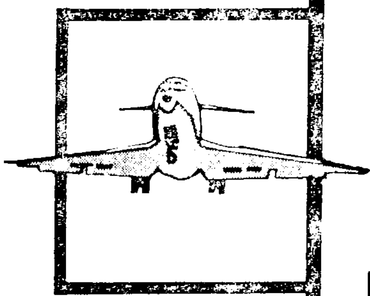

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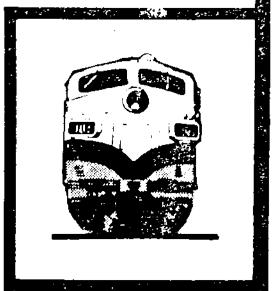
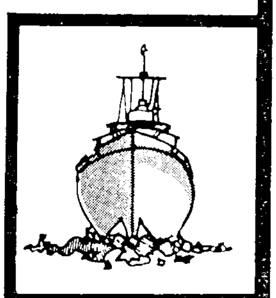
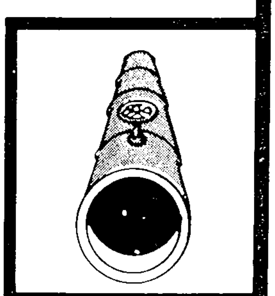


WASHINGTON, D.C. 20594



AIRCRAFT ACCIDENT REPORT

TEXASGULF AVIATION, INC.
LOCKHEED JETSTAR N520S
NEAR WESTCHESTER COUNTY AIRPORT
WHITE PLAINS, NEW YORK
FEBRUARY 11, 1981



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16. Abstract

About 1840 e.s.t., on February 11, 1981, a Lockheed JetStar L-1329-731, N520S, crashed during an instrument landing system approach to runway 16 at the Westchester County Airport, White Plains, New York. The area weather was dominated by low obscured ceilings, rain, fog, and reduced visibility. Winds were strong and gusty with moderate to severe turbulence in the lower levels. Following a recent modification of the generator control circuitry, the aircraft's electrical system had experienced several multiple generator failures.

The National Transportation Safety Board determines that the probable cause of this accident was a distraction to the pilot at a critical time as a result of a major electrical system malfunction which, in combination with the adverse weather environment, caused an undetected deviation of the aircraft's flightpath into the terrain.

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NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594

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Adopted: August 19, 1981

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SYNOPSIS

About 1840 e.s.t., on February 11, 1981, a Lockheed JetStar L-1329-731, N520S, crashed during an instrument landing system approach to runway 16 at the Westchester County Airport, White Plains, New York. The area weather was dominated by low obscured ceilings, rain, fog, and reduced visibility. Winds were strong and gusty with moderate to severe turbulence in the lower levels. Following a recent modification of the generator control circuitry, the aircraft's electrical system had experienced several multiple generator failures.

The National Transportation Safety Board determines that the probable cause of this accident was a distraction to the pilot at a critical time as a the result of a major electrical system malfunction which, in combination with the adverse weather environment, caused an undetected deviation of the aircraft's flightpath into the terrain.

1. FACTUAL INFORMATION

1.1 History of the Flight

On February 11, 1981, about 0845, 1/ the two-man flightcrew of N520S, a Lockheed JetStar L-1329-731, operated by Texasgulf Aviation, Inc., a wholly owned subsidary of Texasgulf, Inc., reported for duty at the Westchester County Airport, New York, for a round trip to Toronto, Ontario. The pilots received a weather briefing from the Universal Weather Service local facility. The pilots and five passengers departed Westchester at 0936. Both pilots were type-rated in the aircraft. The flight arrived at the Toronto International Airport about 1030.

The pilots spent the majority of their layover at the Innotech Aviation lounge, which is located at the Toronto International Airport. About 1115, the pilot-in-command telephoned the company's director of maintenance to report that, en route to Toronto, the aircraft's No. 2 generator had disconnected from the electrical system but had been reset normally; later in the flight, however, generators Nos. 2, 3, and 4 had disconnected simultaneously and Nos. 3 and 4 would not reset until No. 2 generator was reset. No other flight or maintenance problems were mentioned. The director of maintenance told the pilot that he would contact the manufacturer of the generator control units and call the pilot back. Thereafter, a telephone conference took place between the director of

1/ All times herein are eastern standard time, based on the 24-hour clock.

maintenance; several representatives of Phoenix Aerospace, Inc., the manufacturer of the generator control units; and a representative of Colt Electronics Company, the holder of the FAA Supplemental Type Certificate (STC) of which the generator control units were a part. During the conference call, the possibility was discussed that the generator-disconnect problem was related to a problem with the No. 2 generator ground fault transformer. As a temporary measure to eliminate the suspect ground fault detection system on the No. 2 generator, it was suggested that the sensor wires of the detection system be disconnected. Following this discussion, a return call by the maintenance director was made to the pilot, who in turn put the copilot on the phone. The copilot, who also was a qualified powerplants mechanic, and the maintenance director discussed the possibility of disconnecting the sensor wire which, in effect, removed the ground fault transformer from the generator control circuit. The call was completed between 1300 and 1400 hours. The Safety Board could not determine if any work was done on the electrical system before the aircraft departed Toronto.

During the afternoon, the copilot visited two pilot friends at the Worldways Airlines, Ltd., offices. After the accident, one of the pilots recalled that he had told them that while en route to Toronto that morning, his aircraft had lost all four generators and the descent had been made in visual flight conditions. He also said that a generator had not been restored until the aircraft landed, that a modification to the electrical system several weeks earlier had caused generator troubles, and that the backup system ". . . didn't do what it was supposed to do." According to this pilot, the copilot said that some of the basic instruments had been lost. The other pilot recalled the conversation with the copilot differently. He recalled that four generators had been lost for about 9 minutes but that two generators had been restored before the descent was begun. He also recalled that the copilot had said that during the electrical outage, the cockpit had been without normal lighting and instrumentation as the generators came on and off repeatedly. When the copilot returned to the airline's office later in the afternoon, the Worldways pilots inquired about the generator problem and he responded that he did not know if the problem had been fixed, but the aircraft was okay to take back to Westchester.

At 1729, the flight departed Toronto for Westchester with six passengers aboard. After takeoff, the crew reported a problem with the landing gear and requested clearance to return to the airport. A short time later, the crew reported that the problem had been cleared and that the flight would proceed to Westchester.

The flight first contacted the Westchester arrival west approach controller at 1823:40. 2/ Before that time, the pilots had not reported any in-flight problems. On radio contact, the flight was descending to 9,000 feet 3/ and had been cleared to hold northeast of the Brews Intersection 4/ via airways Victor 34 to the Kingston VOR 199° radial to the Brews Intersection. The approach controller instructed the pilots to report when established in the holding pattern, and the flight requested and was given the

2/ After listening to the communications transcript, the company chief pilot identified the voice of the pilot making the radio calls as the copilot; therefore, according to normal company procedures, the pilot would have been flying the aircraft from the left cockpit seat.

3/ All altitudes are mean sea level unless noted.

4/ Brew's Intersection is the intersection of the Kingston VOR 199° radial and the Carmel VOR 229° radial. Distance measuring equipment (DME) is installed at both VOR stations.

following current weather: "It's right on the ground; indefinite zero; sky obscured; 1/8 mile in light rain and fog. Runway 16 RVR 3,500." 5/

At 1824:00, the flight reported leveling at 9,000 feet. At 1826:30, the flight was cleared to 6,000 feet, and when asked what its intentions were if unable to land, the flight responded that it would like to go to La Guardia. The controller acknowledged and reported that the airport visibility was up to 1/4 mile and the RVR was 3,500 feet.

At 1827:30, after observing the aircraft far enough east of the Kingston 199° VOR radial to conflict with the Carmel holding pattern buffer zone, the controller instructed the flight, "turn right heading 220°, vectors into the hold; turn right now, sir expedite turn now." (See appendixes D and E.) Fifteen seconds later the controller transmitted, "Five two zero sierra, what are you doing, sir? I don't quite get where you're going. Turn right heading two two zero now, sir." The copilot acknowledged both transmissions and in both acknowledgements, 220° was repeated. At 1827:55, the controller warned, "You're way east of it," and the copilot responded, "Okay, sorry about that." At 1828:45, the controller advised the crew to expect a 45-minute delay getting into La Guardia; the copilot responded that they had sufficient fuel to do that. The controller responded and informed the flightcrew that they could either hold at 6,000 feet or be taken down to 3,000 feet in order to expedite arrival in case the weather broke. The copilot accepted the descent to 3,000 feet and was cleared to report reaching that altitude; the clearance was acknowledged.

At 1829:45, the approach controller advised the flight that it was ". . . 3 miles east of Brews . . . If you have any trouble cranking in the holding pattern area there, I'll just vector you around." The copilot responded, "There's, there's, I'm sorry about that; we're just a little bit east, that's correct." The controller advised, "That's correct. You're just about 3 miles southeast of Brews at this time. Turn right, turn right three zero zero, vectors to hold you, to keep you in the holding pattern." The copilot acknowledged the instruction.

At 1830:00, the controller advised the flight to turn right 320°, and the copilot responded and repeated the vector. Five seconds later, the crew stated, "We've just lost the right side radio. That's what presented us a problem there. Heading 320° five twenty sierra."

At 1830:40, the controller advised N520S to turn to 320° to intercept the Kingston 199° radial, then to hold north of Brews on the 199° radial, right turns, 1 minute legs; the copilot acknowledged the instruction. Twenty seconds later the controller corrected himself by telling the crew to turn left with a holding left turn north of Brews. The crew acknowledged the correction.

At 1831:15, the controller transmitted, "November five zero sierra, the runway 16 RVR is varying between 4,000 and 3,500, and visibility is now 1/4 mile in light rain. If you'd like, you can try it and see what happens." The copilot responded that they would like to try it, and the controller advised," . . . if you miss, we'll just take you back around and hold at Brews and try it again at a later date. . . ." The copilot acknowledged with, "Sounds great, thank you."

At 1831:45, the controller requested the flight to ". . . say altitude leaving," and the copilot responded, "Five for three." The controller further instructed, " . . .five

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5/ Runway visual range--a sampling of a 250-foot segment of the atmosphere adjacent to the runway, usually at the touchdown point.

twenty sierra, turn right 180°, turn right 180°. This is vectors for the ILS runway 16 final approach course."

About 1 minute later the controller reported an improvement in visibility -- 1/2 mile in light rain. At 1833:05, he reported that the surface wind was 220° at 20 knots and that the runway 16 RVR (at Westchester) was 3,500 feet. He then turned the flight farther right to 210°. A minute later, N520S was cleared to descend to and maintain 2,100 feet, and the copilot acknowledged by reporting out of 3,200 feet. At 1835:00, the controller advised that the RVR was 4,000 feet. Eighteen seconds later, the controller advised that the flight was entering a narrow bank of weather, but reassured the crew that they would be out of it about 4 miles from the outer marker (OM).

