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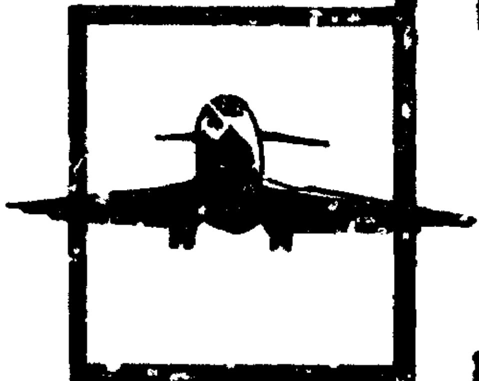

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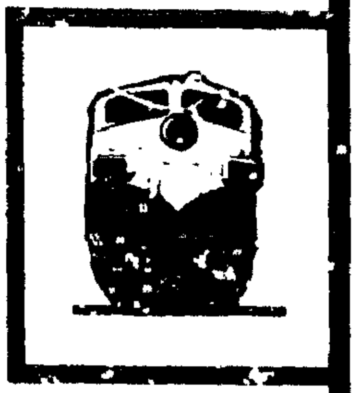

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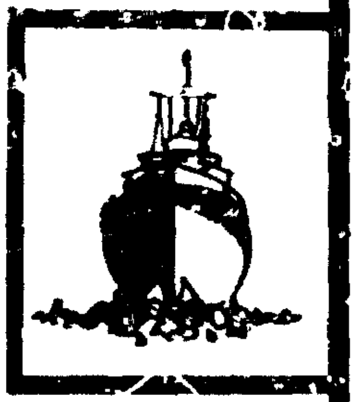
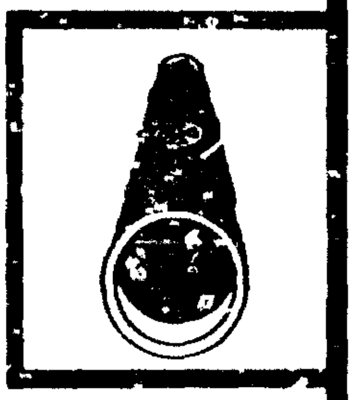


AIRCRAFT ACCIDENT REPORT

SKY TRAIN AIR, INC.
GATES LEARJET 24, N44CJ
FELT, OKLAHOMA
OCTOBER 1, 1981



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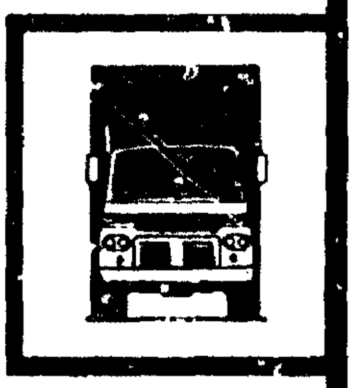

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16. Abstract About 1502 c.d.t., on October 1, 1981, a Sky Train Air, Inc., Learjet 24, N44CJ, crashed 2.5 miles southwest of Felt, Oklahoma. The flightcrew and one passenger, the only occupants on board, were killed.

At 1449:39, while in cruise flight at Flight Level 450, en route to McAllen, Texas, from Casper, Wyoming, the flightcrew made initial contact with the Albuquerque Air Route Traffic Control Center. About 1 minute later, the flightcrew failed to respond to a frequency change instruction and the aircraft's transponder beacon code was lost. The controller made several attempts to contact the aircraft but to no avail. Witnesses at Felt heard an aircraft overhead at a very high speed; one witness who saw the aircraft momentarily, stated it was in a descent angle of about 45° before it struck the ground.

The National Transportation Safety Board determines that the probable cause of the accident was a loss of control, possibly initiated by an unexpected encounter with moderate to severe clear air turbulence, which caused the aircraft to depart the narrow flight envelope boundaries in which it was operating and from which recovery was not effected, the flightcrew's lack of adequate training and experience in the Learjet, and the aircraft's marginal controllability characteristics near and beyond the boundaries of its flight envelope. Contributing to the accident was the flightcrew's probable extension of the spoilers in an overspeed situation, a procedure that had been prescribed in the approved aircraft flight manual until 1 year before the accident.

17. Key Words Clear air turbulence, overspeed, stall, buffet boundaries, controllability, mach tuck aileron buzz, wing spoilers, nose down pitching moment, roll maneuver, high speed dive, special certification review.

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NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594

AIRCRAFT ACCIDENT REPORT

Adopted: May 18, 1982

SKY TRAIN AIR, INC.
GATES LEARJET 24, N44CJ
FELT, OKLAHOMA
OCTOBER 1, 1981

SYNOPSIS

About 1502 c.d.t., on October 1, 1981, a Sky Train Air, Inc., Learjet 24, N44CJ, crashed 2.5 miles southwest of Felt, Oklahoma. The flightcrew and one passenger, the only occupants on board, were killed.

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1. FACTUAL INFORMATION

1.1 History of the Flight

On October 1, 1981, while on a return flight to their company headquarters in McAllen, Texas, from Thermopolis, Wyoming, the president of Sky Train Air Inc., the chief pilot, and another company pilot stopped in Casper, Wyoming, for fuel. The lineman noted a fuel imbalance when 320 gallons of fuel were added to the left wing and only 260 gallons of fuel were added to the right wing tanks. According to the lineman, the crew was aware of the imbalance. A total of 585 gallons of Jet-A with Prist (anti-ice additive) was supplied which filled the wing tanks to capacity. No fuel transferring was necessary during the refueling. The lineman stated that he believed the fuselage tank was full because the nosegear strut was extended 8 to 12 inches. He stated a ground power unit was used to start the engines and he did not notice any difficulties with the aircraft during the crew's preflight checks.

The flight plan filed by the president, reported to be the pilot-in-command, was as follows: IFR to McAllen, Texas, at Flight Level (FL) 450, true airspeed 450 knots, via Airway J170 to Denver, J17 to Amarillo, J17 to San Antonio, J25 to Corpus Christi, direct McAllen; time en route 2 hours 20 minutes with 3 hours 40 minutes of fuel on board. A weather briefing was not given to him because he had reported that he already had the weather information. The crew called the Casper Air Traffic Control Tower for taxi clearance at 1352:08 1/ and began its departure from runway 21 at 1357:02.

At 1449:39, while in cruise flight at FL 450, the flightcrew made initial radio contact with Sector 71 of the Albuquerque Air Route Traffic Control Center (ARTCC). The aircraft was "squawking" transponder code 0570. About 1458, a new controller took over the radar and data positions. At 1459:38, he issued a frequency change to which the crew did not respond. At the time, the controller noticed no transponder target reply from the aircraft. Until 1501:39, he made several attempts to contact the aircraft, but received no response. Albuquerque ARTCC radar computer data showed that radar contact with the aircraft was lost at 1458:07 at FL 447.

Five witnesses at Felt, Oklahoma, located in the southwest portion of the Panhandle, heard an aircraft overhead at a very high speed. One witness stated that he heard a vibration sound which indicated to him the aircraft was overspeeding. Another witness stated that the aircraft was about to break the sound barrier. Of the five witnesses interviewed, only one saw the aircraft --and only momentarily-- and he stated the aircraft was in about a 45° descent angle and the wings appeared to be rocking up and down. All the witnesses stated that they heard an explosion and saw a mushroom cloud of black smoke erupt when the aircraft crashed to the ground. The accident occurred at approximately 1502.

The aircraft crashed 2.5 miles southwest of Felt, Oklahoma. The coordinates of the accident site were 36°32'30" N latitude, 102°48'25" W longitude. This accident location is about 30 miles northwest of another crash site which involved a high altitude loss of control by a Learjet Model 25B. 2/

1.2 Injuries to Persons

Injuries	Crew	Passengers	Others	Total
Fatal	2	1	0	3
Serious	0	0	0	0
Minor/None	0	0	0	0
Total	2	1	0	3

1.3 Damage to Aircraft

The aircraft was destroyed by impact forces.

1.4 Other Damage

Upon impact, the aircraft made a crater in a plowed field.

1/ All times herein are central daylight, based on the 24-hour clock.
2/ Thunderbird Airways, Inc., Learjet 25B, N23T [illegible], Conlon, Texas, April 11, 1980.

1.5 **Personnel Information**

The president, of Sky Train Air, Inc., and the chief pilot were certificated and qualified for the flight. (See appendix B.)

The president held an Airline Transport Pilot (ATP) certificate and a current first class medical certificate with no limitations. He had obtained his Learjet type rating on April 4, 1981. His logbook indicated he had accumulated 6,404 flight-hours, of which about 28.3 hours were in a Learjet. Between September 23 and September 29, 1981, he had flown 15.6 hours as pilot-in-command in N44CJ. Including the accident flight and a 3-hour flight the day before the accident, he had flown 20.1 hours in N44CJ.

The chief pilot also held an ATP with a current first class medical certificate with the limitation that he possess correcting glasses for flight. He had obtained his Learjet type rating August 21, 1978. His employment application indicated he had accumulated over 17,500 flight-hours, of which about 17.4 hours were in a Learjet.

The third company pilot, who according to Company officials should have been in the cabin at the time of the accident, held a commercial pilot certificate with airplane single and multiengine land ratings. He held a current second class medical certificate with no limitations. He did not have a type rating in the Learjet. He had accumulated 1,500 flight-hours, of which about 2.3 hours were obtained as copilot in the Learjet.

1.6 **Aircraft Information**

Gates Learjet Model 24, N44CJ, serial No. 146, was issued a transport airworthiness certificate on December 18, 1967. (See appendix C.) It was certificated for flight to a maximum altitude of FL 450 and at a maximum Mach (M_{mo}) indicated airspeed of 0.82. It was not equipped with the Century III or Howard/Raisbeck Mark II performance modifications to improve its slow speed and stall characteristics. Among other features, it was equipped with General Electric CJ-610-4 engines with thrust reversers, a Collins FD 108 flight director system, a Phase II panel, a JET FC-110 autopilot, and a standby gyro horizon.

Between December 1980 and April 1981, the aircraft had been maintained by a charter operator in accordance with an inspection program approved under FAR Part 91.217(b)(2), an approved inspection concurrent with the issuance of the operator's Air Taxi/Commercial Operator (ATCO) certificate. This maintenance program was on file with the local Federal Aviation Administration (FAA) District Office as required by 14 CFR 91, Subpart D. Required 150-, 300- and 1,200-hour inspections were performed on December 2, 1980. Additionally, as a result of an intermittent pitch-up problem caused by the autopilot, the pitch servo amplifier was replaced and the manufacturer's aircraft modification kits AMK-16B and AMK 80-3 were incorporated into the aircraft. The modification was accomplished on December 5, 1980, in compliance with Airworthiness Directive (AD) 80-22-10 of October 23, 1980. (See appendix D.) The AD required immediate deactivation of the pitch function of the autopilot and placarding to indicate that the pitch axis was inoperative; an inspection before January 1, 1981, to insure that the aircraft was equipped with a torquer pitch axis servo in the elevator control system; modification of the autopilot with a trim monitor test switch; inspection to insure that the appropriate transistors are installed in the pitch trim coupler module; and appropriate changes be made in the approved airman's flight manual (AFM).

According to the aircraft's maintenance records, at the time of the accident, the standby gyro was inoperative and had not been repaired. The lower latch of the main cabin door needed to be replaced; but because parts were not available at the time, the latch was adjusted as well as possible to prevent it from contacting the pressurization door seal. Additionally, flightcrews had reported experiencing cabin pressurization problems in the aircraft on three separate dates: October 7, October 29, and December 8, 1980. On each occasion, the flightcrew reported that, after suddenly reducing engine thrust, reapplication of thrust would not restore the cabin pressurization and an emergency descent was necessary. Maintenance personnel speculated that the outflow valve was probably sticking but troubleshooting did not reveal the exact cause.

Since April 1981, the aircraft had been sold four times. Following its purchase on April 15, the new owner attempted to correct a discrepancy in the autopilot computer when pilots reported that during the aircraft ferry flight with the altitude hold mode engaged above about FL 260 the autopilot continuously trimmed the aircraft noseup. However, the discrepancy was not corrected and the aircraft was sold again on May 7, 1981.

The second sale of the aircraft was contingent upon a repair of the autopilot, which was accomplished by an authorized Gates Learjet Service Center on May 12, 1981. The service center reportedly corrected the discrepancy by replacing the AR-1 amplifier module in the pitch synchronization board of the autopilot computer. The aircraft subsequently was sold to an aircraft dealer and painted on June 10, 1981. The logbook showed that the flight control surfaces were statically balanced following painting as required by the manufacturer.

Between May 14, 1981 and September 16, 1981, while under the dealer's ownership, a required scheduled 6-month inspection and some unscheduled maintenance were performed. According to the repair facility records, the 6-month inspection was performed on July 18, 1981 in accordance with another turbojet operator's approved inspection program in accordance with 14 CFR 91.217(b)(4) - the manufacturer's recommended program. A 6-month inspection is brief, requiring that only four items be checked. According to the manufacturer's maintenance program, however, a 150-hour inspection must be performed at least once every 6 months, or at each 150-hour interval, whichever occurs first. The 150-hour inspection requires inspection of 68 items, most of which are critical to safety of flight. Safety Board investigators found no records that indicated that the 150-hour inspection had been performed since the last scheduled inspection on December 2, 1980.

A review of maintenance work orders for June, July, and August 1981, disclosed no corrective action taken on discrepancies concerning pilot reports of the aircraft "wandering" and rolling side to side with the autopilot heading and altitude hold modes engaged, and about the yaw damper's possible contribution to these control difficulties. Also, it was reported that the autopilot aileron trim was not properly adjusted. Before the aircraft was painted, flight control surfaces were adjusted (with the autopilot engaged) by the Gates Learjet Service Center facility which corrected the autopilot discrepancy. One of the pilots who had ferried the aircraft after the sale of the aircraft on September 16, 1981, stated that the autopilot was placarded inoperative. He further stated that it was necessary to use an auxiliary power unit to start the engines because the batteries were low. The owner at the time of the accident, who was also an aircraft dealer, reported that the Ni-Cad batteries had been replaced with new lead acid batteries. He stated that Sky Train Air Inc. had been operating the aircraft for about 2 weeks in his behalf for sales demonstrations. The owner reported that Sky Train had also experienced a pressurization problem, but this could not be confirmed.

Title 14 CFR 91, Subpart D, requires that large and turbine powered multiengine aircraft be maintained in accordance with a prescribed inspection program, outlined in Sections 91.217 and 91.219, when operated in accordance with 14 CFR 91, as in the case of the accident aircraft. However, no record was on file after April 1981 which indicated any of the owners had filed a prescribed inspection program with the local FAA District Office having jurisdiction over the area in which the aircraft was based.

At the time of the accident, the aircraft had flown 7,412 hours. Ten months had elapsed since its last recorded 150-hour inspection in which the aircraft had been flown 98 hours.

1.6.1 Weight and Balance Information

The maximum certificated takeoff gross weight of the Learjet 24 is 13,500 pounds and the center of gravity (c.g.) envelope at this weight is 22.2 to 31.5 percent mean aerodynamic chord (MAC). Based on the total usable fuel capacity for N44CJ, 5,588 pounds, the aircraft was full of fuel when it departed Casper, Wyoming.

Postaccident computations of the aircraft's weight and balance before takeoff were as follows:

Item	Weight (lbs)	Moment (X1000)
Zero Fuel Weight	7,227.7	1,707.471.8
Crew and Passenger	545.0	61.500.0
Fuel	5,588.0	1,363.870.0
Total Ramp Weight	13,360.7	3,132.841.8
Center of Gravity	28.9% MAC	

The estimated weight and center of gravity at the time the aircraft unexpectedly departed FL 450 were as follows:

Ramp Weight	13,360.7
Fuel Used	- 2,158.0
	11,202.7
Center of Gravity	24.4% MAC

1.7 Meteorological Information

On the day of the accident, the weather in the Oklahoma Panhandle area was characterized by broken to overcast skies and light southerly winds. The area was influenced by a ridge of high pressure extending into central Texas from central Canada. A cold front at the leading edge of the high pressure ridge extended from extreme northeastern Texas, southwest through central Texas. The 200-millibar (about 39,000 feet) constant pressure chart showed an upper low pressure area over southern California with the subtropical and polar jet streams converging east of the low, over Kansas and Nebraska. At 1900, the 200-millibar chart (see appendix B) showed that a ridge to the east of the upper low over New Mexico and Colorado, had intensified. The core of the subtropical jet stream was directly over Felt.

