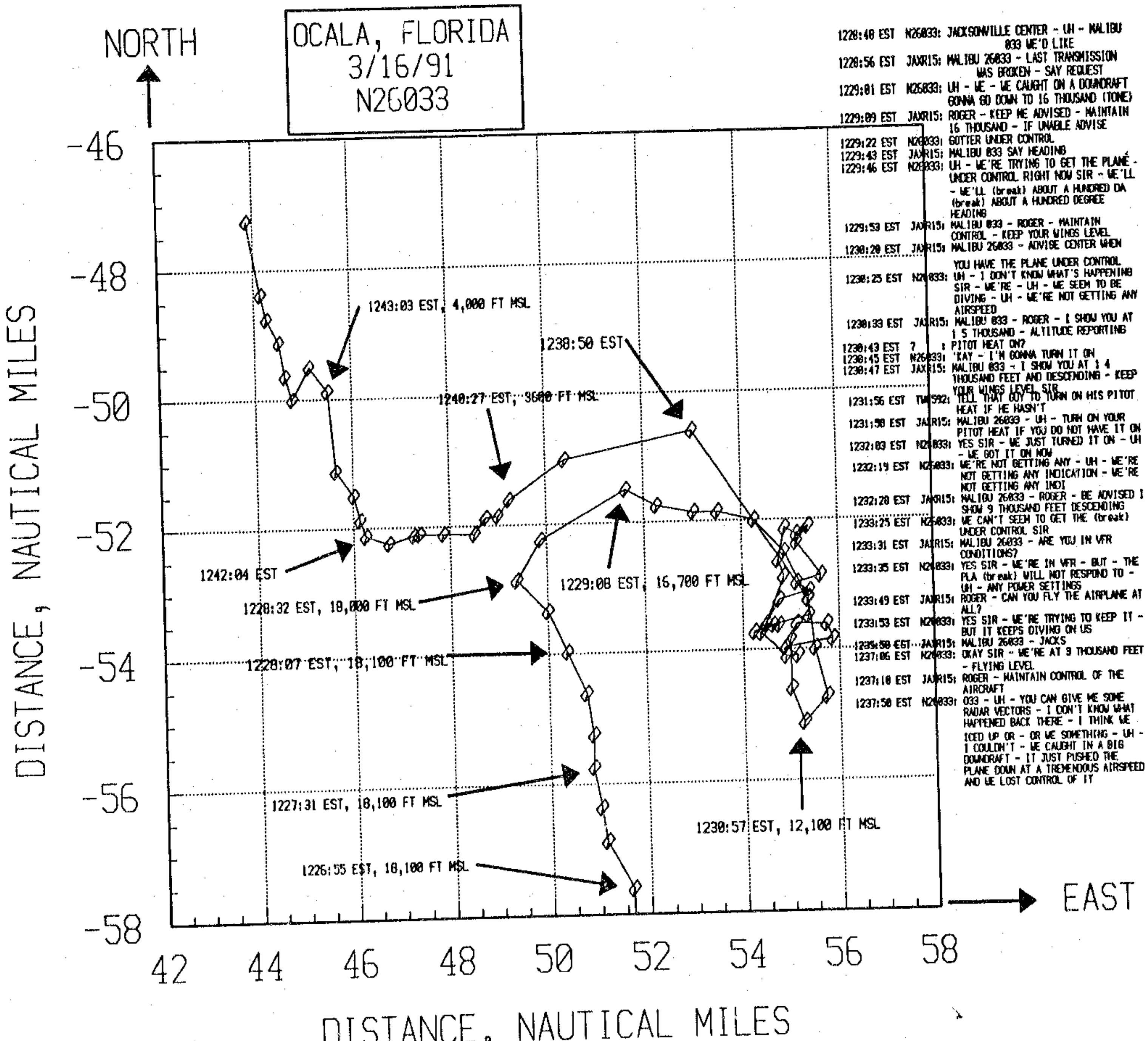
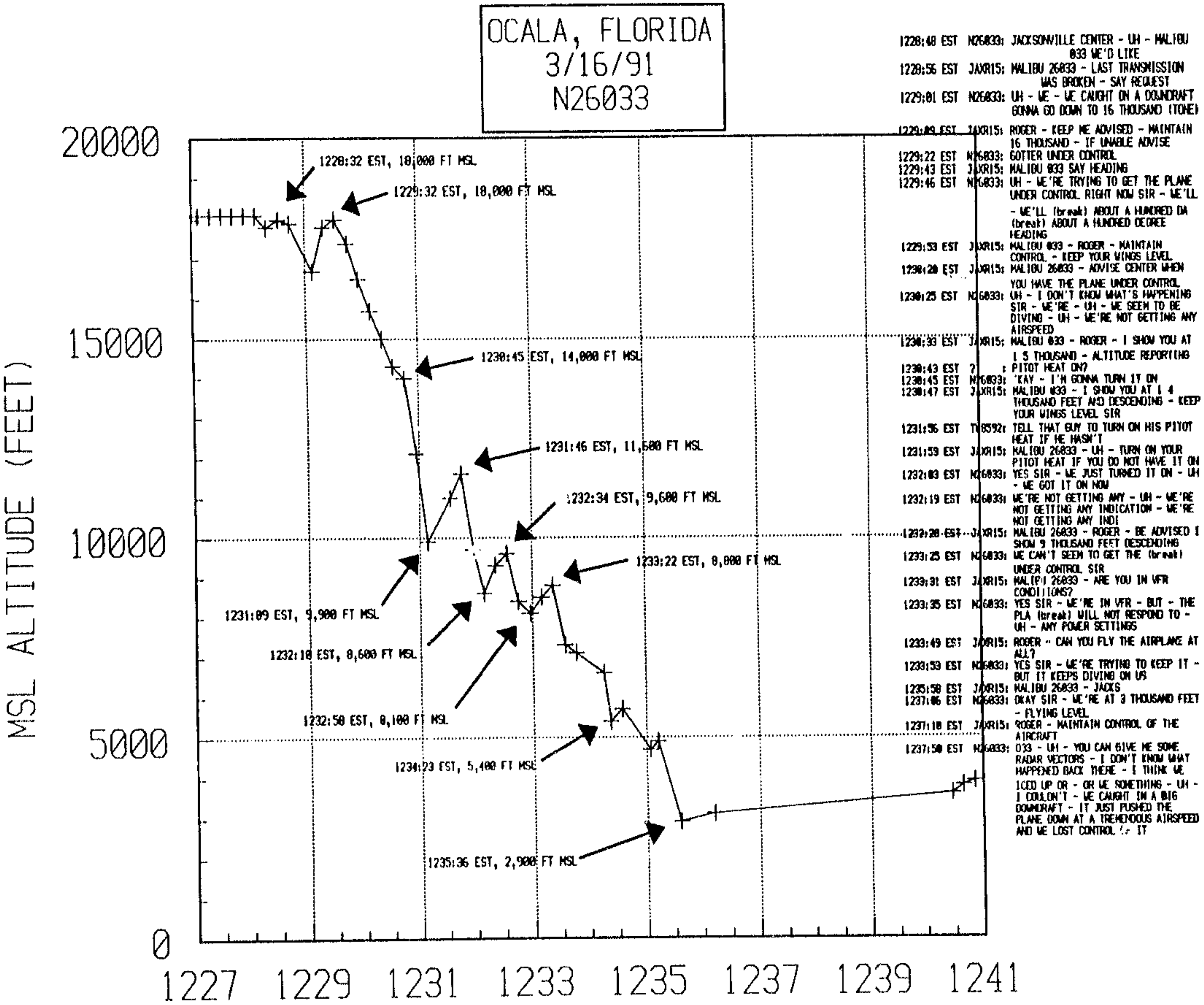

OCALA, FLORIDA
3/16/91
N26033
NORTH
EAST
-46
-48
-50
-52
-54
-56
-58
42
44
46
48
50
52
54
56
58
DISTANCE, NAUTICAL MILES
DISTANCE, NAUTICAL MILES
1243:03 EST, 4,000 FT MSL
1240:27 EST, 3600 FT MSL
1238:50 EST
1242:04 EST
1228:32 EST, 18,000 FT MSL
1229:08 EST, 16,700 FT MSL
1228:07 EST, 18,100 FT MSL
1227:31 EST, 18,100 FT MSL
1226:55 EST, 18,100 FT MSL
1230:57 EST, 12,100 FT MSL
1228:40 EST N26033: JACKSONVILLE CENTER - UH - MALIBU 033 WE'D LIKE
1228:56 EST JAXR15: MALIBU 26033 - LAST TRANSMISSION WAS BROKEN - SAY REQUEST
1229:01 EST N26033: UH - WE - WE CAUGHT ON A DOWNDRAFT GONNA GO DOWN TO 16 THOUSAND (TONE)
1229:09 EST JAXR15: ROGER - KEEP ME ADVISED - MAINTAIN 16 THOUSAND - IF UNABLE ADVISE
1229:22 EST N26033: GOTTER UNDER CONTROL
1229:43 EST JAXR15: MALIBU 033 SAY HEADING
1229:46 EST N26033: UH - WE'RE TRYING TO GET THE PLANE - UNDER CONTROL RIGHT NOW SIR - WE'LL - WE'LL (break) ABOUT A HUNDRED DA (break) ABOUT A HUNDRED DEGREE HEADING
1229:53 EST JAXR15: MALIBU 033 - ROGER - MAINTAIN CONTROL - KEEP YOUR WINGS LEVEL
1230:20 EST JAXR15: MALIBU 26033 - ADVISE CENTER WHEN YOU HAVE THE PLANE UNDER CONTROL
1230:25 EST N26033: UH - I DON'T KNOW WHAT'S HAPPENING SIR - WE'RE - UH - WE SEEM TO BE DIVING - UH - WE'RE NOT GETTING ANY AIRSPEED
1230:33 EST JAXR15: MALIBU 033 - ROGER - I SHOW YOU AT 1 5 THOUSAND - ALTITUDE REPORTING
1230:43 EST ? : PITOT HEAT ON?
1230:45 EST N26033: 'KAY - I'M GONNA TURN IT ON
1230:47 EST JAXR15: MALIBU 033 - I SHOW YOU AT 1 4 THOUSAND FEET AND DESCENDING - KEEP YOUR WINGS LEVEL SIR
1231:56 EST TWA592: TELL THAT GUY TO TURN ON HIS PITOT HEAT IF HE HASN'T
1231:58 EST JAXR15: MALIBU 26033 - UH - TURN ON YOUR PITOT HEAT IF YOU DO NOT HAVE IT ON
1232:03 EST N26033: YES SIR - WE JUST TURNED IT ON - UH - WE GOT IT ON NOW
1232:19 EST N26033: WE'RE NOT GETTING ANY - UH - WE'RE NOT GETTING ANY INDICATION - WE'RE NOT GETTING ANY INDI
1232:28 EST JAXR15: MALIBU 26033 - ROGER - BE ADVISED I SHOW 9 THOUSAND FEET DESCENDING
1233:25 EST N26033: WE CAN'T SEEM TO GET THE (break) UNDER CONTROL SIR
1233:31 EST JAXR15: MALIBU 26033 - ARE YOU IN VFR CONDITIONS?
1233:35 EST N26033: YES SIR - WE'RE IN VFR - BUT - THE PLA (break) WILL NOT RESPOND TO - UH - ANY POWER SETTINGS
1233:49 EST JAXR15: ROGER - CAN YOU FLY THE AIRPLANE AT ALL?
1233:53 EST N26033: YES SIR - WE'RE TRYING TO KEEP IT - BUT IT KEEPS DIVING ON US
1235:58 EST JAXR15: MALIBU 26033 - JACKS
1237:06 EST N26033: OKAY SIR - WE'RE AT 9 THOUSAND FEET - FLYING LEVEL
1237:10 EST JAXR15: ROGER - MAINTAIN CONTROL OF THE AIRCRAFT
1237:50 EST N26033: 033 - UH - YOU CAN GIVE ME SOME RADAR VECTORS - I DON'T KNOW WHAT HAPPENED BACK THERE - I THINK WE ICED UP OR - OR WE SOMETHING - UH - I COULDN'T - WE CAUGHT IN A BIG DOWNDRAFT - IT JUST PUSHED THE PLANE DOWN AT A TREMENDOUS AIRSPEED AND WE LOST CONTROL OF IT

FIGURE 12



OCALA, FLORIDA
3/16/91
N26033
MSL ALTITUDE (FEET)
20000
15000
10000
5000
0
1227
1229
1231
1233
1235
1237
1239
1241
TIME (EASTERN STANDARD)
1228:32 EST, 18,000 FT MSL
1229:32 EST, 18,000 FT MSL
1230:45 EST, 14,000 FT MSL
1231:46 EST, 11,600 FT MSL
1232:34 EST, 9,600 FT MSL
1233:22 EST, 8,000 FT MSL
1231:09 EST, 9,900 FT MSL
1232:10 EST, 8,600 FT MSL
1232:50 EST, 8,100 FT MSL
1234:23 EST, 5,400 FT MSL
1235:36 EST, 2,900 FT MSL
1228:48 EST N26033: JACKSONVILLE CENTER - UH - MALIBU 033 WE'D LIKE
1228:56 EST JAXR15: MALIBU 26033 - LAST TRANSMISSION WAS BROKEN - SAY REQUEST
1229:01 EST N26033: UH - WE - WE CAUGHT ON A DOWNDRAFT GONNA GO DOWN TO 16 THOUSAND (TONE)
1229:09 EST JAXR15: ROGER - KEEP ME ADVISED - MAINTAIN 16 THOUSAND - IF UNABLE ADVISE
1229:22 EST N26033: GOTTER UNDER CONTROL
1229:43 EST JAXR15: MALIBU 033 SAY HEADING
1229:46 EST N26033: UH - WE'RE TRYING TO GET THE PLANE UNDER CONTROL RIGHT NOW SIR - WE'LL - WE'LL (break) ABOUT A HUNDRED DA (break) ABOUT A HUNDRED DEGREE HEADING
1229:53 EST JAXR15: MALIBU 033 - ROGER - MAINTAIN CONTROL - KEEP YOUR WINGS LEVEL
1230:20 EST JAXR15: MALIBU 26033 - ADVISE CENTER WHEN YOU HAVE THE PLANE UNDER CONTROL
1230:25 EST N26033: UH - I DON'T KNOW WHAT'S HAPPENING SIR - WE'RE - UH - WE SEEM TO BE DIVING - UH - WE'RE NOT GETTING ANY AIRSPEED
1230:33 EST JAXR15: MALIBU 033 - ROGER - I SHOW YOU AT 1 5 THOUSAND - ALTITUDE REPORTING
1230:43 EST ? : PITOT HEAT ON?
1230:45 EST N26033: 'KAY - I'M GONNA TURN IT ON
1230:47 EST JAXR15: MALIBU 033 - I SHOW YOU AT 1 4 THOUSAND FEET AND DESCENDING - KEEP YOUR WINGS LEVEL SIR
1231:56 EST TW8592: TELL THAT GUY TO TURN ON HIS PITOT HEAT IF HE HASN'T
1231:59 EST JAXR15: MALIBU 26033 - UH - TURN ON YOUR PITOT HEAT IF YOU DO NOT HAVE IT ON
1232:03 EST N26033: YES SIR - WE JUST TURNED IT ON - UH - WE GOT IT ON NOW
1232:19 EST N26033: WE'RE NOT GETTING ANY - UH - WE'RE NOT GETTING ANY INDICATION - WE'RE NOT GETTING ANY INDI
1232:28 EST JAXR15: MALIBU 26033 - ROGER - BE ADVISED I SHOW 9 THOUSAND FEET DESCENDING
1233:25 EST N26033: WE CAN'T SEEM TO GET THE (break) UNDER CONTROL SIR
1233:31 EST JAXR15: MALIBU 26033 - ARE YOU IN VFR CONDITIONS?
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1233:49 EST JAXR15: ROGER - CAN YOU FLY THE AIRPLANE AT ALL?
1233:53 EST N26033: YES SIR - WE'RE TRYING TO KEEP IT - BUT IT KEEPS DIVING ON US
1235:58 EST JAXR15: MALIBU 26033 - JACKS
1237:06 EST N26033: OKAY SIR - WE'RE AT 3 THOUSAND FEET - FLYING LEVEL
1237:10 EST JAXR15: ROGER - MAINTAIN CONTROL OF THE AIRCRAFT
1237:50 EST N26033: 033 - UH - YOU CAN GIVE ME SOME RADAR VECTORS - I DON'T KNOW WHAT HAPPENED BACK THERE - I THINK WE ICED UP OR - OR WE SOMETHING - UH - I COULDN'T - WE CAUGHT IN A BIG DOWNDRAFT - IT JUST PUSHED THE PLANE DOWN AT A TREMENDOUS AIRSPEED AND WE LOST CONTROL OF IT

FIGURE 13

airplane descended to 16,700 feet at 1229:08 and returned to FL180 at 1229:32. The airplane then descended from FL180 to14,000 feet in [illegible] seconds, and its ground speed increased from about 180 knots to more than 250 knots on a southeastly heading. The descent rate slowed briefly at 14,000 feet but then continued rapidly to 9,900 feet where a climb was initiated to 11,600 feet. At 1231:46, a series of descents and climbs began from 11,600 feet that were accompanied by sharp turns to the right and left and by a net loss of altitude until about 1237:06 when the pilot reported level at 3,000 feet.

Bronson, Florida

History of the Flight

About 0953 eastern standard time, on March 17, 1991, the pilot of a Piper PA-46-310P Malibu, N9112K, departed St. Petersburg, Florida, for Bedford, Massachusetts, on an IFR flight plan. At 1032:18, the airplane began to descend erratically from about 17,300 feet, and it crashed near Bronson, Florida, about 1036. The pilot and three passengers aboard the airplane were killed, and the airplane was destroyed.

The Safety Board's investigation of the accident disclosed that the pilot called the St. Petersburg FSS about 1952 on March 16, 1991, and filed his IFR flight plan with an estimated time of departure of 0930 on March 17. He also asked for the St. Petersburg weather forecast for the next morning. The forecast provided was as follows: clouds -- ceiling 1,500 broken; visibility -- 4 miles in light rain and fog; occasionally -- 700 broken with two miles in rain and fog. The pilot did not ask for other weather information.

According to the ATC transcript, at 1014:16 on March 17, the pilot of N9112K called Jacksonville Center and reported climbing out of 10,200 feet. The controller responded and, at 1016:09, cleared the pilot to fly a heading of 340° and to climb and maintain 16,000 feet. The pilot acknowledged the clearance. At 1028:35, the controller cleared the pilot to fly direct to Taylor and direct to Charleston with the remainder of the route to Bedford as filed. He also cleared the pilot to climb and maintain FL220 as a final altitude. At 1028:46, the pilot acknowledged the clearances.

At 1033:00, the pilot of N9112K said "One Two Kilo, we're having a problem." At 1033:03, the Jacksonville controller said "Uh, One Two Kilo, say again." At 1033:08, the pilot responded "(Two) Kilo, we're having a ..." This was the last recorded radio transmission from the pilot.

During the next several minutes, the controller continued to call the pilot and to provide emergency airport information. There was no response. At 1037:30, the controller informed the pilot that radar contact with N9112K was lost 6 miles northwest of the Williston Airport.

According to a witness traveling east on Highway 27 between Bronson and Williston, Florida, about 1035, he saw a single-engine airplane descend out of the clouds spinning clockwise with its nose down about 20 degrees and its right wing down about 25 degrees. As he watched, it disappeared to the west into pine trees north of the highway. He found the airplane's fuselage after a 15- to 20-minute search, determined that the occupants were beyond assistance, and left to call the sheriff's office.

There was no postcrash fire. The occupants died of multiple blunt traumatic injuries. The accident occurred during daylight at latitude 29° 27' 00" N and longitude 82° 32' 57" W at an elevation of about 100 feet msl.

Weather

The 0950 aviation weather report for Gainesville, Florida (about 20 miles northeast of Bronson) was as follows: ceiling -- estimated 400 feet broken, 700 feet overcast; visibility -- 2 miles in rain and fog; temperature -- 59°F; dew point -- 58°F; wind -- 070° at 12 knots; altimeter -- 30.18 inches Hg. The 1050 report was similar except the visibility was 1½ miles.

A study of meteorological data indicates that N9112K probably was in clouds at 17,000 feet. The freezing level was near 13,000 feet. GOES weather data (infrared and visible) indicate that cumulus clouds were forming within 10 miles north of where N9112K's first deviation from normal flight occurred. Correlation of weather radar data with ATC radar data showed the airplane to have been in or near a moderate convective echo (VIP 2) at the time of the first deviation.