At 1835:45, the RVR was reported to be 5,500 feet, and the crew replied, "That's great." Shortly thereafter, N520S was cleared for a runway 16 ILS approach and cleared to the tower frequency. When the flight contacted the control tower, the local controller cleared it to land on runway 16. He advised the crew of pilot reports that warned of severe turbulence and wind shear on final--one aircraft had reported a 20-knot increase in windspeed. The controller informed the crew that the wind was now 190° at 20 knots; the local controller's transmission was acknowledged. About 1 minute later, the recorded wind was given as 190° variable to 220° at 25 knots, gusting, the tower visibility 7/8 mile, and the RVR more than 6,000 feet. The copilot acknowledged.

At 1839:40, the local controller noticed on his Brite display radarscope that the flight was beginning to divert to the right of the centerline of the localizer; he then informed the crew that the wind was 200° at 23 knots. The crew did not acknowledge the transmission.

At 1840:00, the local controller contacted the approach controller to determine if N520S had executed a missed approach. The approach controller did not know where the flight was, but he had also seen the flight diverting to the right of the localizer course about 2 miles from the runway.

A witness, who had stopped his car about 300 yards from the runway 16 approach lights, saw the aircraft descending in the vicinity of the ILS localizer. The witness said that there was fog and heavy drizzle accompanied by strong, gusting, and variable winds. His attention was directed to the aircraft by the illumination of the aircraft's landing lights, which he said could be seen clearly. He estimated that he was about 2 1/2 miles from the aircraft when he first saw it. As he watched the aircraft, he believed that it might be circling to land on a runway other than runway 16. He stated that the aircraft disappeared from his view below a tree-covered ridge and about 8 seconds later, a fireball erupted from the ground and rose to a height of about 300 feet. At that height, the glow spread horizontally on each side until the fireball disappeared.

The plane had crashed on the uninhabited peninsula of Rye Lake, northwest of Westchester County Airport. Access to the accident site was difficult because of terrain. The aircraft first contacted trees in a heavily wooded area about 6,000 feet from the approach end of runway 16 on a bearing of 322° magnetic and about 2,300 feet right of the centerline of the localizer. The aircraft's altitude when it first hit trees was 440 feet; the hill ahead had an elevation of 450 feet. The centerline of the glide slope abeam the contact point was about 820 feet m.s.l. The aircraft's altitude was 380 feet below the glide slope centerline. The crash of N520S occurred about 1840, during the hours of darkness, at 41°5'5"N and 73°43'51"W.

About 1815, 25 minutes before the crash, a Gulfstream II made an ILS approach to runway 16. The pilot stated that he encountered moderate to severe turbulence with large wind velocity changes in the final stages of the approach. He stated that about 200 feet above the ground the airspeed dropped by 20 knots, followed shortly by an increase of 30 knots. This aircraft was followed by an Air Florida Boeing 737; the pilot stated that 1,000 feet above the ground he incurred about a 15-knot airspeed loss. He also stated that the turbulence was moderate to severe. His color-coded weather radar did not show any thunderstorm echoes.

At 1920, about 40 minutes after the accident, a Lockheed JetStar made two ILS approaches to runway 16. The first approach was not completed because of low-level turbulence. The aircraft was equipped with an inertial navigation system (INS) and during the descent from 3,000 feet to 2,100 feet--the crossing altitude of the runway 16 OM--the INS showed that winds were from 210° at 59 to 63 knots. The pilots described the turbulence during the glide slope descent as light to moderate and occasionally severe with momentary airspeed excursions as large as 30 knots from the planned airspeed. The pilot recalled that about 500 feet above the ground he made full aileron inputs and large thrust lever adjustments to control the aircraft. At decision height (DH), he abandoned the landing effort because of the turbulence and high, fluctuating airspeed. As the aircraft neared the OM for a second approach, the INS winds indicated 210 to 220° at 59 to 66 knots. The turbulence, although constant, had abated slightly, and the final approach was normal and a successful landing was completed.

1.2 Injuries to Persons

Injuries	Crew	Passengers	Others	Total
Fatal	2	6	0	8
Serious	0	0	0	0
Minor/None	0	0	0	0
Total	2	6	0	8

1.3 Damage to Aircraft

The aircraft was destroyed by impact forces and fire.

1.4 Other Damage

Trees were burned and broken within the wreckage area and the ground was contaminated with fuel.

1.5 Personnel Information

Both pilots were properly trained and certificated in accordance with current regulations. Qualification and recurrent programs included emergency procedures training, including electrical system failure. The training program syllabus did not include study of wind shear phenomena or simulated exercises of wind shear encounters. The company Policy and Procedures Manual did not contain references to recommended cockpit procedures for takeoff, en route, or approach and landing phases of flight nor flightcrew coordination functions, particularly during an emergency.

The investigation disclosed that both pilots had adequate rest before the accident flight and interviews with company pilots indicated that both pilots were in good physical and mental health. (See appendix B.)

1.6 Aircraft Information

The aircraft, Lockheed JetStar modified Model 1329-731, serial No. 5084, was certificated, equipped, and maintained in accordance with Federal Aviation Administration (FAA) requirements. The aircraft center of gravity was within prescribed limits for the approach and landing. The estimated landing weight at the time of the accident was 37,409 lbs including 10,764 lbs of jet-A fuel. (See appendix C.)

Fuel System.--All normal in-flight fuel management functions are controlled from the fuel management panel, located between the main instrument panel and the forward end of the flight control panel. The panel is in full view of both pilots. The complete fuel system is controlled, operated, and protected electrically. The main fuel system consists of four tanks in sealed integral areas of the wings and an auxiliary fuel system, consisting of two external wing-mounted tanks and associated equipment. The internal tanks hold 1,530 gallons of fuel and the auxiliary tanks, 1,202 gallons of fuel. The total fuel supply is 2,732 gallons.

The fuel system has two primary methods of supplying fuel to the engines: direct wing tank-to-engine flow and crossfeeding from the auxiliary tanks to the engines. To assure continual flow under all conditions, there are eight electrical fuel boost pumps. The pump switches are located on the fuel control panel. When feeding directly from tank to engine, the main electric boost pumps remain on; however, the engines can operate at low altitude without using the electric boost pumps since the engine-driven pumps have the capacity to supply fuel from the associated tank.

If the auxiliary tanks contain fuel, fuel should be crossfed after takeoff. To select auxiliary tank fuel, the four crossfeed valves must be opened and all six boost pumps should be activated. The crossfeed separation valve switch, which permits fuel flow from one side of the aircraft to the other, should be in the closed position to prevent fuel flowing from one side of the aircraft to engines on the opposite side. With the main tank boost pump switches energized during crossfeeding, the fuel system is provided with pressure from the main fuel source when the auxiliary tanks are emptied and auxiliary pressure is lost. When auxiliary pump pressure is lost, a warning light will illuminate on the fuel management panel. When both auxiliary tanks are empty, the auxiliary boost pumps should be turned off and the crossfeed valves closed. These valves are driven by the electrical system essential direct current (d.c.) bus. If a fault occurs on this power source, the Lockheed JetStar II Airplane Flight Manual Emergency Operation Procedures require that the fuel crossfeed valves and separation valve be opened.

Electrical System.--Four engine-driven starter-generators supply 28 volts d.c. to the main d.c. distribution bus, which provides 28-volt power for the essential d.c. bus through the normal reverse current relay. Power from the essential d.c. bus charges two 26-volt, 36-amphere hours, nickel-cadium batteries. One starter-generator can supply sufficient power for ordinary requirements. If power is lost to the essential d.c. bus, the output of a selected starter-generator can be routed to the essential d.c. bus so that the main d.c. bus is bypassed. If none of the starter-generators is operable, battery power can supply the essential d.c. bus, but the main d.c. bus cannot be energized. Each starter-generator is governed automatically by a generator control unit (GCU), which regulates output voltages, equalizes loads, protects against ground faults and overvoltage, and connects the starter-generator to the main d.c. bus. Also, two ground transformers, one circling the feeder line and the other circling the ground line, operate in series in each of the four starter-generator circuits.

In the case of an electrical system emergency, four generator transfer relays and a bus tie transfer relay can separate the essential d.c. bus from the main d.c. bus by connecting the essential bus to the starter bus. Components powered from the main d.c. bus include the cockpit lights, the landing lights, generator and inverter control, air traffic control transponder, and copilot's d.c.-powered flight attitude and navigation instruments. The essential d.c. bus provides power to generator "OUT" lights, crossfeed valves, generator trip and reset, auxiliary hydraulic pump, and the pilot's d.c.-powered flight attitude and navigation instruments.

Control switches and indicators for the d.c. power supply are located on the left forward corner of the overhead panel console, which is accessible to both pilots. Generator OUT lights are provided on this panel for each generator; generator OUT and/or overheat lights are provided on the annunciator warning panel, which is located on the right side of the center instrument panel. A failure illuminates the master caution lights, located on the instrument panels directly in front of each pilot.

Alternating current (a.c.) electrical power is supplied by a system of three inverters, two transformers, an a.c. control panel, and a network of relays. Using 28-volt d.c. input, transformers step down a portion of the voltage to 26-volt a.c. If either the No. 1 inverter or the windshield inverter fails, the loads can be assumed by the No. 2 inverter. If any two inverters fail, the remaining inverter can assume the loads of the essential a.c. bus and heat the pilot's forward windshield. The pilot's control switches and indicators for the a.c. power supply are on a control panel located on the right forward portion of the overhead panel console, which is accessible to both pilots. A.c. power failure lights are provided on the annunciator warning panel, and a failure also causes the master caution light to illuminate.

The main a.c. bus provides power to the copilot's flight director, instrument lights, and a.c.-powered flight attitude and navigation instruments. The essential a.c. bus provides power to the pilot's flight director, instrument lights, and a.c.-powered flight attitude and navigation instruments.

Emergency procedures to be performed by the pilots in case of electrical systems failure, overheat, or fire are contained in the airplane flight manual and the flightcrew training manual.

Modification of the Electrical System.--On January 12, 1981, N520S was flown from Westchester County Airport to the AiResearch Aviation Company maintenance facility at MacArthur Airport, Ronkonkoma, New York, for major maintenance, including modification of the electrical system. The service, performed in compliance with FAA STC No. SA1596CE, dated June 6, 1980, was completed on January 30, 1981. The modification required the removal of carbon-pile generator control units, associated wiring, and connectors and installation of solid state control units. The operational functions of the new system were identical to the original installation. The STC was issued to Colt Electronics Company, North Kansas City, Missouri. The solid state control units were supplied by Phoenix Aerospace, Inc., Phoenix, Arizona.