The National Weather Service radar facilities at Amarillo, Texas, and Garden City, Kansas, showed no thunderstorms in the vicinity of the Panhandle. However, the 1545 Geostationary Operational Environmental Satellite (GOES) showed cloud patterns indicative of atmospheric wave activity in the Panhandle area. According to the

1800-hour soundings, at Amarillo and Dodge City, Kansas, the temperature at FL 450 was about -68° C. Therefore, the true altitude of an aircraft indicating 45,000 feet actually would have been 43,700 feet above mean sea level. The tropopause sloped from 6,000 feet above FL 450 over Amarillo to 800 feet above FL 450 over Dodge City.

The 1800 winds aloft observed at Amarillo and Dodge City are as follows:

Altitude (feet above sea level)	Wind (degrees true/knots)	Wind Shear (knots/1,000 feet)
Amarillo - 45,855	273/71	+6.57
Dodge City - 45,339	281/93	-3.55

The aviation area forecast pertaining to the Oklahoma Panhandle area on October 1 and valid from 0800 until 0200 October 2, contained no forecasts of turbulence for the area and altitude N44CJ was transiting. There were no pertinent SIGMETS 3/ or AIRMET advisories. 4/

1.8 Aids to Navigation

Not applicable.

1.9 Communications

There were no known communications difficulties.

1.10 Aerodrome Information

Not applicable.

1.11 Flight Recorders

The aircraft was not equipped with a flight data recorder (FDR) or a cockpit voice recorder (CVR), nor was either required by regulation.

1.12 Wreckage and Impact Information

The aircraft struck a level plowed field in an approximate 45° nosedown, left wing down attitude at high speed (figure 1.) The ground was composed of a layer of loose dirt and a sublayer of rock about 3 feet below the surface. The aircraft disintegrated from extreme forces when it struck the layer of bedrock and formed an impact crater 48 feet long 17 feet wide and 2 to 3 feet deep. Wreckage was scattered in a fan shaped pattern about 900 feet long and 850 feet wide. The crater was oriented along a magnetic heading of 135°. (See appendix F.) Several relatively heavy items, such as the engines and landing gear trunnions where scattered between magnetic bearings of 105° and 155° from the impact crater. There was evidence of soot deposits and fire damage to small, random portions of the wreckage as a result of the impact and explosion. There was no evidence of an inflight fire.

3/ Significant Meteorological Information
4/ Airmen's Meteorological Information.

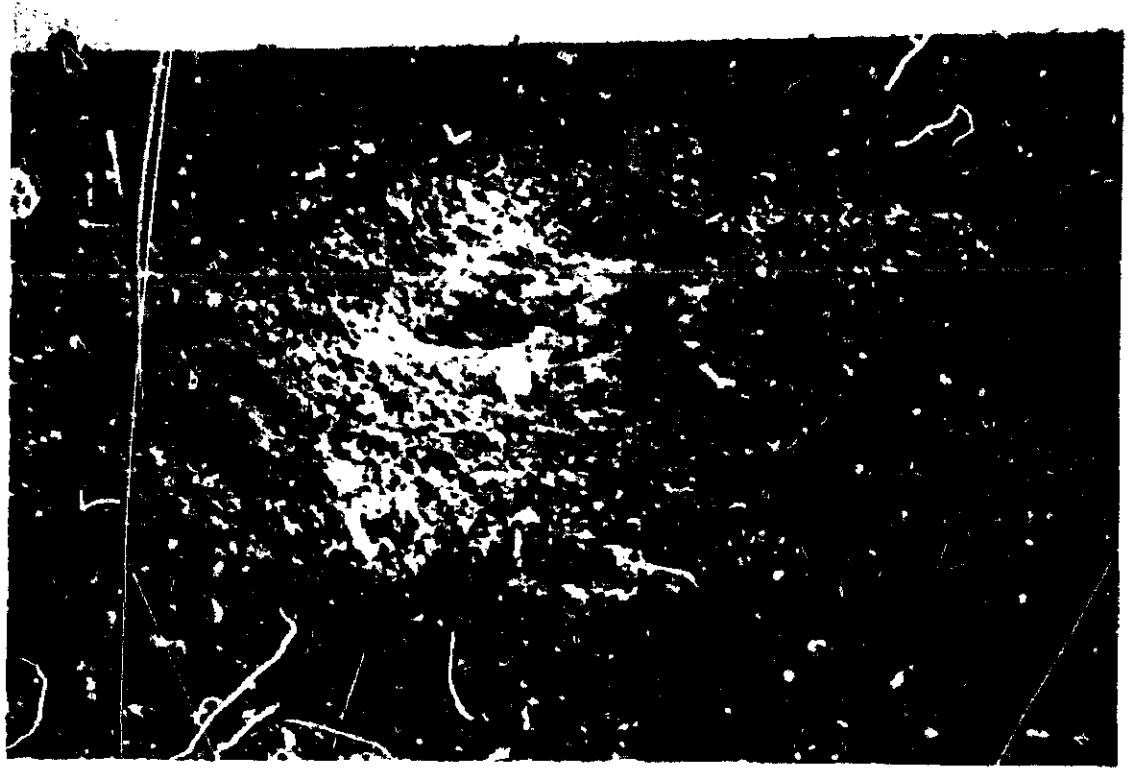


Figure 1.--View looking southeast at impact crater.
Wreckage debris scattered beyond crater.

All major portions of the airframe and pieces of the primary flight control surfaces were accounted for and identified. These included, in part, pieces from both wingtip fuel tanks; both ailerons, trim tabs, counterweights and flaps; and the left and right elevators and rudder. Also, the horizontal stabilizer trim acuator and one wing spoiler actuator were recovered. The degree to which the airframe was destroyed prevented determining primary flight control system continuity. Because of the destruction of the components, the position of the landing gear before impact could not be determined.

Examination of portions of the ailerons and elevators disclosed evidence that these control surfaces had not been removed for static balancing when the aircraft was painted as indicated in the logbook.

1.13 Medical and Pathological Information

There was no known evidence of medical factors which would have prevented the flightcrew from performing its flight duties.

The extensive injuries of the crew prevented meaningful postmortem and toxicologic examinations.

1.14 Fire

There was no evidence of an inflight fire. Fire damage occurring to portions of the wreckage after ground impact was insignifcant.

1.15. Survival Aspects

The accident was not survivable.

1.16 Tests and Research

Examination of both wing flap actuators disclosed that the flaps were in the retracted position at ground impact.

The horizontal stabilizer trim actuator jackscrew was installed in the manufacturer's test and rigging stand. Measurement of the jackscrew disclosed an extension of 17.09 inches, which corresponded to a -1.53° of stabilizer leading edge (L.E.) down position. The stabilizer originally was rigged by the manufacturer at 0° to -0.5° L.E. down with the actuator fully extended. Therefore, the position of the stabilizer was -1.53° ±0.5° L.E. down when the aircraft struck the ground. This stabilizer position corresponds to a trim position of about a 0.75 Mach indicated (M_I) cruise speed.

Examination of the wing spoiler actuator by the Safety Board's metallurgical laboratory disclosed that the piston rod-end broke from overload bending forces (figure 2). The actuator gland was driven sufficiently into the cylinder to shear the setscrew. Impact marks on the exterior of the actuator barrel (see figure 3) had deformed the inside wall of the barrel (see figure 4). The piston (see figure 5) was jammed within the distorted area 0.65 inch from its fully retracted position which indicates that the actuator piston had been moved by impact forces into the spoiler retract direction when the piston became jammed. The position in which it was jammed correlated with an extended spoiler deflection angle of 20.5°. The deflection angle, in turn, corresponded to the position the spoiler would seek due to opposing air loads at an airspeed of 369 knots. This speed is 69 knots above the maximum airspeed (V_{mo}) for the aircraft. However, it was not possible to determine what portion of the distance that the piston had moved from the progressive forces associated with the impact breakup sequence.

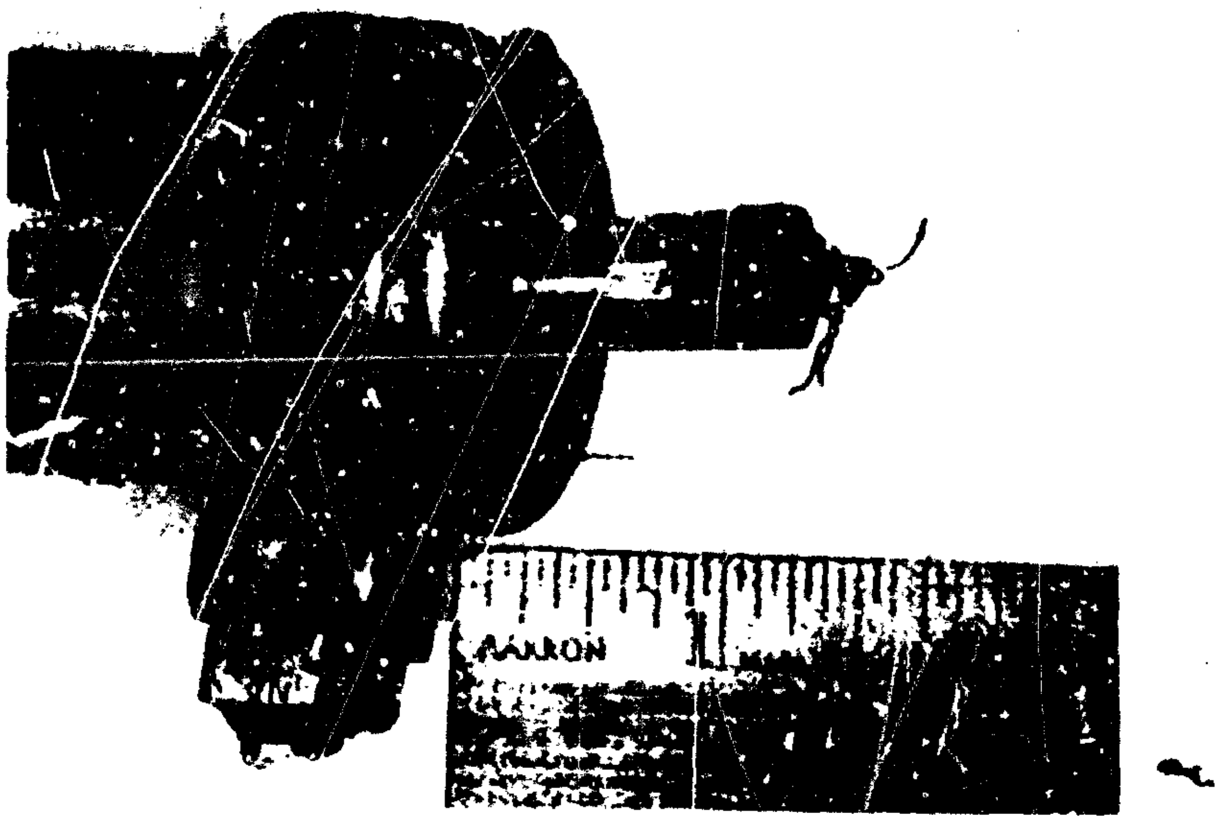


Figure 2.—Closeup view of the piston rod end in position in the actuator. Arrow indicates direction of bending of piston rod.

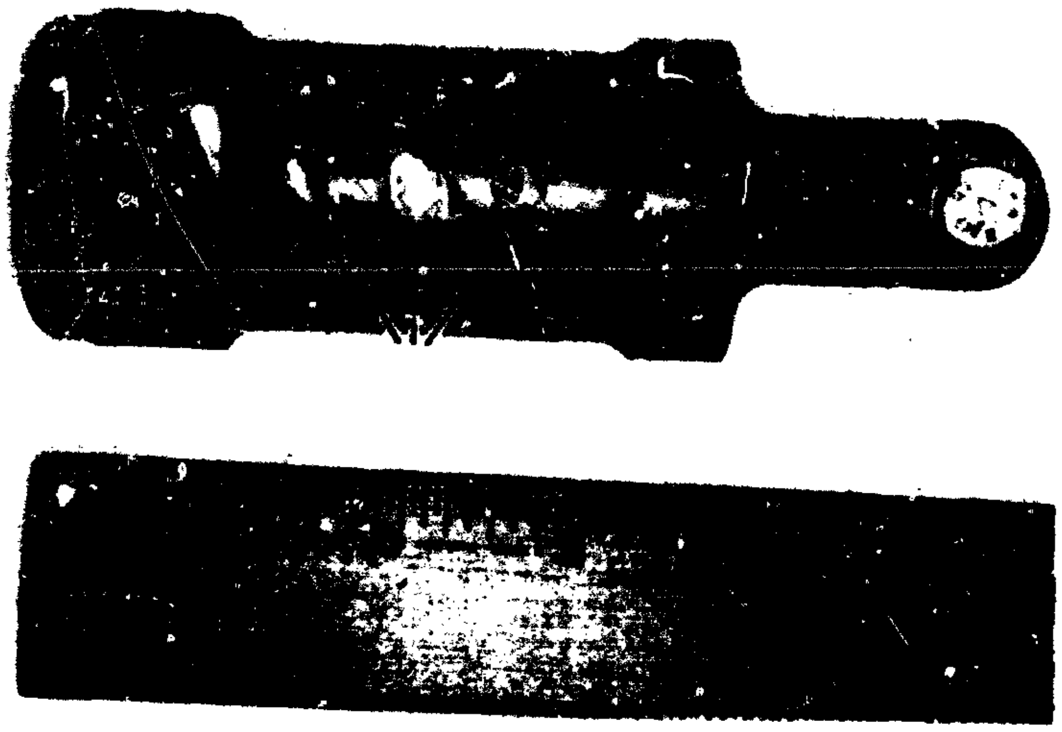


Figure 3.—Arrows indicate impact damage on the barrel.

Figure 4.—View of the inside wall of the barrel. The top two arrows indicate the impact deformations.

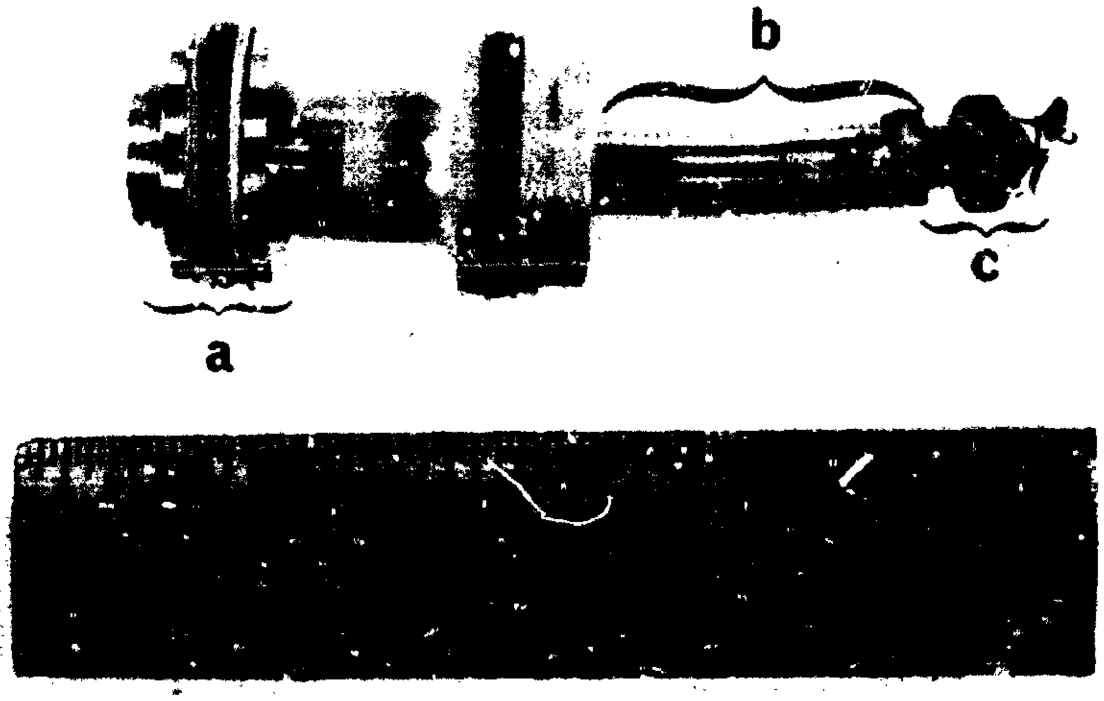


Figure 5.—View of (a) piston, (b) rod, and (c) rod end, after disassembly.