Pilot

The pilot of N9112K was 48 years old, and he held a commercial pilot certificate with airplane single-engine land and instrument ratings. His second class medical was issued on July 25, 1989. At the time of the accident he held a third class certificate which contained a limitation that corrective lenses be worn while the pilot exercised the privileges of his pilot certificate.

According to the pilot's log book, he had acquired 2,252 flight hours which included about 152 hours of instrument time. Also, he had flown about 268 hours in the PA-46. He had flown about 19 hours and 44 hours in the preceding 30-day and 90-day periods which included 0.8 hours of instrument time. During the 6 months that preceded the accident, he had logged 2.7 hours of instrument flight time.

The pilot completed the PAC training school for Malibu pilots and owners on December 7, 1989, during which he flew the flight simulator for 2.5 hours and the PA-46 for 3.8 hours. He completed a biennial flight review about 16 months before the accident.

Postaccident toxicological tests were negative for alcohol and licit and illicit drugs. An autopsy disclosed no significant preexisting medical problems.

Airplane

N9112K, Serial No. 46-08042, was owned by Fuller Aircraft Leasing Inc. of Chestnut Hill, Massachusetts. The accident pilot was the president of Fuller Aircraft Leasing. The last 100-hour inspection was completed on January 15, 1991. The airplane had a total of 662 hours time in service, including 11 hours since its last inspection.

Weight and balance calculations disclosed that N9112K weighed 4,406 pounds upon departure from St. Petersburg and the CG was 148.7 inches aft of the datum. The limitations were 4,100 pounds for takeoff and 147.1 inches aft of datum. The forward baggage compartment contained 111 pounds of baggage and the rear compartment contained 289.5 pounds. Both were limited to 100 pounds each.

Information received from a friend and fellow-Malibu owner indicated that the pilot of N9112K was particular about proper maintenance of his airplane. Also, the pilot was aware of the previous PA-46 accidents and believed them to have been related either to malfunctions of the autopilot or misuse of the autopilot because the pilots may not have known how to use the autopilot properly. According to the friend, the pilot of N9112K had worked hard at understanding the airplane systems and believed that he did understand the autopilot and related systems.

Wreckage

The fuselage with the right wing stub and complete left wing struck two tall pine trees, slid downward between the two trees, and struck the ground in an attitude of approximately 20 degrees with the right wing low. The fuselage was extensively damaged; immediately forward of the cabin entry door, it was crushed to about one-half its original width. The nose section was crushed upward and aft, and the firewall was separated along its upper side. The engine and propeller were attached with relatively minor damage to the propeller.

The entire horizontal stabilizer was separated, including its bulkhead attachment structure; its main portions were located in an area about 1 statute mile north to north-northwest of the fuselage. Skin with some spar structure from the left horizontal stabilizer was located about 1.86 miles north-northwest of the fuselage.

The outboard portion of the right wing was about 1,500 feet north-northwest of the fuselage; it had separated near the wing splice (wing station 107.5). The upper cap of the main spar was bent upward near its fracture face, and the lower cap had separated, creating a 45-degree scarf. The rear spar cap was buckled and torn, and the spar was twisted about 30 degrees, top edge forward. From about 69 inches to 129 inches outboard of the splice, the leading edge was crushed chordwise and downward. This area matched a crushed and deformed area on the leading edge of the vertical stabilizer.

The inboard portion (stub) of the right wing was attached to the fuselage; the forward and rear attachment fittings were bolted in place at the root. The upper surface of the wing was bent upward, and it contained a chordwise buckle about midway between the root and stub end. The rear spar was twisted down and aft of the outboard end for about 18 inches.

The left wing stub was attached to the fuselage, but the front attachment bolt was sheared. The rear fitting was in place. The upper caps of the main and aft spars were bent downward, and the lower cap of the aft spar was similarly bent. The web of the main spar was buckled consistent with a downward loading of the stub panel.

The outboard portion of the left wing was separated at the wing splice but was laying near the stub wing. A 7-inch section of the main spar upper cap was missing outboard of the splice. The lower cap of the main spar had separated in tension. The four lower stringers exhibited tensile overload failure through the rivet holes. Numerous rivet holes in the lower skin were elongated in the outboard direction.

The tips of the main spar of the horizontal stabilizer were twisted in a nose down direction, and the upper and lower caps were buckled consistent with aft chordwise loading. The spar was fractured near the spar splices on the left and right sides. The lower cap of the main spar was buckled in compression near the point where it was bolted to the fuselage bulkhead. The skin for the left stabilizer was complete and in one piece with about 28 inches of the main spar (outboard end) attached by the upper cap. The third and fourth ribs inboard from the tip were attached to the lower skin, and the first and second ribs were attached to the upper skin. This structure was located 1.86 miles north-northwest of the fuselage.

The vertical stabilizer with a 44-inch section of the aft fuselage attached was separated at its front attachment point but remained attached to the aft fuselage section at the rear main spar attachment. It was close to the fuselage with some control cables connecting the two structures. The rudder was missing; the bottom portion was located in the vicinity of the skin from the left horizontal stabilizer. The leading edge of the vertical stabilizer was crushed and deformed downward and aft in a left to right direction.

The landing gear was in the retracted position. Examination of the engine and propeller disclosed no preexisting defects or preimpact malfunctions. The cockpit instrument panel was intact but was bulged and damaged in many locations. The electrical master, battery, two alternator, and avionic master switches were on. The pitot heat, propeller heat, and windshield heat switches were on. The surface deice, ice light, cabin heat, and air conditioner switches were off. The standby vacuum switch was off. The weather radar was on with a 30 nmi range selected, and the storm scope was on. The cabin pressurization system controls were set to 18,000 feet on the inner scale; the rate of change knob was at the 9 o'clock position; and the cabin altitude was 250 feet.

Components of the KFC 150 flight control system were tested. The flight computer functioned properly and responded to flight director commands. In the autopilot mode, the altitude hold, autotimer, heading, pilot, and roll functions operated properly. The autopilot disconnect and rate monitors functioned correctly, and the altitude hold mode captured a selected altitude of 18,500 feet.

The KAS 297B had crash damage to its case. When power was applied, the unit displayed a selected altitude of 22,000 feet and a selected vertical speed of 200 fpm up. An altitude of 18,500 feet was selected, and the arm, capture, and altitude holds functioned correctly. The vertical speed synchronization feature functioned correctly.

The pitch trim servo and pitch servo were damaged. The motor would not run on either servo. On the trim servo, the rotor was mechanically free, but the transfer relay for engage/disengage solenoid would not operate. On the pitch servo, the motor brushes were missing. The autotrim sense switches and springs in the pitch servo appeared intact, and there was no evidence of water damage or corrosion. The autotrim sense switches and the engage/disengage solenoid functioned correctly. The roll servo operated normally. The yaw servo was badly damaged and could not be tested. The mounts for the pitch, pitch trim, and roll servo were damaged. The clutch slip torques were measured; all were within specified limits.

The vertical gyro in the flight command director was disassembled and examined. There was no evidence of internal damage. When connected to a test harness, the gyro operated normally but with an offset null position of 5 degrees right bank and 2 degrees pitch up. The null information was transmitted to the flight computer.

The encoding altimeter was slightly damaged, but it functioned correctly when tested from 1,100 feet to 25,000 feet. All encoded altitudes were accurately reported.

Flightpath Study

The recorded ATC radar data (See Figures 14 and 15) were used by a Safety Board aircraft performance engineer to reconstruct the flightpath of the airplane and to study the possible time histories of pitch angle, roll angle, indicated airspeed, and G load. The flightpath study revealed that before significant excursions began, the airplane was climbing about 200 fpm on a north-northeast heading and was flying at 150 to 160 KIAS. As the airplane reached about 17,300 feet, it entered a descent followed by an abrupt, steeply banked turn to the right. About 20 seconds elapsed from the start of the descent to the completion of a heading change to the east. The airplane continued in an easterly direction for about 1 minute while further altitude excursions occurred.

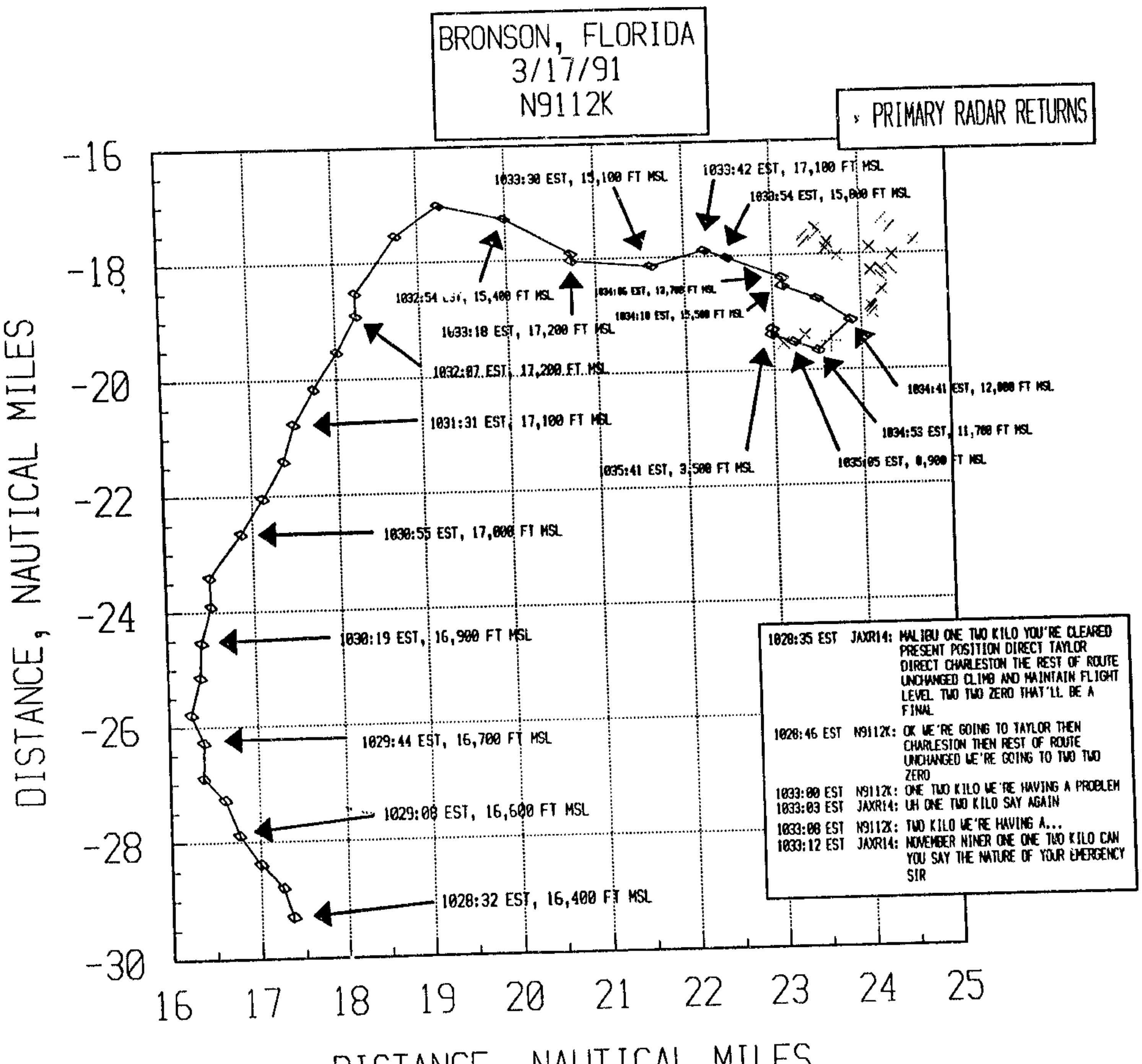
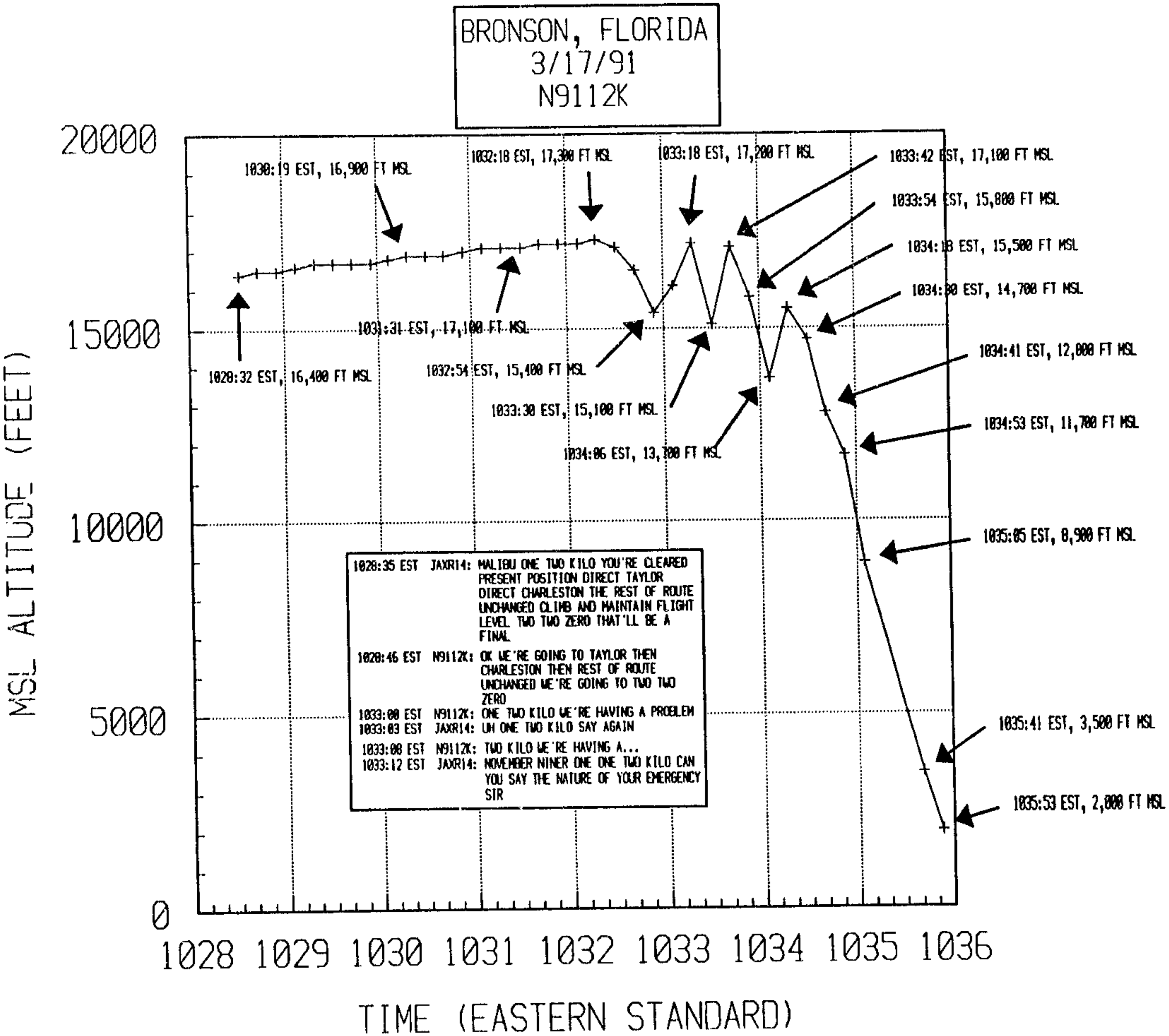

BRONSON, FLORIDA
3/17/91
N9112K
PRIMARY RADAR RETURNS
DISTANCE, NAUTICAL MILES
-16
-18
-20
-22
-24
-26
-28
-30
16
17
18
19
20
21
22
23
24
25
DISTANCE, NAUTICAL MILES
1033:30 EST, 15,100 FT MSL
1033:42 EST, 17,100 FT MSL
1033:54 EST, 15,000 FT MSL
1033:18 EST, 17,200 FT MSL
1032:07 EST, 17,200 FT MSL
1034:41 EST, 12,000 FT MSL
1034:53 EST, 11,700 FT MSL
1035:05 EST, 8,900 FT MSL
1035:41 EST, 3,500 FT MSL
1031:31 EST, 17,100 FT MSL
1030:55 EST, 17,000 FT MSL
1030:19 EST, 16,900 FT MSL
1029:44 EST, 16,700 FT MSL
1029:08 EST, 16,600 FT MSL
1028:32 EST, 16,400 FT MSL
1028:35 EST JAXR14: MALIBU ONE TWO KILO YOU'RE CLEARED PRESENT POSITION DIRECT TAYLOR DIRECT CHARLESTON THE REST OF ROUTE UNCHANGED CLIMB AND MAINTAIN FLIGHT LEVEL TWO TWO ZERO THAT'LL BE A FINAL
1028:46 EST N9112K: OK WE'RE GOING TO TAYLOR THEN CHARLESTON THEN REST OF ROUTE UNCHANGED WE'RE GOING TO TWO TWO ZERO
1033:00 EST N9112K: ONE TWO KILO WE'RE HAVING A PROBLEM
1033:03 EST JAXR14: UH ONE TWO KILO SAY AGAIN
1033:08 EST N9112K: TWO KILO WE'RE HAVING A...
1033:12 EST JAXR14: NOVEMBER NINER ONE ONE TWO KILO CAN YOU SAY THE NATURE OF YOUR EMERGENCY SIR

FIGURE 14


BRONSON, FLORIDA
3/17/91
N9112K
MSL ALTITUDE (FEET)
20000
15000
10000
5000
0
TIME (EASTERN STANDARD)
1028 1029 1030 1031 1032 1033 1034 1035 1036
1028:32 EST, 16,400 FT MSL
1030:19 EST, 16,900 FT MSL
1031:31 EST, 17,100 FT MSL
1032:18 EST, 17,300 FT MSL
1032:54 EST, 15,400 FT MSL
1033:18 EST, 17,200 FT MSL
1033:30 EST, 15,100 FT MSL
1033:42 EST, 17,100 FT MSL
1033:54 EST, 15,800 FT MSL
1034:06 EST, 13,700 FT MSL
1034:18 EST, 15,500 FT MSL
1034:30 EST, 14,700 FT MSL
1034:41 EST, 12,000 FT MSL
1034:53 EST, 11,700 FT MSL
1035:05 EST, 8,900 FT MSL
1035:41 EST, 3,500 FT MSL
1035:53 EST, 2,000 FT MSL
1028:35 EST JAXR14: MALIBU ONE TWO KILO YOU'RE CLEARED PRESENT POSITION DIRECT TAYLOR DIRECT CHARLESTON THE REST OF ROUTE UNCHANGED CLIMB AND MAINTAIN FLIGHT LEVEL TWO TWO ZERO THAT'LL BE A FINAL
1028:46 EST N9112K: OK WE'RE GOING TO TAYLOR THEN CHARLESTON THEN REST OF ROUTE UNCHANGED WE'RE GOING TO TWO TWO ZERO
1033:00 EST N9112K: ONE TWO KILO WE'RE HAVING A PROBLEM
1033:03 EST JAXR14: UH ONE TWO KILO SAY AGAIN
1033:08 EST N9112K: TWO KILO WE'RE HAVING A...
1033:12 EST JAXR14: NOVEMBER NINER ONE ONE TWO KILO CAN YOU SAY THE NATURE OF YOUR EMERGENCY SIR
FIGURE 15

The airplane's altitude decreased to 15,400 feet, and it accelerated to more than 230 KIAS while attaining the near easterly heading. The airplane then ascended to about 17,200 feet while losing much of its airspeed in about 20 seconds. The airplane descended and climbed two more times before entering a final descent with a large right bank angle. About 3 minutes elapsed from the first indication of a descent to the final descent. The aircraft crashed about 6 nmi east of its original ground track.

Flightpath and Trajectory Studies

The flightpath studies for this special investigation were based on recorded radar data from ATC radar sites that were tracking the particular airplane. Occasionally, data from more than one radar site were used for the study of the same airplane. Winds aloft and temperatures were established from National Weather Service (NWS) upper air sounding data acquired from locations near the accident sites.

