

National Transportation Safety Board

Office of Aviation Safety

Washington, DC 20594



WPR23FA185

AIRWORTHINESS

Group Chairman's Factual Report

March 10, 2025

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A ACCIDENT

Location: San Clemente Island, California
Date: May 10, 2023
Time: 0749 PDT
 1449 UTC
Airplane: Learjet Inc. 36A / N56PA

B AIRWORTHINESS GROUP

Group Chairman	Van S. McKenny IV National Transportation Safety Board Washington, DC
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C SUMMARY

On May 10, 2023, at 0749 Pacific daylight time, a Learjet 36A, N56PA, was destroyed when it was involved in an accident near San Clemente Island, California. Both pilots and the additional crewmember were fatally injured. The airplane was operating as a Title 14 Code of Federal Regulations Part 91, other work use flight.

The airplane departed Point Magu Naval Air Station (KNTD), Oxnard, California, at 0723 local time as the lead airplane using callsign FENIX01 (N56PA) in formation with a second Learjet airplane utilizing the using callsign FENIX02 (N544PA). Shortly after entering W291 (warning area 291), at 15,000 feet mean sea level (MSL), the aircrew of FENIX02, which was in a formation positioned off of FENIX01's right wing, observed the lead airplane's flaps partially deploy. They notified the lead airplane, who acknowledged the radio call. The aircrew of FENIX02 then observed the flaps retract. Seconds later, the aircrew of FENIX01 radioed that they detected an odor in the cabin. The aircrew of FENIX02 then radioed that they observed white or gray colored "smoke or gas" apparently coming from the "left side AFT Cabin area." Unidentified fluid was also observed trailing the airplane. At this point the lead airplane was not maintaining heading or altitude.

FENIX02 then observed flames coming from around the aft equipment bay (tailcone) door and told the aircrew of FENIX01 that they were on fire and to declare an emergency. The aircrew of FENIX01 declared an emergency and their intentions to land at San Clemente Island Naval Auxiliary Landing Field (NUC). FENIX02 then took over as lead for the formation flight and maneuvered in front of FENIX01 to lead them to the airfield. FENIX02 last observed and heard radio transmissions from FENIX01 as they descended through about 9,000 feet MSL.

The airplane wreckage was located about 4 miles northwest of the last recorded Automatic Dependent Surveillance-Broadcast (ADS-B) data point and one mile offshore in about 300 feet of water.

D DETAILS OF THE EXAMINATION

1.0 Airplane Information

The Learjet 36A is a long-range, twin turboprop-powered business aircraft configured as a cantilever low-wing monoplane with a slight leading-edge sweep, cantilever T-tail, and retractable tricycle landing gear with two wheels on each main gear unit. The Learjet 36A has a maximum takeoff weight of 17,000 pounds¹. It is powered by a pair of Honeywell TFE 731-2C-2B turboprops rated at 3,500 pounds of thrust each.

1.1 Certification Information

Bombardier provided flight test information² that was used to comply with Federal Aviation Regulation (FAR) Part 25.863 titled "Flammable Fluids Fire

¹ Type Certificate Data Sheet (TCDS) A10CE for Learjet models 35A and 36A.

² Gates Learjet Report No. 26-D307

Protection". The flight test report states that the "tailcone³ compartment is ventilated and maintained at a positive pressure during flight, and fluids from the left engine drain will not enter the tailcone through the flush scoop on the tailcone." An additional test report⁴ stated that "fluid released into the tailcone drained overboard, and local positive differential pressure at the access door prevented re-entry of fluid. Re-entry of fluid around the drag chute did not occur."

1.2 Accident Airplane Information

The accident airplane, a Learjet 36A, serial number 023, was manufactured in 1976 (Figure 1). The airplane was purchased by the Phoenix Air Group from 1st Source Leasing, Inc, on December 4, 1991. The registration was changed from N6YY to N56PA⁵ on December 26, 1991. The airplane was equipped with special mission equipment involving underwing hard points and electrical power to the hard points in accordance with Supplemental Type Certificate (STC) SA1670CF approved March 8, 1992. The special mission equipment installation was field approved on January 20, 1993, by the Federal Aviation Administration FAA was reinstalled in accordance with revised FAA approved drawings and reports on January 16, 1995.