1.16.1 Radar Information

Since the aircraft was not equipped with an FDR, the Safety Board attempted to use recorded radar information to reconstruct the aircraft's flightpath, using a National Aeronautical and Space Administration (NASA) Ames Research Facility computer program and the radar information from the Albuquerque, Denver, and Kansas City ARTCCs which were recording information from the aircraft at the time of the accident. The last 4 minutes 40 seconds of the recorded radar data from the flight was reviewed. Calculations of the aircraft's performance were made based on the radar information, aircraft's performance specifications, and meteorological data.

Because of the error tolerances inherent in the radar computer data and the lack of accurate wind and temperature information, it could not be concluded that the aircraft was actually performing precisely as depicted by the data. However, past comparison of this technique with actual FDR data has shown that it provides good trend information.

The data from all three radar sites re[illegible]ed that the aircraft was in cruise flight at FL 451 and on course, averaging Mach 0.78, or about 206 KIAS, for 2 minutes before it suddenly climbed 100 feet at 1456:21. At this same time, all three radar sites lost the secondary radar (transponder beacon codes Mode A and Mode C) returns for a 37- to 40-second period. However, the Kansas City facility received primary (skin paint) radar returns during this period. When the beacon code was received again at 1457:01 by all three sites, the aircraft had leveled at FL 449, a 300-foot loss in altitude. It remained at this flight level for about 1 minute until about 1458:07, at which time the aircraft lost an additional 200 feet, descending to FL 447. At this point, the Albuquerque and Denver facilities lost the beacon codes, but the Kansas City radar facility continued receiving them for an additional 39 seconds until 1458:46, at which time the aircraft was at FL 380. According to the FAA, there is no site radar capability in the area of the accident below 15,000 feet m.s.l. The performance calculations for this last reported altitude indicated that the aircraft was descending at a rate of 10,000 feet per minute. The trend in the aircraft's speed indicated that it initially decreased its speed slightly from the stable cruise condition to a slight increase in speed when the beacon codes were lost.

Each ARTCC facilities received three to four primary radar returns following the final loss of the beacon codes. The last return was received at 1459:24. Although the absence of encoded altitude information prevented using the data points in performance calculations, they indicated that the aircraft turned left 20° to 30° after the altitude information was lost. The elevation of the accident site is 4,470 feet m.s.l. Therefore, the height of the last beacon code return above the accident site was 33,530 feet, and its horizontal distance from the site was 22,380 feet. These figures compute to an average descent angle of 56°. Since the exact time of the accident could not be determined, the speed and rate of descent could not be calculated based on this information.

1.16.2 Aircraft Characteristics

Equipment --The maximum operating Mach number (0.82 M_I), of the Model 24 Learjet is limited, in part, by its marginal longitudinal stability characteristics. For the Model 24 Learjet to be certificated for flight at FL 450, a much stronger elevator downspring and a bob-weight were added to the flight control system to assist in preventing a pilot from overcontrolling and overstressing the aircraft at high altitude. Also, the aircraft was equipped with a single yaw damper which is designed to prevent a coupled lateral-directional oscillation which is commonly referred to as "dutch roll."

The Model 24 Learjet also incorporates a stick puller system which will cause the aircraft to climb in the event of an overspeed. The system is powered by the left stall warning switch. When the aircraft's speed reaches 0.82 M_I, a Mach sensing switch will activate the overspeed warning horn, and at the same time, send a noseup signal to the autopilot elevator servo actuator (d.c. torquer), causing the aircraft to climb until the condition is corrected. The puller exerts 18 pounds of force on the control column. The system operates as a function of Mach number and, therefore, will not work below about 30,000 feet m.s.l. The aircraft is limited to a maximum altitude at 30,000 feet m.s.l. if the stick puller system is inoperative.

According to the AFM, the Model 24 Learjet can be flown up to Mach 0.82 without the use of the autopilot whereas later use of the autopilot above 0.78 M_I is required for later model Learjets. A wheel master button, located below the four-way trim switch on the outboard horn of the pilot's control wheel will, among other features, stop all normal pitch, roll, and yaw trim runaway and disconnect the autopilot. A maneuver control button is located on the inboard horn of the control wheel. When depressed, the button will temporarily disconnect the autopilot and modes engaged, but once the button is released the autopilot will reengage. However, the heading and altitude hold modes must be reengaged if needed.

The Learjet does not possess sufficient inherent prestall buffet characteristics at low speeds to provide the pilot with a clear warning that the aircraft is stalled before it enters a flight condition from which a normal recovery cannot be accomplished. 5/ Therefore, the aircraft is equipped with an artificial stall warning

5/ FAA Special Condition, CAR 3.120.

system which incorporates a stickshaker and stickpusher to provide a prestall warning in order to prevent an abrupt wing rolloff. The system includes a stall vane on each side of the nose of the aircraft, two angle of attack indicators, two stall warning lights, and a computer. As the critical angle of attack is approached at a point near the stall, $1.07V_{s1}$, the computer activates the stickshaker which induces a mild vibration of the control column while causing the red stall warning lights to flash. If the angle of attack is further increased, an additional signal from the computer actuates the stickpusher (d.c. torquer) and forces the control wheel forward with a force of 60 to 80 pounds. This force diminishes as the angle of attack decreases and can be overriden by the pilot. The system automatically disengages when it has decreased the angle of attack to a point less than that at which the pusher was set to actuate. 6/ Any signals from the autopilot are canceled when the pusher activates. The Model 24 stall warning system, however, is not programed to operate at a higher speed, thereby providing extra stall margin when operating at altitudes above approximately 22,500 feet as are some later models, such as the 24 E/F and 25 D/F, and all Century III modified Learjets.

Airspeed Limitations--Portions of a copy of a Model 24 AFM were recovered from the wreckage. Only the top half of the pages with the limitations, normal, emergency, and performance sections of the AFM were recovered.

The following airspeed limits were extracted from the limitations section of the AFM recovered from the wreckage:

MAXIMUM OPERATING SPEED V_{MO}/M_{MO}	LIMITATIONS KIAS	KCAS
These speeds shall not be deliberately exceeded in any flight condition except where higher speed is specifically authorized for flight tests or pilot training operation or in approved emergency procedures. If V_{MO} is inadvertently exceeded:	305 .82 M_I	300 .81 M

1. Extend spoilers
2. Reduce thrust to idle
3. Level wings if required
4. Rotate nose up not to exceed 1.5 g's.

NOTE

No aerodynamic changes are apparent at either V_{MO} or M_{MO} and the aircraft will respond normally to control movements.

Although several revisions to the AFM were issued on and following October 1, 1980, none of the revisions were found attached to the copy of the AFM or in and around the wreckage. The following revision was approved on October 1, 1980.

6/ FAA Order 8110.6, Review Case No. 38.

These speeds shall not be deliberately exceeded in any flight condition except where higher speed is specifically authorized for flight tests or pilot training or in approved emergency procedures.

WARNING: Do not extend the spoilers, or operate with spoilers deployed, at speeds above V_{MO}/M_{MO} due to the significant nose down pitching moment associated with spoiler deployment.

RECOVERY FROM OVERSPEED

If V_{MO} or M_{MO} is inadvertently exceeded:

WARNING: Do not extend the spoilers, or operate with the spoilers deployed, at speeds above V_{MO}/M_{MO} due to the significant nose down pitching moment associated with spoiler deployment.

1. Thrust Levers - IDLE.
2. Level wings if required.
3. Rotate nose-up not to exceed 1.5 g's.

WARNING: On any speed excursions beyond M_{MO}, the elevator control must be smoothly and steadily applied to prevent encountering excessive aileron activity and airframe buffet. Beyond 0.85 M_I, a 1.5 g pull-up may be sufficient to excite aileron activity and the g level must be limited to that required to maintain lateral control.

Buffet Boundaries--All aircraft in high altitude and high speed flight are subject to airframe buffet caused by shock wave induced airflow separations from the aircraft's lifting surfaces (airfoils). An important factor in understanding the characteristics of high speed airflow is the speed of sound. The speed of sound is the rate at which small pressure disturbances will be propagated through the air as shock waves. This propagation speed is a function of static air temperature. The relationship between airspeed and the speed of sound is termed Mach number. It is not necessary for an aircraft to reach the speed of sound to produce a shock wave. The aerodynamic shape of airfoils will cause local flow velocities on the surfaces to be greater than the speed of the aircraft. Thus, an aircraft will experience the formation of a shock wave as the local airflow over the wing reaches supersonic speed, and this can occur at flight speeds less than the speed of sound. This condition of flight is termed the transonic region and is defined as occurring from about Mach 0.75 to 1.20. In this region, mixed subsonic and supersonic airflows over the aircraft would be encountered. The highest flight speed possible without supersonic flow is termed the critical Mach number of an aircraft. Shock waves, buffet and airflow separation take place above the critical Mach number for aircraft. Significant pressure disturbances and changes in air density occur ahead of and behind the shock wave. These changes produce what is termed compressibility effects which result in trim and stability changes, buffet of control surfaces, and a decrease in their effectiveness. Additionally, the onset of high speed buffet is also influenced by the sudden changes in the angle of attack of the wing. 7/

7/ Aerodynamics for Naval Aviators, by H. H. Hurt, Jr.

Airframe buffet also occurs at low speed because of airflow separation when high angles of attack (stall) are approached. The margin between the high speed buffet and low indicated airspeed which produces stall buffet, decreases as altitude increases. Since high speed buffet and stall buffet are also dependent on the load factors produced by the wing, the aircraft's maneuverability margins at high altitudes are correspondingly reduced.

The AFM buffet boundary chart indicates that the low speed buffet boundary for the aircraft at a gross weight of 11,200 pounds at FL 450 and 1.5 g's is 181 KIAS (0.68M). The chart does not depict the high speed buffet boundary. However, a note on the chart states that the high speed buffet at 1.5 g's does not occur until the speed is in excess of M_{MO} (0.82 M_I).

1.17 Additional Information

1.17.1 Gates Learjet Service News Letter

Gates Learjet Service News Letter 49, dated May 1980, and issued immediately after a previous high altitude loss of control type accident, requested that operators review their emergency procedures regarding potential overspeed conditions. The manufacturer specifically urged careful review of procedures relating to emergency descent, inadvertently exceeding V_{mo}/M_{mo}, pitch axis malfunction, and normal or primary pitch trim system runaway.

Regarding the overspeed condition, the letter, in part, states:

> At Mach No.'s in excess of M_{mo}, aileron activity could be encountered, and this activity increases in amplitude as Mach No. is increased. This activity has been described as aileron "buzz" or aileron "snatch" and is a random frequency and amplitude movement of the ailerons and control wheel. Pulling "g's" in that regime of flight increases the aileron activity, so one must not pull abruptly on the elevator control to slow the aircraft, but must apply a steady force of the magnitude necessary to produce as much "g" force as possible without losing roll control. Exceeding V_{mo} in the lower Mach No. regime produces higher recovery elevator control forces, but no aileron activity. Another phenomenon which occurs at Mach No.'s beyond the red line is "Mach Tuck." This phenomenon is caused by aft movement of the wing center of pressure and results in a nose-down pitching moment. The stick puller is provided as a device to ensure no excursion beyond M_{mo}. It should never be turned off during normal operation of the aircraft. If, for any reason, there is a malfunction that requires turning off the stick puller, the aircraft should be operated at speeds well below M_{mo} as prescribed in the applicable Flight Manual procedures. As in any airplane, speeds beyond the red line must be avoided by maintaining the desired attitude with appropriate flight controls and by decreasing thrust while executing the prescribed Emergency Procedures.
>
> NOTE: IF M_{MO} IS INADVERTENTLY EXCEEDED TO THE POINT WHERE THE AIRPLANE SEEMS TO BE OUT OF CONTROL, LOWER THE LANDING GEAR. The landing gear doors may be lost or damaged, but the main concern is to facilitate recovery by using the extended gear to slow the forward speed of the airplane . . . .

Spoilers

The use of the spoilers is not prescribed in Pitch Axis Malfunction and Runaway Trim Emergency Procedures. The reason is that the nose down pitch change which the spoilers produce may aggravate pitch down problems.

* * *

1.17.2 Special Certification Review of the Learjet

As a result of other Learjet accidents (see appendix G), the FAA undertook a special certification review (SCR) of the Learjet which addressed primarily items suspected of being potential factors in the accidents. The following extracts regarding specific problem areas discussed in the interim SCR report, were made available to the Safety Board on May 8, 1981:

> This interim report will generally establish that the Learjet airplanes do possess certain critical flight characteristics, which require compensation by complex systems to insure an adequate level of safety. Records review indicates that approvals of these compensating systems were based on possible inadequate rules, extensive rationalization rather than actual demonstration of adequacy, early "state-of-the-art" engineering judgment, equivalent safety determinations, and apparently inadequate system analysis. It appears that most of the reported problem areas involve a system(s) whose proper functioning is critically required to provide an acceptable level of safety for the airplane; and these installed systems are possibly inadequate to perform their intended function. 8/

1) High Speed Characteristics

   a. M_{MO} (0.81) is limited by longitudinal stability characteristics.

   b. Mach tuck (nose down pitch divergence caused by aft movement of center of pressure due to compressibility) begins prior to M_{MO}. 9/

   c. Extension of the spoilers at high speed causes a large nose down pitching moment. For the Lear 25 D/F Models, stick force required to hold airspeed with spoiler extension at V_{MO} varies from 46 lbs. at aft c.g. to 84 lbs. at forward c.g.

8/ As a result of its preliminary findings, the FAA issued AD 80-16-06 on August 4, 1980, which was superseded by AD 80-19-11 on September 4, 1980.
9/ Maximum Operating Limit Speed - "V_{mo}/M_{mo} must be established so that it is not greater than the design cruising speed V_c and so that it is sufficiently below V_D/M_D or V_{DF}/M_{DF}, to make it highly improbable that the latter speeds will be inadvertently exceeded in operations." V_D/M_D means design diving speed and V_{DF}/M_{DF} means demonstrated flight diving speed.

d. Aileron "buzz" onset occurs just above M_{MO}; at higher Mach numbers and/or higher load factors, aileron "snatch" (rapid, large deflection aileron motion) occurs. Loose (misrigged) aileron cables could increase the amplitude and lower the onset Mach number, since the major factor which damps this motion is control system friction.

e. The Mach overspeed warning and stick puller systems operate only from the copilot's pitot-static system. If an error in the copilot's system results in a low Mach reading for any reason, the overspeed warning will occur beyond M_{MO}.

f. During STC approvals on three different aircraft (one Model 25D and two Model 35s), it was noted in a dive to M_{DF} with a separate trailing cone calibrated static system that the pilot's Machmeter stopped increasing at approximately 0.80-.81 Mach number and remained at this reading out to a true Mach number of 0.86.

On the recovery, the pilot's Mach indicator began working again at .805 Mach. Changing the Machmeter did not eliminate this characteristic. The copilot's Machmeter indicated correctly on the Model 25D, but both Model 35 copilots' Machmeters read less than the correct Mach number.

The majority of the problem was traced to a production static system calibration error in a dive using a production indicator. This was not detected during original prototype testing with a sensitive Machmeter and a trailing cone.

In addition, part of the problem was possibly caused by the static sources not being flush with the surface after the airplanes were painted. The end result of the airspeed problem was that the production airplanes were actually going .01 to .015 Mach faster than expected.

g. Lear 25 TIR [Type Inspection Report] data shows that the speed increase after an upset was less if the spoilers were not used, because the heavy nose down trim change made it harder to get the nose up to 1.5 g's for recovery. The AFM specifies spoiler deployment as the first action in an overspeed condition.