The ATC radar data, the position of the crash site, the range of estimated impact times, aircraft data, weather data, and the local magnetic variation data were used as input for a computer program (FLIGHT) which calculates performance parameters, such as airspeed, ground speed, roll angle, and accelerations for each of the input data points. The parameter values calculated by FLIGHT result in a mathematically smoothed flightpath of the aircraft based on the input data. Because the smoothing of the data tends to remove erratic data trends, short duration flightpath deviations cannot be reconstructed using FLIGHT's output data. For example, FLIGHT roll calculations, when compared with roll angle data from flight data recorders, have shown that the calculated roll angle may be less than the actual roll angle, and may commence sooner and end later than the actual roll angle data.

With regard to the trajectory studies, the trajectory for each part was defined by its weight and drag, both of which were estimated, in conjunction with the initial conditions of ground track, altitude, speed, and flightpath angle. The initial conditions, as influenced by the winds loft, were varied until the trajectories of all parts that started at a common separation point reached the ground position as noted in the wreckage scatter diagrams. When the best match was determined, the altitude, ground track, flightpath angle, and ground speed of the airplane were defined. When ground speed and flightpath angle were determined, indicated airspeed could usually be determined.

Piper Aircraft Corporation (PAC) Tests

In March 1990, the Piper Aircraft Corporation (PAC) performed supplemental static tests of a PA-46 horizontal stabilizer. The chordwise load distribution was in accordance with the gust load criteria in 14 CFR 23.425 which applied maximum torsion to the surface. The horizontal stabilizer was loaded until failure occurred at a total load of 2,939 pounds. This load value exceeded the required ultimate loads for the "gust-maximum torsion" and "maneuver-maximum bending" conditions by 60 percent and 20 percent, respectively. In May 1990, Piper also tested PA-46-310P and PA-46-350P elevator balance weights and found that the failure loads exceeded design loads by 267 percent.

A structural loads review was conducted of the wing, horizontal stabilizer, vertical stabilizer, elevator, rudder, and ailerons of a PA-46 at a representative weight of 3,730 pounds and a CG of 138.5 inches aft of the datum. Based on this review, it was estimated that a minimum of 7.7 G would have been required to cause wing failure. A ground vibration survey of a typical in-service Malibu was conducted. The PAC concluded that the mass, inertia, and stiffness properties of the airplane were unchanged and similar to those recorded during certification.

Piper conducted flight tests of a PA-46-310P horizontal stabilizer, elevator, and trim tab to compare actual in-flight (measured) stabilizer loads with the analytical values used in certification of the PA-46. The horizontal stabilizer was instrumented with strain gages to measure loads and stresses and with pressure transducers and position transducers to measure chordwise pressure distributions and elevator/tab positions, respectively. Television cameras were mounted to the airplane to view the empennage during the tests. The tests included trimmed maneuvers, out-of-trim maneuvers, checked-pitch maneuvers, and pitching-acceleration maneuvers. Airspeeds ranged from 180 KCAS to 200 KCAS, except for the sudden full elevator deflection test performed at 121 KCAS to 126 KCAS (close to maneuvering speed). Acceleration levels as high as 4.2 G at 200 KCAS were recorded. All of the maneuvers performed exceeded design certification requirements, and the measured flight loads and stresses were all below tested limit loads and allowable stresses.

Metallurgical Examinations

A Safety Board metallurgist conducted a special examination of the structures of the five airplanes that were involved in the U.S. accidents. The examinations concentrated on the critical structural components, such as the wings, wing spars, vertical stabilizer and rudder, and horizontal stabilizer, including the elevator, elevator trim tab, and fuselage attachments. These examinations disclosed no evidence of fatigue fractures, preexisting cracks, or corrosion. The fractures were all typical of overstress separations.

Ice Protection Equipment

All of the five airplanes involved in the U.S. accidents were equipped for flight into known icing conditions. Flight into severe icing conditions was not approved. The equipment consisted of wing leading edge pneumatic deice boots, electrothermal windshield, heated pitot tube and lift detector, electrothermal deice pads on propeller blades, and empennage pneumatic deice boots. Also, the airplanes were equipped with dual alternators and a standby vacuum pump as a part of the supplemental type certificate for the ice protection systems.

The POH contained supplementary information on operation of the ice protection equipment, including a checklist for operation of the equipment and warning and cautionary notes about operations in icing conditions. One of the notes cautioned that KIAS must be 130 or more during flight in icing conditions and that if 130 KIAS could not be maintained with maximum continuous power, action should be taken to exit the icing conditions.

In October 1991, the PAC modified the normal procedures checklists in the POH to provide for a ground check of the ice protection systems if flight into icing conditions (visible moisture below +5°C) is anticipated. Also, the before takeoff checklist was modified to provide for activation of the pitot, stall warning, windshield, and propeller heat, if required.

Autopilot and Flight Director Systems

Each of the airplanes involved in the accidents and incidents included in the special report was equipped with a King Radio Corporation Model KFC 150 flight control system. Also, except for the Mexican-registered airplane, each was equipped with a King model KAS 297B vertical speed and altitude selector (see Appendix B for a detailed description of these systems).

The KFC 150 system has the capability to integrate the airplane's navigational equipment with autopilot control of the airplane through an autopilot and flight director computer that has control switches mounted on the airplane's instrument panel. The KAS 297B adds the capability of selecting a desired vertical speed for climbs and descents in 100 fpm increments up to 3,000 fpm. It also permits preselection of a desired altitude which, when reached, will be held by the altitude hold function of the autopilot.

The KFC 150 incorporates an electric pitch trim system that provides automatic trim in pitch during autopilot operation. The airplane also has a manual electric pitch trim capability that is operated by two rocker switches on the pilot's flight control wheel. Pitch trim can also be controlled manually by a trim wheel on the center control pedestal. The autopilot and flight director are engaged by switches on the autopilot and flight director computer panel. They can be disengaged by the same switches or by a switch on the pilot's control wheel which, when depressed and released, will disengage the autopilot and cancel all flight director modes. When depressed and held, the switch will interrupt electric trim power, disengage the autopilot, and cancel all flight director modes.

A control wheel steering switch (CWS) is also provided on the pilot's control wheel. When it is depressed and held, it disengages the autopilot pitch, pitch trim, and roll servos and allows the pilot to control the airplane; it does not disengage the autopilot, yaw damper (if installed), or the flight director. When the CWS is released, the autopilot and flight director are automatically synchronized to the airplane's existing pitch attitude or to its existing pressure altitude if the altitude hold mode had been previously selected. If the vertical speed hold mode had been previously selected, the speed is resynchronized to the airplane's actual vertical speed when the CWS is released.

With the autopilot engaged and a flight director heading mode selected, the maximum value of bank and pitch that the flight director will command are 20 degrees of bank and a pitch attitude of +15 degrees and -10 degrees, respectively. The autopilot will automatically disengage if roll rates exceed 14^0 per second or if pitch rates exceed 8^0 per second.

A trim warning light is provided on the autopilot and flight director control panel. The light is illuminated continuously if electric trim power is not available to the system or the system has not been preflight tested. The light flashes and is accompanied by an audible warning whenever a manual electric trim fault is detected, such as the pitch trim servo operating without a command. The light will illuminate steadily and will be accompanied by a steady audible tone whenever an autotrim failure occurs such as the trim servo running without a command, the trim servo not running when it is commanded to run; or the trim servo running in the wrong direction.

With the autopilot engaged, the airplane's pitch attitude is controlled by the autopilot, and the pilot must avoid displacement of the control wheel to alter the airplane's pitch attitude. Such a displacement is interpreted by the pitch servo as pressure on the system which is relieved by operation of the autotrim. However, the autotrim will operate in opposition to the control wheel displacement; that is, if the displacement is in the nose up direction, the autotrim will operate to pitch the airplane nose down. Under these circumstances, the pilot is in effect fighting the autopilot for pitch control of the airplane, which can result in high pitch control forces.

The pilot can override the pitch servo clutch with about 40 pounds of pressure on the control wheel, but the pitch trim servo will continue to operate until its limit has been reached or until electric power to the trim motor is interrupted. The above conditions can be interpreted by the pilot as an autopilot malfunction. If the autopilot is then disconnected by use of the autopilot disconnect/trim interrupt switch, the relatively large pitch control forces are not released, and the pilot may interpret such a condition as a continued failure of the autopilot system even though the autopilot disengage light flashes accompanied by an aural tone to indicate that the autopilot has been disconnected.

The proper method of acquiring pitch control of the airplane is to first disconnect the autopilot by use of the autopilot disconnect switch, or to interrupt autopilot operation by depressing and holding the CWS switch, and then applying pressure to the control wheel to alter the pitch attitude. However, if pressure is applied before the above switches are activated, the airplane will be mistrimmed when the autopilot is subsequently disengaged. The amount of mistrim is a function of the time and amount of pressure applied to the control wheel before the autopilot is disconnected or interrupted.

PA-46 Pilot Training Programs

Under the current Federal Aviation Regulation (FAR), no special requirements exist for flying the PA-46 as a pilot in command (PIC). The current requirements are that a PIC hold category and class rating appropriate to the aircraft (airplane, single engine land) and a certification from an authorized flight instructor that the pilot is competent to pilot an airplane that has more than 200 horsepower or that has a retractable landing gear, flaps, and a controllable propeller, as the case may be. Also, the pilot must be rated for instrument flight for operation of the airplane at and above FL180 where IFR flight is mandatory.

The PAC has conducted an initial training program for pilots and owners of PA-46 airplanes since first deliveries of the airplane began in 1984 and a recurrent training program since 1985. Also, in the late 1980s and early 1990s, several other organizations provided formal pilot training in the PA-46 since insurance companies would not provide insurance for the pilot of a PA-46 airplane unless the pilot had attended an approved training program for the airplane. In 1992, all but one insurance company required that pilots attend an approved PA-46 training program as a prerequisite to obtaining insurance.

Safety Board personnel and FAA personnel reviewed the PA-46 training program conducted by the PAC. The program included an academic portion, instruction in a training device, and flight training sessions. The academic portion of the program provided minimal instruction on the KFC 150 flight control system and the KAS 297B vertical speed and altitude selector system. The training device was configured as a standard Malibu cockpit and it was used for training in cockpit procedures, attitude instrument flying, and emergency procedures. The training device incorporated the KFC 150 system but did not have the KAS 297B installed.

The flight training was usually conducted in the student's own PA-46, and the amount of instruction provided by PAC instructors varied depending on the student's experience and proficiency. The student's instrument flying skills were evaluated to some extent, and the PAC instructors made recommendations on whether additional training was needed. Training on recovery from unusual attitudes in IMC and partial-panel instrument flying was not provided.

As the result of discussions among Safety Board, FAA, and King Radio Corporation personnel about the information provided in the POH for the PA-46 and in the King publications on the KFC 150 and KAS 297B systems, the company, in January 1992, issued a 24-page training supplement on the systems. This supplement provided additional information on operation of the systems, including emergency procedures and ways in which the systems could be misused. The training supplement was provided to the PAC and other organizations that provide formal training in the PA-46.

Following the Safety Board's and the FAA's review of the PAC's PA-46 training program, the PAC made a number of changes to the program. These changes include the incorporation of the KAS 297B system into the training device; expansion of the academic portion of the program regarding operation of the KFC 150 and KAS 297B systems and use of the manufacturer's 24-page training supplement; the addition of an active training mockup of the KFC 150 and KAS 297B systems; and additional emphasis in the flight training portion of the program on operation and misuse of the KFC 150 and KAS 297B systems, improving basic instrument flying skills, and recovery from unusual attitudes during simulated instrument flight.

Federal Aviation Administration Actions

Following the Bronson, Florida, accident, the FAA assembled a special certification review (SCR) team to review the type certificate of both models of the PA-46 airplane. The review was completed in late 1991, and it included airframe structures, ice protection systems and equipment, propulsion, autopilot systems, vacuum and electrical systems, production certification, and service history. The SCR team issued a report (see Appendix B for an executive summary and recommendations) in December 1991. The team's overall conclusion was as follows:

> No one major design feature of the Malibu/Mirage airplane or Bendix/King autopilot was found to be non-compliant with the certification requirements; however, several areas were identified for improvement of design and clarification of operational instructions.

On March 21, 1991, the FAA issued airworthiness directive (AD) 91-07-08 which imposed the following restriction on the PA-46 series airplanes:

1. Flight in IFR meteorological conditions is prohibited.
2. Flight into areas of known or forecasted moderate or severe turbulence should be avoided.
3. Use of autopilot, CWS button, or vertical trim control for altitude changes is prohibited.
4. Pitot heat must be on for entire flight except for takeoff and landing sequences.
5. Induction air selection must be in alternate position for entire flight except for takeoff and landing sequences.
6. Remove the vertical speed and altitude selection control panel (KAS 297B) from the instrument panel, if installed, and secure and cap the remaining electrical connector.

On April 19, 1991, the FAA issued revision 1 to the above AD. The revision removed the prohibition on flight in IFR meteorological conditions and added the following restriction:

1. Flight into known or forecasted ice, thunderstorms, moderate or severe turbulence is prohibited.

   After completion and review of the SCR team's report, the FAA on February 13, 1992, issued revision 2 to AD-91-07-08. This revision rescinded the AD.

High Intensity Electromagnetic Radiated Field (HIRF) Susceptibility Tests

As a part of its investigation of the accidents involving the Piper PA-46, the Safety Board conducted a High Intensity Electromagnetic Radiated Fields (HIRF) diagnostic screen test of the King KFC/KAP 150 autopilot system installed in a Piper Malibu airplane. All tests were conducted in the airplane on the ground.

The testing was conducted in September 1991, and consisted of a series of short-range near-field electromagnetic radiation tests of up to 300 V/m (volts per meter) at several locations within the airplane. The testing also included a loop probe-induced electrostatic discharge (ESD) test of up to 18,000 volts applied to the connector area of the KAS 297B vertical speed and altitude selector and KC 192 flight computer. The testing was performed in the frequency range from 1 to 990 MHz. The system was not tested in the microwave range from 1 to 18 GHz. In addition, a test of connector susceptibility was performed using a current injection probe.

The testing consisted of observing the effects of exposure to radiated fields. The airplane was not instrumented for electromagnetic field testing; all effects detected were by observation of the units under test and the flight control system components of the airplane.

During the testing, no uncommanded runaway conditions or loss of control of airplane flight control systems were observed. The autopilot disconnect system was exercised throughout the testing and was satisfactorily disconnected under all test conditions. For additional details see Appendix D.

Aeroelastic Analysis of the PA-46 Airplane

Since August 1990, National Aeronautics and Space Administration (NASA) engineers provided assistance to the Safety Board's special investigation regarding in-flight structural failures in the PA-46 airplanes that might have been related to aeroelastic instability. In June 1991, NASA agreed to conduct aeroelastic analyses of the wing and horizontal stabilizer of the PA-46 airplane to determine potential modes of structural failure. Analyses of the vertical stabilizer were not performed because accident wreckage did not indicate possible instability in the vertical stabilizer as a cause of the structural failure.

To accomplish the objectives, NASA engineers performed static and dynamic analyses of a NASTRAN finite element model of the PA-46 airplane. The static analyses included those to determine aeroelastic loads for the wing and horizontal stabilizer; wing, aileron, and elevator reversal speeds; and wing static divergence speed. The dynamic analyses included those to determine flutter and divergence speeds for a cantilevered wing and complete airplane configurations. Where possible, the results were compared with ground-test, flight-test, or analytical data obtained from the Piper Aircraft Company. The results indicate that the airplane is free of aeroelastic instabilities, such as flutter and static divergence within its flight envelope.

Airspeed Measuring Systems

When an aircraft moves through an air mass, pressure is created ahead of the aircraft, adding to the existing static pressure within the air mass. When a symmetrically shaped object, such as a pitot head, is placed into the moving air stream, the flow of air will separate around the nose of the object so that the local velocity at the nose is zero. At the zero velocity point, the pressure measured is equal to the sum of the dynamic pressure and ambient static pressure, and is defined as total pressure. The dynamic pressure is determined by subtracting the ambient static pressure measured in an area not affected by the moving air stream from the total pressure.

In an aircraft airspeed measuring system, the total pressure is measured by the pitot head and is transmitted through the pitot system plumbing to one side of a differential pressure measuring instrument (airspeed indicator). The ambient static pressure is measured at static ports, which are mounted in an area that is not significantly influenced by the moving air stream. The static pressure measured at these ports is transmitted to the opposite side of the differential pressure measuring instrument. In effect, the differential pressure instrument (whether it be an airspeed indicator gage, a flight data recorder pressure transmitter, or a component within an air data computer) subtracts the ambient static pressure measured by the static system from the total pressure measured by the pitot system. The resultant dynamic pressure is a direct measurement of indicated airspeed. (See figure 16 and 17).

Since the ambient static pressure is a component part of total pressure, any change in static pressure would normally result in an equal change in both the pitot and static pressure systems. Therefore, a change in ambient static pressure, such as that encountered during a change in altitude, would normally have no effect on airspeed measurement. Only a change in dynamic pressure produced by a change in the aircraft's velocity would cause a change in the indicated airspeed. If, however, only one side of the airspeed indicator sensed a change in the ambient static pressure, an erroneous change in indicated airspeed would result, even though the actual dynamic pressure remained unchanged. Such a condition would occur if either the pitot or static system was blocked or was otherwise rendered insensitive to external pressure changes.

In the event of a blocked pitot or static system, the direction of the indicated airspeed error would depend on the part of the system that is blocked and the direction of change in the ambient static pressure. Under conditions in which the pressure in the static system increases with respect to the pressure in the pitot system, the indicated airspeed will read low erroneously. For the opposite condition, in which the pressure in the static system decreases with respect to the pressure in the pitot system, the indicated airspeed will read high erroneously. The latter would exist if the pitot head is blocked so that a constant

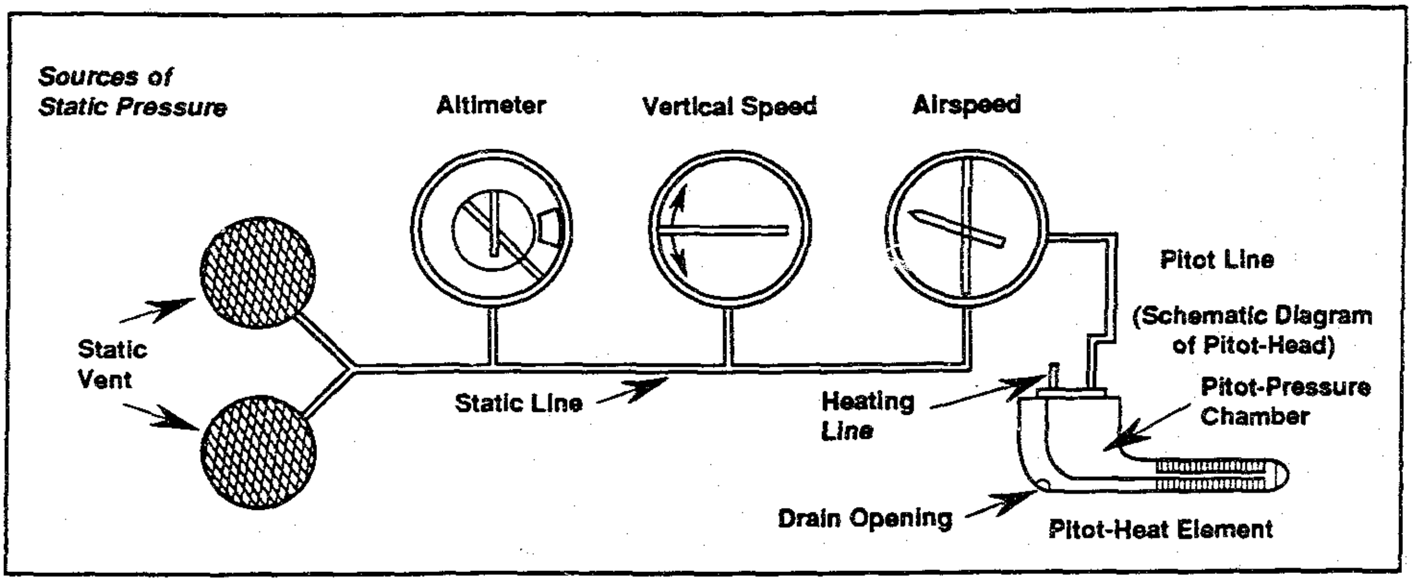


Figure 16.
Typical Pitot Static System for General Aviation Aircraft

The pitot pressure line is connected to one side of the diaphram, while the inside of the sealed case is connected to the static line. As the diaphram moves in response to increased or reduced pitot pressure, the airspeed indicator needle moves accordingly through the mechanical means of gears, levers, and springs.