On January 30, after completion of inspections, required maintenance, and modification, a ground runup of N520S was made. During this runup, the No. 4 generator tripped offline. The GCU was observed to be malfunctioning and, upon inspection, was found to be smoking. The generator was removed from the aircraft, and the GCU was replaced. The malfunctioning unit was returned to the supplier for repair and was later reinstalled on the aircraft. On January 31, 1981, a test flight was made in the local area to check out the engines and other aircraft systems. About 10 minutes after takeoff, the No. 2 generator tripped off line but it was reset without difficulty. Shortly thereafter, the Nos. 1, 2, and 3 generators tripped off and again all generators were reset without difficulty. The pilot decided to return to the AiResearch facility to correct the electrical problem; however, while en route to MacArthur Airport, the annunciator panel generator failure light illuminated because all four generators had faulted and tripped. Once again, the generators were reset successfully and a normal landing was made following this third incident.

After AiResearch personnel adjusted the electrical system, a second test flight was scheduled the same day. Again, about 10 minutes after takeoff, the No. 2 generator tripped off line and was successfully reset. For the next 10 to 15 minutes, the flightcrew attempted to create an electrical overload by simultaneously turning on the auxiliary fuel pumps, the landing lights, and the auxiliary hydraulic pump. They could not cause the loss of a generator, and the flight returned to MacArthur Field for further adjustment of the generator system. Later that day, a third local flight was made and no generators were lost.

On February 1, N520S was flown from White Plains to Chicago Midway Airport, Illinois. About 1 hour after leaving White Plains, the No. 2 generator tripped off but it was reset without difficulty. On the descent into Midway, the No. 2 generator again tripped off and was immediately reset. The aircraft landed without further failures. On February 3, N520S departed Midway Airport on a night instrument flight (IFR) to White Plains. During the climb to cruise altitude, the Nos. 1, 2, and 3 generators tripped off. The pilot elected to reset only generator Nos. 1 and 3, because he considered generator No. 2 to be the problem source. However, about 10 minutes later, the No. 1 and 3 generators tripped again and were reset without difficulty. No further generator failures occurred and the flight landed at White Plains.

At this point, technical personnel of Colt Electronics Company and Phoenix Aerospace, Inc., were contacted to help determine the cause of the generator-loss problem. On February 5, they inspected the electrical system and found that the modification conformed to the installation drawings; however, system abnormalities were found. Excessive resistance was detected in the No. 2 generator equalizer bus lead and the current fault sensors of the No. 2 generator systems. Loose wires were found at the d.c. bus contactor and the a.c. power control coil of the No. 1 generator system. After corrective measures were taken, the system was inspected on the morning of February 6. In a deposition, the Phoenix Aerospace technical specialist said that before leaving White Plains, he had recommended to Texasgulf personnel that current fault sensors on the No. 2 generator system should be replaced before flight and in the No. 3 generator system as soon as practicable. At the time of the accident, neither unit had been replaced.

The following afternoon, a test flight was made in which the No. 2 generator tripped off line when the speed brake was actuated. The generator was reset, and there were no additional malfunctions during the remainder of the flight. The copilot of the accident aircraft served as pilot of this flight. No work was performed on the aircraft, nor was it flown during the period between the completion of this test flight and the aircraft's departure for Toronto on February 11.

<u>Pilot Alerting Systems and Standby Attitude Instruments</u>.--The accident aircraft was equipped with an Intercontinental Dynamics Corporation (IDC) "Rad/bar" altimeter with a voice terrain advisory feature. This instrument incorporates a barometric altimeter display, a radio altimeter display on the face of the same instrument, and aural voice warnings of height above terrain, below glide slope deviations, and decision height. The volume of audible callouts can be controlled and the brightness of lighting on the radio altimeter numbers and DH alerting light can be controlled. The system depends upon generator-supplied electrical power. The instrument was severely

damaged on impact, and it could not be determined if it was functional or powered at the time of the accident.

A single Jet Electronics and Technology, Inc., (J.E.T.) self-contained, illuminated, attitude direction indicator system was provided in the cockpit of N520S. This instrument provides flight-attitude information from a nickel-cadium battery, which is independent of the aircraft's basic generator and battery system. The post-impact condition of the instrument precluded a determination of whether it was functional or powered at the time of the accident.

A Teledyne angle of attack indicator was also installed. The angle of attack instrument provides a more precise indication than airspeed readings of the performance of the aircraft. Angle of attack may be used for primary control during an encounter with hazardous low-level shear because it provides indications of required corrective actions. The indications are independent of whether the shear consists of horizontal wind changes, updrafts, downdrafts, or a combination thereof. Postimpact condition of the instrument precluded a determination of whether it was providing accurate information at the time of the accident.

The aircraft was equipped with dual Collins INS, a RCA Primus-400 WXD weather radar with a Data Nav III system (R-Nav), and a Global Navigation 500A-2 VLF/OMEGA navigation system. These units, in addition to the regularly installed VHF navigation receivers, can independently provide guidance to fly precisely to selected waypoints. The aeronautical charts, which the flightcrew carried, displayed the geographical coordinates of the Brews Intersection and the Kingston and Carmel VOR stations. These waypoints could be displayed in the cockpit, along with the desired course, groundspeed, and distance to the waypoint selected by the pilot. The Safety Board could not determine from wreckage analysis if these navigation aids were used in the vicinity of the Brews Intersection.

1.7 Meteorological Information

Westchester County Airport was in a southerly surface air flow, which was preceding a cold front located about 50 miles to the west. Conditions ahead of the cold front were characterized by low, obscured ceilings, rain, and fog. Winds were strong and gusty out of the south.

The following surface observations at Westchester County Airport were taken before and at the time of the accident:

> 1809--special; ceiling--indefinite, 0 feet obscured; visibility--1/4 mile; weather--light rain and fog; wind--200°, 12 knots, gusting to 21 knots; altimeter setting--29.80 inches.
>
> 1845; type: local; ceiling: indefinite 100 feet,obscured; visibility--7/8 mile; weather--none; temperature: 53°F, dewpoint--49°F; wind--190°, 14 knots; altimeter settings--29.82 inches; remarks: aircraft mishap

At 1830, the National Weather Service (NWS) radar at New York City reported Westchester County Airport to be in an area of 3/10 coverage of light rain showeres. There were no thunderstorms reported.

The following are brief descriptions of the upper air soundings taken at 1900 at Albany, New York, and Chatham, Massachussetts:

Albany: There was a shallow surface inversion to 1,100 feet. The column was saturated to 8,300 feet. The freezing level was about 10,600 feet.

Chatham: There was a strong surface inversion to about 3,000 feet. The column was nearly saturated to about 4,500 feet. The freezing level was about 11,000 feet.

The 1900 winds aloft from the surface to 5,000 feet at Atlantic City, New Jersey, Albany, and Chatham were:

Altitude (feet above sea level)	Direction (° true)	Speed (kns)
Atlantic City		
Surface	200	18
1,000	210	56
2,000	200	55
3,000	195	67
4,000	200	72
5,000	210	70
Albany		
Surface	150	22
1,000	175	40
2,000	180	52
3,000	190	64
4,000	195	83
5,000	200	83
Chatham		
Surface	170	35
1,000	190	65
2,000	195	71
3,000	200	74
4,000	205	74
5,000	205	72

The following pilot reports are pertinent to the accident: (1) "Location: over Hancock, New York; time: 1730; altitude: 4,500 feet; type aircraft: PA 31; turbulence: severe; remarks: moderate turbulence Binghamton to Poughkeepsie." (2) "Location: Westchester County Airport; time: 1812; type aircraft: SW 4; turbulence: moderate; remarks: on final (approach) to Westchester County, 200 feet, (airspeed) increase 20 knots."

The area forecast, which was valid during the time of the accident, contained flight precautions as follows: moderate to occasionally severe turbulence below 20,000 feet over the entire area. Low-level shear potential over the area because of a strong southerly flow ahead of a cold front moving through the region. Moderate to occasionally severe turbulence below 20,000 feet over the entire forecast area. The area forecast incorporated several AIRMET's which indicated similar weather warnings. The terminal forecast issued by the NWS for Westchester County Airport for the time period of the accident included low ceilings, reduced visibility in fog, and strong gusty winds accompanied by low-level wind shear.

Three significant weather advisories (SIGMET) were in effect at the time of the accident, two of which warned of severe icing above the freezing levels and of embedded thunderstorms in the frontal area. The third SIGMET, Golf 8, warned of severe turbulence below 20,000 feet with strong low-level wind shear below 2,000 feet.

The weather briefing received by the pilots from the Universal Weather Service facilities before their morning departure to Toronto included weather conditions at their estimated time of arrival back at Westchester County Airport. The forecast was given as follows:

> For 1830 local: 300 feet broken, 600 feet overcast; 1 to 2 miles in moderate rain, occasionally heavy rain and fog; variable indefinite 300 feet obscured; 1/2 mile in heavy rain and/or thunderstorms. Wind direction 190 degrees at 15 mph gusting to 35.

The pilot was advised of the possibility of moderate to severe wind shear in the lower levels at the time of his arrival.

About 1500, an unidentified crewmember of N520S telephoned from Toronto for a weather update from Universal Weather Service. He was given the following forecast:

> For 1830 local at Westchester: 600 feet overcast; 1 mile in light rain and fog; occasionally moderate to heavy rain. Winds 180 degrees 15 gusting to 35 (not identified as to knots or miles per hour), chance of indefinite 200 feet obscured, 1/2 mile in light rain and fog and/or thunderstorms with light rain showers.

The pilot was again advised of the possibility of turbulence and wind shear at the lower levels.

1.8 Aids to Navigation

Runway 16 at Westchester County Airport is equipped with an instrument landing system (ILS). The inbound crossing altitude at the OM radio locator (LOM) is 2,100 feet, the magnetic heading of the localizer is 162°, and the glide slope descent angle is 2.95°. The DH is 200 feet above the touchdown zone elevation of 439 feet. Minimum visibility for a full ILS approach is 2,400 feet, which is recorded by a transmissometer located 2,550 feet from the approach end of runway 16. The touchdown point is 1,365 feet from the runway threshold.

The ILS, commissioned in December 1953, was flight-checked the day after the accident, and was found to be within prescribed tolerances. The last previous flight check was a periodic check which was flown on January 8, 1981; the annual inspection was flown on August 30, 1980. During the periodic and annual checks, the localizer and glide slope were within tolerances.

1.9 Communications

There were no known communication difficulties.

1.10 Aerodrome And Ground Facilities

Westchester County Airport, White Plains, New York, is located 13.6 miles southwest of the Carmel VORTAC. The landing area consists of two runways: 16-34 and 11-29. Runway 16 is served by ILS, VORTAC, nondirectional beacon, and surveillance radar approaches. 6/ Runway 34 is served by ILS, VOR, and surveillance approaches. Runway 11-29 is used for visual approaches.

Concrete-surfaced runway 16 is 6,548 feet long and 150 feet wide. A left side visual approach slope indicator (VASI) is provided. The runway is equipped with high intensity runway lights and a simplified short approach lighting system (SSALS) including sequence flashers.

The automatic terminal information system (ATIS) is broadcasted regularly. Communication frequencies are provided for all tower and approach control services. An ASR-8 radar, without altitude readout capability, is provided to the approach control facility and a Brite-Scope-4 display is provided in the tower cab.