If a pitch upset occurs near M_{MO}, the airplane can accelerate rapidly into a region where the flying qualities are unacceptable. Consider, for example, any type of nose down pitch axis malfunction (such as trim runaway, pusher hardover, autopilot hardover, etc.). In this case, if the pilot restrains the control column, the pull force can go as high as 50-60 lbs. (80 lbs. for pusher malfunction.) Because of pilot reaction time (3 seconds according to 8110.10), 10/ the speed will have increased

10/ FAA Notice of September 22, 1972, concerning trim malfunctions.

beyond the limit Mach number. If the pilot follows the AFM procedure for overspeed and deploys the spoilers (which is instinctive), the required pull force will increase an additional 50-80 lbs. Also, because of the pitch instability due to Mach tuck, the pull force will continue to increase as speed increases. Adding the maneuvering stick force required to pull 1.5 g, the total pilot force required for recovery can be as high as 150-200 lbs.

The stick puller was installed to prevent Mach overspeed, but in the event of a nose down pitch axis malfunction, and/or deployment of the spoilers, its 18 lb. pull becomes insignificant.

At some Mach number beyond M_{DR}, the elevator effectiveness will decrease due to shock wave formation. Additionally, stretch in the longitudinal control system at very high control forces can negate any further elevator deflection in the recovery direction.

At the same time these extreme pitch forces are being generated, the pilot can have a severe roll control problem due to aileron "buzz" and "snatch." An active pitch axis malfunction is not required for this scenario to take place. A passive failure on the ground to the 0.81 Mach warning/puller switch allows the system to test properly on preflight, yet be totally inoperative. In this case, an inadvertent overspeed due to gust upset, unannunciated autopilot softover, pitot static system error, pilot inattention, fuel burnoff, flying into a colder airmass, etc., can put the airplane into an overspeed condition with no warning.

If, after the pilot notices the overspeed, he deploys the spoilers, or if aileron "snatch" rolls the airplane to an excessive bank angle, it may become impossible to recover.

Model 24

2) Learjet Model 24 and 25 unmodified (straight wing) airplanes have speed margins between pusher actuation and aerodynamic stall that may be inadequate to compensate for the many airplane and system variables that affect these margins. Since 3 KIAS was previously found to be minimum margin for $\dot{\alpha}$ (alpha dot) 11/ equipped Century III airplanes, it is logical to conclude that the margins should be even greater on the non-equipped (straight wing) airplanes.

3) Learjet unmodified (straight wing) airplanes have stall characteristics such that the artificial stall warning (shaker) and stall deterrent (pusher) systems must perform their intended functions in all reasonably foreseeable operating conditions. This would include reasonable pilot abuse and imperfect maintenance practices. Service experience indicates that the systems are not preventing aerodynamic stall encounters.

11/ The rate of change of the wing angle of attack.

4) A pilot would instinctively momentarily resist or overpower an unexpected pusher actuation. With inadequate pusher/stall margins this could lead to aerodynamic stall encounter and uncontrollable rolloff. In close proximity to the ground, such loss of lateral control could result in loss of the airplane and may be a factor in Learjet landing and takeoff accidents.

5) The maintenance of aircraft and system components affecting the pusher/stall speed margins is quite critical on all Learjets. Current maintenance manual procedures are not mandatory and could result in the above margins not being maintained in service. Additionally, the manual does not adequately define the qualifications of the pilot required to flight test the airplane after certain maintenance is performed. The criticality of the airplane and systems relative to the pusher/stall speed margins, and the precise flight test techniques and adjustments required, dictate that the "qualified" pilot be an FAA Approved production flight test pilot.

6) Stall characteristics at high altitude were not evaluated on unmodified (straight wing) Learjets.

7) Pusher malfunction tests have not taken into consideration a possible unannunciated fault in the 1/2g limiter.

1.18 **Useful or Effective Investigation Techniques**

No new or unusual investigation techniques were used during this investigation.

2. ANALYSIS

2.1 **General**

Although the president of the company and the chief pilot were experienced pilots, were rated in the Learjet, and were current to operate the aircraft, both were inexperienced in the Learjet. There was no evidence that indicated the pilot-in-command had any previous experience in turbojet aircraft, other than the 28.3 hours accrued in the Learjet. The chief pilot's flight-experience of 5,000 hours in the DC-8 would have equipped him with sufficient knowledge of high altitude, high speed flight. However, it is doubtful that he had ever operated in the flight regime at 45,000 feet in other aircraft he had previously flown. The third pilot, who was reportedly a passenger on board the aircraft, was not rated in the Learjet nor had he had any previous experience in turbojet aircraft. Based on the experience gained through previous Learjet accident investigations, the Safety Board believes that the lack of pilot experience in this type of aircraft was a causative factor in the accident.

There was no known evidence of previous medical factors in either of the pilots which would have prevented them from performing their required flight duties.

Safety Board investigators attempted to determine which pilot may have been flying the aircraft at the time of its departure from FL 450. Witnesses were questioned and a recording of the ARTCC tape of communications with the aircraft was played for those who knew the flightcrew. However, the physical descriptions of the pilots and their positions in the aircraft given by ground service personnel were inconsistent. Additionally, statements regarding which pilot was communicating with Albuquerque ARTCC at 1449:39 were contradictory. Therefore, the Safety Board could not determine who was piloting the aircraft or which seats the pilots occupied at the time of its departure from FL 450.

In view of the total destruction of the aircraft and the lack of CVR and FDR information, the Safety Board was unable to determine precisely the circumstances of the accident. However, the nature of this accident was similar to other Learjet accidents which involved a loss of control from high altitude and from which the flightcrews were unable to recover the aircraft. Accordingly, the analysis of the accident in an attempt to explain how the accident could have occurred is based on the maintenance history, meteorological information, ATC radar data, portions of the wreckage, FAA's SCR report, and knowledge gained from previous Learjet investigations.

2.2 Airworthiness

Between April 1981 and September 16, 1981, the aircraft had been sold four times. There was no record that the successive owners filed maintenance programs at the FAA District Offices having jurisdiction over the areas where the aircraft was based as required by Federal regulation. Since December 2, 1980, a required comprehensive (150-hour) inspection had not been performed by any subsequent owner. Critical items on the aircraft had not been examined closely by qualified maintenance personnel in 10 months, during which time the aircraft had been flown infrequently. Because there was no record, the Safety Board presumes that the open discrepancy concerning the inoperative standby gyro and the lower latch of the main cabin door had not been corrected. The Board believes also that a previously reported pressurization problem could have been the result of an abnormal leak around the cabin door seal associated with the door latch problem.

On December 5, 1980, a previously reported pitch-up problem in the autopilot was corrected and the aircraft was modified in accordance with AD 80-22-10. This modification was designed to prevent a malfunction in the pitch trim coupler which could also lead to a pitch control problem. The April 1981 reported pitch-up problem was apparently corrected through replacement of the AR-1 amplifier module in the pitch synchronization board of the autopilot computer on May 12, 1981, by an authorized Gates Learjet Service Center. However, there were continuous pilot reported discrepancies concerning the autopilot which the Safety Board believes were not associated with the previous maintenance performed. The discrepancies concerned roll oscillation, "wandering" with the heading and altitude hold modes engaged, and the yaw damper's possible contribution to these control difficulties. The discrepancies could have constituted a nuisance in flight and most likely resulted in the pilots avoiding the use of the autopilot. It was reportedly placarded inoperative by a pilot who delivered the aircraft to the current owner. A reported aileron misrigging could be attributed to the change in flight control surface balance after the aircraft had been painted. Since a review of the maintenance records for June, July, and August 1981 did not disclose that any of the previously reported open discrepancies had been corrected, the Safety Board concludes that these problems probably continued to exist and that the aircraft had not been properly maintained since April 1981.

The previously reported intermittent pressurization problem could have been a factor in the accident. Although the autopilot discrepancies could have caused the flightcrew to avoid using it, there is no speed restriction on operation without an autopilot as there is with later model Learjets, which have a speed limit of 0.78 M_I. However, use of the autopilot in turbulent air would assist in stabilizing the aircraft. Additionally, if the yaw damper had failed or malfunctioned, control of the aircraft could have been extremely difficult under turbulent conditions.

2.3 Loss of Control

The area in which the aircraft was transiting at FL 450 was characterized by a confluent zone of polar and subtropical jet streams. Based upon 2-minute average winds, the upper air sounding at Amarillo showed wind shear changes of greater than 6 knots per 1,000 feet at FL 450. The wind shears east of the aircraft's course over Dodge City were slightly less than 6 knots per 1,000 feet. Also, the aircraft was well within 6,000 feet of the tropopause, a transition zone between the troposphere and stratosphere, and a region where clear air turbulence is likely to be encountered. The weather pattern would have been conducive to moderate, and possibily severe clear air turbulence at FL 450. Considering these conditions and the accepted guidelines for turbulence forecasting, the Safety Board believes that a turbulence forecast should have been issued with the aviation area forecast. A turbulence SIGMET is not generally issued unless a pilot reports encountering turbulence, and there were no pilot reports of turbulence for 3 hours before the accident. However, it should be noted that there was no other traffic in the area at FL 450 for at least 30 minutes before the accident.

The radar computer data showed that the aircraft was flying level at FL 451 and on course for 2 minutes before there was a disturbance in its cruise altitude at 1456:21 and the aircraft suddenly climbed 100 feet. For unknown reasons, at this time the ATC radar facilities did not receive the transponder beacon code for 37 to 40 seconds. When the beacon code was again received about 1457:01, the aircraft had lost 300 feet, leveling at FL 449 before entering an uncontrolled descent at 1457:57 at the rate of 10,000 feet per minute.

The initial disturbance in altitude was not necessarily unusual nor is 100 feet a significant deviation. The encoding beacon code altitude resolution is normally ± 50 feet. When an aircraft is at the edge of this limit, it can transmit an encoded altitude change of 100 feet even though the actual change is only a few feet of cruise altitude. Generally, an aircraft's transponder will indicate remaining at the new altitude or a return to the original altitude seconds later. However, this was not the case in this accident; the next reading was 300 feet below the original altitude. Three radar sites did not receive the accident aircraft's mode A or mode C beacon codes at the time of the altitude variation. Therefore, it is possible that the aircraft experienced an altitude excursion greater than 300 feet during approximately 40 seconds when the beacon codes were lost. This altitude excursion could be an indication that the aircraft encountered moderate to severe turbulence.

The Safety Board was not able to determine the reason for the interruption in the transponder beacon code reception. The ATC facilities began receiving the beacon codes as usual immediately following the gap in reception. It is possible that the transponder antenna could have been shielded as a result of an unusual attitude and caused the interruption. However, since radar data were used from three sites at different locations, it would be improbable for all three sites to lose the beacon codes at the same time.

The computation techniques used in the computer program, and the lack of accurate wind and temperature information prevented a precise determination of the aircraft's speed. Small variations in wind velocity and temperature can significantly affect the speed calculations. However, averaging the calculated Mach numbers and indicated airspeeds during the 2 minutes before the disturbance indicated that from a constant 0.78 M_I, there was first a slight decrease in Mach number followed by a slight increase in Mach number corresponding to the altitude excursion. This trend information indicates that a potential overspeed condition could have occurred. Further calculations, using the radar data, indicated that at the beginning of the final descent, the aircraft experienced an increase in drag, an increase above what is normal in the clean configuration. The reason for this is not known. The linear track of the remaining beacon code positions, as well as the primary radar returns toward the accident site, disclosed a 56° descent angle. Since the ARTCC radar can track an aircraft down to 15,000 feet m.s.l. in the area of the accident site, the Safety Board could not determine the reason radar contact was lost shortly after the aircraft descended below FL 380.

Witness observations and a survey of the accident site disclosed that the aircraft struck the ground at a steep angle and at very high speed, resulting in total destruction of the aircraft. Since the aircraft struck the ground at very high speed and the major aircraft structure and flight control surfaces were located in the vicinity of the accident site, the Safety Board concludes that none of the major structures of the aircraft separated while it was inflight.

The trim position of the horizontal stabilizer actuator jackscrew showed a normal cruise speed trim setting. Analysis of the spoiler actuator indicates that at some point either during the descent or during the impact sequence, the spoilers were in the extended position. The Safety Board believes that, in the absence of conclusive evidence of a mechanical failure or malfunction, an encounter with clear air turbulence of sufficient intensity probably caused the initial altitude upset. Further, the atmospheric conditions could have caused an overspeed, and activation of the stick puller would have resulted in an altitude excursion. It is unlikely that a mistrim condition occurred since the stabilizer actuator jackscrew was in a cruise trim setting, consistent with the radar speed data. An overspeed condition probably would have prompted the flightcrew to extend the spoilers since previous investigations have indicated that extension of the spoilers is a natural reaction to an overspeed. Moreover, this procedure was recommended in earlier AFM's. Extension of the spoilers or the landing gear could be an explanation for the increase in drag as indicated by the radar data. The Safety Board believes that if the crew had lowered the landing gear rather than extending the spoilers, they would have been able to regain control of the aircraft.

The aircraft has an adequate range between the onset of high speed buffet and low speed buffet at all altitudes and weight conditions provided there is adherence to the aircraft's performance limitations. Increased load factors caused by manuevering, such as pull-ups or level banked turns, however, will reduce the buffet-free speed range. Additionally, a sharp, unexpected turbulence encounter can easily cause an aircraft to exceed these margins. Although initial buffet margins can be exceeded, it does not necessarily mean that control difficulties will be immediately encountered. The degree to which the margins are exceeded will determine the aircraft's reaction. The accident aircraft's buffet margin was 0.14 M_I, or about 41 KIAS in 1.5g flight. However, since the aircraft was operating in this relatively narrow area of its flight envelope, a loss of control could have occurred from a transient condition which might have placed the aircraft either below its low speed or above its high speed buffet boundary. This situation would most likely have occurred if the flightcrew had been inattentive (even momentarily) and did not take timely and proper corrective action. Because the Safety Board was not able to determine the magnitude of the potential gust factors involved, it is not possible to determine which buffet boundary would have been crossed in the turbulence encounter. Both boundaries were susceptible. However, a loss of control from either situation could result in a high speed uncontrollable descent if the pilot reacted inappropriately.

Considering the phenomenon of the existing weather, a gust upset of sufficient intensity could result in an overspeed and in control difficulty. Based on the FAA's SCR report, Mach tuck can occur prior to M_{mo} and aileron "buzz" can be encountered just beyond this speed (0.82 M_I). A production error in the copilot's pitot-static system or an error caused because the static sources were not flush with the fuselage, e.g., as a result of the recent painting, could be contributing factors leading to an overspeed. Such errors would have affected the proper operation of the stick puller and overspeed warning horn. If the flightcrew had been inattentive even momentarily and the aircraft had been allowed to accelerate beyond M_{mo}, abnormal pitch forces, and a severe roll control problem could have been encountered without warning. If the flightcrew had deployed the spoilers at this point without instantly reducing thrust, the control column pull forces would have increased and the speed instability and roll control could have progressed to the point where it would have become impossible to recover the aircraft. Additionally, if the flightcrew suddenly reduced thrust in an attempt to prevent an overspeed, they could have encountered the pressurization problem that was previously reported and had this distraction to compound their difficulty.

Conversely, if the turbulence encounter was such that the aircraft stalled because it crossed its low speed buffet boundary, an uncontrollable wing roll-off and steep nosedown maneuver could result in a sudden high speed dive. If the flightcrew did not react quickly and appropriately, it also may have been impossible to recover from such a maneuver. According to the SCR report, the stall speed margins in many of the unmodified wing Model 24 aircraft have been found to be inadequate. Maintenance of the stall warning and pusher system is therefore critical to the safety of flight. It is possible that this system in the accident aircraft may not have been properly adjusted since the aircraft had not been recently inspected in accordance with the manufacturer's recommended or FAA approved maintenance program.

The Safety Board could not conclusively rule out the possibility of flightcrew incapacitation as a factor in this accident because of the previous reported cabin pressurization problem. However, only about 1 minute 46 seconds elapsed between the time of the initial altitude excursion and the uncontrolled descent from FL 450. The aircraft descended 1 minute after this initial altitude excursion which is believed to have been caused by an encounter with clear air turbulence. Additionally, the evidence suggests that at some point during the upset and descent, the flightcrew deployed the spoilers. Therefore, the Safety Board, believes it was unlikely that the uncontrolled descent was caused by flightcrew incapacitation.