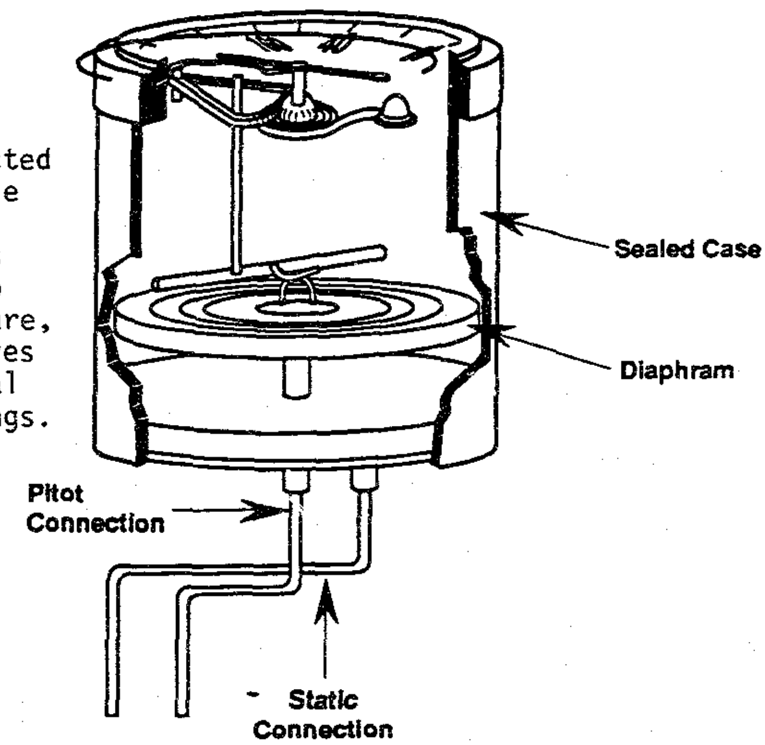


Figure 17.
Typical Airspeed Indicator for General Aviation Aircraft

pressure is trapped in the pitot system while the aircraft is ascending. This is because the static system pressure would decrease and the resultant differential pressure would appear as an increase in dynamic pressure.

Indicated airspeed error may also occur when the pitot system becomes insensitive to changes in total pressure in such a manner that the system vents to an ambient static pressure source. The pressure measured by the pitot system will equalize with the pressure in the static system, and the dynamic pressure (indicated airspeed) will decrease to zero. The vent source in a pitot head which can produce this kind of error is the moisture drain hole located downstream from a blocked total pressure sensing inlet.

As a result of a fatal airline accident in 1974[4] that occurred because the flightcrew reacted improperly to erroneous airspeed indications associated with pitot tube icing, the Safety Board, in cooperation with the pitot head manufacturer, conducted wind tunnel icing tests of a similar pitot head. The results of this testing were as follows:

> A pitot head of the same type that provided pitot pressure to the first officer's airspeed/Mach indicator was exposed to icing conditions in a wind tunnel. With the pitot heater inoperative, 1 to 2 inches of ice formed over the pressure inlet port. During the exposure, a thin film of water flowed into the pressure port, some of which flowed out of the drain hole.
>
> Blockage of the drain hole by ice seemed to depend on the length of time required for ice to form and block the total pressure inlet port. The longer it took for ice to form and block the total pressure port, the more likely it became that the drain hole would be blocked by ice. Also, the greater the angle between the longitudinal axis of the pitot head and the relative wind, the greater the likelihood that the drain hole would become blocked with ice.
>
> Constant altitude pressure measurements showed that when the total pressure inlet port was blocked by ice and the drain hole remained open, pressure changes occurred that would cause a reduction of indicated airspeed. However, when both the total pressure port and a drain hole were blocked, the total pressure remained constant, which could cause indicated airspeed to remain fixed. Also, abrupt and small pressure fluctuations occurred shortly before either the pressure port or drain hole became blocked by ice.

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[4] Northwest Airlines Inc., Boeing 727-251, N274US, near Theils, New York, December 1, 1974; NTSB-AAR-75-B, August 13, 1975.

According to information provided by a major manufacturer of pitot tubes, an unheated tube subjected to severe icing conditions will become blocked with ice in less than 10 seconds. The manufacturer tests its pitot tubes in an icing wind tunnel but only under severe conditions. Under moderate conditions, it was estimated that an unheated pitot tube would be blocked with ice in about 30 seconds, and in light icing conditions an unheated tube would be blocked in about 1 minute. The rapid collection of ice on a pitot tube is attributed to its relatively small size, its location in the free air stream that is not influenced by disturbances from other structures, and its relatively sharp edges that provide a definitive null point in the air stream that flows around the tube. Also, moisture and ice crystals flow directly into the tube which, if unheated, will collect in the elbow of the tube.

ANALYSIS

General

As a consequence of the Bristol, Bakersfield, Naylor, and Lakeville fatal accidents, which occurred within a 13-month period of time after May 30, 1989, the Safety Board consolidated the independent investigations into a special investigation to determine whether similarities existed among the accidents that could account for the apparent similarities in events that preceded the fatal collisions with the ground; that is, the unexplained departures from controlled flight, high speed descents, and airframe failures in flight. As additional similar accidents and incidents occurred involving the PA-46 airplane, the Safety Board included them in the special investigation.

As a result of the first two fatal PA-46 accidents, preliminary analyses of the evidence suggested one similarity that might exist - - a structural weakness or defect that led to premature failure of the airframes in flight. This hypothesis led to a special review of the design, manufacture, and testing of the PA-46 structure to verify its conformity to the applicable FAA airworthiness standards, including verification of the PA-46's operating envelope in terms of speeds and load factors. This review was conducted predominantly by the PAC with Safety Board and FAA participation, and it indicated that no structural deficiencies existed with the design, manufacture, or testing of the PA-46 or the accident airplanes. Further, a review of the airplane's flutter characteristics by PAC and NASA indicated that the airplane was free of aeroelastic instabilities when it was operated within its flight envelope.

All five of the U.S. accidents involved failures and separations of critical structures during flight. Metallurgical examinations of the critical structural components showed that all of them had failed as a result of overstress. These examinations and the special review of the airplane's structural integrity indicate that the airplanes were apparently performing well beyond their operating limitations in terms of speeds or load factors, or both, when the failures occurred. Performance analyses based on ATC radar information and a NASA computer program, which included known environmental and aerodynamic data, indicate probable airplane performance in each of the accidents that substantially exceeded the airplane's design operating limits.

The Safety Board also directed its attention to other failures or malfunctions that could have led to departures from controlled flight followed by speeds and load factors substantially in excess of airplane design limits. Part of this attention was devoted to the pilots involved in the accidents and the manner in which they might have misused the flight controls and other controls before and during the essentially uncontrolled descents.

The pilots involved in the U.S. accidents generally had similar levels of flight experience, including instrument flight and experience in the PA-46 airplane. The pilot in the Bakersfield accident had substantially more flight experience than the others. All but the Bristol pilot had attended the PAC training school for PA-46 owners/pilots and demonstrated different levels of performance. However, all of the pilots met the regulating requirements for the flights they were conducting except for the Bakersfield pilot whose third class medical certificate had expired 6 days before the accident and the Bronson pilot who had not flown sufficient instrument time (6 hours) during the 6 months preceding the accident to qualify for flight in IMC. The postaccident autopsies of the pilots disclosed no preexisting medical conditions that might have adversely affected the ability of the pilots to complete their flights safely, except for the Bakersfield pilot, who had evidence of preexisting heart problems. Further, there was no evidence that licit or illicit drugs or alcohol were factors in the accidents.

Ocala, Florida

The Safety Board's review of the Ocala incident revealed conclusively that erroneous airspeed indications caused by a pitot tube blocked with frozen moisture initiated the control difficulties demonstrated by the pilot of N26033 during an erratic descent from FL181 to about 3,000 feet. The frozen moisture was present because the pilot had not activated the heat to the tube before ascending in IMC above the freezing level, which was near 13,600 feet. According to correlations of ATC radar data with radio communications between the pilot and Jacksonville Center, the pilot declared that he had no indication of airspeed while he was descending through 15,000 feet at a rate of about 4,000 fpm. About 1 minute 30 seconds later, a pilot of a commercial flight informed the Jacksonville controller that the pilot of N26033 should turn on the pitot heat. After the controller relayed the message to the pilot of N26033, the pilot confirmed that he "...had just turned the pitot heat on...."

The effects of pitot tube icing can appear in several forms. If the pressure inlet port is blocked completely by ice but the moisture drain remains open to ambient pressure, the indicated airspeed will be erroneously low and will eventually reach zero. If both the inlet port and the drain hole are blocked by ice, the airspeed indicator will tend to perform like an altimeter; that is, the indicated airspeed will increase as the airplane ascends above and will decrease as the airplane descends below the altitude where the blockages occurred.

Both situations can create significant difficulties to a pilot in IMC because indicated airspeed is an important airplane performance parameter. A further problem associated with a blocked pitot tube is that indicated airspeed will no longer respond properly to power changes.

In IMC conditions where indicated airspeed tends to deviate in either of the two ways described above, a pilot who does not suspect the possibility of an erroneous airspeed indication and does not react thereto by maintaining airplane attitude control by reference to other flight instruments, may fixate on the airspeed indicator and may tend to control the airplane accordingly. For instance, a pilot who sees the airspeed decreasing below the desired airspeed may lower the pitch attitude and increase the power to regain the airspeed. If the airspeed observed on the indicator by the pilot does not increase, and the pilot also disregards other performance instruments (altimeter, vertical speed indicator, and attitude indicator) that show the airplane descending at an abnormal rate and pitch attitude, the pilot may further decrease the pitch attitude. Under such circumstances, the airplane's structural design limits can easily be exceeded in terms of actual airspeed as the airplane descends rapidly. Further, fixation on the indicated airspeed to the exclusion of other performance instruments can result in lateral control problems as well as pitch control problems. Finally, the combination of pitch and lateral control problems can lead to spatial disorientation of the pilot to the extent that control of the airplane is lost completely.

The remedy for all erroneous flight instrument indications is a rapid and accurate cross check of all the related performance and control instruments to ensure that the various indications are compatible with known airplane performance capabilities and limitations. For instance, if the airspeed indication appears low for an established cruise power setting, the pilot must confirm that the airplane is not in ascending flight by reference to altimeter, vertical speed, and attitude indications. If the latter indications are normal for constant altitude flight and the power settings are normal, the pilot should maintain their indications while verifying and confirming the abnormal airspeed indication. Once it is confirmed, the pilot can then devote attention to correction of the problem.

Since indicated airspeed not only provides important information about airplane performance but also defines important control and structural limits, pilots are very conscious of maintaining the airspeed within proper limits, particularly in IMC. If the indicated airspeed approaches either the high speed or low speed limit, the pilot is inclined to take quick action to return the airspeed within the limits. With regard to the Ocala incident, the pilot declared to ATC that he had no indication of airspeed about the time that the airplane was descending through 15,000 feet at a rate of about 4,000 fpm. Several minutes later, he confirmed that the pitot heat had been off. An indication of no airspeed at that rate of descent verifies that the inlet pressure port on the pitot tube was blocked with ice but that the water drain port was open allowing static pressure to enter the pitot line to the airspeed indicator. With static pressure balanced on both sides of the diaphragm in the airspeed indicator, the indicator would read zero. Further, the high rate of descent confirms that the pilot had taken radical action without success in an attempt to obtain airspeed indications.

Although the pilot of N26033 was able to prevent a complete loss of control of the airplane, he was unable to fly the airplane in any semblance of a controlled manner. Consequently, the timely suggestion provided by the pilot of a commercial airline flight "to turn the pitot heat on" probably was sufficient to alert the pilot of N26033 that his airspeed indicator was erroneous and that he should rely on other performance instruments to control the airplane. The airplane's radar descent profile continued to show radical deviations in ascent and descent after the pilot stated that he'd "just turned the pitot heat on" but the magnitude of the deviations were reduced and the rates of ascent and descent slowed significantly following receipt of the pitot heat comment. Although deviations continued after the pilot entered VMC about 7,000 feet, which demonstrates the response that a low or zero indicated airspeed can generate from a pilot, they stopped after further descent to about 3,000 feet where the airspeed indications apparently returned to normal because the ice block in the pitot tube had melted. Consequently, the Safety Board believes that if the pilot of N26033 had not been provided with the clue related to pitot heat, he probably would have substantially exceeded the speed and load factor limits of the airplane. Further, vital structural components probably would have separated in flight with fatal consequences. Fortunately, the pilot was able to prevent a complete loss of control of the airplane and to land it in VMC at the Ocala Airport without further incident, although subsequent examination of the airplane revealed numerous loose rivets in the airplane's structure, a bent elevator trim tab, and a missing wheel well door.

The Safety Board concludes that the pilot failed to activate pitot heat while flying in IMC at and above the freezing level and that he responded improperly to erroneous airspeed indications that resulted from blockage of the pitot tube by atmospheric icing. These errors resulted in the temporary loss of control of the airplane.

Bristol, Indiana

With respect to the Bristol, Indiana, accident of May 31, 1989, the pilot was apparently using a stormscope to avoid thunderstorms as indicated by his transmission about 1540 that he was having a little "point control problem." Apparently, "point control" is a reference to the stormscope that shows lightning discharges associated with convective activity as a point of light on the cockpit display. The characteristics of the "problem" could not be determined, but the pilot continued into the area of thunderstorms and deviated several times to the west of course to avoid bad weather. Apparently these deviations were based on visual determinations that the weather ahead should be avoided.

The pilot may have visually identified a relatively clear path for descent below 13,000 feet, action that he requested about 1559 and 1604. However, he apparently entered IMC at 13,000 feet, precluding further visual observation of the convective clouds ahead. Consequently, the Safety Board believes that his entry into a "big cell" about 1606:05 was inadvertent. According to correlations of ATC radar data and ground-based weather radar data, the pilot made a right turn to "get out of here," which took the airplane farther into the more severe convective activity to the east of his position, rather than a left turn that would have taken the airplane into a relatively clear area. Apparently he turned the wrong way because he was unable to detect either visually or by means of the stormscope the more severe convective activity to the east. The Safety Board believes that these complications and the consequences demonstrate the hazards of using stormscopes or airplane weather radar to select a relatively clear flightpath through an area of strong to very strong convective weather. Further, this is why the operating procedures for the stormscope warn against its use as a means to penetrate an area of thunderstorms.

Penetration of thunderstorms or significant convective activity near the freezing level is particularly hazardous because heavy rain and turbulence are more prevalent near this level. Also, significant icing can occur below, at, and above the freezing level. According to U.S. Air Force guidance, most of the worst thunderstorm hazards occur in the temperature range of -8°C to +8°C.[5] As a result, the U.S. Air Force recommends that if penetration of a thunderstorm cannot be avoided, entry into the storm should be accomplished at least 5,000 feet above or 5,000 feet below the freezing level. With respect to the Bristol accident, the freezing level was near 14,000 feet. Consequently, the pilot of N9114B entered the thunderstorm at an altitude that potentially presented the most significant hazards to flight. According to a trajectory study of structural components that separated from the airplane during its uncontrolled and rapid descent, the components separated near 10,000 feet, an altitude that probably was reached shortly after the pilot made his last transmission, "Four Bravo, can't hold it, hold on" at 1606:37. Therefore, within about 30 seconds of entering the "big cell" the airplane was essentially destroyed by excessive airspeed or load factors, or both, confirming how hazardous the conditions were within the thunderstorm.

Bakersfield, California

According to meteorological conditions in the Bakersfield area near the time of the accident, the pilot of N8888M would have entered IMC about 6,500 feet and would have remained in IMC throughout the climb to 9,000 feet. Also, upper air data indicate that the freezing level was near 6,500 feet, cloud tops extended to 18,000 feet or more, and there was evidence of embedded convective showers and light to moderate icing.

According to the flightpath study, N8888M was climbing initially at a steady rate of about 1,500 fpm. The airplane may have been decelerating because based on climb performance data from the POH, this exceeded the airplane's 110 KIAS climb capability of about 1,340 fpm by 160 fpm. Above 8,000 feet, the rate of ascent decreased to about 1,300 fpm and the airspeed decreased to about 90 KIAS. As the airplane approached 9,000 feet, its airspeed increased to about 100 KIAS and its climb rate decreased to near zero. The radar ground track of the airplane shows that minor course corrections were made throughout

[5] AFM 51-12, Volume I, Weather For Aircrews, Department of the Air Force, April 2, 1990.

the climb which was accomplished from 6,500 feet to 8,000 feet in about 2 minutes. Therefore, it is believed that the pilot encountered no significant difficulties throughout the climb. Also, it appears that the autopilot probably was engaged in the vertical speed select mode and that above 8,000 feet he made an adjustment to the rate of climb.

The flightpath study indicates that difficulties were encountered during the transition from ascending flight to cruise flight at 9,000 feet, the pilot's assigned altitude. After nearly arresting the climb at 9,000 feet, it was continued to 9,200 feet over a period of about 25 seconds while the airspeed increased from about 100 KIAS to 135 KIAS. During the next 15 seconds, the airplane ascended to 9,400 feet while turning left about 30 degrees. At 1543:45, N8888M began a rapid descent in which the airspeed increased from about 140 KIAS to speeds in excess of 265 KIAS.

The Safety Board's analysis of the evidence indicates several possibilities for the difficulties encountered during the leveling process at 9,000 feet. The first involves possible pilot misuse or malfunction of the KAS 297B vertical speed/altitude selector and autopilot systems that control the transition from climbing to cruise flight. If properly selected and operating, the KAS 297B will switch the autopilot from the vertical speed hold mode into the pitch round out mode (capture) and then to the altitude hold mode. The switching is accomplished as a function of the airplane's vertical speed.

The second possibility involves blockage of the pitot tube by atmospheric ice that was collected on the tube during the climb above the freezing level. The pitot heat switch and other anti-ice/deice switches were found in the off position in the wreckage of N8888M. Also, the atmospheric conditions were conducive to light to moderate icing during the ascent. Given these conditions, it is probable that ice would have collected rather quickly on the pitot tube without noticeable collection on other larger surfaces like the windshield and wing leading edges.

The third possibility that might explain the levelling difficulties and the subsequent loss of control is incapacitation of the pilot. According to the autopsy, the pilot had previously suffered a myocardial infarction, but the pathologist who conducted the autopsy could not find evidence of an acute infarction that would have incapacitated the pilot. However, the occurrence of the crash and, therefore, death before evidence of an acute infarction could materialize, does not exclude the possibility of incapacitation. Also, the pilot's other preexisting heart problem under conditions of stress could have prevented him from controlling the airplane.

The evidence indicates that the pilot had difficulty in the PAC PA-46 training sessions in understanding the autopilot and flight director systems in the airplane. However, he received a considerable amount of additional instruction in the systems from an experienced instructor who believed that the pilot of N8888M could manage the systems properly in IMC. Also, the pilot had considerable flight experience and had flown his Mirage for more than 50 hours during the 2 months that preceded the accident, including 8 hours of actual instrument time. Therefore, his currency and proficiency in the Mirage should have been adequate for the flight.

Functional tests of the KC192 flight computer and KAS 297B vertical speed/altitude selector could not be accomplished due to extensive crash-damage to the components. However, there is no evidence of previous malfunctions in the equipment. The pitch, trim, and yaw servos in the autopilot system functioned properly, and the clutch slip torques were within or very close to specification limits. The roll servo could not be functionally tested due to crash damage, but disassembly disclosed no preexisting mechanical or electrical circuitry problems. Also, the elevator trim tab jackscrew was in the 30 percent nose-down trim position, and the yaw, roll, pitch, and pitch trim servos were disconnected, indicating that a runaway nose-down trim condition was improbable. The Safety Board cannot conclusively exclude a possible malfunction in the KAS 297B vertical speed/altitude selector as a cause of the problems during the transition from climbing to cruise flight at 9,000 feet. However, because the pitch servo clutch torques were within limits, we believe that any such problems should not have resulted in loss of pitch control of the airplane in a steep high-speed descent followed by a loss of lateral control. We believe the problems were more likely related to ice blockage of the pitot tube.

As noted with respect to the Ocala incident, blockage of the pressure inlet port of the pitot tube during flight in IMC can present a confusing situation to a pilot because of the adverse effects on the airspeed indicator. Normally, the airspeed indicator is a very reliable instrument and probably one that many pilots tend to trust more readily than gyro-operated flight instruments. Pilots who have not experienced pitot tube blockage in IMC, or have not thought clearly about the symptoms and effects of blockage, may tend to fixate on the airspeed indicator to the partial if not complete exclusion of other attitude control instruments.