Figure 1. Photo of the accident airplane in flight. (Source: Phoenix Air Group)

³ Learjet documents reference the aft equipment bay as the tailcone.

⁴ Gates Learjet Report No. 25-D594

⁵ FAA Registration records.

1.3 Maintenance information

The airplane maintenance records were reviewed and provided the following information in Tables 1 and 2

Table 1. Airplane operational times as of May 9, 2023.

Component	Total Time (hours)	Total Cycles
Airframe	18,933.0	10,008
Engine 1 (Left)	19,740.0	11,270
Engine 2 (Right)	9,799.4	7,128

The following table lists the significant maintenance that was recorded in the airplane's maintenance logbook over the previous 360 operational hours.

Table 2. Maintenance summary table.

Date	ACTT	Significant Maintenance Actions
6/28/21	18,573.3	Eddy current inspection of L & R forward engine support beam support fittings around engine mount attachment lugs.
8/24/21	18,573.3	Right engine. Engine total time: 9438.8 hours. Completed 250 hour SOAP (Spectrometric Oil Analysis Program), 300-hour, 600-hour, 1,200 hour (oil change), and 1500-hour inspection.
9/2/21	18,573.3	Left engine. Engine total time: 19,379.4 hours. Completed 250 hour (SOAP), 300-hour, and 600-hour inspection
9/8/21	18,573.3	RVSM inspection in accordance with (IAW) 24-month mx checklist.
9/9/21	18,573.3	12,000-hour, 12-year, 2,400-hour, 1,200-hour, 600-hour, 300-hour inspections.
6/13/22	18,746.6	Left engine. Engine total time: 19,552.7 hours. Completed 250-hour (SOAP) inspection.
6/16/22	18,746.6	Right engine. Total engine time: 9,612.1 hours. Completed 250-hour (SAOP) inspection.
8/30/22	18,807.0	Right engine. Engine total time: 9,672.5 hours. Completed 300-hour inspection.
8/31/22	18,807.0	Completed 300-hour inspection.
8/31/22	18,807.0	Left engine. Engine total time: 19,613.1 hours. Completed 300-hour inspection.
9/2/22	18,807.0	Removed and replaced main landing gear actuator pin.

3/31/23	18,915.4	Left hand hardpoint leaks through mounting screws. Resealed hardpoint fasteners per Learjet Structural Repair Manual (SRM) Chapter 1.
3/31/23	18,915.4	Fasteners on top of the left-hand wing below engine leaking fuel. Repaired leaking fasteners per Learjet SRM 57-00-00.
3/31/23	18,915.4	Fasteners on top of right-hand wing below engine leaking fuel. Repaired leaking fasteners per Learjet SRM 57-00-00.
3/31/23	18,915.4	Right hand hardpoint leaks through mounting screws. Resealed hardpoint fasteners per Learjet SRM Chapter 51.
3/31/23	18,915.4	Repair and alteration of left hand and right-hand wing ribs at Wing Station (WS) 181.
4/3/23	18,915.4	Removed left hand tip tank for other maintenance (FOM). Reinstalled left hand tip tank and performed ops and leak check IAW Learjet 35/36 MM Ch 28. No defects noted at this time.
4/3/23	18,915.4	Removed left hand aileron for FOM. Reinstalled left hand aileron IAW Learjet 35/36 Maintenance Manual (MM) Ch 27.
4/4/23	18,915.4	Left hand taxi/landing light inoperative. Removed and replaced left-hand taxi light. Operational check good.
4/4/23	18,915.4	RECOG light inoperative. Replaced RECOG light. Operational check.
4/4/23	18,915.4	Right hand taxi/landing light inoperative. Removed and replaced left-hand taxi light. Operational check good.
4/4/23	18,915.4	Removed right hand aileron for FOM. Reinstalled right hand aileron IAW Learjet 35/36 MM Chapter 27.
4/4/23	18,915.4	Removed right hand tip tank for FOM. Reinstalled right hand tip tank and performed ops and leak checks IAW Learjet 35/36 MM Chapter 28. No defects noted at this time.
4/4/23	18,915.4	Upper beacon light inoperative. Replaced upper beacon light assembly IAW Learjet 35/36 MM Chapter 33.
4/4/23	18,915.4	Inspect battery installation as follows battery cases for condition and that lids are properly secured, structure under batteries for traces of electrolyte or corrosion, batter vent tubes for kinks, obstructions and security of attachment vent fit and inlet and outlet fittings for obstructions corrosion and security of attachment.
4/4/23	18,915.4	Check engine fire extinguisher container pressure gauge for proper pressure and plumbing for condition and security. Complied with fire bottle pressure gauges inspection IAW Learjet 35/36 MM Chapter 26.
4/4/23	18,915.4	Drag chute and cannister due 6-month inspection. Removed and replaced drag chute and canister IAW Learjet 35/36 Chapter 26.
4/4/23	18,915.4	Performed 3 month/100-hour inspection emergency power supply IAW Learjet 35/36 MM Chapter 05