Since the Learjet has characteristics which could lead to critical control problems in the high altitude, high speed regime of flight, complex compensating features were incorporated into the flight control system or required by Federal aviation regulations to provide for an appropriate level of safety. The integration of these compensating features with the aircraft's primary flight control system requires strict adherence to sound maintenance practices to operate the aircraft safely. The minimum maintenance, accorded the aircraft while it was rapidly changing hands could have compromised this level of safety. Owners and operators must familiarize themselves sufficiently with newly acquired aircraft, Federal regulations, and maintenance programs to insure that aircraft are properly maintained. This responsibility also extends to insuring compliance with all pertinent airworthiness directives and acquiring all pertinent service bulletins, flight manual, and service manual revisions, as appropriate. Because the AFM recovered from the wreckage did not include any of the current revisions and the revisions were not located elsewhere in the wreckage, the Safety Board believes that the flightcrew probably did not have a current AFM aboard the aircraft. Although this suggests that they may not have been aware of the relatively recent changes in the AFM restricting the use of spoilers, this fact could not be verified. The portion of the manual recovered from the wreckage was a copy of a Model 24 flight manual and the amendment concerning the warning about not deploying the spoilers above V_{MO}/M_{MO} could not be found.

2.4. Training

Complementary to proper maintenance practices in assuring flight safety of any aircraft are proper operational practices based on thorough pilot training and maintaining flying proficiency. Thorough pilot training and a high level of flying proficiency are essential if the Learjet is to be operated safely. The Learjet, like any other turbojet, operates extensively in the high altitude environment where it achieves its greatest cruise performance. In fact, the Learjet operates at cruise altitudes which are considerably higher than most other civil turbojets. This environment can also have an adverse affect on the handling qualities of an aircraft. The low density of the air, clear air turbulence, wind shears, and temperature fluctuations commonly encountered in this upper atmospheric region are all factors affecting the aircraft's handling and performance qualities. Additionally, there are certain potential risks to occupants with exposure to this dangerous environment.

For these reasons, it is essential that pilots who initially transition into a turbojet aircraft acquire some knowledge about the high altitude environment in which they will be flying 75 percent of the time. Title 14 CFR 61.63(d) requires only that an applicant for a type rating hold an appropriate class and instrument rating and pass the appropriate flight test. In order to operate a turbojet, a pilot must obtain a type rating for that aircraft. There is no requirement for turbojet pilots to take high altitude flight training. But, if a pilot intends to obtain a rating in a particular turbojet aircraft and does not have any previous turbojet experience, good judgment would dictate obtaining thorough training in the type aircraft for which he is seeking the rating and some knowledge about the environment in which he will be operating the aircraft.

The Safety Board believes that the requirements of 14 CFR 61.63(d) may be sufficient in providing general guidelines to an applicant about the training needed for a type rating. In the Board's opinion, however, the effectiveness and appropriateness of the type rating flight check will depend, in part, upon the thoroughness of the aircraft's evaluation made concurrent with the original type certification of a turbojet, turboprop, or helicopter aircraft by FAA specialists assigned to the Flight Operations Evaluation Board (FOEB). Their evaluation should initially determine whether a type rating is necessary, what the type rating flight check should consist of, and what areas should be emphasized in training. These areas must include a careful review of the unique qualities of the aircraft and any anticipated problems that might be expected with it in service. The results of this review must be used in developing the required training program for a particular aircraft. Additionally, this training and flight test information should be given widespread distribution. It is the responsibility of the Flight Standardization Board (FSB) to review the recommendations from the FOEB and develop the minimum standards and qualifications for designated pilot examiners, flight instructors, and pilots. The FSB is also responsible for distributing this information to all FAA Regions. In turn, this information must be made available to all FAA Field Offices, its inspectors, and the aviation community to provide for the standardization of pilot training and qualifications in a particular aircraft.

The evidence collected in this accident and other Learjet accidents investigated by the Safety Board indicates that in some instances the flightcrews did not obtain the training that they should have received. In the October 1, 1981, accident, the chief pilot was experienced in turbojet aircraft although he was not experienced in the Learjet. He obtained his Learjet type rating on August 2, 1978, after receiving formal training and accruing 10.4 hours in the aircraft. However, from that date until September 19, 1981, he had not flown a Learjet and had accumulated only a total of 17.4 hours in the Learjet at the time of the accident. The pilot in command had no other experience in turbojet aircraft. He obtained his Learjet type rating through 20 hours of informal ground school from an FAA designated pilot examiner who 1 week later gave him a flight check. The pilot did not obtain nor was he required to obtain Learjet flight training prior to his flight check. The Safety Board believes that the training and proficiency of the flightcrew were probably inadequate to operate the Learjet safely.

In view of the Learjet's accident record, the Safety Board believes the FAA did not make a thorough enough evaluation of its unique handling characteristics before it was placed into service. The various modifications to improve its low speed handling characteristics, the numerous revisions to the AFM to guard against potential problems which can occur on landing in icing conditions, the prohibition against runaway stabilizer trim training, the prohibition against the use of the wing spoilers in an overspeed condition, the introduction of the aileron "buzz" phenomenom in flight simulator training, the establishment of an SCR team, the modifications to the autopilot system, and the additional preflight checks of this system are some of the results of an inadequate initial and timely followup evaluation of the Learjet which otherwise may have prevented several accidents. In the Board's view, this history underscores the necessity of evaluating aircraft beyond what is routinely examined. The evaluation must also consider the unique handling qualities and subsystems aboard the aircraft. In this regard, it is evident that the role of the FOEB and FSB should not end with the type certification process but should continue throughout the operational life of the aircraft.

In 1981, the Gates Learjet Corporation instituted a unique seminar program, "Checklist '81: Professional Approach Review." The objective of the 1-day safety seminars, which were offered throughout the country, was to educate and assist professional pilots of business jets in attaining a higher level of flight proficiency. There was enthusiastic participation and acceptance of the program. As a result, "Checklist '82" began on June 7, 1982. The popularity of this program is encouraging; however, it is the Safety Board's concern that all presently rated turbojet pilots who may need to attend are not required to attend nor would they necessarily be available or willing to participate. Safety Board representatives who attended Checklist '81 observed that part of the program also included a review of some of the unique characteristics of the Learjet which could lead to potential problems if not handled correctly by the pilot. The question and answer period made evident the inherent role of the FAA in establishing the overall training and proficiency standards for which the seminar was attempting to encourage. For these reasons, the Safety Board believes that the FAA must review the role and responsibility of the FOEB and FSB in establishing such training and proficiency standards, particularly in regards to general aviation aircraft.

2.5 Flight Recorders

This accident again illustrates the need for flight data recorders and cockpit voice recorders in multiengine turbine-powered aircraft. Unless probable causes can be definitively established, proper corrective action cannot be taken. Recorders have greatly enhanced the aviation community's ability to improve flying safety and to prevent future accidents through the invaluable data they have provided in those aircraft for which they are required.

Although as in this accident, ATC radar does provide information on altitude (assuming the altitude encoding transponder is operational and the aircraft signal reaches the ground-based antenna), position, and ground speed, the data are very limited in their usefulness. Data points are not sampled frequently enough, nor is the precision of the data good enough, to derive more than trend information regarding the flight.

The Safety Board realizes that currently available air carrier type recording systems are generally unsuitable for the smaller turbine-powered aircraft comprising much of the fleet not already covered by requirements for recorders. We continue to support the development of smaller, lighter, lower cost recorders using up-to-date technology.

Several recorder manufacturers have indicated that such recorders have been under development for some time and could be produced and marketed within 7 to 12 months after a technical standard order (TSO) covering them is issued by the FAA. Anticipated prices appear compatible with other general aviation equipment and should be acceptable to industry. The Safety Board strongly urges the FAA to adopt standards and requirements for the installation of these recorders in complex, high performance aircraft. Without such requirements, the Board will continue its campaign to persuade manufacturers and operators of these aircraft to voluntarily install such recorders.

3. CONCLUSIONS

3.1 Findings

1. The pilots were certificated and current to operate the aircraft, but based on the available information, their training and experience in the Learjet was inadequate to operate it safely.

2. There was no evidence of physical impairment or incapacitation of the pilots.

3. The aircraft had not been maintained in accordance with Federal regulations.

4. There was evidence of maintenance discrepancies which could have been factors in the accident.

5. There was evidence of potential moderate to severe clear air turbulence in the area the aircraft was transiting at the time of the accident.

6. There was no forecast for clear air turbulence in the area in which the aircraft was flying.

7. The aircraft was at a normal cruise speed before the occurrence of an altitude excursion which was probably induced by turbulence.

8. There was no evidence of a mechanical failure or malfunction which could have caused the altitude excursion.

9. The aircraft could have either crossed its high speed or low speed buffet boundary to a point where critical control problems could have developed.

10. Loss of control by the flightcrew could have resulted from even momentary inattention and a failure to react properly and in a timely manner.

11. The flightcrew probably deployed the spoilers at some point beyond airspeed limits in an attempt to regain control of the aircraft; this probably imposed excessive control wheel forces and prevented recovery of the aircraft.

12. Extension of the spoilers beyond airspeed limits would have been contrary to procedures currently in the AFM. However, extension of the spoilers had been a previous procedure to follow in the event of an overspeed.

13. The AFM recovered from the aircraft wreckage did not contain the current revisions.

3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of the accident was a loss of control, possibly initiated by an unexpected encounter with moderate to severe clear air turbulence, which caused the aircraft to depart the narrow flight envelope boundaries in which it was operating and from which recovery was not effected, the flightcrew's lack of adequate training and experience in the Learjet; and the aircraft's marginal controllability characteristics near and beyond the boundaries of its flight envelope. Contributing to the accident was the flightcrew's probable extension of the spoilers in an overspeed situation, a procedure that had been prescribed in the approved aircraft flight manual until 1 year before the accident.

4. RECOMMENDATIONS

Clear air turbulence is a phenomenon which is difficult to forecast and detect, and when encountered has the potential to cause jet upsets and uncontrolled descents. It is the number one cause of non-fatal accidents in scheduled air carrier service. In this regard, the Safety Board has been concerned about its affects in causing injuries to passengers and crewmembers in air carrier operations and its recent involvement in Learjet upsets and uncontrolled descents. In an attempt to alleviate this problem, the Safety Board issued the following recommendation on September 15, 1981:

> Define the relationship between clear air turbulence and upper fronts as analyzed by soundings and develop forecasting techniques to utilize the information to improve clear air turbulence forecasts. (Class II, Priority Action) (A-81-103)

As a result of this accident, the National Transportation Safety Board made the following recommendations:

--to the Federal Aviation Administration:

> Encourage timely adoption of the Society of Automotive Engineers (SAE) standard for "general aviation" flight recorders (intended for installation in multiengine, turbine-powered fixed-wing aircraft and rotorcraft in any type of operation not currently required by 14 CFR 121.343, 121.359, 135.151, and 127.127 to have a cockpit voice recorder and/or a flight

data recorder), and issue a Technical Standard Order (TSO) covering such recorders immediately after the SAE document is approved. Include in the TSO requirements that:

a) specify a cockpit voice recorder (CVR) of high enough audio quality to render intelligible recorded data on each of two channels which reserves one channel for voice communications transmitted from or received in the aircraft by radio, and one channel for audio signals from a cockpit area microphone;

b) specify all flight data recorder (FDR) parameters, ranges, accuracies, and sampling intervals cited in Tables I and II (appendix H);

c) specify crash and fire survivability standards for CVRs and FDRs which are at least as stringent as those of TSO-C51a for Type I (nonejectable) and Type III (ejectable) recorders as appropriate.

(Class I, Urgent Action) (A-82-106)

Require that all multiengine, turbine-powered, fixed-wing aircraft certificated to carry six or more passengers manufactured on or after a specified date, in any type of operation not currently required by 14 CFR 121.343, 121.359, and 135.151 to have a cockpit voice recorder and/or a flight data recorder, be prewired to accept a "general aviation" cockpit voice recorder (if also certificated for two-pilot operation) with at least one channel for voice communications transmitted from or received in the aircraft by radio, and one channel for audio signals from a cockpit area microphone, and a "general aviation" flight data recorder to record sufficient data parameters to determine the information in Table I (appendix H) as a function of time. (Class II, Priority Action) (A-82-107)

Require that all multiengine, turbine-powered rotorcraft certificated to carry six or more passengers manufactured on or after a specified date, in any type of operation not currently required by 14 CFR 127.127 to have a cockpit voice recorder and/or a flight data recorder, be prewired to accept a "general aviation" cockpit voice recorder (if also certificated for two-pilot operation) with at least one channel for voice communications transmitted from or received in the aircraft by radio, and one channel for audio signals from a cockpit area microphone, and a "general aviation" flight data recorder to record sufficient data parameters to determine the information in Table II (appendix H) as a function of time. (Class II, Priority Action) (A-82-108)

Require that "general aviation" cockpit voice recorders (on aircraft certificated for two-pilot operation) and flight data recorders be installed when they become commercially available as standard equipment in all multiengine, turbine-powered fixed-wing aircraft and rotorcraft certificated to carry six or more passengers manufactured on or after a specified date, in any type of operation not currently required by 14 CFR 121.343, 121.359, 135.151, and 127.127 to have a cockpit voice recorder and/or a flight data recorder. (Class III, Longer Term Action) (A-82-109)

Require that "general aviation" cockpit voice recorders be installed as soon as they are commercially available in all multiengine, turbine-powered aircraft (both airplanes and rotorcraft), which are currently in service, which are certificated to carry six or more passengers and which are required by their certificate to have two pilots, in any type of operation not currently required by 14 CFR 121.359, 135.151, and 127.127 to have a cockpit voice recorder. The cockpit voice recorders should have at least one channel reserved for voice communications transmitted from or received in the aircraft by radio, and one channel reserved for audio signals from a cockpit area microphone. (Class II, Priority Action) (A-82-110)

Require that "general aviation" flight data recorders be installed as soon as they are commercially available in all multiengine, turbojet airplanes which are currently in service, which are certificated to carry six or more passengers in any type of operation not currently required by 14 CFR 121.343 to have a flight data recorder. Require recording of sufficient parameters to determine the following information as a function of time (see Table I (appendix H) for ranges, accuracies, etc.):

altitude
indicated airspeed
magnetic heading
radio transmitter keying
pitch attitude
roll attitude
vertical acceleration
longitudinal acceleration
stabilizer trim position
or pitch control position.