In this accident, it appears that the airspeed indicators probably began to provide erroneously low indications about the time the pilot attempted to level the airplane at 9,000 feet. As determined by the flightpath study, the airplane's derived airspeed increased from about 90 KIAS to about 135 KIAS during the levelling process, indicating that the pilot did not reduce power significantly from climb power, probably to increase the airspeed to a cruise airspeed indication. If the indicated airspeed did not increase but instead decreased because of the blocked pitot inlet, the pilot probably would have disconnected the autopilot and attempted to lower the pitch attitude to increase the airspeed. However, since the airplane was still at climb power it would tend to climb, particularly with the pilot's attention devoted largely to the low airspeed indication. This could account for the airplane having ascended to 9,200 feet and then to 9,400 feet over a period of about 40 seconds before it entered a rapid descent. We believe that the rapid descent was probably initiated by the pilot in an attempt to prevent the indicated airspeed from decreasing to less than the stall speed -- about 69 KIAS. Since the airplane's derived airspeed at that point was about 140 KIAS, nose-down trim would have been required to prevent the airplane from climbing further, which probably accounts for the position of the elevator trim jackscrew -- about 30 percent nose-down trim. Also, about that time, the airplane entered a steep right turn, and its actual airspeed increased to over 190 KIAS.

As the airplane's actual airspeed increased substantially during the descent, the related vibrations may have been misinterpreted as stall buffet based on the erroneously low indicated airspeed, which could have stimulated further nose-down pitch changes and increased power as a remedy. As actual airspeed increased to more than 265 KIAS, portions of the airplane's horizontal stabilizer apparently began to distort and separate, which made further control of the airplane impossible between 6,500 feet and 4,500 feet, according to the trajectory study of airplane structure that separated in flight.

Although the pilot's fixation on indicated airspeed was probably the initiating event in his loss of control of the airplane, spatial disorientation could easily have occurred because of the fixation. Fixation results in the omission of a cross check of other performance and control instruments. If the omission lasts for more than a few seconds in a dynamic situation, the pilot may tend to disbelieve the other instruments in preference to a single instrument when the cross check is resumed, particularly if the dynamics of the situation have confused the pilot's internal motion sensing and position sensing systems. When this occurs, the pilot is spatially disoriented, and he or she may tend to fixate more strongly on the single instrument.

As noted before, the remedy for fixation is a rapid and accurate cross check of all the pertinent flight instruments. The pilot must not rely on any single performance instrument to determine what the airplane is doing. From the sequence of events in this accident that led to a rapid loss of control, the Safety Board believes that the evidence best supports a conclusion that the pilot's systematic cross check of all performance and control instruments was deficient due to his fixation on the airspeed indicator. Although the Safety Board could not exclude other possibilities, we believe that the most probable cause of the accident was the pilot's failure to activate pitot heat before flying at and above the freezing level in IMC followed by his improper response to erroneous airspeed indications that resulted from ice blocking the pitot tube. It is also possible that the pilot suffered a cardiac event, induced by the stress of attempting to remedy an erroneously low airspeed indication, that prevented him from controlling the airplane after the high speed descent began.

Naylor, Missouri (N22EK)

The first 90 minutes of the pilot's flight from UOS to SGF appear to have been uneventful as the pilot avoided heavy convective weather to the south of his route of flight. His weather radar apparently was operational as he reported to ATC "a small cell about 30 miles out" shortly after departure from UOS.

At 1125:23, the pilot requested a clearance from FL200 to FL220 which was approved by Memphis Center. The pilot apparently intended to climb above the clouds in southeastern Missouri as he reported to Memphis Center at 1128:13 that he was in a layer at FL200 to FL210 and that he was going to try to "get over it." According to the ATC radar profile and transcript, the pilot continued to climb above FL220 at a constant rate of about 500 fpm to FL227 while he was discussing the Topeka, Kansas, and SGF weather situation with the Columbia FSS flight watch specialist. The discussion ended about the time the airplane reached FL227, indicating that the pilot was probably using the autopilot for the climb from FL200 to FL220 without the altitude preselect feature that should have automatically levelled the airplane at FL220. Consequently, he probably climbed above FL220 while distracted by his discussions of weather with the Columbia FSS.

About 1132, the pilot of N22EK apparently realized that he had exceeded his altitude clearance limit, and he began a descent to FL220. However, the descent continued through FL220 to about FL204, at which time (1133:35) a climb was initiated and, at 1133:39, the pilot told the Columbia FSS that he was having "a little bit of trouble" and was trying to level the airplane at FL200.

Shortly after that transmission, the airplane's rate of climb increased substantially and the airplane climbed from FL206 to FL231 in about 36 seconds for an average rate of climb of about 4,200 fpm. Also, according to the flightpath study, the indicated airspeed decreased approximately to stall speed. After reaching FL231 at 1134:12, the airplane entered a rapid and uncontrolled descent during which radar contact was lost at an altitude of 8,400 feet. At 1134:15, shortly after ascending to FL231, the pilot made his last known transmission, "Two Two Echo Kilo, I've lost my ah... cho Kilo, Mayday, Mayday, Mayday."

There are a number of factors that cannot be positively excluded as possible initiating events in the loss of control of the airplane at FL231, such as failure of the cabin pressurization system, a significant reduction in or a complete loss of engine power due to ice formation in the air induction system, autopilot malfunctions, and electrical and vacuum systems failure. However, several conditions existed that might have led to the loss of control.

First, the meteorological data and the pilot's radio transmissions indicate that the airplane entered clouds at FL200 over southeastern Missouri. Also, these clouds were within about 5 miles of a moderate level (VIP2) convective cloud, and light to moderate mixed icing probably existed within the clouds above the freezing level--about 13,000 feet. The pitot heat switch was found in the off position, and the induction air selector was in the primary position.[6] Therefore, both pitot tube icing and induction air icing could have been encountered during the ascent from FL200 to FL227 and the subsequent descent to FL204. However, ground witnesses heard the engine apparently at a high power setting when the airplane emerged from the overcast clouds about 2,000 agl feet near the accident site.

[6] The pilot must manually select the alternate position in the induction air system to avoid icing in the system under conditions conducive to icing.

Therefore, a loss of engine power at high altitude from induction system icing can probably be excluded as a factor in the accident.

The pilot's last transmission "... I've lost my ... cho...." suggests that something vital had been lost that was adversely affecting control of the airplane. Although a complete loss of cabin pressure at FL200 and above could be serious if oxygen was not available, we believe that such a loss should not have caused pitch control problems unless it occurred very rapidly. Also, emergency oxygen was available to the pilot, and his attempt to "level at FL 200" would not have been consistent with a rapid loss of pressurization. Similarly, although pitch control problems could occur if the pilot attempted to assist the autopilot during the climb and descent without first disconnecting or interrupting autopilot control, the pilot's use of the words "I've lost my..." does not seem to relate to such complications. Therefore, the Safety Board believes that the pilot "lost" his airspeed indications because the inlet pressure port in the pitot tube was blocked by ice.

The conditions in the clouds that the airplane entered at FL200 were conducive to light to moderate mixed icing. Since the pitot heat switch was found in the off position, the airplane apparently entered the clouds with the pitot heat off. Further, the airplane remained in the clouds during the pilot's intended climb to FL220. Since the pilot was discussing the weather situation with the Columbia FSS during the latter portion of the climb, we believe that he was distracted and inadvertently climbed to FL227 before realizing that he had exceeded his altitude clearance limit. When this occurred (about 1131:45), the pilot began a descent, apparently to return to FL220. We believe that during this activity, he probably noticed that the indicated airspeed was low because about 1132:35 the rate of descent began to increase as the airplane descended through FL220 and below, probably due to the pilot's efforts to increase the indicated airspeed. According to the flightpath study, the derived indicated airspeed increased from about 110 KIAS to 198 KIAS during this descent.

Shortly after the pilot terminated the descent about FL203, he told the Columbia FSS at 1133:39 that he was "having a (?) bit of trouble" and was "trying to level out at flight level two zero zero...." However, the airplane began a rapid climb that ended about 1134:12 at FL231 where the airplane apparently stalled. This climb also demonstrates that the pilot was probably fixated on the airspeed problem and did not realize that the airplane was ascending rapidly, a situation that should have been evident on the other performance instruments -- altimeter, vertical speed indicator, and attitude indicator. When the airplane stalled at FL231, it entered an uncontrolled and rapid descent.

The airplane descended rapidly after the pilot declared an emergency, but its vital structural components apparently remained intact until it emerged from the clouds near 2,000 agl feet with its landing gear extended. The high drag of the extended landing gear apparently prevented the airplane from accelerating to airspeeds of about 265 KIAS or more that cause catastrophic failures in the structure of the horizontal stabilizer. Therefore, the pilot may have been able to regain control of the airplane when it entered VMC below the clouds. However, an abrupt pullup from the approximate 20-degree nose-down attitude caused catastrophic failures in both wings and the airplane crashed.

The Safety Board believes that the evidence supports a conclusion that the airplane was in IMC above the freezing level without the pitot heat activated. Therefore, the Safety Board determines that the probable cause of the accident was the pilot's failure to activate the pitot heat before flying in IMC above the freezing level followed by his improper response to erroneous airspeed indications that resulted from blockage of the pitot tube by atmospheric icing.

Lakeville, Michigan (N315RC)

The evidence related to the cause of this accident is sparse, but it appears that the airplane was in and near convective precipitation at and above the freezing level of about 12,500 feet for about 90 seconds before it entered a rapid descent and lost vital structural components in flight.

The evidence indicates that the pilot had no preexisting medical or physiological problems that might have adversely affected him during flight. Although he had possessed his instrument rating for less than a year, he had logged about 116 hours of actual instrument time and about 50 hours of simulated time. Also, he had flown the PA-46 for about 197 hours including 45 hours during the 90 days that preceded the accident. Further, he had logged 18 hours of actual instrument time during those 45 hours. Therefore, his proficiency and currency for flight in IMC in the PA-46 should have been adequate for the flight.

According to the flightpath study based on ATC radar data, the airplane had climbed steadily at a rate of about 1,000 fpm at 120 KIAS from 4,200 feet to 13,300 feet. At 13,300 feet, the airspeed decreased to about 110 KIAS, and near 13,800 feet, it decreased to less than 80 KIAS. At the latter altitude, the airplane began a slight turn, the airspeed continued to decrease, and at 13,900 feet, the airplane's highest altitude, it began a steep right turn and a rapid descent. Also, according to a correlation with the ATC transcript, the pilot acknowledged a frequency change about 5 seconds before arriving at 13,900 feet.

The steady rate of climb indicates that the pilot probably was using the autopilot with the vertical speed hold mode engaged on the KAS 297B. Therefore, when the speed began to decrease below 110 KIAS near 13,300 feet, the pilot might have applied forward pressure on the control wheel to decrease the airplane's pitch attitude and increase the airspeed without first disconnecting or interrupting autopilot control of the airplane. In such an event, the pitch trim system would have interpreted the forward pressure as a need for more nose-up trim and would have positioned the elevator trim tab accordingly. Consequently, when the forward pressure on the control wheel was released, the autopilot would have responded by increasing rapidly the airplane's pitch attitude. If the pitch rate exceeded 8 degrees per second, the autopilot would have disconnected if operating properly. Also, the rapid increase in pitch attitude may have reduced the airspeed quickly to stall speed. Under such circumstances, the airplane could have stalled and entered uncontrolled flight rather quickly.

Another possible explanation for the loss of control involves flight in icing conditions at and above the freezing level. Because the pitot heat switch was found in the off position, and the induction air selector was in the primary position, it is possible that the pilot encountered air induction system and pitot tube icing when the airplane approached the freezing level near 12,500 feet. Also, he may have encountered propeller and airframe icing. Because icing of these components can occur rather quickly in convective shower activity below, at, and above the freezing level, it is possible that the engine began to lose power as the airplane climbed above 13,000 feet. That could account for the loss of airspeed above that altitude with little or no reduction in the rate of climb.

According to the airplane performance data, the pilot should have been able to climb at a rate of about 1200 fpm at 14,000 feet with normal climb power available. Also, according to the ATC radar data and the flightpath study, the airplane's indicated airspeed decreased from about 120 KIAS to 110 KIAS near 13,200, with further reductions to near stall speed at 13,900 feet. These reductions in indicated airspeed suggest that the airplane's performance was degrading while the rate of climb continued. Therefore, the reductions in indicated airspeed as the airplane climbed in IMC above the freezing level must have been related to either a reduction in thrust or an increase in drag. The former could be related to throttle retardation, induction system icing, or propeller icing, while the latter could be related to airframe icing. Since the Cleveland Center controller had requested a "best rate of climb through 14,000 feet," to which the pilot agreed, it is doubtful that he would have reduced the power under the circumstances. Therefore, the Safety Board believes that induction system icing probably reduced the air flow to the engine and the power available from the engine. Further, it is possible that the drag on the airplane was increased by airframe icing, all of which combined to reduce the airspeed to stall speed as the airplane ascended to 13,900 feet.

Although a stall in IMC could induce a loss of control, the Safety Board believes that pitot tube blockage with ice may also have been a factor in the loss of control. With an airspeed indication erroneously low or near zero, the pilot might have fixated on the airspeed indicator in an attempt to restore flying speed subsequent to the stall. In the process, he descended too rapidly with a consequent rapid increase in actual airspeed that would not have been apparent from the erroneously low indications on the airspeed indicators produced by a blocked pitot inlet pressure port. Also, as the airplane rapidly attained a high actual airspeed, the related vibrations could have been mistaken for stall buffet which could have stimulated lower pitch attitudes and further increases in actual airspeed. In any event, the airplane exceeded airspeed limitations by a substantial margin which resulted in catastrophic failures and separations in the airplane's horizontal stabilizer. According to a trajectory study of various portions of the airplane wreckage, the in-flight structural separations began between 9,000 feet and 6,000 feet in the descent. Also, these altitudes were achieved with an average rate of descent from 13,900 feet of about 11,850 fpm which suggest that the pilot was not aware at all of what his actual airspeed must have been.

Although the Safety Board cannot exclude the pilot's misuse of the autopilot as the stall-inducing event, we believe that the most probable cause of this accident was the pilot's failure to use the airplane's ice protection equipment, which resulted in a performance loss due to induction icing or propeller icing, or both, while flying in convective IMC at and above the freezing level. The performance loss led to a stall, and the recovery developed into a high speed descent, possibly due to the pilot's improper response to erroneous airspeed indications that resulted from blockage of the pitot tube by atmospheric icing.

Bronson, Florida (N9112K)

In many respects, this accident appears to be similar to the incident that occurred the previous day to the pilot of N26033 who landed his airplane at Ocala, Florida, after encountering ice blockage of the pitot tube. Ocala is about 30 miles southeast of Bronson.

The pilot in this accident was qualified to fly the PA-46. However, according to his log book, he was not current for flying in IMC because he had not flown the required 6 hours of instrument time in the preceding 6 months. In fact, his log book indicated that he had flown only 2.7 hours of instrument time during the preceding 6 months. Therefore, his lack of instrument currency and proficiency probably were factors in the accident. There was no evidence that medical or physiological problems may have adversely affected his performance. Also, he was not under the influence of any drugs or alcohol.

The airplane weighed about 400 pounds more than its certificated gross takeoff weight on departure from St. Petersburg, and its CG was 1.6 inches aft of the limit for the takeoff. These conditions did not appear to have adversely affected the airplane during its takeoff and initial climb. However, these conditions may have been a factor in the pilot's inability to regain control of the airplane after control was lost during the en route climb from 16,000 feet to FL220.

According to ATC radar data, about 1031:55, during the en route climb to FL220, the airplane descended from about 17,200 feet to 16,800 feet and returned to 17,300 feet over a 23-second period. At 1032:18, the airplane again began a descent which, at 1032:30, increased rapidly. The descent continued through 16,500 feet where, at 1032:43, a right turn began. The descent continued to 15,400 feet where it was arrested at 1032:54 and a climb was begun. The climb continued to 17,200 feet and another descent was begun at 1033:18. During the climb, at 1033:00, the pilot told Jacksonville Center "... we're having a problem." At 1033:08, in response to the controller request to repeat the transmission, the pilot said "(Two) Kilo, we're having a ...." There were no further recorded transmissions from the pilot of N9112K.

Since the freezing level was near 13,000 feet, the Safety Board believes that the pilot of N9112K encountered atmospheric icing similar to that encountered in virtually the same area by the pilot of N26033 the previous day. However, since the propeller heat, pitot heat, and windshield heat switches were in the on position, and the induction air selector was in the alternate position in the wreckage of N9112K, the "problem" mentioned by the pilot could have been related to other factors, such as a KFC 150 or KAS 297B malfunction, misuse of the KFC 150 or KAS 297B functions by the pilot, or an inoperative heating element in the pilot tube.

With regard to the above factors, the airplane had been in a gradual climb at a rate of about 200 fpm for more than 3 minutes when the excursions from climbing flight began. According to the flightpath study, the airplane's indicated airspeed was about 150 KIAS during the shallow climb. Therefore, the pilot probably had the autopilot engaged with the vertical speed hold mode selected on the KAS 297B as he was known to use the autopilot extensively; also, when tested after the accident, the KAS 297B displayed an altitude of 22,000 feet and a rate of climb of 200 fpm. According to a close friend and fellow-Malibu owner, the pilot of N9112K believed that he knew the KFC 150 and KAS 297B systems well. Given these conditions, if the pilot had encountered a problem with these systems, we believe that it would have been a malfunction in the system itself rather than pilot misuse.

Although not all parts of the autopilot/flight director/KAS 297B systems could be functionally tested after the accident due to crash damage, many of the components were tested with no indications of preexisting defects or malfunctions, including the autopilot disengage and interrupt features. Therefore, had a malfunction in the autopilot and related systems occurred, the pilot should have been able to disconnect the autopilot without complications or problems. Further, the pilot should have been able to maintain control of the airplane in IMC even though his instrument flying currency apparently had lapsed, providing that other systems or flight instrument failures were not part of the problem.

The vertical gyro in the flight command director operated satisfactorily when tested after the accident although the null position was displaced slightly in bank and pitch, which would not have affected the accuracy of the attitude indicator function of the flight director. Also, there was no evidence of failure in either the vacuum systems or electrical systems. The standby vacuum system had not been activated. The pilot was known to have been meticulous about the maintenance of the airplane and its systems. Therefore, it is doubtful that any of the flight instruments were defective when he departed St. Petersburg, and the post accident testing indicates that one of the most important flight instrument gyros (the vertical gyro) was functional.

Notwithstanding the above possibilities of malfunctions or failures during flight that might have caused a serious problem, given all of the facts, conditions, and circumstances known about the accident, including similarities to the incident that occurred to the pilot of N26033 in the same general area on March 16, 1991, the Safety Board believes that the airplane encountered icing conditions in the clouds at and above the freezing level along the route and that the icing conditions eventually caused a problem for the pilot of N9112K.

The first manifestation of the problem may have developed from ice blocking the inlet pressure port in the pitot tube, resulting in erroneously low airspeed indications. If so, the pilot may have tried to correct the problem by discontinuing the climb and initiating a descent. The descent would not have remedied the situation; therefore, he may have added power which returned the airplane to a climbing attitude. The pilot might then have become concerned about the indicated airspeed and might have initiated a more rapid descent that placed the airplane almost 2,000 feet below its original altitude before another climb was initiated, during which the pilot told ATC that "... we're having a problem."

It is probable that the pilot eventually recognized the source of the problem--the lack of heat to the pitot tube, propeller, and windshield--turned on the related switches, and selected alternate air for the air induction system. However, he may not have realized that the application of heat to the pitot tube does not quickly remove the ice, and the alternating descents and climbs continued along with a turn to the right, suggesting that he remained focused almost entirely on the airspeed indicator.[7] As a result, the airplane entered its final descent about 1034:18 from an altitude of 15,500 feet. This was about 2 minutes, 18 seconds after the pilot first mentioned having a problem. According to a trajectory study of the separated structure, catastrophic structural failures occurred about 1035:05 near an altitude of 9,000 feet. The failures occurred because of excessively high airspeeds in the descent that destroyed the horizontal stabilizer.

Again, although other failures can not be totally excluded, the Safety Board determines that the most probable cause of this accident was the pilot's failure to activate the pitot heat before ascending above the freezing level in IMC followed by his improper response to erroneous airspeed indications that resulted from blockage of the pitot tube by atmospheric icing. Contributing to the accident was the pilot's lack of currency in flying in IMC.