4/4/23	18,915.4	Left hand battery case swelled during top charge. Removed and replaced left hand battery IAW Learjet 35/36 MM Chapter 24.
4/4/23	18,915.4	Left hand jettison valve inoperative. Replaced ground wire at ground ref 27 IAW Learjet 35/36 IAW Chapter 20 performed operations check IAW Learjet 35/36 MM Chapter 28. No defects noted at this time.
4/20/23	18,922.1	Fuel crossflow light remains on with switch in open position. Performed operational test of fuel transfer IAW Learjet 35/36 AMM Chapter 28. Operational test good, no faults found.
4/20/23	18,922.1	Left fuel computer roll back. Turned on at FL300, reset at a lower altitude. Downloaded left fuel computer IAW Honeywell Service Bulletin (SB) TFE731-76-3067, buffer full. No faults noted.
4/28/23	18,929.0	Replaced pitch servo actuator for autopilot.

2.0 Wreckage Examination

The Airworthiness Group examined the wreckage two times⁶, first on December 6, 2023, and then on October 30-31, 2024. During both examinations the wreckage was entirely laid out. It was estimated that approximately 40% of the airplane had been recovered and was available for examination (Figure 2).

⁶ The salvage operation and Sherri's Department documented the condition of the wreckage on the seabed and during recovery using video.

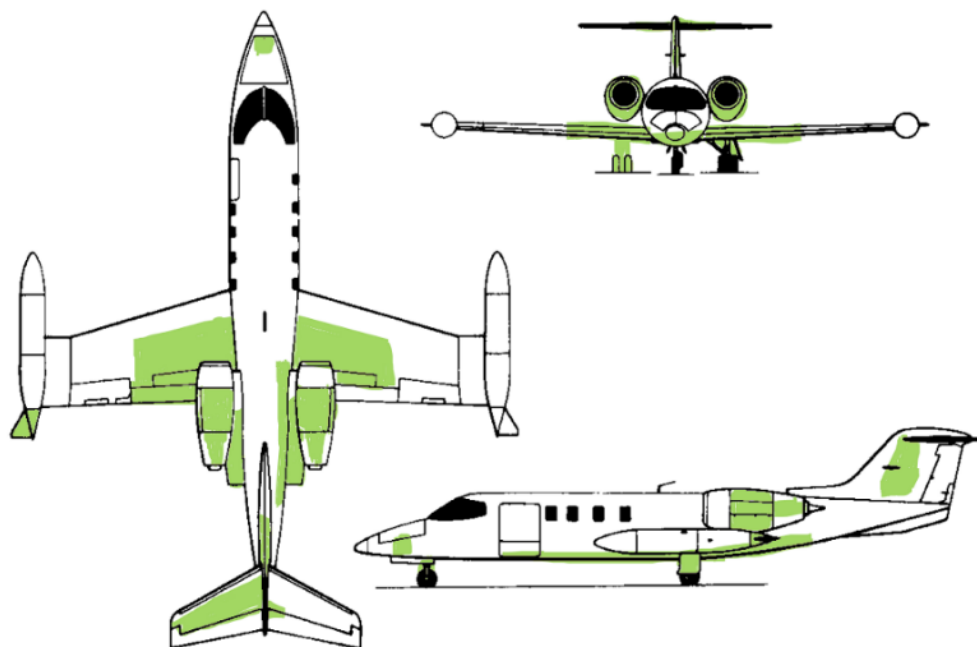


Figure 2. A 3-view diagram of the airplane. Areas shaded in green represent the portions of the airplane wreckage that was recovered and examined.

2.1 Cockpit

The cockpit structure was completely fragmented. Some cockpit instrumentation was recovered for examination (Table 3).