(Class III, Longer Term Action) (A-82-111)

—to the Federal Aviation Administration in conjunction with the activities of the Flight Operations Evaluation and the Flight Standardization Boards:

Establish a requirement that manufacturers provide, as part of the initial certification of a new general aviation turbojet airplane, a training guide for pilot transition into the airplane. The training guide should encompass the entire flight envelope in which the airplane will be operating and any unique aspects of its systems design, handling characteristics, and performance including the hazards of exceeding the flight envelope. The training guide should be an approved manual for use by appropriate inspectors, pilot schools, flight instructors, and pilot examiners. (Class II, Priority Action) (A-82-123)

Establish a requirement that manufacturers provide a training guide for pilot transition into currently certificated general aviation turbojet airplanes. The training guide should encompass the entire flight envelope in which the airplane will be operating and any unique aspects of its systems design, handling characteristics, and performance. The training guide should be an approved manual for use by appropriate inspectors, pilot schools, flight instructors, and pilot examiners. (Class II, Priority Action) (A-82-124)

Review the criteria currently prescribed for evaluating the type-rating requirement for successive models of turbojet airplanes built by the same manufacturer evolving from an original design, to determine if they are sufficient to provide adequate consideration of performance differences, operating environments, unique operational normal and emergency procedures, and systems design. If the criteria are found to be inadequate, revise them appropriately, and review existent type-rating requirements under the new criteria. (Class II, Priority Action) (A-82-125)

Upon approval of each specific training guide for general aviation turbojet airplanes require that the criteria used by inspectors and pilot examiners in conducting type-rating flight checks include full consideration of the material provided in the training guides. (Class II, Priority Action) (A-82-126)

Establish a minimum training curriculum to be used at pilot schools which covers special considerations involved in a pilot's initial transition into general aviation turbojet airplanes, including the aerodynamic, meteorological and physiological aspects of high performance, high altitude flight. (Class II, Priority Action) (A-82-127)

Require that pilot applicants for an initial type-rating in a general aviation turbojet airplane complete a minimum training curriculum at an approved pilot school or an equivalent military training program for turbojet airplanes. (Class II, Priority Action) (A-82-128)

Require that type-rating flight checks in general aviation turbojet airplanes include actual demonstration of pilot competency in handling characteristics in high altitude flight at speed ranges compatible with the specified flight envelope of the airplane. (Class II, Priority Action) (A-82-129)

—to the manufacturers of multiengine, turbine-powered airplanes and rotorcraft:

Prewire all newly manufactured multiengine, turbine-powered fixed-wing aircraft certificated to carry six or more passengers in any type of operation not currently required by 14 CFR 121.343, 121.359, and 135.151 to have a cockpit voice recorder and/or a flight data recorder, to accept a "general aviation" cockpit voice recorder (if certificated for two-pilot operation) with at least one channel for voice communications transmitted from or received in the aircraft by radio, and one channel for audio signals from a cockpit area microphone, and a "general aviation" flight data recorder to record sufficient data parameters to determine the information in Table I (appendix G) as a function of time. (Class II, Priority Action) (A-82-101)

Prewire all newly manufactured multiengine, turbine-powered rotorcraft certificated to carry six or more passengers in any type of operation not currently required by 14 CFR 127.127 to have a cockpit voice recorder and/or a flight data recorder, to accept a "general aviation" cockpit voice recorder (if certificated for two-pilot operation) with at least one channel for voice communications transmitted from or received in the aircraft by radio, and one channel for audio signals from a cockpit area microphone, and a "general aviation" flight data recorder to record sufficient data parameters to determine the information in Table II (appendix H) as a function of time. (Class II, Priority Action) (A-82-102)

Install "general aviation" cockpit voice recorders (on aircraft certificated for two-pilot operation) and flight data recorders when they become commercially available as standard equipment in all newly manufactured multiengine, turbine-powered fixed wing aircraft and rotorcraft certificated to carry six or more passengers in any type of operation not currently required by 14 CFR 121.343, 121.359, 135.151, and 127.127 to have a cockpit voice recorder and/or a flight data recorder. (Class III, Longer Term Action) (A-82-103)

—to the users of multiengine, turbine-powered airplanes and rotorcraft:

Encourage your members who own or operate multiengine, turbine-powered aircraft (both airplanes and rotorcraft) certificated for two-pilot operation to carry six or more passengers, in any type of operation not currently required by 14 CFR 121.359, 135.151, and 127.127 to have a cockpit voice recorder, to install "general aviation" cockpit voice recorders, and urge that they record voice communications transmitted from or received in the aircraft by radio on one channel, and audio signals from a cockpit area microphone on a separate channel. (Class II, Priority Action) (A-82-104)

Encourage your members who own or operate multiengine, turbojet airplanes certificated to carry six or more passengers, in any type of operation not currently required by 14 CFR 121.343 to have a flight data recorder, to install "general aviation" flight data recorders as soon as they are commercially available, and urge that they provide for recording sufficient parameters to determine the following information as a function of time (see Table I (appendix H) for ranges, accuracies, etc):

altitude
indicated airspeed
magnetic heading
radio transmitter keying
pitch attitude
roll attitude
vertical acceleration
longitudinal acceleration
stabilizer trim position
or pitch control position.

(Class III, Longer Term Action) (A-82-105)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ JIM BURNETT
Chairman

/s/ PATRICIA A. GOLDMAN
Vice Chairman

/s/ FRANCIS H. McADAMS
Member

/s/ G. H. PATRICK BURSLEY
Member

May 18, 1982

5. APPENDIXES

APPENDIX A

INVESTIGATION AND HEARING

1. **Investigation**

The Safety Board was notified of the accident at 1705 on October 1, 1981. A team of four investigators was dispatched to the scene the following day. Investigative groups were established for the areas of operations, structures, and systems. Additional support was later provided by the Safety Board's Headquarters staff in the areas of weather, metallurgy, and ATC radar.

Parties to the investigation included the Federal Aviation Administration and the Gates Learjet Corporation.

2. **Public Hearing**

No public hearing was held; however, depositions were taken.

APPENDIX B

CREW INFORMATION

Pilot John A. Willard, Jr.

Pilot John A. Willard, Jr., 32, president of Sky Train Air held Airline Transport Pilot (ATP) Certificate No. 1850737, obtained October 23, 1975, with an airplane multiengine land and sea ratings, and type ratings in the Douglas DC-3, DC-4, Lockheed L-188, Convair PBY5, and the Learjet. Pilot Willard, who was president of Sky Train Air, Inc., also held a commercial pilot certificate with airplane single engine land, rotorcraft-helicopter, and flight instruction ratings. He held a first class medical certificate dated August 4, 1981, with no limitations.

Based on his logbook, pilot Willard had a total pilot time of 6,404 hours. However, his logbook did not show any flight time logged for the period February 17, 1980 to September 23, 1981. Thereafter, he had logged a total of 21.2 hours as of September 29, 1981, of which 1.8 hours was in a single engine aircraft. He had obtained his Learjet type rating in a Learjet 23 on April 4, 1981, and had reported a total time of 5 hours in the Learjet at that time. His logbook indicated that between September 23 and September 29, 1981, he had logged a total of 15.6 hours in N44CJ, all as pilot-in-command, for a total of 22.3 hours in that type of aircraft, including the 1.7-hour flight test on April 4, 1981. Another pilot reported having given him about 1.5 hours of dual instruction on April 27, 1981. Including the accident flight and the 3-hour flight the day before, he had a total of 28.3 hours in the Learjet.

Pilot Willard's training in the Learjet consisted of 20 hours of informal ground school on a weekend. The FAA pilot designee who provided the ground school training stated that the training pertained to the Model 23 in which pilot Willard planned to take his flight check. The following weekend, the pilot designee gave pilot Willard his flight check. There was no record that he had any previous turbojet experience of significance.

Chief Pilot Romaine J. Durnine

Pilot Romaine J. Durnin, 58, who was chief pilot for Sky Train Air Inc., held ATP Certificate No. 320698, obtained June 25, 1964, with an airplane multiengine land rating with type ratings in the Curtis Wright CW-46, Douglas DC-4, DC-6, DC-7, DC-8, deHavilland DH-4, Lockheed L-188 (Electra) and the Learjet. He held a commercial certificate with airplane single engine land and sea ratings and type ratings in the Douglas DC-3, DC-B26, Lockheed L-382 (C-130) and North American B-25. He held a first class medical certificate dated April 1, 1981, with the requirement that he have correcting glasses in his possession during flight.

Pilot Durnin's logbook was not available and officials of Sky Train Air Inc. could not provide an account of his current flight time. According to his employment application, dated April 21, 1981, he had reported 17,500 flight hours, including 400 hours which had been accumulated in the last 90 days; 200 hours in the DC-4 and 200 hours in the DC-8. He listed a total time of 3,000 hours in the C-46; 100 hours in the DC-3; 2,000-hours in the DC-4; 5,000 hours in the DC-8; 2,600 hours in the L-382; and 500 hours in the DH-4. He did not list any flight time for the Learjet or other aircraft in which he was type rated.

Between 1968 and 1981, Pilot Durnin had worked for four other employers as a pilot before his employment with Sky Train Air, Inc. All four former employers either had or continued to operate large transport type aircraft, and the last three contacted verified his employment as a captain in the C-46, DC-4, DC-6, and DC-8. He retired from the United States Air Force as a pilot at the rank of lieutenant colonel.

Pilot Durnin obtained his type rating in the Learjet 24 (S/N 145) on August 2, 1978. The duration of his flight check with an FAA inspector was 1.7 hours. His Learjet training was obtained through Northern Air School of Aeronautics, Grand Rapids, Michigan. He had obtained 8.7 hours of flight training before his type rating. The chief pilot had flown N44CJ for 1 hour on September 19, 1981, before taking a recurrent flight check (FAR Part 61.58) on September 21 for a duration of 0.8 hour in the aircraft. He again flew the aircraft for 0.7 hour as pilot-in-command on September 30, and apparently as copilot for 3 hours on the flight to Thermopolis, Wyoming, the day before the accident. His total Learjet time is estimated to have been 17.4 hours including the flight on the day of the accident. However, it is not known if he had flown a Learjet between the time he obtained his rating and the time of his employment with Sky Train Air, Inc.

APPENDIX C

AIRCRAFT INFORMATION

FAA certification of the Gates Learjet Model 24 was approved March 17, 1966, under 14 CFR 25, effective February 1, 1965, with amendments 25-2 and 25-4, and Special Conditions. The Model 24 was initially certificated for flight up to 41,000 feet, but beginning with Serial No. 140, the aircraft was approved for flight up to 45,000 feet.

Gates Learjet 24, N44CJ, serial No. 24-146 was issued a transport airworthiness certificate on December 18, 1967. The total time on the aircraft was computed to be about 7,412 hours. A required 6,000-hour inspection was performed on August 19, 1978, at a total time of 6,143.4 hours. The aircraft had flown 26.5 hours since its last inspection on July 10, 1981. Most of the airworthiness directives (AD) applicable to the aircraft were performed. It is questionable whether AD 80-19-11 had been complied with because there was no evidence the change had been entered in the copy of the Model 24 AFM recovered from the wreckage.

The pitot static system was last inspected January 20, 1980, in accordance with 14 CFR 91.170. The transponder was last inspected on March 7, 1979. Title 14 CFR 91.177 requires that it be inspected within the preceding 24 calendar months.

The engines installed on N44CJ were General Electric CJ-610-4. The original engines had been removed from the aircraft and installed on another Model 24 Learjet. As a result, N44CJ was re-equipped with higher time engines on April 27, 1981. The engine data is as follows:

Position	Serial No.	Total Time (approximately)
Left Engine	GE 241-175	4,109 hrs.
Right Engine	GE 241-181	4,064 hrs.

APPENDIX D

GATES LEARJET AIRWORTHINESS DIRECTIVE VOLUMES I & II

GATES LEARJET

Airworthiness Directive

Volumes I & II

80-22-10 GATES LEARJET: Letter issued October 23, 1980. Applies to 23, 24, 25, 28 and 29 series airplanes certified in all categories.

COMPLIANCE: Required as indicated, unless previously accomplished.

A) Before further flight:

1. Deactivate the pitch function of the FC-110 Automatic Flight Control System (AFCS) or Automatic Flight Control Stability System (AFC/SS), as indicated below, by pulling the AFCS Pitch DC Circuit Breaker to the off position, banding it to prevent use of this function and checking to assure this function is the only deactivated circuit or control:

SERIES	SERIAL NUMBERS	LOCATION
23	003 thru 014	Pilot's Switch Panel
	015 thru 099	Pilot's Sub Panel
24	100 thru 139	Pilot's Sub Panel
	(except 131, 132 & 134)	
	131, 132 & 134	Pilot's circuit breaker panel
	140 thru 229	Autopilot computer rack
	230 and up	(under pilot's seat)
25	003 thru 069	Pilot's circuit breaker panel
	(except 032)	Autopilot computer rack
	032	(under pilot's seat)
	070 and up	Pilot's Sub Panel
		Pilot's circuit breaker panel
28	001 and up	Pilot's circuit breaker panel
29	001 and up	Pilot's circuit breaker panel

2. Install a locally fabricated placard on or near the autopilot control head in clear view of the crew, using letters at least 3/32 inch high, which reads:

AUTOPILOT PITCH AXIS INOPERATIVE

OBSERVE APPROPRIATE AFM AIRSPEED LIMITATIONS FOR INOPERATIVE AUTOPILOT

and operate the airplane in accordance with this placard.

3. Insert in the appropriate section of the existing Airplane Flight Manual (AFM) the FAA approved temporary Airplane Flight Manual Change dated October 22, 1980, pertaining to emergency procedures for pitch axis malfunction.

B) On or before January 1, 1981, accomplish all of the following at a Gates Learjet authorized service center holding appropriate FAA repair station ratings (see attached list):

1. Visually inspect the elevator control system to assure that Pitch Axis Servo (D.C. Torquer), P/N 6600163-( ) is installed.

a) If installed, modify the airplane by incorporating autopilot pitch trim monitor test switch in accordance with Gates Learjet Airplane Modification Kit AMK 80-16.

b) If not installed, modify the airplane by replacing the pitch servo actuator and capstan and incorporating autopilot pitch trim monitor test switch in accordance with Gates Learjet Airplane Modification Kits AMK 80-3 and AMK 80-16, respectively.

2. Insert in the appropriate sections of the existing Airplane Flight Manual (AFM) the FAA approved temporary Airplane Flight Manual changes dated October 21, 1980, for autopilot trim monitor.

C) When paragraph B of this AD has been accomplished, the requirements of paragraphs A)1. and 2. of this AD are no longer applicable.

D) Airplanes may be flown in accordance with FAR 21.197 to a location where the requirements of this AD can be accomplished provided the autopilot is not operative during that flight.

E) Any equivalent method of compliance with this AD must be approved by the Chief, Aircraft Certification Program, FAA, Central Region, Room 238, Terminal Building No. 2299, Mid-Continent Airport, Wichita, Kansas 67209.

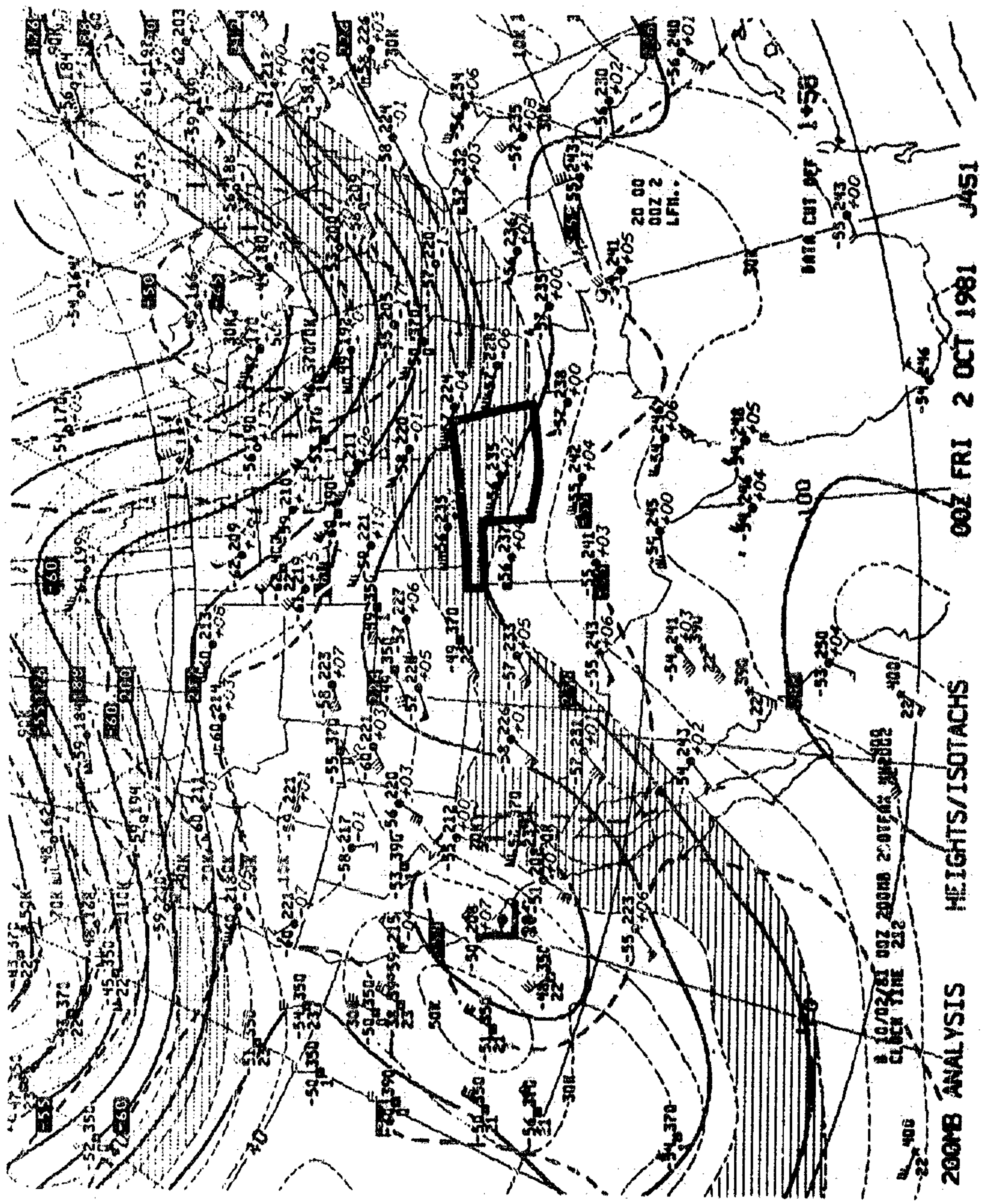
This Airworthiness Directive becomes effective upon receipt.