1.11 Flight Recorders

The aircraft was not equipped, nor was it required to be equipped, with flight data recorders or cockpit voice recorders.

1.12 Wreckage

The crash occurred in a wooded area on the upslope of a hill. There was little underbrush and the trees were 50 to 70 feet tall. The aircraft first struck a tree in a slight left wingdown altitude. The aircraft first touched the ground about 400 feet beyond the first tree strike. The incline of the hill where the aircraft first hit the ground was about 20°.

The aircraft structure separated when it hit the first tree. As the engines and possibly both wings passed to the right of the tree, most of the cabin and cockpit passed on the left side. The cabin and cockpit continued to disintegrate throughout the next 250 feet. The swath cut through the trees was on a magnetic heading of 160° and indicated that the left wing was down 20° to 40° as it hit the trees. Pieces of the nose radome were recovered at the first tree. From this point, the aircraft shed various parts until it disintegrated. Burnt tree tops, sooted debris, and ground fire damage began 120 feet beyond the initial tree-impact point.

The mark left in the ground by the aircraft was 55 feet long, 14 feet wide, and 3 feet deep. Pieces of the aircraft internal wing structure, a piece of the nose gear actuator rod, and a windshield wiper blade were found embedded in the gouge. About 2 feet beyond the gouge, an 80-foot-tall tree stood directly in the wreckage path. The tree was still intact with burn and scrape marks around its lower trunk. As the aircraft broke apart, generator lead wires and many smaller gauge wires remained wrapped around

6/ A radar approach may be given to any aircraft upon request and may be offered to pilots in distress. A surveillance approach (ASR) is one in which a controller provides navigational guidance in azimuth only. In addition, the pilot will be advised of the location of the missed approach point (MAP) and his position each mile on final from the runway. If requested by the pilot, recommended altitudes will be issued at each mile, based on the descent gradient established for the procedure. (Source: Airman's Information Manual.)

the base of the northwest side of the tree. Pieces from the aircraft underside were found buried under the wires. Wreckage scatter and ground fire were more widespread beyond this point.

About 100 feet farther along the wreckage path, the ground slope leveled at an elevation of 450 feet. Most wreckage pieces came to rest on this hilltop. The largest pieces of wreckage were found from the aft part of the aircraft and consisted of the empennage, right engines attached within their nacelle pods, and the right inboard wing with a part of the fuselage attached. The two left engines had separated from their nacelle pods and were located about 120 and 160 feet to the right of the wreckage path.

The cockpit section, which was broken apart and severely burned, had come to rest along the wreckage path about 720 feet beyond the initial tree impact point. The farthest piece of debris recovered was the cockpit pressurization controller.

The wreckage scatter covered an area of 800 feet long and 280 feet wide. No parts of the aircraft were found outside the general area of the wreckage site.

Examination Of Aircraft

Fuselage.--The largest piece of fuselage recovered was the lower right side between fuselage stations (FS) 430 and 490. This entire section was still attached to the right inboard wing and had been damaged by ground fire.

The aft pressure bulkhead, normally located at FS 570, was recovered near the empennage section. The bulkhead was battered by impact forces but showed no evidence of fire. The two pressure outflow valves, which are normally attached to the bulkhead center area, had separated from the structure and were not recovered.

The cockpit area broke up extensively and was severely burned. The largest piece of cockpit consisted of the right roof, right skylight panel, the windshield, and the two right windows. This section showed no evidence of fire. The right side window panel, which normally can be unlatched and slid aft, was found partially open. The window panel could be opened or closed. There was no evidence of smoke or soot around the window panel opening. The Safety Board could not determine if the window was open or closed before impact.

Cockpit control and panel instruments were recovered throughout the wreckage area. Some items, such as pieces of the center pedestal section, the landing gear control panel, the global navigation system panel, oxygen supply pressure gauge, and throttle quadrant, were extensively damaged by fire. Other items, such as the RCA Data Navigation Panel, the IDC encoding altimeter, several circuit breaker panels, the cabin pressurization controller, the copilot's seat, and the glare shield, sustained either minor damage or were undamaged. The fire damage pattern in the cockpit appeared random.

A majority of the communication and navigation units were partially consumed by fire or crushed, or both. They were unsuitable for examination. The No. 2 radio receiver was not identified. The electrical power shield, including the GCU's, was severely damaged by fire. The large copper bus bars mounted on the shield were discolored by intense heat. Movement of the power shield caused many of the components on the shield to fall off. Postcrash testing for operation of shield components was impossible. The main batteries were disintegrated; however, there was no evidence of battery thermal runaway.

Wings.--Pieces from the left and right wings were scattered throughout the wreckage path. The largest piece consisted of the right inboard wing between the fuselage and the right auxiliary tank. The entire section had sustained fire damage. Both wing tips were recovered within the wreckage area. Neither wing tip showed evidence of fire damage.

Vertical Stabilizer.--The vertical stabilizer separated from the aircraft at the forward and aft attachment fittings. There was no fire damage, although the outer skin surface was sooted. The lower vertical stabilizer was intact and the upper stabilizer had separated about 2 to 3 feet above the horizontal stabilizer. The detached vertical stabilizer and rudder were recovered beneath the empennage structure.

Horizontal Stabilizer.--The horizontal stabilizer center section and portions of the left elevator were intact and attached to the vertical stabilizer. There was no evidence of fire damage except soot on the outer skin. Pieces of the horizontal stabilizer were recovered throughout the wreckage area. The pitch actuator assembly was attached to the vertical stabilizer and was measured to be 23.9 inches from the actuator fuselage attachment point to the eye of the actuator rod. This measurement corresponds to a pitch trim setting of 5° up.

Ailerons and Trim Tab.--The largest pieces of the left aileron were recovered near the first tree strike and consisted of the left aileron and trim tab between aileron station (AS) 2 and AS 35, and the left aileron outboard end with counterbalance between AS 83 and AS 97.5. Neither piece had sustained fire damage although both were sooted slightly. The aileron trim tab and actuator was intact and in the neutral position. Pieces of the right aileron were recovered near the ground impact area.

Rudder and Trim.--The rudder had separated from the vertical stabilizer and was recovered beneath the empennage section. The rudder had detached at the hinge points and was battered by impact forces. Although slightly sooted, there was no evidence of fire damage. A trim setting could not be determined. Because of the extensive breakup, the integrity of the flight control system before impact could not be determined. Nearly all bellcranks, sectors, pulleys, and other mechanisms were broken, distorted, or separated from their attaching structure. No cables were recovered for examination.

Landing Gear.--All three landing gears had separated from the aircraft structure and were recovered in the wreckage area. The left main landing gear actuator was still attached to the left gear strut and was in the down and locked position. The right main landing gear uplocks were still intact within the right wing wheel and were in the gear-down position. Actuators for the right main gear and nose gear had separated from the gear struts and were not recovered for examination.

Engines.--No. 1 engine, S/N 78122, was recovered about 640 feet from the point of initial tree contact, about 240 feet from the point of ground contact, and about 125 feet to the right of the wreckage path. The engine had separated from the left pod. The No. 1 engine fan blades had heavy impact damage and a number of blades were bent opposite the direction of rotation. There was no evidence of fire around the engine although the inlet fan blades were sooted. The exterior mounted accessories, much of the plumbing, and most of the electrical wiring were stripped from the engine case. The accessory gearbox and the transfer gearbox were torn from their mounts and were recovered upstream on the wreckage path.

No. 2 engine, S/N 75132, was recovered about 675 feet from the point of initial tree contact, about 295 feet from the point of ground contact, and about 170 feet to the right of the main wreckage path. The engine was damaged severely by impact. The fan blades were bent opposite the direction of rotation, and some fan blades had broken near the blade root. A considerable amount of fine wood chips and debris passed through and became lodged in the fan bypass duct. Although most accessories were missing from their mounts, the transfer gearbox and the accessory gearbox were recovered.

The No. 3 and No. 4 engine pod was recovered about 270 feet from the point of first ground contact. The engines remained on their mounts and were attached to a major portion of the right nacelle pod. The pod was found upside down in an area of ground fire; however, the hoses, insulated tubing, and wiring strung over the pod were not burned.

The No. 3 engine, S/N 75108, was moderately damaged. The fan blades were bent slightly opposite the direction of rotation. The fan exit stator vanes were loose and dislodged from their retaining slots. The cooling duct adapter for the starter-generator contained unburned wood fibers jammed into the cooling fan blades. The starter-generator fuel pump and fuel control were attached to their mountings.

Engine No. 4, S/N 75149, was found upside down with severe exterior damage from impact and ground fire. The severely damaged fan blades exhibited leading edge gouging, missing pieces, curled tips, and some blades were bent opposite the direction of rotation. The transfer and accessory gearboxes were severed from their case mounts, but were near their original position on the engine. The engine-driven fuel pump and fuel control unit (FCU) were detached from the accessory gearbox and were lying on the engine. The starter-generator was missing from the accessory gearbox.

Engine Accessories.--A FCU, data plate missing, from No. 1 engine was recovered about 180 feet from the point of ground contact and 110 feet to the right of the wreckage path. It had been damaged heavily by impact. Examination disclosed the power lever angle was about 118°, or slightly below the maximum power setting angle of 120°.

FCU serial No. A4338P, from No. 2 engine, was recovered about 160 feet from the point of ground contact and about 80 feet to the right of the wreckage path. This unit was found hanging by electrical wires from a tree branch about 15 to 18 feet above the ground. The power lever angle was found at about 120°.

From April 6 to 10, 1981, the Safety Board disassembled and inspected the four powerplants at the overhaul facilities of Garrett Turbine Engine Company in Phoenix, Arizona. The FCU's and fuel pumps of No. 3 and No. 4 engines were removed from their respective engines for examination. The fuel components of both engines were slightly damaged and were not operable. The power lever angle of FCU serial No. A-2013C of No. 3 engine was found at 103° and the power level angle of FCU serial No. A-3894P was found at 70°.

The turbine temperature (ITT) gauges of engines Nos. 3 and 4 were not found. The ITT gauge of No. 1 engine was heavily sooted and the needle was indicting about 250° C; the gauge of No. 2 engine was damaged and the needle read about 300°. The N1 compressor rpm gauge of No. 1 engine was not found and the N1 gauges of the No. 2 and No. 3 engines were destroyed by fire. The gauge of No. 4 engine was intact, but the broken needle indicated about 93 percent. Three fuel-flow gauges were recovered, but the needles of two of them were missing. The third needle of a fuel flow gauge to an unidentified engine indicated a fuel flow of 1,200 to 1,250 lbs/hr.

Fourteen of the 16 motor-operated gate-type fuel valves were recovered. A reconstructed layout of this portion of the fuel system disclosed that the fuel flow was from all left tanks to both left engines and from all right tanks to both right engines (crossfeeding). The crossover separation valve was closed and crossfeeding from opposite wing tanks was not possible.