Table 3. Summary of cockpit instrument readings.

Instrument	Condition/Reading
Radio Deviation Indicator	Unreadable
Radio Deviation Indicator	200°
Engine 1 Turbine Temperature	944°C
Engine 1 Fan Speed	999.7%
Engine 2 Turbine Temperature	822°C
Engine 2 Fan Speed	000.0%
Radio	0953.00
UHF Radio	2795.50 MHz (megahertz)
Trim switch panel	Fragmented
Radio Altimeter	Unreadable

Attitude Gyro	Destroyed
Radio Mixing Panel (x2)	Various switch/dial settings
NXT 700 Data Link Transponder (x2)	NXE02168 and NXE02232 Crushed
ACASII/TACSII Processor	Crushed
Air to Air TACAN Controller	048
Autopilot HDG & CRS control panel	No values displayed
Standby Attitude Gyro	80° right roll, 50° nose down
Pressurization panel	AC (Aircraft) Altitude setting 34,000 feet Differential Pressure 7,200
Cabin Vertical Speed Indicator (VSI)	Needle broken off.
Rudder Trim	One needle width left of center
Roll/aileron trim	Pointer over LWD marking, other needle 180° to the other side above the RWD marking
Transmitter/Main Receiver Box (x2)	Impact damaged
Copilot's circuit breaker panel	Fragment

2.2 Structure

The wreckage consisted of remnants of the cockpit including pilot and copilot seats, various instrumentation, control wheel, and the copilot side rudder pedals. The belly skin from behind the cockpit to the forward wing spar with interior floor and seat track structure was attached. Fuselage structure above the cabin floor was not recovered for examination including the fuselage nose, the cockpit window, and all the upper half of the fuselage structure (crown). One cabin window was recovered. Figure 3 is an exemplar view of the aft equipment bay (tailcone) with the following important features labeled; rear engine mount beam, hydraulic reservoir, left and right motive fuel valves, fire bottles, and the fuselage fuel tank aft bulkhead. Fragments of the forward pressure bulkhead were identified (Figure 4), and the entire rear pressure bulkhead was present. Portions of the fuselage fuel tank structure with fuel bladders were present back to the aft fuel tank bulkhead (Figure 5). Both the left and right fuel motive valves had remained attached to the bulkhead. The upper left corner of the fuselage fuel tank aft bulkhead exhibited damage consistent with extreme sustained localized thermal damage (Figure 5 and 6) which is also in the vicinity of the left motive fuel line (see Section 2.5).