Comments on Pitot Icing

Although somewhat of an odd coincidence that four of the five U.S. accidents discussed in this report probably involved ice blockage of the pitot tube, it is perhaps not unexpected given the backgrounds and experience of the pilots involved. None of the airplanes most recently flown by these pilots before transition to the PA-46 was certificated for flight into known icing conditions nor were any of those airplanes equipped with

[7] In the Ocala incident, the pilot apparently did not obtain valid airspeed indications for more than 3 minutes after he turned on the pitot heat. In the meantime, the airplane entered VMC near 7,000 feet which provided visual references for stabilization and control of the airplane. However, he continued to have pitch control problems due to a propensity to dive and add power in an effort to obtain indications of airspeed until the airplane was levelled near 3,000 feet.

significant ice protection equipment. Consequently, when flying those airplanes in IMC, the pilots probably would have avoided forecast icing conditions and flying in visible moisture near and above the freezing level.

With the transition to the PA-46 airplanes, all of which were equipped for flight into known icing conditions, the pilots probably would have been relatively unconcerned about encountering light to moderate icing conditions in flight. Also, the higher altitude capabilities of the turbocharged and pressurized PA-46 airplanes would have provided an improved capability to avoid IMC in freezing conditions, which may have reinforced their relative lack of concern about flight into forecast or actual icing conditions. Further, with relatively little experience in icing conditions, the pilots may have equated visible ice accretion on the windscreen or on the leading edges of the wings as the indication that the ice protection equipment, including pitot heat, should be activated.

However, pitot tubes, because of design and location on airplanes, are efficient collectors of ice and will ingest ice crystals that can block the tube but that will not otherwise accrete as airframe ice. Further, as evidenced by estimates provided by a major manufacturer of pitot tubes, blockage of an unheated pitot tube can occur rather quickly even in light icing conditions. Therefore, pitot tubes should be heated whenever the airplane is in visible moisture and the ambient temperature is +5° c or less.

The Safety Board tends to believe that the pilots involved in the Bakersfield, Naylor, Lakeville, and Bronson accidents, and the pilot involved in the Ocala incident, may have misunderstood or may have forgotten the above aspects related to pitot tube icing in IMC near or above the freezing level and, as a consequence, failed to activate the pitot heat in a timely manner. Also, there was no item in the pretakeoff, climb, or cruise checklists for the PA-46 airplane to remind the pilots that pitot heat should be activated during flight in visible moisture with the ambient temperature at 5° c or less. Finally, the pilots apparently were not aware of the effects of pitot tube icing and, therefore, reacted improperly to the erroneously low airspeed indications caused by blockage of the pitot tubes with atmospheric icing.

FINDINGS

1. The Piper Aircraft Corporation model PA-46-310P and PA-46-350P airplanes were properly certificated.

2. The King Radio Corporation KFC 150 series flight control system and KAS 297B vertical speed and altitude selector were properly certificated for use in the PA-46-310P and -350 series airplane; there was no evidence of malfunction or failures in these components in any of the U.S. accidents.

3. The Federal Aviation Administration's special certification review of the PA-46-310P and -350P series airplanes disclosed proper certification of the airplanes and the KFC

150 flight control system, but the review identified a number of modifications to the airplanes that would improve the reliability and safety of the KFC 150 flight control system and the airplanes.

4. The pilots involved in the five U.S. accidents were qualified, in accordance with existing Federal Aviation Regulations, to fly their respective PA-46 airplanes; however, the pilot involved in the Bakersfield accident did not have a current medical certificate, and the pilot involved in the Bronson accident was not current for flight in IMC due to insufficient instrument flight time in the 6 months that preceded the accident.

5. The airplane structure that separated in flight in the five U.S. accidents failed from airspeeds or load factors, or combinations of both, that substantially exceeded the design limits of the airplanes.

6. The pilots of the airplanes involved in the Bakersfield, Naylor, Lakeville, and Bronson accidents, and the pilot involved in the Ocala incident, were in IMC conducive to atmospheric icing shortly before they lost control of their respective airplanes.

7. The pilots of the airplanes involved in the Bakersfield, Naylor, and Lakeville accidents, and the pilot involved in the Ocala incident had not activated ice protection equipment before or after entering IMC conducive to atmospheric icing.

8. Although the switches were found in the on position, the pilot of the airplane involved in the Bronson accident probably did not activate the ice protection equipment switches until after he had encountered erroneously low airspeed indications due to blockage of the inlet pressure port of the pitot tube with ice.

9. The pilots of the airplanes involved in the Bakersfield, Naylor, and Lakeville accidents, the pilot involved in the Ocala incident, and probably the pilot involved in the Bronson accident, responded improperly to erroneously low airspeed indications caused by blockage of the pitot tube by atmospheric icing.

10. The pilot involved in the Bristol accident improperly used a stormscope to penetratean area of strong to very strong thunderstorms.

11. The PA-46 series airplanes are not equipped, nor are they required to be equipped, with a caution light to identify an inactive heating element in the pitot tube.

12. Because the induction air selector was not positioned to the alternate system before the pilot entered convective IMC at and above freezing level, the PA-46 involved in the Lakeville accident probably incurred induction system icing.

13. Specialized training in high altitude aerodynamics, propulsion, physiology, meteorology, and integrated flight guidance and control systems is needed by the pilots of PA-46 and Mirage aircraft.

SUMMARY

As a result of the Safety Board's investigation of the accidents mentioned in this report, the FAA's special certification review of the PA-46 series airplanes, the NASA's review of the aeroelastic properties of the airplanes, the PAC's review and testing of the airplanes' structural integrity, autopilot STC, and operational limitations, and the King Radio Corporation's provision of assistance and a KFC 150 and KAS 297B training supplement, the Safety Board concludes that there are no limitations to preclude operation of the airplanes within their certificated flight envelopes, including operation of the KFC 150 and KAS 297B in all modes. Further, we believe that all of the above parties should be commended for their significant contributions in verifying that the PA-46 airplanes meet the certification standards originally imposed and that the integrated flight guidance and control system in the PA-46 meets applicable standards.

The Safety Board is particularly pleased that the FAA's special certification review team has taken aggressive action in reviewing all pertinent aspects of the PA-46 certification and has made 61 recommendations regarding reliability and safety improvements, including pilot training improvements. Further, the FAA has initiated action on many of the recommendations, including AD action on four of them. Also, the PAC has revised the POH and airplane flight manual (AFM) normal procedures checklist sections to provide for preflight of the ice protection equipment and pretakeoff activation of some of the equipment if flight into icing conditions is anticipated. In this regard, the Safety Board believes that the climb, cruise, and descent sections of the PA-46 normal procedures checklist should be revised to include reminders for activation of pertinent ice protection equipment if IMC is encountered near and above the freezing level.

As revealed by the investigation of the accidents in this report, we believe that the area of most concern about operating the PA-46 and other similar airplanes is the adequacy of initial and recurrent training received by the pilots. In this regard, we note that effective April 15, 1991, the FAA amended 14 CFR 61.31 to add certain ground and flight training requirements for a pilot in command (PIC) of a pressurized airplane that has a service ceiling or maximum operating altitude, whichever is lower, above 25,000 feet msl. The ground training includes instruction in high altitude aerodynamics and meteorology, and subjects related to the physiological aspects of high altitude flight. The flight training can be accomplished in an airplane or in a simulator that meets the requirements of 14 CFR 121.407.

The Safety Board believes that the above requirements represent improvements in safety for the pilots and passengers of relatively high performance airplanes for which a type rating is not required. However, as a result of the investigation of the five fatal PA-46-310P and -350P accidents, we believe that the above requirements should not be limited to PICs of pressurized airplanes that have service ceilings or maximum operating altitudes, whichever is lower, above 25,000 feet msl. Based on the performance and operating complexities of the PA-46 series airplanes and other similar airplanes, the Safety Board believes that 14 CFR 61.31 should be amended to include pressurized airplanes that have service ceilings or aximum operating altitudes, whichever is lower, at or above 18,000 feet msl. We believe that the lower altitude is needed because it is the altitude at or above which IFR flight is mandatory, which usually imposes an additional workload on the PIC. Also, under standard atmospheric conditions, the air density at 18,000 feet msl is about 57 percent of the air density at sea level, the ambient pressure is about 50 percent of the pressure at sea level, and the ambient temperature is well below freezing. Consequently, sufficient physiological and atmospheric hazards exist at and above 18,000 feet msl to warrant training similar to that required in paragraph (f) of 14 CFR 61.31.

Since the airplanes that meet the criteria specified in 14 CFR 61.31 (f) are likely to have relatively sophisticated integrated flight guidance and control systems similar to the systems in the PA-46 series airplanes, the Safety Board believes that such systems should be included in both ground and flight training that is required by paragraph (f) of 14 CFR 61.31.

Also, we believe that flight schools that provide formal training in small airplanes equipped with relatively sophisticated integrated flight gidance and control systems should be able to provide detailed training information on the systems to its students. The training information should be adequate to enable pilots to diagnose system failures and malfunctions, understand pilot-induced flight control system problems, and use the system in a safe and proficient manner.

Additionally, since the incident and several of the accidents discussed in this report probably involved airspeed indication problems associated with pitot system icing, flight schools that provide the formal training mentioned above should also provide information on the effects of pitot static system blockages and failures on the operation of the integrated flight guidance and control system and the airplane. With regard to the PA-46 airplane, the KFC-150 flight control system is totally independent of indicated airspeed; however, other flight guidance and control systems use indicated airspeed as a control parameter. Therefore, the training information provided should make clear whether indicated airspeed is a control parameter. Further, the effects that erroneous airspeed indications caused by pitot or static system blockages might have on the operation of the integrated flight guidance and control system should be clarified.

It is the Safety Board's understanding that almost all of the PA-46 series airplanes produced are equipped for flight into known icing conditions. Therefore, since these airplanes are capable of operating in IMC at altitudes where the ambient temperatures are always below freezing, we believe that a need exists for a means to caution the pilot that the electrical heating element in the pitot tube is not active.

RECOMMENDATIONS

As a result of this investigation, the National Transportation Safety Board makes the following recommendations to the Federal Aviation Administration:

> Require modifications to the Piper Aircraft Corporation's airplane flight manual and pilot's operating handbook for the PA-46 series airplane to add warnings in the normal procedures checklists for climb, cruise, and descent flight that pertinent ice protection equipment should be turned on if instrument meteorological conditions are encountered near and above the freezing level. (Class II, Priority Action) (A-92-84)
>
> Require modification to the PA-46 series airplanes to provide for a pitot heat operating light similar to the light required by 14 CFR 25.1326 for transport category airplanes. (Class II, Priority Action) (A-92-85)
>
> Consider application of the first and second safety recommendations above to all models of small airplanes certificated to operate in icing conditions and at altitudes of 18,000 feet msl and above. (Class II, Priority Action) (A-92-86)
>
> Amend 14 CFR 61.31 to require the ground and flight training specified in paragraph (f) for pilots in command of pressurized airplanes that have service ceilings or maximum operating altitudes, whichever is lower, at and above 18,000 feet msl. (Class II, Priority Action) (A-92-87)
>
> Amend 14 CFR 61.31 (f) to include integrated flight guidance and control systems as part of the ground and flight training requirements specified in subparagraphs (f) (1) (i) and (ii). (Class II, Priority Action) (A-92-88)
>
> Require the manufacturers of integrated flight guidance and control systems, for which supplements to the airplane flight manual and pilots operating handbook must be provided, to develop and make available to operators detailed training information that will enable pilots to diagnose system failures, understand pilot-induced flight control system problems, and use the system in a safe and proficient manner. (Class II, Priority Action) (A-92-89)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

<u>CARL M. VOGT</u>
Chairman

<u>SUSAN M. COUGHLIN</u>
Vice Chairman

<u>JOHN K. LAUBER</u>
Member

<u>JOHN A. HAMMERSCHMIDT</u>
Member

<u>CHRISTOPHER A. HART</u>
Member

July 21, 1992

Member Christopher A. Hart filed the following concurring and dissenting statement:

I concur in the Special Investigation Report and all of its recommendations except the following recommendation and the supporting text:

> Amend 14 CFR 61.31 to require the ground and flight training specified in paragraph (f) for pilots in command of pressurized airplanes that have service ceilings or maximum operating altitudes, whichever is lower, at and above 18,000 feet msl.

I am unable to support this recommendation at this time because the Report does not contain sufficient supporting data or analysis.

More specifically, it is my understanding that the amendment proposed by this recommendation would affect, in addition to Malibus and Mirages, at lest eight types of pressurized reciprocating-engine and turboprop airplanes, numbering roughly 1600, for which the pilot is not required to have a type certificate. However, the Report does not discuss or provide the accident history of these additional airplanes to demonstrate a need for the proposed amendment. Moreover, the Report recommends 18,000 feet as the cutoff altitude because that is the floor of positive control airspace, but that fact alone does not, in my view, justify its use as the cutoff altitude for this purpose. Finally, the Report gives no reason for applying the requirement to specific airplane types as opposed to, for example, applying it only to pilots who fly above the selected altitude, analogous to permitting only IFR flight above 18,000 feet.

The FAA Special Certification Review of the PA-46 included the following recommendation that, if adopted, might result in an analysis of some of these issues:

> Recommendations: An in-depth review should be conducted by industry and the FAA to update the pilot certification rules (FAR-61) for small airplanes operating above 18,000 feet to adequately consider all aspects of the pilot, the aircraft, and the operating environment (p. 91).

Without such supporting data or analysis, however, I am unable to determine whether our recommendation is warranted, and therefore I do not support it at this time.

CHRISTOPHER A. HART
Member

APPENDIX A

PILOT EXPERIENCE

TYPE EXPERIENCE (HOURS)	BRISTOL	BAKERSFIELD	NAYLOR	LAKEVILLE	BRONSON	OCALA
TOTAL TIME:	1619	8155	1603	983	2252	550
TOTAL INSTRUMENT TIME:	441	1348	365	166	152	55
TOTAL PA-46:	17	51	182	197	268	80
PA-46 INSTRUMENT:	3.9	15.4	54.2	87.6	15.1	unknown
PREVIOUS AIRCRAFT FLOWN:	PA-32-300	PA-24-260	PA-28R-200	PA-28RT-201T	BE A36	PA-32R-301
	PA-28R-200	TAYLORCRAFT	BE F33A	PA-28-180	PA-28-181	PA-28-181
	PA-34-200A	BELLANCA	PA-28-140	C150	PA-28-160	
	PA-34-200T	SWIFT	C150		C150	
		CESSNA				
PREVIOUS TURBO MODEL:	PA-34-200T	none	none	PA-28RT-201T	none	none
PREVIOUS PRESSURIZED MODEL:	none	none	none	none	none	none

APPENDIX B

KFC 150 Flight Control System

All Piper Malibu/Mirage series airplanes involved in the accidents reviewed by the Safety Board's special investigation team were equipped with a King Radio Corporation[8] KFC 150 flight control system. The following system description information was excerpted from the KFC 150 pilot guide and technical manuals.

The system was certified by the King Radio Corporation under Federal Aviation Administration (FAA) supplemental type certificate number SA1778CE-D as approved and installed in the Malibu/Mirage series airplanes by Piper Aircraft Corporation. The KFC 150 system is approved for two-axis (pitch and roll) or three-axis control if the optional yaw damper is installed. The yaw axis control provides yaw damping and turn coordination with or without engaging the autopilot. The KFC 150 autopilot system also has an electric pitch trim system which provides autotrim during autopilot operation and manual electric trim.

The KFC 150 system is composed of the KC 192 Autopilot and Flight Director Computer, KI 256 Flight Command Indicator, KAS 297B Altitude Vertical Speed Selector, KS 270A Pitch Servo, KS 271A Roll/Yaw Servo, KS272A Trim Servo, KM 275 Pitch, Roll, and Trim Servo Mounts (see Figures B-1 and B-2).

The FAA approved flight manual supplement for the KFC 150 system contains the following operating limitations:

A. During autopilot operation, a pilot with seat belt fastened must be seated at the left pilot position.
B. The autopilot and yaw damper must be OFF during takeoff and landing.
C. The system is approved for Category I operation only. (Approach mode selected).
D. Autopilot maximum airspeed limitation: 185 KIAS.
E. Maximum fuel imbalance: 10 gallons.

NOTE: In accordance with FAA recommendation 9AC00-24A0, use of basic "pitch attitude hold" mode is recommended during operation in severe turbulence.

Fundamentals of Operation

The KFC 150 autopilot assists the pilot in the control of the airplane's flight- path. The system operates in the pitch and roll axes, and the with the optional yaw damper, in the yaw axis. The system is driven by signals from: (1) attitude reference sensors, such as the attitude indicator and directional gyros, (2) altitude sensors, such as the altimeter (includes

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[8] Now the Bendix/King Avionics Division of the Allied Signal Aerospace Corporation.

encoding altimeter) and an internal pressure sensor located in the KC 192, and 93) navigation sensors, such as VOR, RNAV, and LORAN. The KFC 150 system does not have provisions to sense or control the speed or engine power settings of the airplane. Speed control is a pilot function.

The attitude, altitude, and navigation signals are processed by microprocessors in the KC 192 Mode controller/computer/annunciator. Errors or deviations in the intended flightpath are sensed, and corrective action is taken to resolve the error by signals to the flight director indicator and/or autopilot servos which operate the airplane's flight control surfaces. Each axis (yaw optional) uses servos to drive the flight control surface in parallel with the airplane's control system. Each servo incorporates a slip clutch to allow the pilot to overpower the autopilot command signals. The flight control system engages pitch, pitch trim and roll servos when the autopilot is activated. The roll axis cannot be engaged without pitch axis engagement. The yaw damper may function independently of pitch and roll control.

Autopilot System Modes of Operation

The following autopilot system modes are discussed by airplane control axis and explained in further detail below.

Roll Axis

The following modes operate about the airplane's longitudinal (roll) axis.

Wings Level

The wings level mode provides guidance to the pilot (or the autopilot) to maintain a wings-level attitude. The airplane's roll attitude is sensed by the KI 256 attitude gyro and corrected to wings level. Roll rates between attitudes of 30 degrees and 0 degrees cannot exceed 14 degrees per second without disengaging the autopilot.

Heading (HDG)

The heading mode provides for the airplane's track as selected by the heading bug on the directional gyro (DG) or horizontal situation indicator (HSI) to be monitored and corrected relative to the heading as displayed on the DG or HSI.

Navigation (NAV)

The navigation mode provides guidance to the pilot (or autopilot) in intercepting and tracking VOR and RNAV courses. When the navigation mode is selected, two signals are fed into the roll microprocessor to begin computation for navigational correction. The first signal is the navigational deviation coming from the navigation receiver. The second is from the compass system. Course deviation is sensed by information from the navigation receiver or LORAN and corrected.

Approach (APR)

The approach mode provides guidance to the pilot and autopilot in intercepting and tracking ILS (both localizer and glideslope), and VOR and RNAV courses. Course deviation is calculated from information sensed by the NAV receiver.

Back Course (BC) approach

The back course mode provides guidance to the pilot (or Autopilot) in intercepting and tracking a reverse localizer course. During a back course approach the glideslope is locked out.

Pitch Axis

The following modes operate about the airplane's lateral (pitch) axis and are explained in detail below:

Pitch Attitude Hold

The pitch attitude hold mode is controlled by a pitch microprocessor in the KC 192. The pitch attitude existing at the moment the flight director is called for, is held as the reference pitch attitude which the autopilot will fly. Any deviation from the pitch attitude is sensed by the attitude gyro and converted to command signals. The pitch attitude mode has two sub-modes which can change the attitude of the aircraft. One is the vertical trim switch (located on the front of the unit), with which the pilot can vary the pitch attitude either up or down at a rate of approximately 0.9 degrees per second when not in altitude hold. When operating in altitude hold, operating the vertical trim switch will command an approximate 500 feet per minute rate of change. The other method of changing pitch attitude is through control wheel steering. Pitch control limits are imposed at 15 degrees up and 10 degrees down.

Altitude Hold

The altitude hold mode will command the autopilot to maintain the engaged altitude. The altitude hold mode is operated by the KC 192 internal pressure detector. An altitude hold transducer continuously monitors the atmospheric static pressure. When the altitude hold mode is called for by the pilot, the altitude existing at the time the mode is selected becomes the reference altitude. Any deviations from that altitude result in commands generated by the pitch microprocessor which cause the aircraft to return to the reference altitude. The pilot may alter the altitude which he is flying and still remain in the altitude hold mode by depressing the control wheel steering switch or by selecting an altitude in the KAS 297B altitude selector.