One engine-mounted starter-generator was not found and one starter-generator was not identified with the associated engine. There was no indication of electrical shorting or arcing in the three starter-generators which were found and examined.

1.13 Medical and Pathological Information

There was no evidence of preimpact incapacitation or preexisting physical problems which could have affected the crewmembers judgment or performance. The results of toxicological blood analyses on both pilots were negative for alcohol, drugs, and cyanide, and showed less than 5 percent saturation for carbon monoxide. (Normal saturation levels are 3 percent to 5 percent for nonsmokers and 8 percent to 10 percent for smokers.)

All of the bodies exhibited multiple blunt impact injuries, extensive skeletal fractures, and multiple contusions and lacerations of the skin surface and internal organs. Most of the bodies had sustained minor thermal injuries.

1.14 Fire

There were postcrash fires and evidence of fuel explosions. The cockpit and cabin structure and furnishings sustained fire damage. Those pieces of the structure which separated from the aircraft sustained the greatest fire damage.

1.15 Survival Aspects

This accident was not survivable because impact forces exceeded human tolerances. Search and rescue efforts were hampered by the area's remoteness, lack of roads or trails, and poor visibility as a result of thick fog. Access to the accident site was by motor launch or foot.

1.16 Tests And Research

ATC transponder information from N520S, including altitude, was received, computerized, and recorded at the New York Air Route Traffic Control Center (ARTCC), the facility which controlled the flight until it was handed over to the Westchester County Airport air traffic controllers. The airport equipment did not have the capability to read aircraft altitude nor did it have the capacity to record the observed flight track.

Significantly, no transponder transmissions were recorded for a period of about 77 seconds when the aircraft was at an altitude of 2,100 feet, the altitude flown immediately before crossing the LOM. Further, transponder signals below 1,000 feet were not received from N520S.

Eighty-three radar recordings were plotted which included altitudes between 8,900 feet and 1,000 feet, and a probable ground track was developed. The probable ground track revealed that the accident aircraft overflew the assigned inbound radial to the holding fix at Brews Intersection by about 6 nmi and that it never entered the proper holding pattern. The computerized profile indicated that after leaving the Brews area, the aircraft maintained normal flight parameters until passing the ILS LOM, when relatively high indicated airspeeds were held during the glide slope descent.

The flight profile placed the aircraft above the glide slope from 2,100 feet to about 1,600 feet where its descent steepened abruptly and its course veered to the right. (See appendixes D and E.)

Wind Analysis.--Wind observations taken at Atlantic City, Albany, and Chatham indicated high winds throughout the area, particularly in the lower atmosphere. However, these observations did not extend below 1,000 feet which coincided with the lowest recorded altitude of the ATC transponder. As revealed by the transponder, the aircraft track deviated from the localizer at an altitude of about 1,100 feet. This altitude corresponds to a terrain clearance beneath the localizer course of about 700 feet. Airborne INS wind readings as high as 66 knots were taken at 2,100 feet in the vicinity of the runway 16 LOM, verifying the presence of high winds on the ILS descent path. Additional INS readings were not made below that altitude. Accordingly, to estimate the possible wind effects below 1,000 feet on the approach of N520S, winds were interpolated between the 1,000-foot level at Atlantic City and the surface wind at Westchester County Airport. Based upon these reported winds and a theoretical curve 7/ which describes the effect of surface friction upon low level winds, the following wind forces and shear values were computed to be representative of the existing winds at Westchester County Airport at the time of the accident.

Height (feet above ground level)	Wind Speed (kns.)
Surface	14
100	31
200	39
300	45
400	50
500	54
600	57
700	60

The shear values between these layers were:

Surface to 100	17
100 to 200	8
200 to 300	6
300 to 400	5
400 to 500	4
500 to 600	3
600 to 700	3

The following are the wind shear severity standards adopted by the International Civil Aviation Organization (ICAO) 5th Air Navigation Conference in 1967:

CLASSIFICATION	KNS/100 FEET
Light	0 - 4 kns.
Moderate	5 - 8 kns.
Strong	9 - 12 kns.
Severe	greater than 12 kns.

7/ Low-Level Wind Shear, A Critical Review (PB-300715), U.S. National Weather Service, Silver Spring, Maryland, April, 1979.

The wind shears described above are considered a steady state condition. However, in the high wind conditions at the time of the accident, the lower atmosphere would become turbulent because of surface friction of the terrain and would cause changing wind shear patterns.

At the time of accident, there was a low-level temperature inversion caused by the advection of warm air over a cooler surface. This inversion was at 3,100 feet over Atlantic City, 1,100 feet over Chatham, and 300 feet over Albany. Since N520S first deviated from the localizer course at 1,100 feet, this altitude probably was the base of the inversion over the Westchester County Airport. An inversion is commonly found to be a shear boundary and upper limit of surface-generated turbulence.

1.17 Additional Information

Another Lockheed JetStar aircraft, N320S, operated by Texasgulf Aviation, Inc., as a part of its corporate fleet, had been modified with the same type Colt/Phoenix generator control regulator units as N520S about June 1980; they were also installed by AiResearch Aviation Company. Generator-loss problems were experienced on N320S after the installation of the solid-state generator control units, but were apparently resolved in July and September 1980, when an exchange of GCU's was made with the manufacturer. The new units had been modified. The only known difference between the electrical equipment on the two aircraft was the Data Nav III system installed on N520S as a part of the RCA Primus 400 Color Radar.

At the time of the crash, four Lockheed JetStar aircraft had been modified with this solid state electrical package--the two Texasgulf aircraft, an aircraft operated by Campbell Taggart, Inc., and an aircraft operated by Federated Stores, Inc. Both of the latter aircraft had experienced generator-loss problems, including multiple failures. The difficulties were corrected by the addition of diodes in the generator control circuitry which minimized what was believed to be electrical stress imposed by the auxiliary hydraulic electrical pump.

1.18 New Investigative Techniques

None

2. ANALYSIS

The pilots were certificated properly and were qualified for the flight. The copilot was type-rated in the aircraft and was fully qualified as pilot in command. He also held an aircraft and powerplants mechanic certificate, which entitled him to perform maintenance service. There was no evidence that medical or physiological problems affected the crew's performance.

The aircraft was certificated, equipped, and maintained in accordance with regulations and approved procedures. There was no evidence of preimpact fire or of preimpact failure or malfunction of the aircraft's structure, powerplants, or flight controls. Although there was no direct evidence to indicate that at the time of impact a total or partial electrical system failure had occurred, a recent modification of the generator control system had resulted in the loss of one or more generators to the electrical bus on several occasions. Corrective maintenance work had been done by personnel of AiResearch Aviation, Inc., who installed the modification, and later by technicians of Colt Electronics Company and Phoenix Aerospace, Inc., who manufactured the modification kit. They were unable to identify the cause of the generators' disconnecting or to adjust the components of the system to prevent recurring electrical failures. The tuning of the new GCU's proved critical since the modified control system was complex and highly sensitive. The interface between the new solid-state GCU's and the original electrical system apparently was not compatible, and the trouble-shooting efforts of the maintenance personnel did not identify the problem. Because the essential components of the electrical were severely damaged by impact and fire, the Safety Board could not determine if the electrical system was operating properly at the time of the accident.

In Toronto, when the copilot disclosed to several other pilots that N520S had lost all four generators for 8 to 9 minutes during the flight to Toronto, he stated that the system"...didn't do what it was supposed to do...and some of the basic instruments had been lost." He also said that the generators repeatedly came on- and off-line as the pilot tried to correct the problem. When the pilot discussed the electrical problem with the company's director of maintenance in White Plains. It was suggested that the No. 2 generator fault transformer be disconnected. Although the copilot was qualified to disconnect the fault circuit, the Safety Board could not determine if he did so. However, disconnecting a ground fault would not have created a hazardous situation.

Since the pilots did not report the electrical power losses en route to Toronto to any ground facility, the Safety Board concludes that if electrical power was lost en route to White Plains, they probably would not have reported it. The first indication of a possible electrical loss en route to White Plains was the landing gear problem after departure from Toronto. The flightcrew did not describe the problem to the Toronto air traffic controllers; however, it most likely involved landing gear retraction, which may have been associated with the electrically driven auxiliary hydraulic pump. When the difficulty was corrected, the aircraft proceeded en route. No further difficulties were evident until N520S overshot the assigned holding pattern at the Brews Intersection which required the air traffic controller to radar vector the aircraft back into the pattern airspace.

About 1811, the New York controller told N520S to expect a "Brews One" arrival procedure for entry to the Westchester County Airport. About 1819, the flight was cleared to the Brews holding pattern. The aircraft was estimated to have crossed the Kingston 199° VOR radial at 1825, which is the turning point to the holding pattern. The flightcrew, while flying southeasterly, had at least 6 minutes from the receipt of the clearance to prepare for the turn toward Brews. Two minutes after flying past the turning point, the flightcrew evidently had not recognized the position of the aircraft in relation to the holding fix. About 1827, N520S was seen by the approach controller overflying the holding pattern airspace limit, and the controller advised the flight to turn. After the copilot acknowledged the advisory, the aircraft did not turn and was again advised to turn right to 220° and that transmission was acknowledged. About 1830, the approach controller advised the flightcrew that if they were having trouble entering the holding pattern, he would radar vector them into position. The copilot acknowledged that they were out of the pattern, and the controller immediately advised the pilot to turn right to a northwesterly heading. The copilot accepted the clearance and stated that they had "lost the right side radio." While the loss of the No. 2 VOR receiver could indicate a loss of generator-supplied electrical power, the New York ARTCC Data Analysis Reduction Tool (DART) computerized record of the N520S transponder disclosed that it was operative at this time. Because the transponder is powered by the main d.c. electrical bus, its operation indicated that a total loss of generators did not occur in the vicinity of Brews Intersection. The Safety Board was unable to determine the cause of the failure of the No. 2 radio.

Following the loss of the No. 2 radio information, the time of which could not be determined, the flightcrew could have determined the desired track into the Brews holding pattern in several ways: (1) Since both Kingston and Carmel VOR stations have distance measuring equipment, the pilot could have estimated accurately the position of the Brews Intersection while immediately requesting the approach controller to provide radar assistance. (2) The flightcrew could have used the available INS and R-Nav navigation receivers to display the Brews Intersection and to provide flight guidance to the Brews holding pattern entry. In fact, the Safety Board believes that under the circumstances at that time and the day's experience of loss of electrically powered equipment, the pilot would have been prudent to have used these aids and to have requested a surveillance radar approach (ASR) or at least a radar-monitored ILS approach.

The flightcrew's lack of awareness of the aircraft's actual position during entry to the Brews holding pattern and the flightcrew's acknowledgement of the controller's clearances to turn without a complying maneuver indicate that the pilots were preoccupied with tasks other than flying the aircraft.