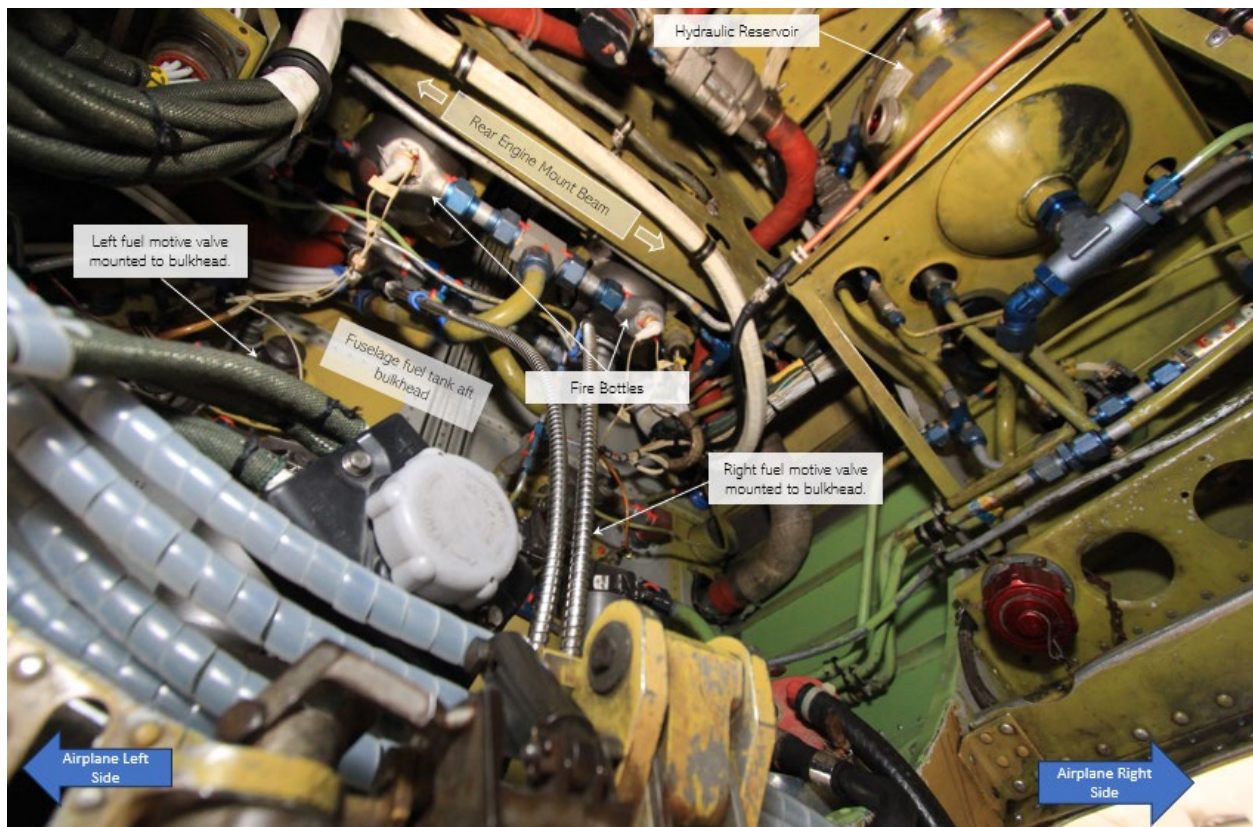


Figure 3. Exemplar view of the aft equipment bay / tailcone area.



Figure 4. Aft pressure bulkhead.

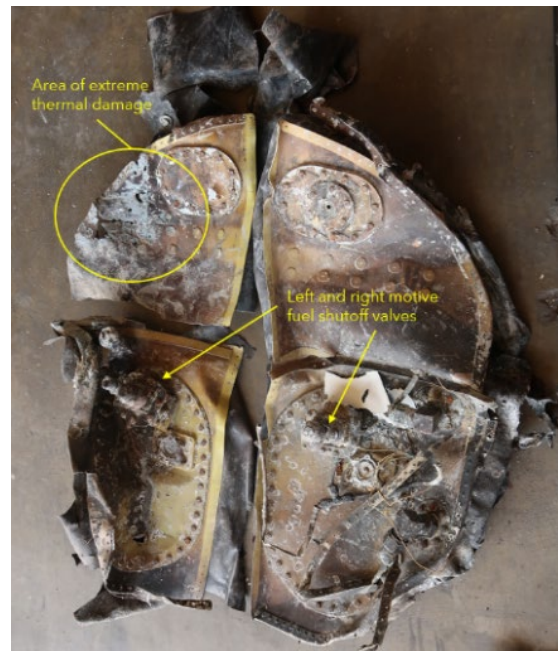
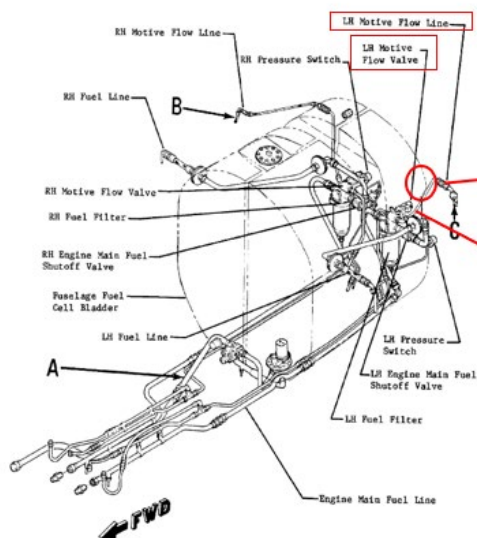


Figure 5. Fuselage fuel tank aft bulkhead.