Glideslope

The glideslope mode is a submode of the approach mode. Glideslope is not allowed if the approach mode has not been called for or the LOCENGAGE signal has not been received. The glideslope mode is also not allowed if the back course mode has been selected. Glideslope deviation is sensed by the navigational receiver and acted on by the pitch microprocessor.

Altitude Select

The altitude select function operates by comparing the altitude sensed by the KC 192 internal pressure detector/encoding altimeter and KAS 297B altitude selector and correcting to a preselected altitude on the KAS 297B.

Vertical Speed Select

The vertical speed function operates through a selection made on the KAS preselector. The vertical speed rate of change is sensed by the encoding altimeter and KC 192 internal pressure detector and corrected by the KAS 297B.

Control Wheel Steering (CWS)

When the autopilot system is engaged, the pilot may take control of the airplane by pressing the CWS switch on the control wheel. Depressing the CWS switch disengages the servo clutches giving the pilot full control while the switch is depressed. Autopilot system-generated flightpath correction information is displayed by the flight director. The CWS switch provides flight director synchronization for vertical speed, pitch attitude, and altitude hold modes when the flight director is active. A new axis reference is established when CWS is released.

Autotrim System

The KFC 150 includes as standard equipment an automatic and manual electric trim. This allows the system to trim off elevator control surface pressures when the autopilot is controlling the elevator through a pitch servo. If the autopilot is not engaged and the pilot is flying the airplane, the manual electric trim switch on the yoke can be used to trim off elevator control pressures.

The autotrim mode receives its command signals from the pitch microprocessor. Signals from sense switches in the pitch servo enter the microprocessor indicating that trim is needed in one direction or the other. The error is resolved by sending the appropriate command to the trim servo motor. If flaps have been selected, speed of servo motor operation is increased.

The autotrim system also includes a proportional rate feature which varies trim servo commands with a variable servo motor speed based on the magnitude of error correction calculations.

KAS 297B Vertical Speed and Altitude Select System

The KAS 297B provides independent control and display of altitude and of vertical speed selection. The two modes--altitude select and vertical speed--are not related.

Altitude select is strictly an ARM function which means that it provides altitude alerting and transfer to altitude hold mode. Altitude alerting occurs whether the mode is armed or not. An alert annunciation illuminates and a 2 second aural tone sounds when the airplane reaches 1000 feet from the selected altitude. If the autopilot is engaged and the altitude select is activated, another vertical mode is required to provide guidance to that selected altitude. If vertical speed select is not activated and the autopilot is engaged, the default vertical mode, Pitch Attitude Hold, is active and must be pilot adjusted to provide guidance to the selected altitude. Altitude select does not provide vertical guidance.

Vertical speed is a guidance mode. Unless altitude arm has been activated, the airplane will not capture a selected altitude. If a vertical speed is displayed when the ENG button is pushed, that vertical speed will be the commanded vertical speed, and pitch angle will be adjusted to maintain the selected vertical speed. If a vertical speed is not displayed, the current airplane vertical speed will become the reference value.

Preflight Test KFC 150 Flight Control System

The KFC 150 system incorporates a system self-test function which is activated by a test button on the KC 192. The test must be performed before the autopilot portion of the system can be engaged, but it need not be performed before using the flight director. A failure of any test prohibits the autopilot from being engaged. The preflight test determines, before takeoff, that the system is operating normally.

The preflight test mode in the KC 192 is activated by the test button on the face of the unit. Items tested during the five-second test mode are as follows:

A. Presence of the top and bottom adapter boards in the KC 192 in their correct locations.

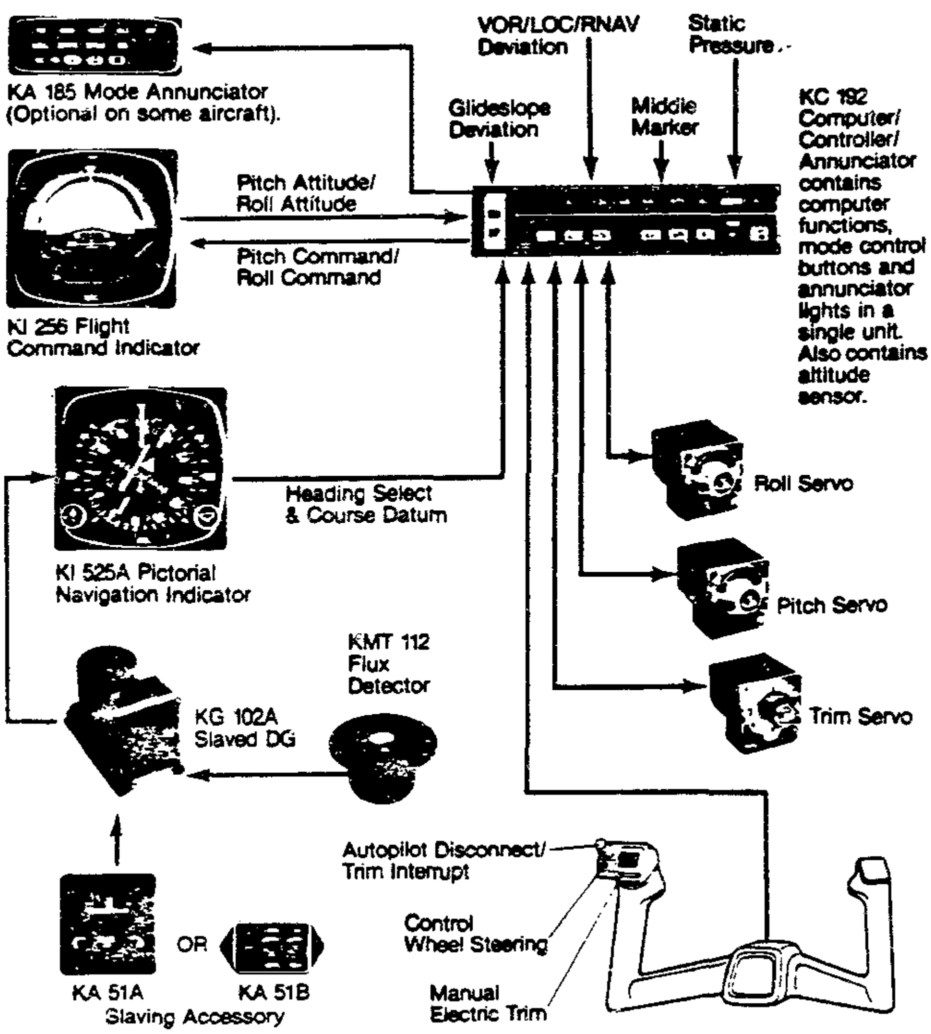
B. Operation of the three microprocessors and the communications bus which links them together.
C. Operation of the mode select input and mode annunciation output serial data lines which are connected to the logic microprocessor.
D. Presence of proper voltage to operate the manual trim.
E. Operation of the autotrim drive and monitor circuits.
F. Operation of the roll and pitch rate monitors.
G. Operation of the autopilot aural and visual warning indicators.

KFC 150 System Safeguards

The KFC 150 flight control system provides the system safeguards to help prevent a failure of the system from affecting the controllability of the airplane. The following conditions will cause the autopilot to automatically disengage:

A. Power failure.
B. Internal KFC 150 flight control system failure.
C. With the KCS 55A Compass System installed, a loss of compass valid signal disengages the autopilot when a mode using heading information is engaged.
D. Roll rates in excess of 14 degrees per second will cause the autopilot to disengage except when the CWS switch is depressed and held.
E. Pitch rates in excess of 8 degrees per second will cause the autopilot to disengage except when the CWS switch is depressed and held.
F. Failures of manual and autotrim systems are monitored. Failures are aurally and visually annunciated.

TYPICAL KFC 150 FLIGHT CONTROL SYSTEM



This Is A 2-Axis (Pitch and Roll) System.

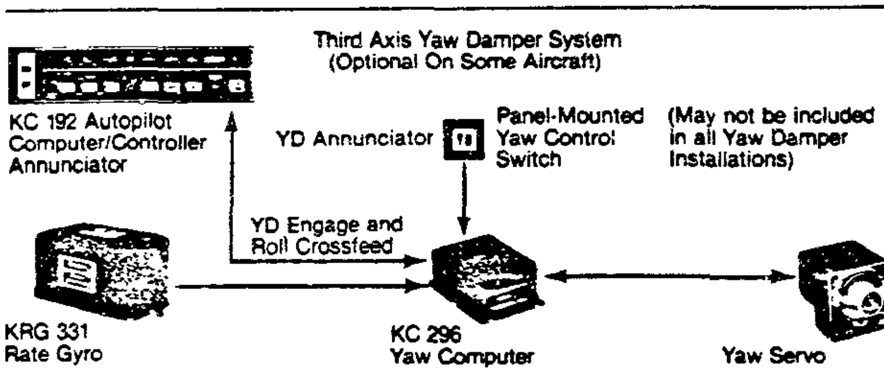
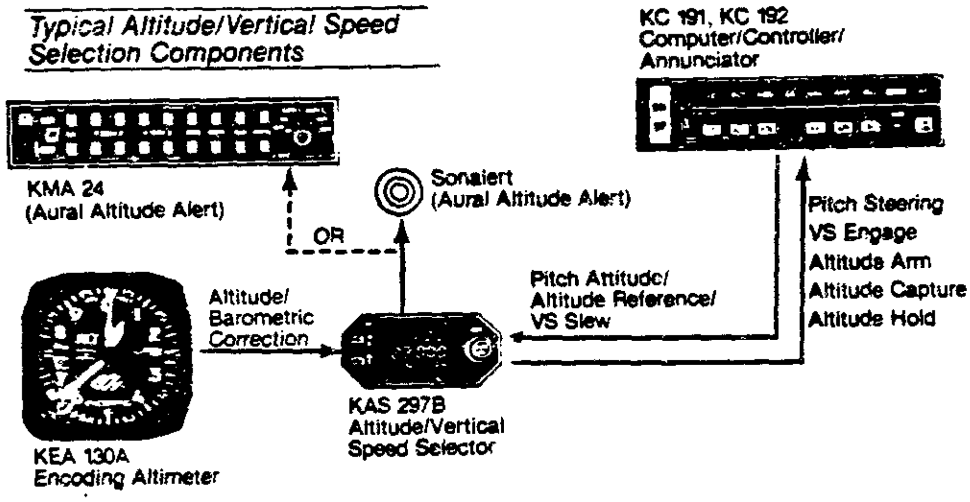
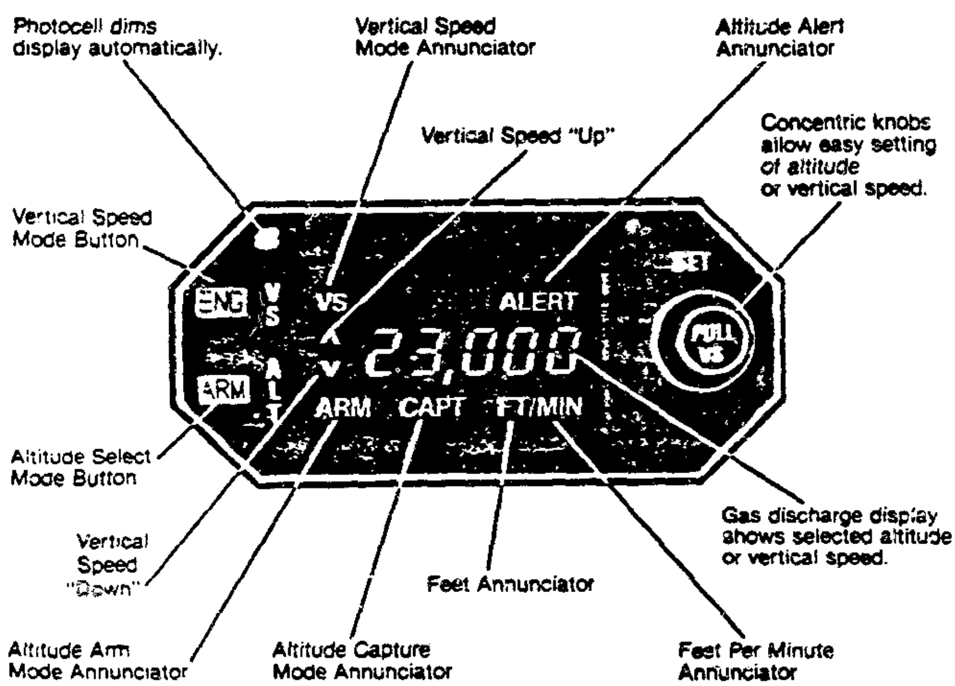


FIGURE B-1





OPTIONAL KAS 297B ALTITUDE AND VERTICAL SPEED SELECTOR

FIGURE B-2

APPENDIX C

FAA Special Certification Review

Executive Summary

The following information was extracted from an FAA report dated December, 1991, entitled: Results of Special Certification Review of the Piper PA-310P (Malibu) and PA-46-350P (Mirage).

The Special Certification Review (SCR) was initiated by the FAA to review the certification of the Piper PA-46-310P Malibu. The review was started as a result of seven in-flight structural breakups. The accidents occurred in a period of about 22 months and involved six PA-46-310P (Malibu) airplanes and one PA-46-350P (Mirage) airplane. After the seventh accident, the FAA issued Airworthiness Directive (AD) 91-07-08 which restricted operation of the PA-46 airplanes. The restrictions were based upon some common environmental conditions the airplanes encountered prior to the accidents.

An SCR team was assembled using FAA National Resource Specialists and technical specialists from several Aircraft Certification Offices. The team reviewed the type certification, including airframe structures, ice protection, systems and equipment, propulsion, production certification and service history. Other appropriate factors were also reviewed that were pertinent to the operation of the airplane, such as airspeed control, pilot training, and proficiency in operating a complex, high altitude, pressurized, turbocharged, single-engine airplane, all with the goal of determining if an unsafe condition exists for the airplane and/or autopilot installation. The charter of the SCR team did not include determining the cause of the seven accidents.

The recommendations contained in this report are divided into four categories: Category 1 are recommendations considered mandatory to relieve the operational restrictions contained in AD91-07-08; Category 2 are recommendations for design changes to correct an unsafe condition; Category 3 are recommendations considered to be product improvements; and Category 4 are recommendations addressed to the FAA for action such as rule changes or clarification of policy and guidance.

The major design feature of the Malibu/Mirage airplane or Bendix/King autopilot was found to be in compliance with the certification requirements; however, several areas were identified for improvement of design and clarification of operational instructions.

The PA-46 Series airplanes have the ability to operate up to 25,000 feet. This increases the exposure of the pilot and the airplane to more severe physiological, psychological, and environmental conditions than are associated with flight at lower altitudes. The air-traffic control environment above 18,000 feet requires additional demands on the pilot. This, coupled with the complexity of the airplane and its systems, requires that the pilot be constantly attentive and proficient. If not operated properly, the airplane can get deviated from the approved flight envelope with potentially disastrous consequences. The team believes that the most likely accident scenario is one in which the pilot loses control of the airplane at altitude, the airplane descends at increasing speed and breaks up as a result of dynamic pressure, or aerodynamic loads outside the certified flight envelope. For these reasons, the team is recommending that special training be required for complex airplanes operated above 18,000 feet and that more detailed information on the proper use and consequences of misuse of autopilots and systems be highlighted to pilots. In addition, the team recommends that consideration be given for providing drag-producing devices, such as speed brakes or gear extension at high speed, to assist the pilot in keeping the airplane within its design flight envelope.

The team identified a possible deficiency in the regulations with respect to using the simplified criteria for establishing empennage flight loads. NASA expertise was utilized to help conduct a rational analysis to determine if calculated loads exceeded the loads Piper used (simplified criteria) in the design substantiation of the PA-46 series airplanes. The team concluded that the structural substantiation for the PA-46-310P and PA-46-350P is adequate for all conditions within the approved flight envelope. The use of the simplified criteria is no longer allowed for developing empennage flight loads on new projects. However, the team recommends that the FAA conduct a review of empennage structural integrity on those high performance airplanes which have used FAR 23 Appendix B for certification.

The team identified some potential failures within the autopilot system which could cause hazardous conditions to the airplane in flight. To reduce the effects of autopilot malfunctions in the PA-46-310P/350P, the team recommends that the installation be changed to automatically disconnect the autopilot if the stall warning activates or if airspeed exceeds 185 knots. However, these failures are not unique to the KFC 150 autopilot, and they are conditions not normally considered when certifying autopilots for FAR 23 airplanes. For this reason, the team is recommending that the FAA reconsider how autopilots are certified and consider that an autopilot hardover is not necessarily the most critical failure condition.

The autotrim system is also a concern. The team has recommended that a "Trim in Motion" alerting system be installed or the authority of the autotrim system be reduced or that both changes be made in the PA-46-310P/350P.

The team has recommended that the primary induction air system be modified so that when alternate air is selected, only air from a sheltered source be available to the engine induction system. The current system design allows saturated air to enter the induction system through the primary air source even though the alternate source is selected.

The team has made numerous recommendations to clarify FAA policy, establish new rules and revise some existing rules for various design and operational aspects for complex, pressurized, single engine, high altitude operation airplanes.

A summary of all the recommendations can be found under Recommendations.

Design and Certification Background

The Piper Malibu (PA-46-310P) was certified in September 1983 and is considered one of the first cabin class, pressurized, piston powered, single-engine aircraft. The certification basis is FAR Part 23 effective February 1, 1965, through Amendment 23-25, effective March 6, 1980; FAR 25.783 (e) of Amendment 25-54, effective October 14, 1980, FAR 25.831(c) and (d) of Amendment 25-41, effective September 1, 1977; and FAR 36 through Amendment 15, effective May 6, 1988. No equivalent safety findings apply. The PA-46 series airplanes were designed and built under the Delegated Option Authority (DOA) as authorized under FAR Part 21.231.

The Malibu is a six-place all-metal cabin monoplane. The wings are of cantilever design that have a high aspect ratio with a positive dihedral. The flaps are either hydraulically or electrically actuated depending on the aircraft serial number (S/N). The tail is conventional with swept vertical surfaces and an extended dorsal fin blended into the upper surface of the rear fuselage. The elevator is horn balanced with a single symmetrical trim tab on the trailing edge. The landing gear is hydraulically actuated. The main gear retracts into the wing root, and the nose gear retracts rearward and is rotated 90 degrees, to lie flat under the baggage compartment.

A Bendix/King autopilot was designed and approved for factory installation in the Malibu. The autopilot also included an optional altitude preselect system. The KFC 150 series autopilot was certified by the Bendix/King Designated Alteration Station (DAS) as authorized by FAR 21.431. The system is a 2-axis autopilot that controls pitch and roll, or a 3-axis system if an optional yaw damper is installed. The autopilot includes an electric pitch trim system which provides a proportional rate autotrim during autopilot operation. The KFC 150 also includes a KAS 297B which is an optional altitude preselect feature. The altitude preselect provides the pilot the ability to select vertical speed hold; ability to select, arm, and upon approaching the selected altitude, automatically transfer into Altitude Hold; and provides altitude alerting. Indication of preselected altitude and vertical speed is displayed on the same indicator and selected by the same knob, that is, vertical speed when the knob is pulled out, and altitude preselect when the knob is pushed in.

Production deliveries began in November 1983, and 403 PA-46-310P airplanes were built and delivered.

The Malibu is powered by a Teledyne Continental TSIO-520-BE (310 horsepower) engine which drives a Hartzell two-blade constant-speed propeller. Piper phased the Malibu out of production and replaced it with the Mirage in 1989. The Mirage is virtually the same as the Malibu except that the Mirage has a Textron Lycoming TIO-540-AE2A (350 horsepower) engine installed. To date, Piper has delivered approximately 120 Mirage airplanes.