Further examination of the DART computer data disclosed that the transponder was inoperative for about 77 seconds beginning at 1835:30 as the aircraft approached the LOM at 2,100 feet, the crossing altitude of the LOM. Transponder information was recorded again at 2,100 feet and continued until the aircraft descended to 1,000 feet where the last transponder information was recorded. This altitude was about 560 feet above airport elevation. The Safety Board believes that the 77-second transponder loss indicates that electrical power had been lost to the main d.c. bus, which normally powers the No. 1 inverter system. Under such conditions, flight attitude and navigational information could be provided to the pilot by the automatic switching of battery power to the essential d.c. bus and by the pilot's transferring essential d.c. bus power to the No. 2 inverter system. The instrumentation on the copilot's flight panel would have been inoperative. However, restoration of a single generator would have provided sufficient electrical power to sustain the total electrical requirement of all aircraft systems. This restoration of one generator would not preclude the flightcrew's further attempts to eliminate an electrical problem which they considered to be of major importance.

The before-landing checklist, normally completed before descent from the LOM, provides for the closing of the fuel crossfeed valves supplying fuel from the external tanks to the engines. Examination of the aircraft wreckage disclosed that the four crossfeed valves were open at the time of the crash. Although the open position of these valves did not endanger the delivery of fuel to the engines in the case of fuel depletion in the external tanks, normal checklist procedures dictate that these valves are closed during takeoff or landing. Because the crossfeed valves were found open the before-landing checklist apparently was not completed. Although this and related occurrences are circumstantial, the facts strongly suggest that a malfunctioning aircraft system had caused a disruption of normal cockpit behavior.

Since a witness saw N520S from his position 300 yards from the runway 16 approach lights, the flightcrew should have seen the high-intensity flashing strobe lights and bars of the approach light system if either's attention had been directed outside the cockpit. The approach light system is aligned with the ILS localizer; if the aircraft had been misaligned with the runway, the pilots could have easily recognized it. The crash site was about 2,300 feet right of the localizer centerline and about 1 mile short of the runway threshold. While in other approach and landing accidents, darkness and rain-cluttered windshields have contributed to errors in judgment of vertical displacement and thereby caused the pilot to descend prematurely, these factors should not have caused a 2,300-foot horizontal displacement from the intended track as the aircraft descended.

At the time of the accident, weather throughout the area was affected by strong pressure gradients causing high winds and widespread turbulence. Pilots who made ILS approaches into Westchester County Airport within 30 minutes before and after the accident reported extremely difficult flying conditions although all aircraft systems were operating normally. One flightcrew reported winds as high as 66 knots in the vicinity of the LOM, while winds observed at the airport varied from 18 to 20 knots with gusts. Pilots reported fluctuating airspeeds throughout the approaches but none reported a sustained change of airspeeds. Although light to moderate wind shear was present during the glide slope descent of N520S, the shear appeared to have been manageable since other flightcrews successfully completed their ILS approaches and landings. In two cases, however, because of the severity of the turbulence and not because of wind shear, pilots made missed approaches although the runway environment was in view at DH.

Strong winds blowing from the right forward quarter would have necessitated the holding of large wind correction angles in order to track the localizer course after crossing the LOM. Since the wind would have diminished as the aircraft descended into the lower levels, the wind correction angle would have had to have been reduced in order for the aircraft to maintain the localizer course. Flightcrew inattention to this demanding tracking task as a result of a cockpit distraction could have contributed to the 2,300-foot displacement. Similarly, many other factors could have contributed to the uncorrected pitchdown of the aircraft and the increased rate of descent, including thrust reductions to compensate for fluctuating airspeed, a moderate decrease in wind velocity, and unrealized flight control inputs.

With one or more generators connected to the electrical bus or with the emergency procedures in effect and the ship's batteries supplying power, the pilot would have had flight attitude and navigation information displayed before him. Therefore, during the moments before the crash, both the computed flight director indications and the raw data of the course deviation indicator would have displayed full-scale fly-left and fly-up deflections to realign the aircraft with the on-course signals of the localizer and the glide slope. If for some reason normal flight instrumentation was lost, and the pilot did not have guidance to navigate to the runway threshold or to maneuver visually to the landing area, he could have controlled the aircraft by reference to the independent standby attitude indicator and the pitot-static and barometric instruments while making a missed approach. Upon reaching a safe altitude, he could have requested ground-based radar assistance to provide guidance to an alternate airport with better landing conditions.

The Safety Board cannot positively conclude that the electrical system functioned as designed. It is possible that an unknown fault occurred in the generator control circuitry so that an electrical malfunction, which invalidated the design logic of the normal or emergency electrical system, persisted and could not be corrected by the pilots at the time of the approach.

In summary, although the precise source and magnitude of the electrical system malfunction could not be identified from available evidence, the Safety Board is convinced that the flightcrew experienced considerable difficulty with this system throughout the entire trip, particularly during the latter stages of the flight from Toronto to Westchester. This was evidenced by the discrepancies after takeoff from Toronto, the overshooting of the assigned holding pattern in the New York area, and the loss of transponder signals immediately preceding the initial stage of the ILS approach into Westchester County Airport. The aircraft's history of electrical problems since the GCU modification and the complete interruption of all generator power during the flight to Toronto are sufficiently serious to cast considerable suspicion on the overall reliability of the aircraft's electrical system. Despite the existence of wind shear, turbulence, darkness, and low clouds in the Westchester area, the Safety Board is also convinced that the experience and proficiency level of these pilots would indicate that they were capable of successfully completing the approach or executing a missed approach in the absence of intervening factors. While the Safety Board could not determine precisely how these electrical system problems were manifiested within the cockpit, it believes that there is sufficient evidence to conclude that an electrical system malfunction did exist, or had existed, during the approach and that this problem caused a major distraction to the flightcrew which compromised adequate monitoring of flight instruments. It is most reasonable to conclude that the distraction, in combination with the severe weather environment, resulted in the undetected deviation from the intended flightpath.

In a Special Study, published August 18, 1976 7/ the Safety Board underscored the need to implement flightcrew coordination procedures which will insure continuous monitoring of the flight instruments from the LOM to landing. Although not required, the company Policy and Procedures Manual and the line training background of the N520S pilots had not included flightcrew coordination or cockpit discipline exercises, particularly those related to the separation of individual flight duties during emergency conditions.

On April 24, 1978, the Safety Board issued three safety recommendations concerning flight operations manuals. The Safety Board believes that flight departments operating four or more aircraft, regardless of size, or two or more large aircraft, or those flight departments having a chief pilot who supervises four or more pilots, should be required to operate with standardized flightcrew coordination procedures. In the recommendation letter, the Safety Board expressed the opinion that, besides accommodating the requirements of the company, these manuals must also contain standard pilot and cockpit procedures for the takeoff, en route, or approach and landing phases of flight, the FAA rejected the recommendations.

Three weeks earlier, on March 30, 1978, the Chairman of the Safety Board solicited the endorsement of the National Business Aircraft Association, Inc. (NBAA) of our attempt to require flight operations manuals that contain standardized procedures. In that letter the Chairman stated:

> The Safety Board realizes that 14 CFR 91 does not require that a corporate/executive operation have a flight operations manual. However, corporate aircraft operations often involve aircraft as sophisticated as air carrier equipment in support of flexible, unpredictable mission requirements. The very nature of corporate flying dictates that basic procedures and policies be documented and well known to all pilots. The Safety Board believes that a flight operations manual is the most practical means to establish and promulgate common administrative and flight operations policies and procedures, and to insure that a strong measure of standardization is conveyed to company pilots.

The NBAA responded to the Safety Board by issuing an "Action Bulletin" on May 10, 1978. The bulletin reminded its member companies that:

> The Aircraft Flight Manual and the Administrative and Operations sections of the NBAA's Standards Manual provide excellent reference material for an operations manual.

7/ Aviation Special Study: "Flightcrew Coordination Procedures in Air Carrier Instrument Landing System Approach Accidents." August 18, 1976, NTSB-AAS-76-5.

Regardless of the FAA's rejection of our recommendations, the Board continues to believe that standardized crew coordination procedures should be contained in a flight operations manual, particularly for those departments that operate with interchangeable crew complements, and those procedures must be adhered to by all crewmembers.

3. CONCLUSIONS

3.1 Findings

1. The generator control circuitry had been modified by the replacement of carbon-pile voltage regulators with solid state generator control units. The modification had been completed about 2 weeks before the accident.

2. Following modification, a series of single and multiple electrical failures occurred during flight. Corrective maintenance efforts did not eliminate the problem since all generators had disconnected from the main d.c. electrical bus on the morning of the accident.

3. The No. 2 ground fault transformer on the power shield may have been disconnected before departure at Toronto, but the disconnection would not have created a hazardous situation.

4. The flightcrew unknowingly overflew the Brews Intersection, and the aircraft was directed to the intended track by radar vectors provided by a controller.

5. The flightcrew apparently did not use INS or R-Nav navigation equipment for tracking information at the Brews Intersection nor did they request assistance from the controller for a radar-monitored approach and landing after they had lost a VHF radio receiver.

6. Weather in the vicinity of the airport was low, obscured ceilings, rain, fog, and reduced visibility. Strong, gusty winds, with moderate to severe turbulence, were prevalent throughout the area. Winds were observed as high as 66 knots at the LOM and as low as 12 knots at the airport.

7. Pilots, who made ILS approaches before and after the accident aircraft, stated that moderate, occasionally severe turbulence, with widely fluctuating airspeeds, occurred throughout their approaches.

8. Light-to moderate wind shear was present during the glide slope descent. The shear increased to severe intensity as the aircraft descended below 200 feet.

9. The last radar position was recorded at 1,000 feet. Without a flight data recorder, flight performance analysis was not possible below that altitude.

10. During the descent to the Westchester County Airport, there were two indications that N520S had electrical difficulties--(1) the flightcrew's report at the Brews Intersection that they had lost No. 2 radio information, and (2) the loss of recorded transponder signals in the vicinity of the LOM. The landing gear problem during the departure from Toronto may have been related to an electrical problem.

11. A single generator has the capacity to supply power for the entire electrical requirement of the aircraft's systems, including the flight instruments of both pilots.

12. If generator-supplied electrical power is lost, the aircraft's batteries can power the pilot's flight attitude and navigation instruments. The changeover is automatic; the copilot's electrically operated flight instruments are inoperative.

13. If the aircraft batteries are depleted, flight control guidance is provided by an independent battery-powered, illuminated standby attitude indicator, and barometric or pressure related instruments. These instruments are available to both pilots.

14. During its approach to Westchester County Airport, a witness saw the landing lights of the accident aircraft. The illumination of these lights indicates that electrical power from at least one generator was available to operate the flight attitude and navigation instruments of both pilots.

15. The witness was located near the approach light system, which is equipped with high-intensity flashing strobe lights. If the attention of either pilot had been directed outside the cockpit, aircraft deviations from the centerline of the approach light installation should have been easily recognized.

16. The crash site was 2,300 feet right of the approach light installation, which is aligned with the localizer centerline, and 1 mile from the runway threshold.