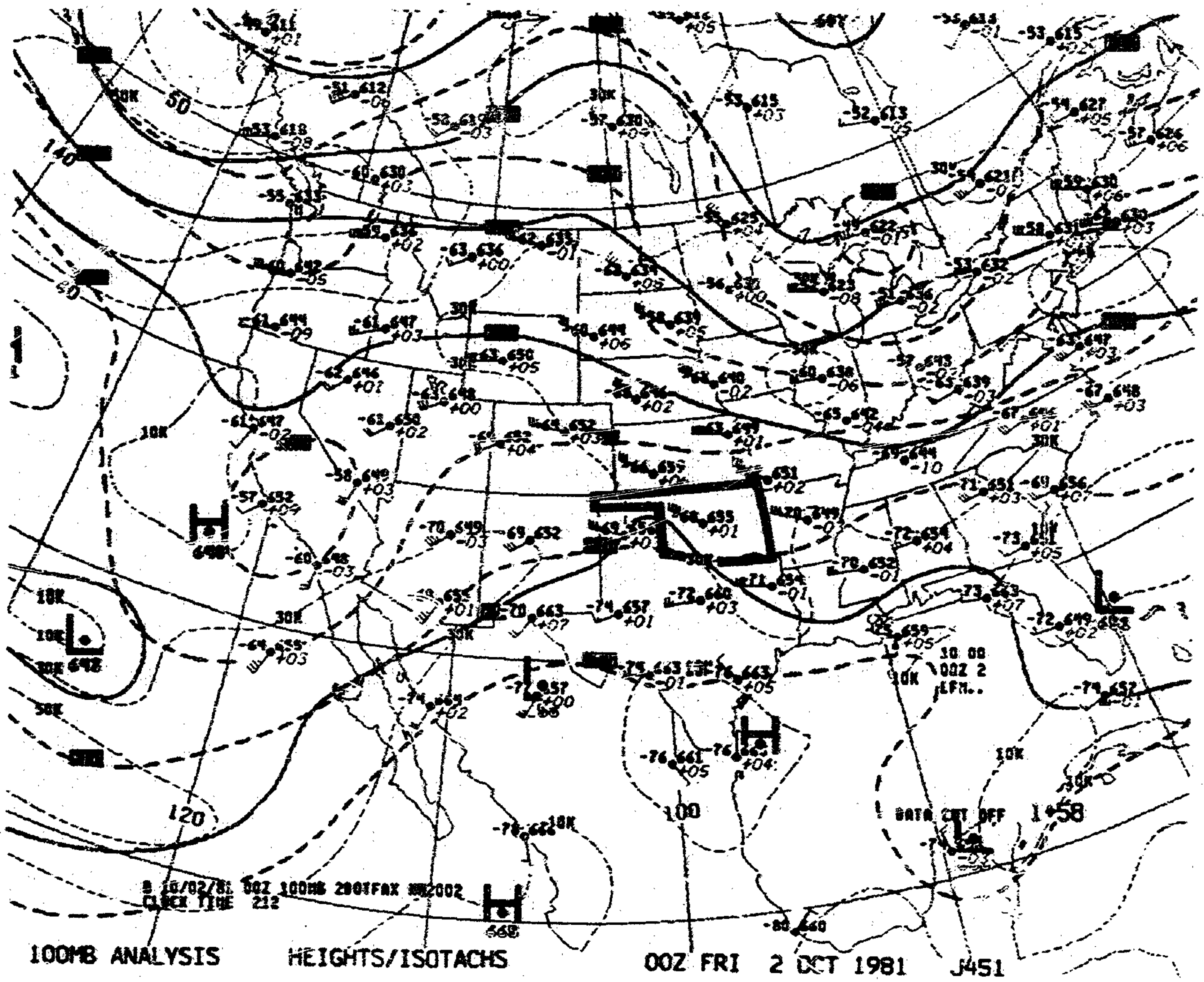
FOR FURTHER INFORMATION CONTACT:

Larry Malir, Aircraft Certification Program, Systems and Equipment Section, Federal Aviation Administration, Room 238, Terminal Building 2299, Mid-Continent Airport, Wichita, Kansas 67209; Telephone (316) 942-4281.

APPENDIX E

CONSTANT PRESSURE CHARTS

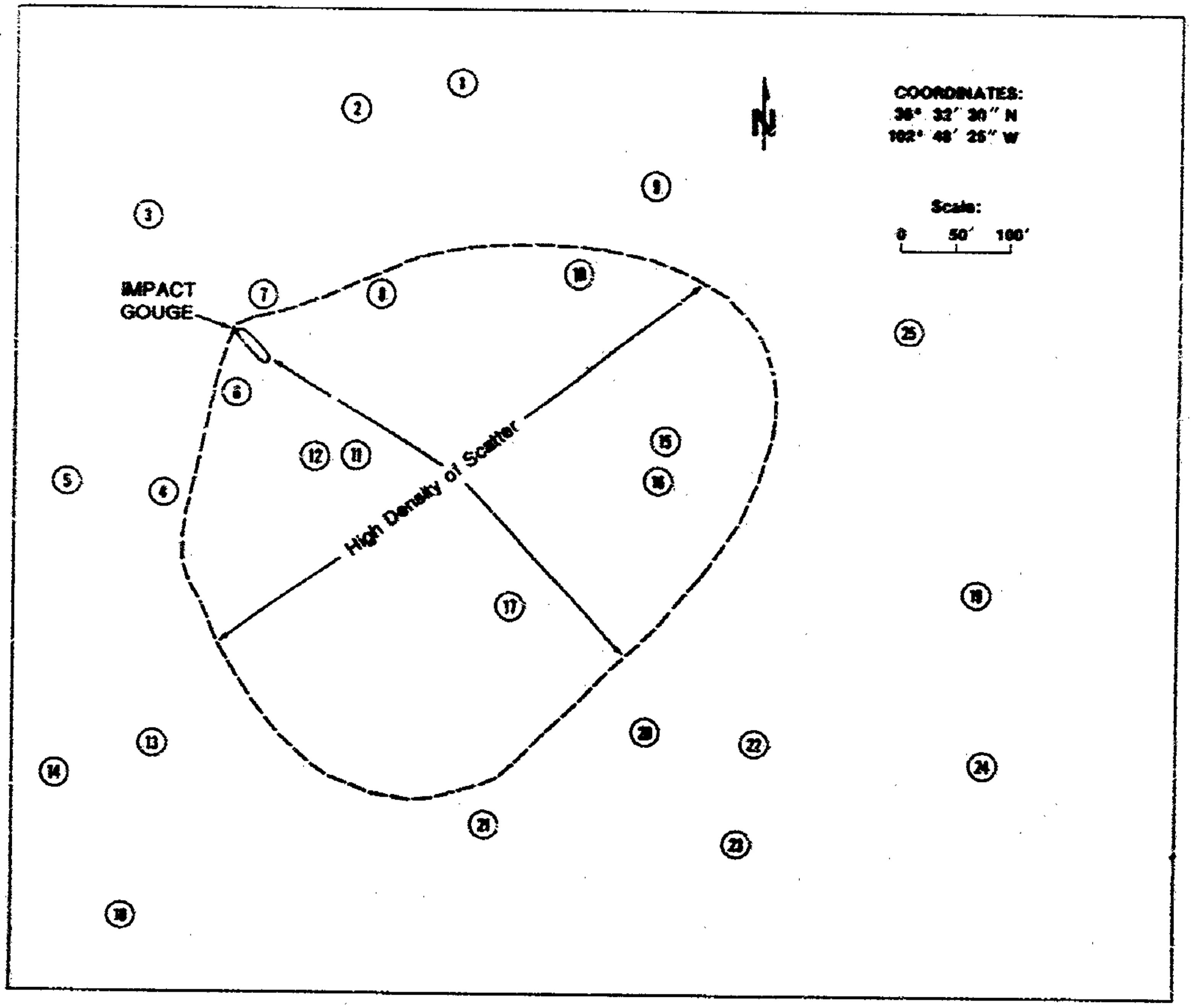



100MB ANALYSIS HEIGHTS/ISOTACHS 00Z FRI 2 OCT 1981 J451
DATA CUT OFF
CLOCK TIME 212

APPENDIX 3
WRECKAGE DISTRIBUTION CHART

LEGEND:

1. Piece of Cabin Window Frame
2. Seat Cushion
3. Piece of Wing Skin
4. Piece of Nose Tire
5. Access Panel
6. Piece of Left Aileron
7. Horizontal Stab. Pivot Casting
8. Piece of Elevator
9. Piece of Cabin Floor with Seat Belt
10. Piece of Horizontal Stab.
11. Drag Chute
12. Piece of Tip Tank
13. Piece of Fuselage Skin
14. Piece of Wing Skin
15. Piece of Right Elevator
16. Piece of Horizontal Stab.
17. Rudder
18. Cockpit Blower Motor
19. Right Engine
20. Nose Gear Trunnion
21. Main Gear Trunnion
22. Piece of Right Aileron
23. Left Engine
24. Gyro
25. Piece of Crew Seat Frame



APPENDIX G

LEARJET ACCIDENT AND INCIDENT HISTORY

Some relatively recent incidents and accidents involving Learjet aircraft are discussed herein to present the background and the development of the corrective actions which have been taken by the FAA prior to the October 1, 1981, accident.

On August 31, 1974, a Colorado Flying Academy Learjet 25B, serial No. 151, crashed near Briggsdale, Colorado. The airplane departed Denver at 1331 m.d.t. on a training flight en route to Cheyenne, Wyoming, with two passengers aboard. The last radio contact with the flight was at 1336 when the aircraft was at 17,400 feet. The sky was clear with about 40 miles visibility.

The Safety Board retrieved information from the cockpit voice recorder (CVR), which was installed in the aircraft as an owner's option. Based on this information, it appeared that the instructor pilot, in the right seat, decided to introduce a runaway trim emergency to the student pilot who was on his fourth lesson for his type rating. The runaway trim maneuver followed an unusual attitude. About 1348:39, the instructor is understood to have stated, "runaway trim," and the student stated 2 seconds later, "okay turn it off." Three seconds later, the student stated, "the . . . spoilers," and 3 seconds later, the instructor stated, "spoilers can't do that." Three seconds later, at 1348:50, the landing gear and the overspeed warning horns sounded; the overspeed horn warning continued to the end of the recording at 1349:15. At 1348:56, a voice identified as the instructor's stated, "can't pick up . . . pull." A witness on the ground estimated that the aircraft was in a 45° dive angle before impact. The aircraft struck the ground in a wings level, 20° to 40° nosedown attitude.

The instructor held ratings in the Learjet Models 23, 24, and 25. He had 9,323 hours of flight time. His total Learjet flight time was not known. He had flown the Learjet 130 hours in the past 90 days and had accumulated 161 hours in the Learjet Model 25. The student's flight experience was not known.

Examination of the wreckage disclosed that the landing gear, wing flaps, and spoilers were retracted at the time of ground impact. The horizontal stabilizer jackscrew was found in the full nosedown position.

On October 20, 1978, a Kelco Aircraft Company Learjet 25, serial No. 019, crashed 1.5 miles southeast of Vickery, Ohio. The aircraft departed the Cleveland-Hopkins Airport at 1019 e.d.t. with a pilot, copilot, and an FAA Operations Inspector on board for the purpose of giving the copilot an "airtaxi" flight check. The flight check was to consist of some "high work" maneuvers, such as slow flight, stalls (approach to shaker), steep turns, possible simulated emergencies, such as a runaway pitch trim, an engine fire, and an emergency descent; and "low work," such as landings, go-arounds, and simulated engine-out maneuvers. The flight climbed to 16,500 feet, and at 1027, the crew advised the Cleveland ARTCC that they would be operating in the area of the Sandusky VOR. About 6 minutes into the flight, at 1032:49, a sound similar to a keyed microphone was received by the ARTCC, followed by five statements of "Pull up" in rapid sequence; a final, but louder "Pull it out" was received at 1033:20. It was determined that the altitude alert had sounded at 1032:32, and 4 seconds later, the overspeed warning horn had sounded. Witnesses on the ground reported observing the aircraft in about a 60° dive angle, and they stated they did not see any smoke, fire, or pieces of the aircraft separate before ground impact.

Both pilots held a type rating in the Learjet. The pilot had 150 hours and the copilot had 230 hours in the Learjet.

Examination of the wreckage revealed that the wing flaps and the spoilers were retracted at impact. The position of the landing gear could not be confirmed. The horizontal stabilizer trim actuator was positioned to a minus 2.69°. This position equated to a cruise speed of 276 KIAS, at the estimated gross weight and c.g. of the accident aircraft. It was also determined that the aircraft accelerated to 306 KIAS (V_{mo}) in 6 to 7 seconds. Flight tests made as a part of the Safety Board's May 1979 Study of Selected Performance Characteristics of Modified Learjet Aircraft," showed it would have required a negative "g" maneuver to achieve such acceleration. Simulated nosedown runaway trim conditions could not duplicate this condition. It was also noted that, "...extension of the spoilers is not a viable procedure to prevent acceleration in a nosedown trim runaway condition. Extension of the spoilers at V_{mo} with full nosedown trim required an elevator force estimated at 120 to 140 pounds to maintain level flight. At 250 knots, the elevator force was measured at 98 pounds with full nosedown trim and spoilers extended."

The investigation of these accidents prompted research related to the following key areas:

(1) Runaway pitch trim training techniques;
(2) Use of spoilers in a high speed recovery;
(3) Flightcrew backgrounds and qualifications; and
(4) Operation of the flight control system--pitch servo clutch assemblies, autopilot/automatic flight control system, stall warning system, and the effectiveness of the control cables, ailerons and stabilizer/elevator system at high speeds.

On March 2, 1979, the pilot of a Learjet Model 24B, serial No. 209, operated by the Syntek Corporation, reported a longitudinal control problem at FL 350 while en route from Greensboro, North Carolina, to Nashville, Tennessee. The pilot stated that the stickshaker came on four times, and he responded by turning the two stall warning switches off one at a time. Each time he turned them back on, the aircraft would abruptly pitch nosedown, and the associated stall warning switch circuit breakers would pop. By deactivating the stall warning system, he was able to isolate the problem. However, in spite of his action, he had difficulty with pitch control during the landing but was able to make a safe landing following four attempts at Greensboro. The pilot made a 10° flap landing at a higher than normal airspeed and used the stabilizer trim for pitch control.

The longitudinal control problem was traced to the pitch axis servo drive unit (electromagnetic clutch). The clutch contains ferrous powder which normally coagulates or packs into a solid mass when a magnetic field is introduced electrically by signals from the autopilot or stall warning stickshaker/stickpusher system. The energized clutch then transmits torque to the elevator control system in the appropriate direction. The powder normally decoagulates and the clutch rotates freely when the magnetic field is removed.

Examination of the electromagnetic clutch of the Syntek aircraft revealed that the ferrous powder was packed even in the absence of electrical power. Such a condition could produce a nosedown pitching moment with normal operation of the autopilot which would require as much as 80 pounds of pull force on the control column to counter. Even without electrical power, the jammed clutch would affect the breakout force and the force gradient of the longitudinal control system before the elevator could be moved. Gates Learjet personnel theorized that moisture contamination caused the ferrous powder to pack and jam the clutch. During previous overhauls, Gates Learjet personnel have found various degrees of moisture contamination.

The Safety Board examined the clutch in its metallurgical laboratory and found no foreign substances in the ferrous powder. However, some of the particles of the powder continued to pack into small hard lumps. The reason for this peculiarity was not determined, but it was believed that some undetermined property in the material was causing the clutch to jam even in the absence of a magnetic field.