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Distribution System Locator
Figure 5 (Sheet 1 of 3)

EFFECTIVITY: 35-002 AND SUBSEQUENT

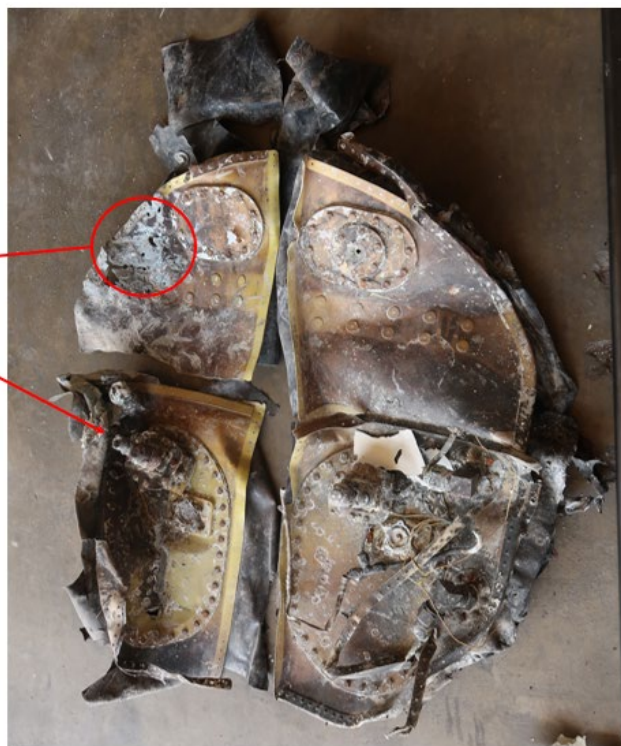
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Figure 6. Illustration of the fuselage fuel tank and system components relative to the fuel tank aft bulkhead (figure source: Learjet 35A, MM 28-20-00).

The aft equipment bay (tailcone) right side fuselage structure had heat/fire damage, the left side of the equipment bay was not present, and the entire fuselage structure aft of the avionics bay was not present. The aft half of the right-side engine mount fairing remained attached to fuselage skin. A 6-foot vertical center section of the vertical stabilizer was present, the left horizontal stabilizer remained partially attached to the vertical stabilizer, the right horizontal stabilizer and both elevators were missing (Figure 7). The horizontal stabilizer trim jack screw was attached to the vertical stabilizer structure and the leading edge portion of the horizontal stabilizer. The trim jack screw was extended centimeters (2.76 inches) measured from the end of the cylinder to the center of the screw rod end eye (Figure 8). The measurement is consistent with full nose down trim⁷. The interior of the vertical stabilizer was coated in black soot (Figure 9).

⁷ Bombardier 5/14/2024 email to the NTSB: "The screw attaches to the stab forward of the pivot point, so when it's fully extended, the stab is leading edge full up, which would be full nose down trim."



Figure 7. Vertical stabilizer (upside down)



Figure 8. Elevator trim jack screw.

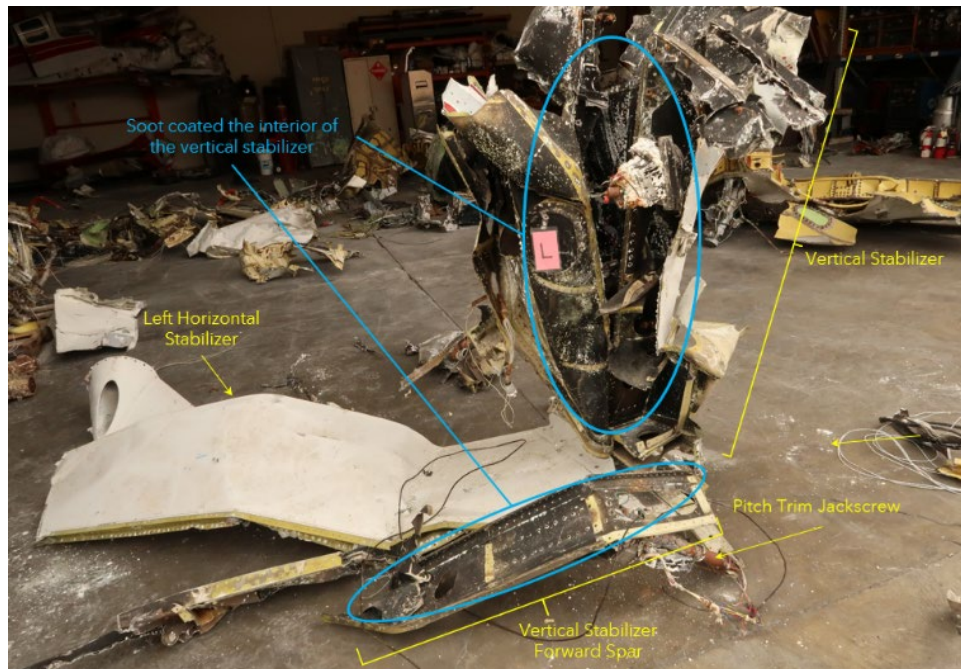


Figure 9. Airplane wreckage tail section (upside down).