Recommendations

1. Piper SB No. 944 which replaces certain rivets should be considered for AD action. (Category 2)

2. FAA should evaluate the crown flush rivet allowable for applications subject to vibration from the effects of propeller slipstream impingement on the structure. (Category 4)

3. Rational analysis should be used by Piper to develop design maneuver and gust tail loads using data available from the Piper instrumented flight tests (Reference 1) and the available NASA aerodynamic simulations. (Category 3)

4. Piper should reevaluate wing downwash effects on the horizontal stabilizer gust loads. (Category 3)

5. Rational data should be developed by Piper and then used to reevaluate the wing steady roll conditions. (Category 3)

6. Piper should update the wing analysis report to reflect the Mirage wing static test results. The steady roll cases should be reevaluated. (Category 3)

7. Piper should use data from the flight tests to develop rational maneuver and gust design loads on the horizontal stabilizer for comparison with static test results . Drag load estimates should be included. (Category 3)

8. Piper should use data from the flight tests to develop elevator and tab design loads. (Category 3)

9. The FAA should consider an increase in the elevator balance weight design criteria. Military criteria require a limit load factor normal to the plane of the surface of 100g. (Reference MIL-A-8870A.) These criteria are considered more appropriate for a balance weight in a severe buffet environment, such as stall buffet. (Category 4)

10. Piper should re-evaluate the vertical fin load distributions using rational data derived from the flight test data. (Category 3)

11. It is considered important to assist the pilot in keeping the airplane within its design flight envelope. Therefore, consideration of speed brakes, or the ability to extend the landing gear up to the design dive speed is recommended. (Category 3)

12. The effects of autopilot and electric trim malfunctions and the need for constant monitoring when the autopilot is engaged should be added to the PA-46-310P/350P airplane flight manual. Errors and inconsistencies in the Piper and Bendix/King

airplane flight manuals for the autopilot should be corrected. The airplane flight manual should be revised to prohibit the use of normal electric trim after a trim warning and require that the TRIM circuit breaker be opened. (Category 3)

13. A limitation and a placard requiring a preflight test of the electric trim system to verify normal operation and detect passive failures should be added to the PA-46-310P/350P airplane flight manual by an AD. (Category 2)

14. A general aviation airworthiness alert should be issued for the Piper PA-46-310P/350P that contains the information in items 12 and 13 above.

15. An AD should be issued applicable to the Piper PA-46-310P/350P modified by Bendix/King STC SA1778CE-D to accomplish the following changes to the autopilot and electric trim system: (Category 2)

    a. Limit the authority of the electric autotrim system when the autopilot is engaged in an appropriate manner, such as by causing an autopilot disconnect if the trim wheel is moved continuously by more than a specified amount and/or install a pitch trim in motion aural and visual alert which will activate if the electric trim system rotates the trim wheel continuously for more than a specified number of seconds.

    b. Interlock the stall warning sensor with the autopilot to disconnect the autopilot if the stall warning activates.

    c. Install sensors, which will cause the autopilot to disconnect if the indicated airspeed exceeds 185 knots when there is not significant pitch axis mistrim.

16. Bendix/King should develop an improved monitor for vertical gyro excitation failures to prevent single failures from causing a multiaxis autopilot malfunction. (Category 3)

17. The FAA should assure that future changes to the software of the Bendix/King 100 series autopilots be developed at least in accordance with level 2 of RTCA/DO-178A or that the maximum servo torque settings for future installations, which make use of the new software, be limited to prevent airplane responses to servo hardovers from exceeding the limits of AC 23.1329-2, paragraph 4.b.(1). (Category 4)

18. The FAA and Bendix/King should review the certification data to determine if other airplanes with the Bendix King 100 series autopilot installed should be modified in accordance with some or all of the recommendations of item 15 and 16 above. (Category 4)

19. The FAA should consider creating an additional set of requirements in FAR 23 applicable to airplanes capable of flight at and above altitudes of 18,000 feet. For this category of airplane, the following rules and policy material should be reviewed for possible changes. (Category 4)

    a. FAR 23.1331(a)(3) should be changed to incorporate the requirements of FAR 25.1331(a)(1) for an integral power failure indication within each instrument rather than permitting a separate power indication such as a vacuum gage. Perhaps this change should be made for all FAR 23 airplanes. See detailed discussion in Section IV, Attitude Indicator.

    b. The installation of a standby attitude instrument system should be required.

    c. FAR 23.1329(e) should be revised to require that a single malfunction will not produce a signal in more than one axis which will produce a hazardous deviation in the flight path. AC 23.1329-2 should define what constitutes a hazardous deviation to the flight path when considering multi-axis malfunctions.

    d. The time delays associated with autopilot malfunctions should be reviewed with respect to realistic values for single pilot operation in instrument flight conditions. For this category of airplanes, perhaps a monitored autopilot which alerts the pilot to malfunctions and disconnects before exceeding specified deviations from the flight path should be required.

    e. FAR 23.677 should be reviewed and additional requirements considered to limit the maximum trim authority of powered trim systems to less than the maximum transient control forces of FAR 23.143, to require a trim in motion alert for both manual and autopilot operation, and to require the ability to manually override the powered trim system.

20. The Flight Standards Service should consider developing requirements for a new rating for private and commercial pilots applicable to airplanes capable of operating at altitudes above 18,000 feet. The training program for this rating should include air traffic control procedures in positive control airspace, planning for normal descent, high altitude weather, and the operation and monitoring necessary for the complex systems found in these airplanes such as pressurization, anti-ice, powered controls, autopilot, flight director, and complex navigation systems. (Category 4)

21. It is recommended that PAC develop an alternate air system that will provide unsaturated, moisture-free air. This improved system should be required for installation on all PA-46 series airplanes by means of an AD. (Category 2)

22. It is recommended that the FAA review FAR 23.1091(b)(2) and policies and guidance pertaining to sheltered source in order to assure the desired minimum level of safety when certification with ice protection provisions of FAR 23.1419 are applied. (Category 4)

23. It is recommended that a mandatory inspection be made of the magneto pressurization adapter assembly for the PA-46-310P to assure that P/N 646797 is installed and correctly positioned. (Category 2)

24. It is recommended that for the PA-46-310P the minimum oil quantity (7 quarts) be established as a limitation as required by Piper SB 871, the airplane and the POH should be revised by AD, and the AD should require a placard adjacent to the engine oil service port. (Category 2)

25. It is recommended that FAR 23.1551 be revised to require indication of only usable oil quantity. (Category 4) Page 49

26. It is recommended that an AD be issued for the PA-46-310P to require installation of the improved oil pump suction tube assembly P/N 64980 as specified in Piper SB 871. (Category 2)

27. It has been determined that the PA-46-310P/350P vacuum gauge (P/N 96395-0) does not display adequacy of power markings for the vacuum system and is, therefore, considered in noncompliance with FAR 23.1331(a)(3). Continuous vacuum power is required for continued safe operation in certain instrument meteorological conditions; therefore, it is recommended that an AD be issued to mandate corrective action to include compliance with Piper SB 947 and any addendum. This should include both modification of the vacuum gage marking and a change to the limitation section of the appropriate POH. (Category 2)

28. Since dual vacuum pump operation is required for flight into known icing and loss of all vacuum sources will result in loss of pilots attitude information, degradation of the autopilot operation, and loss of airfoil ice protection, it is recommended that Piper and Airborne Air and Fuel Products coordinate the issuance of a SB to provide a more reliable clutch installation for the optional vacuum pump (P/N 28C444CW-4) on all Piper model PA-46-310P airplanes. (Category 3)

29. The FAA should consider developing a regulation similar to FAR 25.1331(a)(1) requiring an "integral" annunciator (flag) for all flight instruments that are vacuum operated for use in instrument meteorological conditions. (Category 4) Page 53

30. It is recommended that PAC develop a change to the basic POH to inform the pilot that the pitot heat should be on during all operations in visible moisture when outside air temperature (OAT) is less than 5° C. (Category 3) Page 56

31. It is recommended that the FAA develop a regulatory change for small airplanes that are approved for flight into known icing that would require pitot heat operating light similar to FAR 25.1326. (Category 4)

32. It is recommended that Piper develop a SB to provide a "guarded" manual pressurization control for the PA-46-310P airplane. This guarded control should be similar to the installation in the PA-46-350P airplane. (Category 3)

33. Since previous investigations of the PA-46 series empennage mounted autopilot servos have indicated that water has penetrated the servo housing covers, it is recommended that the moisture cover designed for the pitch servo as identified by Piper SL 1009 be required to be installed by an AD, in order to prevent possible malfunctions of the pitch servo due to water damage. (Category 2)

34. The PA-46 series yaw servo has also shown to be subject to water damage and should also be provided a better means of water protection. The present moisture cover for the yaw servo as identified by Piper SL 1009 does not provide this protection. It is recommended that King develop a service change that would afford positive protection of the yaw servo from water damage to the servo components and that the change be mandated by AD. (Category 2)

35. In order to ensure drainage of the elevator lower fairing, additional drainage provisions should be provided so no water can be trapped within the elevator lower fairing. Piper should develop a SB to accommodate this modification. An AD should be issued to require the additional drainage provisions. (Category 2)

36. It is recommended that PAC develop maintenance procedures and production processes that allow elevator trim cable turnbuckle adjustment without severing the cable guide tube. (Category 3)

37. It is recommended that Piper develop a SB to inspect for severed tubes and provide corrective action in the event that an elevator trim cable guide tube has been severed and that an AD be issued to mandate the SB recommended above. (Category 2)

38. The type inspection report (TIR) for the Model 350P should be amended to explain the significant difference between the pitot-static calibrations for the 310P and the 350P. (Category 3)

39. The type of certification basis for the Models 310P and 350P should be corrected to reflect the authority for the allowed exemption to FAR 23.221(a). (Category 4)

40. Reduced power descent procedures should be reviewed for both emergency and normal conditions to ensure that they are compatible and practical for a general aviation pilot with average skills. Configurations, power settings, airspeeds, and their management

31. It is recommended that the FAA develop a regulatory change for small airplanes that are approved for flight into known icing that would require pitot heat operating light similar to FAR 25.1326. (Category 4)

32. It is recommended that Piper develop a SB to provide a "guarded" manual pressurization control for the PA-46-310P airplane. This guarded control should be similar to the installation in the PA-46-350P airplane. (Category 3)

33. Since previous investigations of the PA-46 series empennage mounted autopilot servos have indicated that water has penetrated the servo housing covers, it is recommended that the moisture cover designed for the pitch servo as identified by Piper SL 1009 be required to be installed by an AD, in order to prevent possible malfunctions of the pitch servo due to water damage. (Category 2)

34. The PA-46 series yaw servo has also shown to be subject to water damage and should also be provided a better means of water protection. The present moisture cover for the yaw servo as identified by Piper SL 1009 does not provide this protection. It is recommended that King develop a service change that would afford positive protection of the yaw servo from water damage to the servo components and that the change be mandated by AD. (Category 2)

35. In order to ensure drainage of the elevator lower fairing, additional drainage provisions should be provided so no water can be trapped within the elevator lower fairing. Piper should develop a SB to accommodate this modification. An AD should be issued to require the additional drainage provisions. (Category 2)

36. It is recommended that PAC develop maintenance procedures and production processes that allow elevator trim cable turnbuckle adjustment without severing the cable guide tube. (Category 3)

37. It is recommended that Piper develop a SB to inspect for severed tubes and provide corrective action in the event that an elevator trim cable guide tube has been severed and that an AD be issued to mandate the SB recommended above. (Category 2)

38. The type inspection report (TIR) for the Model 350P should be amended to explain the significant difference between the pitot-static calibrations for the 310P and the 350P. (Category 3)

39. The type of certification basis for the Models 310P and 350P should be corrected to reflect the authority for the allowed exemption to FAR 23.221(a). (Category 4)

40. Reduced power descent procedures should be reviewed for both emergency and normal conditions to ensure that they are compatible and practical for a general aviation pilot with average skills. Configurations, power settings, airspeeds, and their management

should be addressed in detailed steps that are considered practical for expected operation of this type airplane. Use of flaps for high speed descent should be discouraged. (Category 3)

41. The emergency procedures section of the AFM should include unusual attitude recovery procedures. Procedures should be prescribed for both nose high (low airspeed) cases and nose low (high airspeed) cases. This information would enhance safe operation of this airplane. (Category 3)

42. Allowed optional locations for equipment items in the cockpit should be specified in the installation instructions. In particular, the locations allowed for the KAS 297B display/control unit should be specified. The locations should be within the pilot's instrument cross check field of view and within easy arm's reach such as on or near the glare shield (adjacent to the standby compass) or in the upper area of the pilot's instrument panel (near the altimeter). This recommendation should be implemented prior to reinstallation of the KAS 297B as removed by AD 91-07-08-R-1. (Category 1)

43. The failure of the attitude sensor is addressed in recommendation 5. in the autopilot section. (Category 3)

44. Information should be provided in the approved supplements to properly inform the pilot of the possible misuse of the KAS 297B capability for pre-selecting an altitude opposite to the engaged vertical speed direction (climb and descent carets) and to caution against selecting large climb/descent rates that may result in exceeding the airplane performance capabilities, (especially when expecting an automatic pilot level off after a prolonged climb/descent to a pre-selected altitude). (Category 3)

45. The design and/or interface for the encoding altimeter and vertical speed altitude selector (KAS 297B) should be modified to preclude any sensing by the autopilot that permits control inputs to the servos as a result of resetting the altimeter barometric pressure settings. This has been accomplished by Bendix/King in accordance with Modification 3. (Category 3)

46. In addition to the present caution note, information should be presented in the approved supplements about the hazards associated with large mistrim conditions occurring as a result of autotrim operation associated with improper procedures when the autopilot is engaged. It should be emphasized that proper trimming (especially directional) of the airplane should be maintained prior to autopilot engagement and for each phase of flight (climb, cruise, descent, and approach). (Category 3)

47. Proper emergency use of the Radio Master Switch should be defined (especially as a backup method for disabling the electric trim system in the Model 350P). Emergency use of the switch would be contingent upon the assurance that the minimum equipment

needed to maintain airplane control during instrument flight conditions is retained. (Category 3)

48. The Bendix/King TIRs should be amended to describe the rationale that weights below the maximum were tested for autopilot malfunctions and document the acceptability of tested vertical speed rates at values less than the system's maximum rate capability. (Category 3)

49. Policy and guidance for autopilot certification should be reviewed with respect to automatic system disconnect in the event of a glideslope signal loss and/or automatic reversion. (Category 4)

50. The supplement procedures must be standardized between Piper and Bendix/King so that identical information is published. Bendix/King and Piper should clearly establish a coordination process for changes to approved data. (Category 3)

51. The manufacturer should consider publishing a recommended turbulent air penetration airspeed based upon the minimum maneuvering airspeed that is likely to be encountered in service rather than the currently listed maneuvering airspeed schedule versus weight. (Category 3)

52. The AFM should warn against the use of the installed visor checklist for all operations and the fact that revised procedures could conflict with it. (Category 3)

53. Flight Manual Supplement pre-flight procedures must clearly ensure the following mandatory checks:

    a. Normal operation of the electric pitch trim servo motor.

    b. Proper engagement and disengagement of the trim servo clutch.

    c. Normal function of the AP Disc/Trim Inter Switch.

54. The cycling of circuit breakers for procedural functions should be discontinued unless required for emergency actions. (Category 3)

55. Piper should add a recheck of clutch torque settings to their procedures to preclude the possibility that the preset value might be other than the required settings specified in STC SA1778CE-D. SB KM 275-1 was issued in 1986 because clutch torque settings were found to be incorrect. Because the adapter modules are installed in the computer by Piper at the time the system is installed, Piper should record the dash numbers of the adapter modules that they install in each serialized computer. (Category 3)

56. The FAA should revise the type certification data sheets (TCDS). (Category 4)

57. The PAC PA-46-310P/350P initial training course should be revised to include additional emphasis on recovery from unusual attitudes while under the "hood." (Category 3)

58. A training syllabus for the PA-46-310P/350P should be developed to ensure coverage of all systems with emphasis on use and consequences of misuse of the autopilot, electric trim, and the KAS 297B altitude preselect. (Category 3)

59. Owners/operators should develop a pilot education clinic consisting of safety lectures, operating instructions, and proficiency flights. (Category 4)

60. An in-depth review should be conducted by industry and the FAA to update the pilot certification rules (FAR-61) for small airplanes operating above 18,000 feet to adequately consider all aspects of the pilot, the aircraft, and the operating environment. (Category 4)

APPENDIX D

HIRF Susceptibility Tests

Electromagnetic Radiation Test-Near Field Probe

The near field probe tests were conducted by a small diameter loop antenna connected to a 10-watt amplifier placed approximately 1/2 to 3 inches away from the connecting cables or surfaces of the tested units. The probe was operated with the power amplifier being driven by a Radio Frequency (RF) signal generator both with and without modulation. The modulation was both sine wave and square wave with frequency modulation varied from 1Hz to several kHz.

The tests were run at 11 locations which included the KAS 297B altitude preselect, KC 192 autopilot flight computer, and system servos. Radiation in the vicinity of the pitch servo located in the empennage caused observable effects. The effect was characterized as "chattering" of the servo.

The KC 192 and KAS 297B effects were sensitive to location of the test probe. No effects on either unit were caused by illumination of the front panel of the units. The most noticeable effects were generated by placing the probe along the wires in the vicinity of the connectors on the reverse sides of the units. The sensitivity to placement of the probe showed that the available signal strength varied rapidly with distance from the RF source.

Pitch and roll servo "chatter" (a short-cycle oscillatory vibration with little net movement) was induced by applying the RF signal to the KC 192 autopilot flight computer in the 320 to 370 MHz range at a measured field strength level of 16 V/m. As the signal strength was increased above this threshold, the amount of audible noise and the frequency of the "chattering" increased in direct proportion to the increase in applied field intensity. Other system disturbances occurred at thresholds of 170 V/m to 300 V/m. These disturbances were also defined as pitch and roll servo "chatter." At no time did the "chatter" result in visible movement of the elevator or aileron surfaces.

During testing, the autopilot system shut down when it was exposed to a signal in the frequency range from about 160 to 180 MHz at field strength of 180 to 230 V/m. The external power supply to the airplane's electrical system was then disconnected and the voltage on the airplane's power bus was allowed to fall below 23 volts DC before the autopilot system could be reengaged. This anomaly was attributed to the autopilot's built-in test system.

The KC 192 flight computer detected a failure and annunciated a visual and aural alert and then subsequently shut down the trim function when the autopilot was radiated at 305 MHz. Illumination of the KAS 297B altitude preselector at 111.7 and 248 MHz caused the altitude preselect to generate gradually increasing and decreasing pitch commands displayed on the KAS 297B. The results depended directly on the field intensity applied and changed to the original value after removal of the RF source. The pitchup command was accompanied by pitch and roll servo "chattering." During the tests, the pilot was exercising the airplane control yoke through its full range of motion. He observed that he could feel the chatter caused by the servos in the control yoke. The flight control surfaces of the airplane did not move at any time during the chattering of the servos.

Modulation

In all cases of observed effects, removal of the modulation from the RF carrier caused a cessation of the effects. Without modulation, no effects were observed. The KS 270A pitch servo was uniquely sensitive to modulation. Upsets occurred only for sine wave modulation at 430 Hz +/- 20 Hz. Square wave modulation did not effect the system.

The KAS 297B and KC 192 were sensitive to both sine and square wave modulation and effects were observed in a range from 15 Hz to 430 Hz. Some effects were measured as high as 470 Hz.

Effects from illuminating the pitch servo, the altitude preselect, and the KC 192 were usually at the same RF. Effects at two of the locations occurred in the same RF frequency range. The KC 192 and KAS 297B both upset at 348 MHz in the UHF (Ultra High Frequency) range and at four narrow frequencies between 111.7 and 140 MHz in the VHF (Very High Frequency) range. The pitch servo responded to illumination in the 170 to 180 MHz range. There were no cases where the effect on all components tested occurred at the same RF frequency.

The following items describe the nature of the upsets and the RF frequencies and signal strengths which accompanied these upsets:

1. Illumination of the pitch servo control resulted in pitch servo chatter and did not affect the functioning of the autopilot or roll servo.
2. Illumination of the autopilot and the altitude preselect at different frequencies caused both roll and pitch chatter.
3. The RF bandwidth over which the malfunctions took place was from very narrow (less than 1 MHz) to as wide as 50 MHz. This narrow and wide band susceptibility character was present in both the VHF and UHF bands.
4. The KAS 297B altitude preselect displayed pitch-up and pitch-down commands proportional to the applied field intensity. The command value returned to the original value when the field was removed.
5. The servo chatter effects caused by direct radiation of the servo required an AM modulation of 430 Hz (± 20 Hz). No other modulation from 30 Hz to 15 kHz caused servo chatter.

Electrostatic Discharge Test (ESD)

Fast risetime radiated ESD testing was performed by discharging an electrostatic generator to a small diameter loop probe placed in the vicinity of the airplane-autopilot connector. The test was performed at the three locations that had previously demonstrated a response to the electromagnetic radiation probe. In all cases, the electrostatic discharge voltage was increased in 1 to 2 KV steps from 1KV to 18 KV. No adverse effects were noted.

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