Although the Safety Board noted that Gates Learjet had discontinued use of the electromagnetic clutch which was manufactured by Jet Electronics (part No. 2380066), in new aircraft, 220 Learjets were equipped with the clutch unit at that time, and it was a mandatory item for flight. The clutch unit was the same as the type installed in the Kelco Aircraft Learjet. The Syntec incident prompted concern that magnetic clutches may have been a factor in the Kelco accident. In its investigation of this accident, the Safety Board identified only two servo clutches which were the primary yaw units. These servo clutch units were corroded, but the source of the corrosion could not be identified. Of the remaining eight servo clutch units installed in the aircraft, six exhibited no evidence of packing, one was destroyed, and the other was not located. Therefore, the condition of the pitch axis electromagnetic clutch units in the Kelco aircraft could not be determined. As a result of the Syntec incident and the accidents, foregoing and in view of the potential catastrophic results of control difficulties caused by jammed electromagnetic clutches, the Safety Board issued safety recommendations A-79-21 through -23 to the FAA on April 18, 1979.

As a result of the Syntek Corporation incident investigation, several actions were taken by the FAA and the Gates Learjet Corporation to correct the magnetic clutch problem. A temporary AFM supplement was issued prescribing specific emergency procedures to follow in the event of a pitch axis malfunction. Copies of the Safety Board's recommendations were widely distributed and two operations bulletins describing the problem were issued to all FAA field offices. In its response of July 16, 1979, to the Safety Board's recommendations, the FAA stated that it believed it was not necessary to restrict the operations of Learjets equipped with the electromagnetic clutches because of the temporary AFM change. However, these procedures only proved to be interim measures with respect to the clutch servo unit problem.

Between 0330 and 0400, on October 3, 1980, a National Jet Industries Learjet 25, serial No. 010, experienced an upset while in cruise flight at FL 450 over Butler, Missouri. The crew was on an air taxi cargo flight from Columbus, Ohio, to Pueblo, Colorado. With the autopilot and altitude hold engaged, the aircraft smoothly but suddenly pitched up, and gained more than 300 feet before the copilot pushed the primary trim switch to the nosedown position which disengaged the autopilot; the aircraft continued to deviate in a noseup attitude. Stall buffet was encountered and the left engine flamed out. Both pilots pushed full forward on the control column and the copilot selected secondary trim and also turned off the stall warning switches in an attempt to lower the nose, but to no avail. About 37,000 feet, the right engine flamed out. The aircraft began to respond to control movements about 32,000 feet, and the engines were restarted between 24,000 and 28,000 feet. The crew diverted to Wichita, Kansas, where they landed successfully.

The Safety Board's meteorological examination of the weather conditions existing in the area of the flight disclosed the existence of an upper front with wind shears greater than 10 knots per 1,000 feet. The Safety Board believes that this condition provided the potential for gravity waves 1/ and/or turbulence at the aircraft's flight level. The wave action or turbulence would have existed in a shallow layer, probably less than 1,000 feet thick. Based on the crew's statements of the incident, it was considered possible that the aircraft encountered the vertical component of a gravity wave.

Inspection of the aircraft by the FAA and the Gates Learjet Corporation disclosed that although the possibility of packed ferrous powder in the aircraft's electromagnetic clutch causing the control difficulty in the incident could not be excluded, the possibility could not be verified during ground tests of the servo unit--an inconclusive ground test is not unusual. It was noted that the amount of powder and the amount of lubricant were not in accordance with specifications. Subsequent flight tests and analysis of the findings caused engineers to conclude that the control difficulty could have been cause by a packed pitch axis electromagnetic clutch.

At the conclusion of its investigation, the FAA issued Emergency AD-80-22-10 on October 23, 1980, which required deactivation of the pitch function in the FC-110 autopilot AFCS or AFC/SS until the electromagnetic clutches had been replaced with the improved, in-production d.c. torquer clutches (motor driven) and certain other changes had been made. The d.c. torquer clutches have continuously been installed since the model 25B, serial no. 067. Other changes required by the AD involved inspection of the autopilot trim coupler circuit board to assure that proper transistors were installed, and incorporation of a pitch trim monitor preflight test switch along with appropriate changes to the AFM. Upon accomplishment of these items, the autopilot pitch axis function could be restored. Operators were given until April 1, 1981, to make the changes.

A failure of the transistors in the trim coupler board in the autopilot computer could cause a disturbance in the pitch axis of the aircraft. It was learned that Delco germanium transistors were believed to be more resistant to thermal runaway failures than the germanium transistors built by other manufacturers. Hence, the reason for the inspection. According to the manufacturer, a failure would normally be preceded by spurious autopilot disconnects because the trim monitor would sense an incorrect electrical phase relationship between stabilizer and elevator trim positions. In other words, the trim coupler would have disconnected the autopilot if an unwanted trim motion of the stabilizer occurred. The control force required to maintain the desired flight attitude at the time of a disconnect under this condition might range anywhere between 10 and 80 pounds. However, a pilot would still retain elevator control, but it could be limited depending on the amount of stabilizer mistrim present at the time of the disconnect. Therefore, a pilot may receive some kind of warning of a potential significant disturbance in the autopilot before control difficulty would become substantial. To prevent this type of failure from recurring, the FAA ordered compliance with the appropriate Jet Electronics Service Bulletins SB 4-2020-30, -32, -33, or -34, which are a part of Gates Learjet's aircraft modification kit, AMK 80-16B, mentioned in the airworthiness directive. The transistors installed in the trim coupler board of the National Jet Industries Learjet were Delco germanium and tests for faults were negative.

1/ Atmospheric gravity waves are a disturbance in which bouyancy (or reduced gravity) acts as the restoring force on parcels of air displaced from hydrostatic equilibrium.

On April 11, 1980, Thunderbird Airways, Inc., Learjet 25B, serial No. 196, was on a return flight from Vernal, Utah, to Houston, Texas, at FL 410, after having completed an air taxi cargo flight. About 1716 c.s.t., the Albuquerque, New Mexico, ARTCC heard the sounds of a keyed microphone and a Mach overspeed warning horn with a lot of background noise. It was apparent that the flight was in difficulty, and that the pilot attempted to identify himself and asked for a lower altitude, but did not make any further audible transmissions. The aircraft entered what was believed to be a steep, high speed descent and impacted 6 miles west of Conlon, Texas.

Investigation of this accident disclosed a relatively high probability of clear air turbulence in the area at the altitude the aircraft was transiting. It was determined that at the time of impact, the landing gear and flaps were retracted, the spoilers were extended, and the stabilizer actuator jackscrew was in the full nosedown position. The aircraft was equipped with d.c. torquer clutches, rather than electromagnetic clutches in the autopilot system. The aircraft's autopilot computer was equipped with the non-Delco germanium transistors. The transistors were destroyed and tests for the possibility of their failing could not be performed. As a result of this possible type of failure, this accident, and the National Jet Industries incident, AD-80-22-10 was promulgated to require that a trim monitor test feature be incorporated into the autopilot system (this was later superseded by AD-80-26-02).

On May 19, 1980, a Northeast Jet Company, Learjet 25D, N125NE was on a dead head flight from West Palm Beach, Florida to New Orleans, Louisiana. Only the pilot and copilot were aboard. About 2 1/2 minutes after the aircraft reported at FL 430 at 1201:42 in the vicinity of the Covia Intersection on Airway J58, the Jacksonville, Florida, ARTCC received an unusual staccato sound transmission over the frequency, followed 4 seconds later by a transmission from the pilot stating "put out the spoilers." Fourteen seconds later, the copilot states, "Can't get it up...it's in a spin..." Fifteen seconds later, radio and radar contact with the aircraft was lost at about 104 miles west of Sarasota, Florida. Floating debris from the aircraft was located at the 290° radial, 104.5 miles from Sarasota, in the Gulf of Mexico and was later recovered. The flightcrew was not found and there were no known witnesses to the accident.

The Safety Board determined that the probable cause of the accident was an unexpected encounter with moderate to severe clear air turbulence, the flightcrew's improper response to the encounter, and the aircraft's marginal controllability characteristics when flown at and beyond the boundary of its high altitude speed envelope, all of which resulted in the aircraft exceeding its Mach limits and a progressive loss of control from which recovery was not possible. Contributing to the accident was the disconnection of the Mach overspeed warning horn with an unauthorized cut-out switch. The absence of an overspeed warning probably delayed the crew's response to the turbulence encounter. Also contributing to the accident were the inconsistencies in aircraft flight manuals and flightcrew training programs regarding the use of spoilers to regain control.

The Safety Board was concerned about the manner in which certain flights were conducted. In response to the Board's letter requesting flight test data for the nosedown trim runaway condition, Gates Learjet reported in a letter dated December 15, 1980:

> The enclosed data was recorded. . . on a Model 25B (with the FAA aboard) on February 27, 1975. Stabilizer load flight test data is not available. Note that the runaway was stopped after three seconds; not allowed to run to the stop. In the one case at 300 KIAS, the trim was run to the stop and required an 85 pound pull to hold the airspeed. There is no Model 25B flight test data available to directly correlate the computer scenario of running the trim to the stop with a three second delay in any action by the pilot. In the flight test when the trim was run to the stop, the test pilot did have his hands on the wheel.

As a result of the foregoing accidents and incidents, the Safety Board issued these recommendations to the FAA on June 27, 1980.

> Convene a Multiple Opinion Team to evaluate the flight characteristics and handling qualities of Series 20 Learjet aircraft, with and without slow flight modification, at both low- and high-speed extremes of the operational flight envelope under the most critical conditions of weight and balance (and other variable factors) and to establish the acceptability of the control and airspeed margins of the aircraft at these extremes. (Class I, Urgent Action) (A-80-53)

> Advise all Learjet operators of the circumstances of recent accidents and emphasize the prudence of rigid adherence to the operational limits and recommended operational procedures. (Class I, Urgent Action) (A-80-54)

> Evaluate information contained in the Gates Learjet Service New Letter 49 dated May 1980 pertaining to procedures to be followed if the aircraft inadvertently exceeds V_{mo}/V_{mo} and, based on this evaluation, require appropriate revisions to the aircraft flight manual. (Class I, Urgent Action) (A-80-55)

In its response dated September 25, 1980, the FAA stated that with regard to recommendation A-80-53, part of an evaluation had already been accomplished in conjunction with the Safety Board's February 1979 "Study of Selected Performance Characteristics of Modified Learjet Aircraft." The FAA stated that a separate investigation was initiated on June 17, 1980, to accomplish a certification review of the Learjet. In addition, they stated that their Office of Flight Operations had established a separate team to "review the adequacy and effectiveness of Learjet crew training."

On December 7, 1980, the flightcrew of Learjet 25, serial No. 054, operated by Continental Oil Company, experienced a simultaneous flameout of both engines at about 40,000 feet while the aircraft was climbing to FL 430 northeast of Childress, Texas. The engines were air started passing through 25,000 feet, and a precautionary landing was made at Childress. Extensive examination and testing of the CJ610-6 engines by General Electric disclosed that the flameouts were caused by reduced engine stall margin due to excessive blade tip clearance and excessive compressor case runout. As a result of its investigation of this incident, the Safety Board issued recommendation A-81-69 to the FAA on June 29, 1981.

APPENDIX H

PARAMETER LISTS

TABLE I

PARAMETER LIST (FIXED WING AIRCRAFT)

PARAMETERS	RANGE	INSTALLED SYSTEM 1/ MINIMUM ACCURACY (TO RECOVERED DATA)	SAMPLING INTERVAL (PER SECOND)
Relative Time (from recorder on prior to takeoff)	8 hrs. minimum	±0.125% per hour	1
Indicated Airspeed	V_{SO} to V_D (KIAS)	±5% or ±10 kts., whichever is greater. Resolution 2 kts. below 175 KIAS	1
Altitude	-1,000 ft. to max cert. alt. of A/C	+100 to +700 ft. (see Table I, TSO C51-a)	1
Magnetic Heading	360°	±5°	1
Vertical Acceleration	-3g to +6g	±0.2g in addition to ±0.3g maximum datum error	4 (or 1 per second where peaks ref. to 1g are recorded)
Longitudinal Acceleration	±1.0g	±0.05g in addition to max. datum error of ±0.1g	2
Pitch Attitude	100% of usable range	±2°	1
Roll Altitude	±60° or 100% of usable range, whichever is greater	±2°	1
Stabilizer Trim Position OR	Full range	±3% unless higher accuracy uniquely required	1
Pitch Control Position	Full range	±3% unless higher accuracy uniquely required	1

1/ When data sources are aircraft instruments (except altimeters) of acceptable quality to fly the aircraft, the recording system excluding these sensors (but including all other characteristics of the recording system) shall contribute no more than half the values in this column.

TABLE I (2)

Engine Power, Each Engine			
Fan or N_1 Speed or EPR or Cockpit Indications Used for Aircraft Certification	Maximum range	±5%	1
OR			
Prop. Speed and Torque (Sampled Once/Sec as Close Together as Practicable)			1 (prop speed) 1 (torque)
Altitude Rate 2/ (need depends on altitude resolution)	±8,000 fpm	±10%. Resolution 250 fpm below 12,000 ft. indicated	1
Angle of Attack 2/ (need depends on altitude resolution)	-20° to +40° or 100% of usable range	±2°	1
Radio Transmitter Keying (Discrete)	On/Off		1
TE Flaps (Discrete or Analog)	Each discrete position (U,D,T/O,APP)		1
	OR		
	Analog 0-100% range	±3°	1
LE Flaps (Discrete or or Analog)	Each discrete position (U,D,T/O,APP)		1
	OR		
	Analog 0-100% range	±3°	1
Thrust Reverser, Each Engine (Discrete)	Stowed or full reverse		1
Spoiler/Speedbrake (Discrete)	Stowed or out		1
Autopilot Engaged (Discrete)	Engaged or Disengaged		1

2/ If data from the altitude encoding altimeter (100 ft. resolution) is used, then either one of these parameters should also be recorded. If, however, altitude is recorded at a minimum resolution of 25 feet, then these two parameters can be omitted.

TABLE II

PARAMETER LIST (ROTORCRAFT)

PARAMETERS	RANGE	INSTALLED SYSTEM 1/ MINIMUM ACCURACY (TO RECOVERED DATA)	SAMPLING INTERVAL (PER SECOND)
Relative Time (from recorder on prior to takeoff)	4 hrs. minimum	±0.125% per hour	1
Indicated Airspeed	V_{min} to V_D (KIAS) (minimum airspeed signal attainable with installed pitot-static system)	±5% or ±10 kts., whichever greater	1
Altitude	-1,000 ft. to 20,000 ft. pressure altitude	±100 to ±700 ft. (see Table I, TSO C51-a)	1
Magnetic Heading	360°	±5°	1
Vertical Acceleration	-3g to +6g	±0.2g in addition to ±0.3g maximum datum error	4 (or 1 per second where peaks ref. to 1g are recorded)
Longitudinal Acceleration	±1.0g	±0.05g in addition to maximum datum error of ±0.1g	2
Pitch Attitude	100% of usable range	±2°	1
Roll Attitude	±60° or 100% of usable range, whichever is greater	±2°	1
Altitude Rate	±8,000 fpm	±10%. Resolution 250 fpm below 12,000 ft. indicated	1

1/ When data sources are aircraft instruments (except altimeters) of acceptable quality to fly the aircraft, the recording system excluding these sensors (but including all other characteristics of the recording system) shall contribute no more than half the values in this column.

TABLE II (2)

Engine Power, Each Engine			
Main Rotor Speed	Max. range	±5%	1
Free or Power Turbine Speed	Max. range	±5%	1
Engine Torque	Max. range	±5%	1
Flight Control Hydraulic Pressure			
Primary (Discrete)	High/Low		[illegible]
Secondary-if applicable (Discrete)	High/Low		1
Radio Transmitter Keying (Discrete)	On/Off		1
Autopilot Engaged (Discrete)	Engaged/Disengaged		1
SAS Status-Engaged (Discrete)	Engaged/Disengaged		1
SAS Fault Status (Discrete)	Fault/OK		1
Flight Controls			
Collective	Full range	±3%	2
Pedal Position	Full range	±3%	2
Lat. Cyclic	Full range	±3%	2
Long. Cyclic	Full range	±3%	2
Controllable Stabilator Position	Full range	±3%	2

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