17. Adequate slant-range visibility existed for outside reference to align the aircraft with the landing area and adequate flight instrumentation should have existed, at least on the pilot's flight panel, for vertical guidance and localizer alignment to decision height if both pilots had not been distracted from the task of flying a safe flightpath.

18. The company training program included emergency training procedures, including electrical system failures. The training program did not include standardized flightcrew coordination procedures, particularly during emergency situations, and it did not include study of wind shear phenomena or simulated exercises of wind shear encounters.

3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was a distraction to the pilot at a critical time as a result of a major electrical system malfunction which, in combination with the adverse weather environment, caused an undetected deviation of the aircraft's flightpath into the terrain.

4. RECOMMENDATIONS

As a result of this accident and several others involving general aviation aircraft, the National Transportation Safety Board reiterates the following recommendations made to the Federal Aviation Administration on April 13, 1978:

> Develop, in cooperation with industry, flight recorder standards (FDR/CVR) for complex aircraft which are predicated upon intended aircraft usage. (Class II, Priority Action) (A-78-27)
>
> Draft specifications and fund research and development for a low-cost FDR, CVR, and composite recorder which can be used on complex general aviation aircraft. Establish guidelines for these recorders, such as maximum cost, compatible with the cost of the airplane on which they will be installed and with the use for which the airplane is intended. (Class II, Priority Action) (A-78-28)
>
> In the interim, amend 14 CFR 91 and 135 to require that no operation (except for maintenance ferry flights) may be conducted with turbine-powered aircraft certificated to carry six passengers or more, which require two pilots by their certificate, without an operable CVR capable of retaining at least 10 minutes of intracockpit conversation when power is interrupted. Such requirements can be met with available equipment to facilitate rapid implementation of this requirements. (Class II, Priority Action) (A-78-29)

On November 6, 1980, following earlier correspondence, Administrator, FAA, responded again to these recommendations. His latest comments were as follows:

> A-78-27: We recently updated the status of this recommendation in our letter of July 29, 1980. To reiterate our remarks, during August 1979 FAA received a proposed standard for a composite cockpit voice recorder/flight data recorder (CVR/FDR) from one of the major manufacturers of both CVRs and FDRs. Working with this proposed standard and other examples as a base, FAA has developed a proposed draft standard for a composite CVR/FDR.
>
> A new public procedure to expedite the issuance of standards for specified materials, parts, processes, and appliances used on civil aircraft was issued by FAA on June 2, 1980, with September 9 as its effective date. . . . FAA will publish its proposed standard for a composite CVR/FDR under this new procedure. A copy of the latest draft of the CVR/FDR and a copy draft of the CVR/FDR Standard and a copy of the new TSO procedures are enclosed. As a result of a recent NTSB recommendation, FAA is requesting SAE to develop the standard from our draft material.
>
> A-78-28: Although initially the FAA had planned to establish a regulatory project to develop an Advance Notice of Proposed Rule Making (ANPRM) for identification of appropriate standards, further review of the matter indicated that this regulatory procedure was not necessary. Research and development previously accomplished by the U.S. Army and by NASA was already being incorporated by several equipment manufacturers in their own development plans.

A-78-29: In partial fulfillment of this recommendation, 14 CFR 135 was amended, as published October 10, 1978, in Vol. 43 FR 46742, to require under Section 135.151 that no person may operate a turbojet airplane having a passenger seating configuration, excluding any pilot seat, of 10 seats or more, unless it is equipped with an approved cockpit voice recorder.

In further fulfillment of this recommendation, the FAA currently is drafting an NPRM which would require under Part 91, General Operating and Flight Rules, several additional equipment items, including a CVR on all multiengine turbojet airplanes. This would expand the coverage under Section 135. 151 since there would be no minimum seating requirement specified.

The FAA will keep the Board advised as to progress relating to these recommendations.

Also as a result of this accident on August 26, 1981, the Safety Board recommended that the Federal Aviation Administration:

Review the approval of Supplemental Type Certificate SA 1596 CE and the effect of the installation of the STC in Lockheed JetStar Model 1329 aircraft. (Class II, Priority Action) (81-92)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ FRANCIS H. McADAMS
Members

/s/ PATRICIA A. GOLDMAN
Member

/s/ G. H. PATRICK BURSLEY
Member

JAMES B. KING, Chairman, and ELWOOD T. DRIVER, Vice Chairman, did not participate.

August 19, 1981

APPENDIXES

APPENDIX A

INVESTIGATION AND HEARING

INVESTIGATION

The Safety Board was notified about 1950 on February 11, 1981, that a Lockheed JetStar II had crashed during an approach to the Westchester County Airport, White Plains, New York. The Safety Board immediately dispatched investigative personnel from the New York Field Office and Washington, D.C., headquarters to the scene. Working groups were established for operations, air traffic control, witnesses, weather, powerplants, structures, systems, maintenance records, human factors, and performance.

Participants in the on-scene investigation included representatives of the Federal Aviation Administration, Texasgulf Aviation, Inc., the Lockheed-Georgia Company, Garrett, Turbine Engine Company, AiResearch Company, and National Business Aircraft Association, Inc.

PUBLIC HEARING

No public hearing was held in conjunction with this accident.

APPENDIX B

PERSONNEL INFORMATION

Mr. Joseph Morgan Gregory, Pilot

Mr. Gregory, 63, held Airline Transport Pilot Certificate No. 390812, with commercial privileges, single engine land and rotorcraft/helicopter. He held type-ratings in the Rockwell Saberliner N-265, Lockheed JetStar L-1329, Lockheed L-18, Douglas DC-3, and DC-4. His flight instructor rating had expired. He held a first-class medical certificate, dated October 8, 1980, with limitations to wear glasses for near and distant vision.

Mr. Gregory had accumulated about 24,000 total flying hours, of which about 4,500 hours were flown in the Lockheed JetStar L-1329. He had not flown during the 24-hour period before the flights of February 11. In the last 30 days and 7 days, he had flown 14:50 hours and 3:10 hours, respectively.

Mr. Gregory was given a 2-hour recurrent briefing on systems and procedures of the JetStar aircraft on November 17, 1980. The ground training was followed by a full pilot-in-command flight check in accordance with 14 CFR 61.58. During the check, Mr. Gregory made four takeoffs and landings. The briefing and flight check were conducted at Westchester County Airport.

Mr. Shanley Scott Sorenson, Copilot

Mr. Sorenson, 42, held Airline Transport Pilot Certificate No. 1678302, with commercial privileges, single engine land. He held type-ratings in the Gulfstream 159 and Lockheed JetStar L-1329. He held Airplane and Powerplants Mechanic Certificate No. 528-50-3164. He held a First Class Medical certificate, dated March 19, 1980, with no limitations.

Mr. Sorenson had accumulated 8,947:50 total flying hours, of which 1,374:25 hours were flown in the Lockheed JetStar L-1329. He had 15 hours rest before the flights of February 11, 1981. In the last 30 days and 7 days, he had flown 28:05 hours and 8:20 hours, respectively.

Mr. Sorenson participated in a JetStar recurrent training at the flight safety facility at Marietta, Georgia, April 21 through 24, 1980. During the recurrent training, Mr. Sorenson received ground schooling on the powerplant, hydraulic, electrical, anti-ice/deice, and air conditioning/pressurization systems. He received 6 hours left seat and 6 hours right seat time in the JetStar simulator. Second-in-command Sorenson received his initial training on the JetStar in January 1979, and his second-in-command pilot check in the same month. He attended a recurrent training class in March 1979, and in that same month received a type-rating on the JetStar aircraft.

Texasgulf Aviation, Inc., has contracted with Flight Safety International, Inc., to maintain a pilot training program to assure that each pilot is adequately trained and proficient to perform his assigned duties. The operator's "Manual of Policy and Procedures" sets forth the training requirements for flightcrews. The training program consists of ground and flight training, each phase consisting of initial, transition, and recurrent training. The flight portion may be conducted in the pertinent aircraft or an approved simulator. The company manual further states that a pilot may not be assigned to flying until he successfully completes an en route check. Thereafter, the pilot may not serve as a pilot unless he passes a similar en route check each 12 calendar months. Safety Board investigators did not find evidence that any Texasgulf pilot had been given a recurrent en route check.

APPENDIX C

AIRCRAFT INFORMATION

The aircraft, United States registration N520S, was a Lockheed JetStar, modified model 1329-731, serial No. 5084. A certificate of aircraft registration was issued to Texasgulf Aviation, Inc., on May 11, 1981. The aircraft was maintained in accordance with the requirements of Part 91.217(b)(5) of the FAA regulations. The program was based on the operator's maintenance needs outlined by Lockheed-Georgia Company, Marietta, Georgia, and AiResearch Aviation Company, Inc., Los Angeles, California. The program was performed by AiResearch Aviation Company, Inc., MacArthur Airport, Long Island, New York.

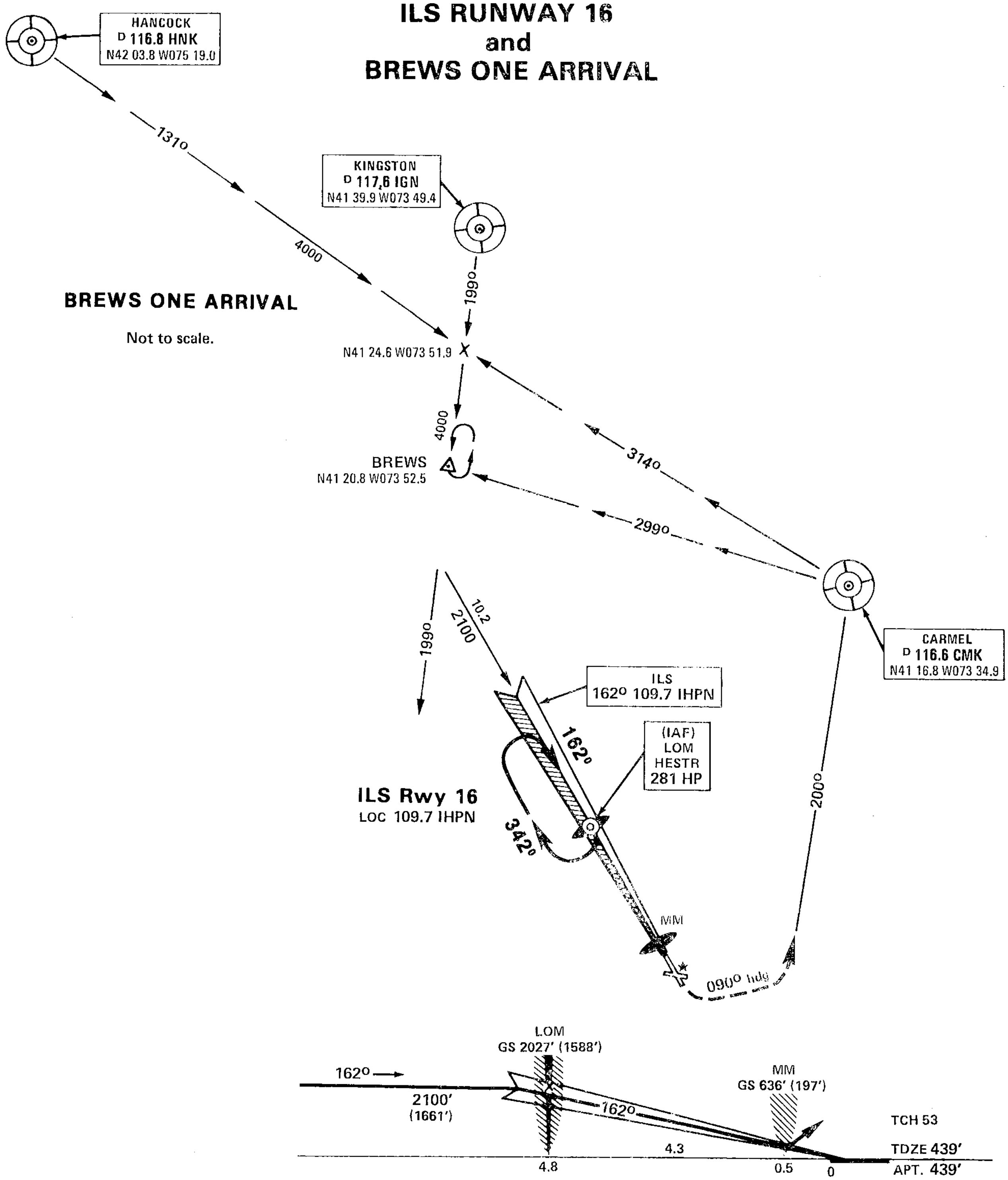
The basic aircraft was modified by addition of four AiResearch TFE 731-3 turbo-fan engines, which are rated at 3,700 pounds thrust at 76° F.