Both left and right wings sections from the wing root to the outboard end of each flap, and the wing spar carry-through were examined. Both wing structures outboard of the flaps were not present. Both flaps were retracted into the wing flap channel and appeared to have been in the retracted position at the time of wing fragmentation. Soot and thermal heat damage was observed on the inboard root sections of both wings and on the wing spar carry-through. Thermal heat damage and soot deposition existed on the inboard half of each wing flap. Thermal heat damage and extensive soot deposition was evident on the keel beam section and the inboard landing gear doors (Figure 10).



Figure 10. Composite image of both wing sections joined by the wing spar carry through.

Both main landing gear and outer gear doors were present, the right-wing main landing gear remained attached to the wing, while the left-wing main landing gear had separated. The main landing gear door actuators were fully extended. The main gear doors had separated with a portion of the underwing beam structure, which had soot discoloration on the interior, and black longitudinal soot streaks on the exterior. The gear doors were mostly undamaged, the door hooks were undamaged and had no unusual witness marks. These landing gear components are consistent with the landing gear having been "blown down" using the emergency pneumatic (nitrogen charge) system.

Both engines were recovered and were found separated from the airframe. Both engine forward and aft engine mounts exhibited fracture and fragmentation features consistent with overload.

Fire and heat damage was concentrated in the vicinity of the aft equipment bay (tailcone), aft portion of the fuselage fuel tank, both wheel well areas and the inboard section of both flaps (Figure 11).

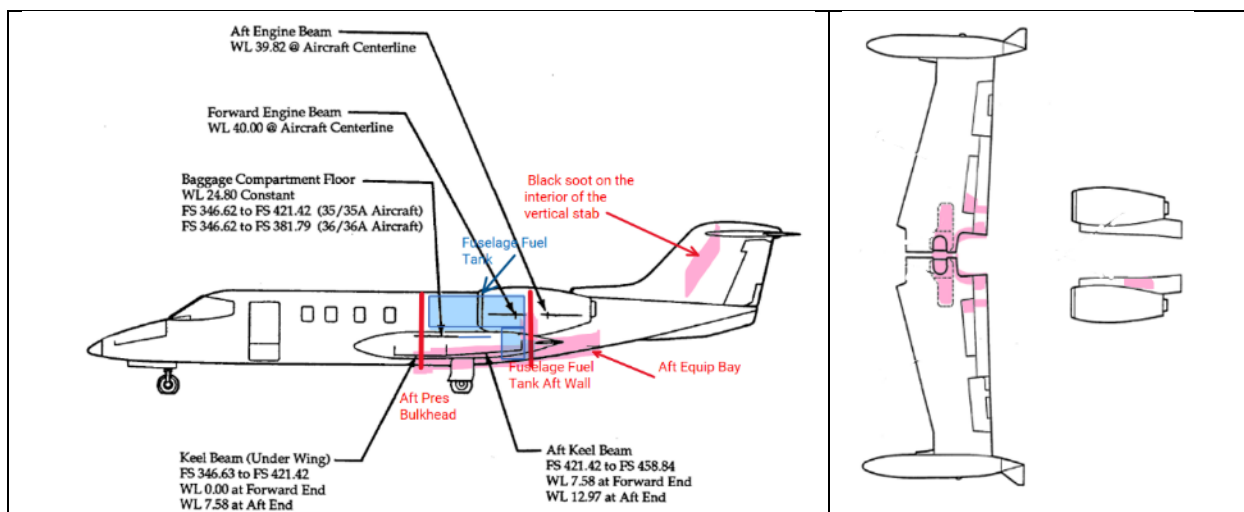


Figure 11. Diagram showing areas of fire/heat damage. (Diagram source: Learjet 20/30 Series Structural Repair Manual)