Engine	Serial No.	Total Time	Time Since Overhaul	No. Cycles
1	P75137	2,173:20	1,386	1,387
2	P75132	1,891:15	2,042	1,344
3	P75108	1,929:55	1,221	1,221
4	P75140	2,173:20	1,384	1,387

Aircraft Total Time: 7,413 hours
Total Landings: 5,308

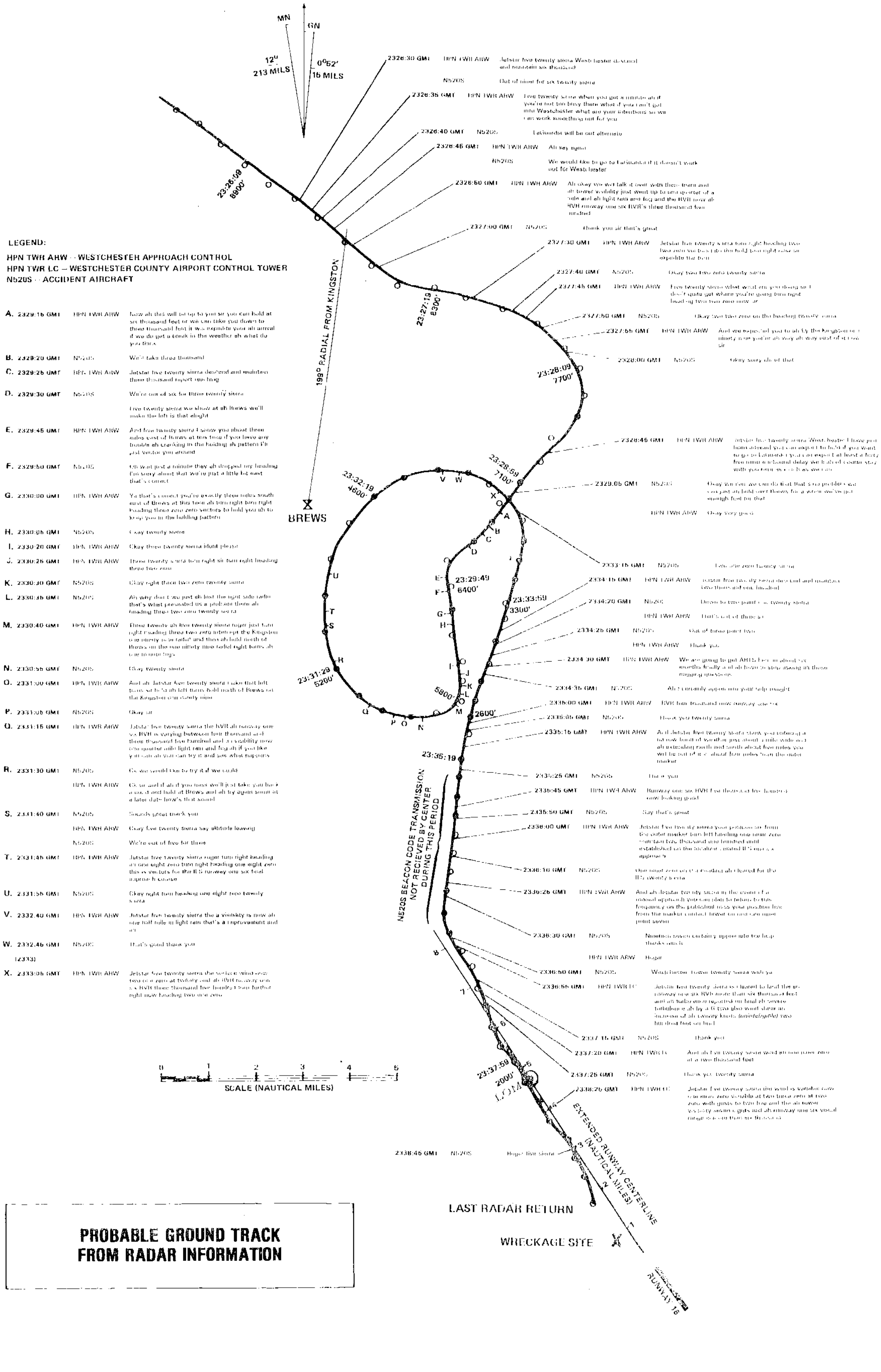
APPENDIX D

WESTCHESTER COUNTY AIRPORT
WHITE PLAINS, NEW YORK
ILS RUNWAY 16
and
BREWS ONE ARRIVAL



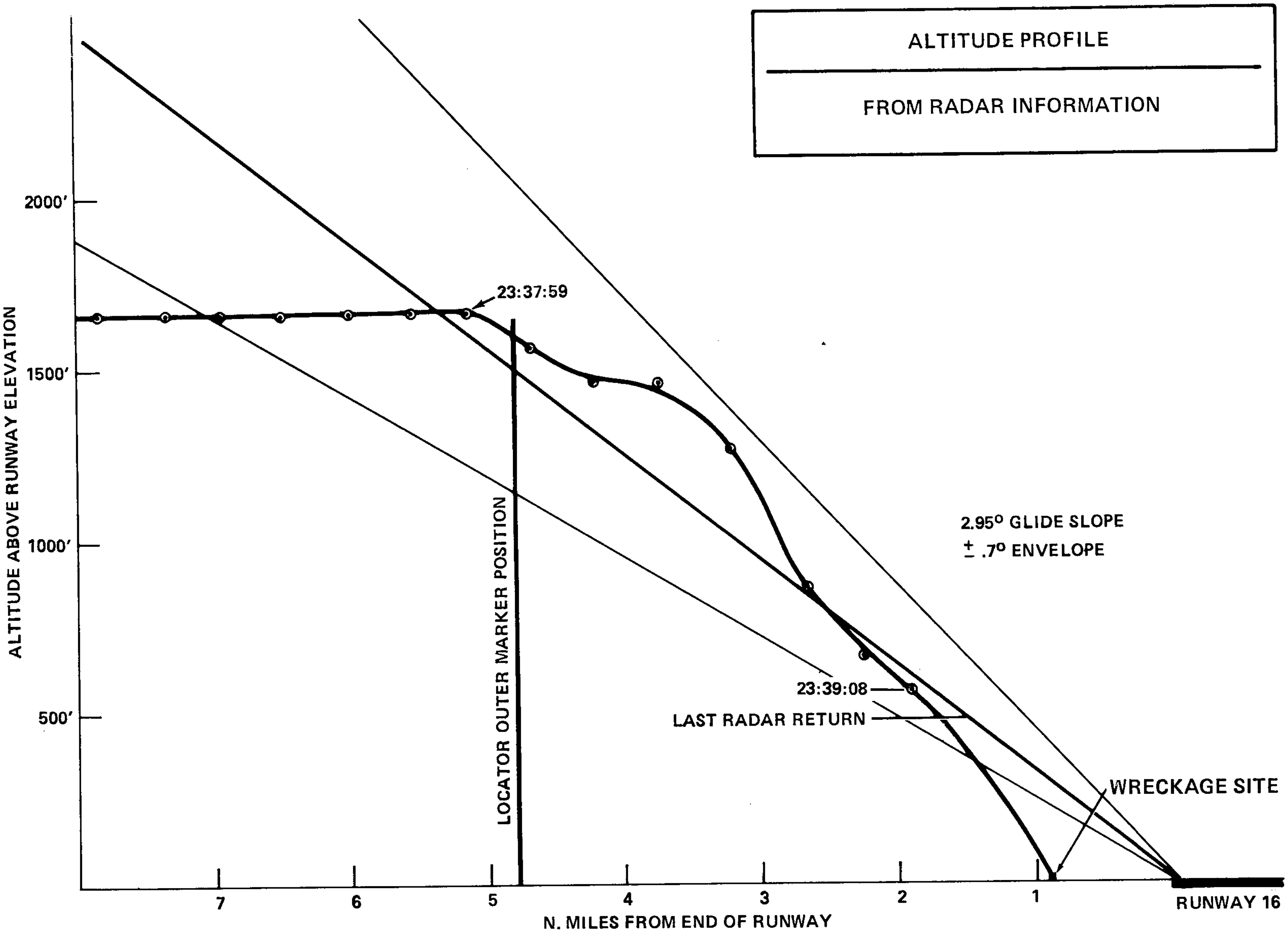
MISSED APPROACH: Climb to 1000' then climbing LEFT turn to 2100' via heading 090° and inbound CMK VOR R-200 to CMK VOR and hold.

APPENDIX E



PROBABLE GROUND TRACK FROM RADAR INFORMATION

APPENDIX F


ALTITUDE PROFILE
FROM RADAR INFORMATION
ALTITUDE ABOVE RUNWAY ELEVATION
2000'
1500'
1000'
500'
23:37:59
LOCATOR OUTER MARKER POSITION
2.95° GLIDE SLOPE
± .7° ENVELOPE
23:39:08
LAST RADAR RETURN
WRECKAGE SITE
7
6
5
4
3
2
1
RUNWAY 16
N. MILES FROM END OF RUNWAY