2.3 Engine Pylons

The principal structure of the engine nacelles consists of the nose section, upper and lower cowls, and the aft section. The complete nacelle assembly is cantilevered from the pylon by engine support fittings, and structural carry-through fittings that extend inboard from the nacelle, through the pylon, and attach to the fuselage assembly⁸. The aft engine beam and carry-through is located just aft of the fuselage fuel tank aft bulkhead. Engine accessory lines and connections such as the fuel line, hydraulic pressure and return lines, motive flow fuel line, bleed air, hydraulic pump case drain line, fire extinguishing agent plumbing, and PT2 line are connected via fuselage fittings between the forward and aft engine beams (Figures 12 and 13). Engine wire circuitry wires are bundled together (engine harness) and pass from the nacelle into the aft equipment bay (tailcone) via a bulkhead connector to the interior of the aft equipment bay. The ITT, N1 monopole, and fire loop wires are bundled together and pass through the interior of the aft engine beam.

⁸ Learjet 20/30 Series Structural Repair Manual, 51-00-00

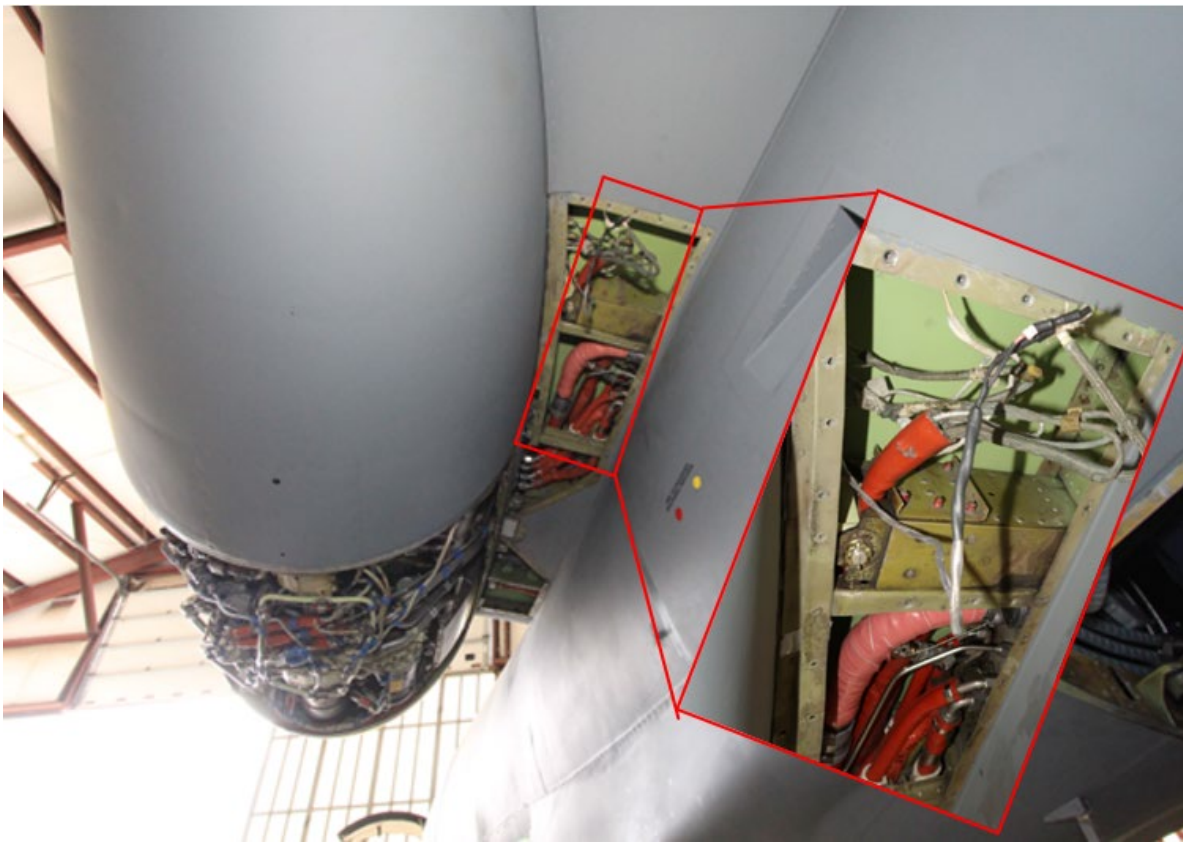


Figure 12. Exemplar photo of the left engine pylon and associated engine service connections. See figure 13 for connection details.

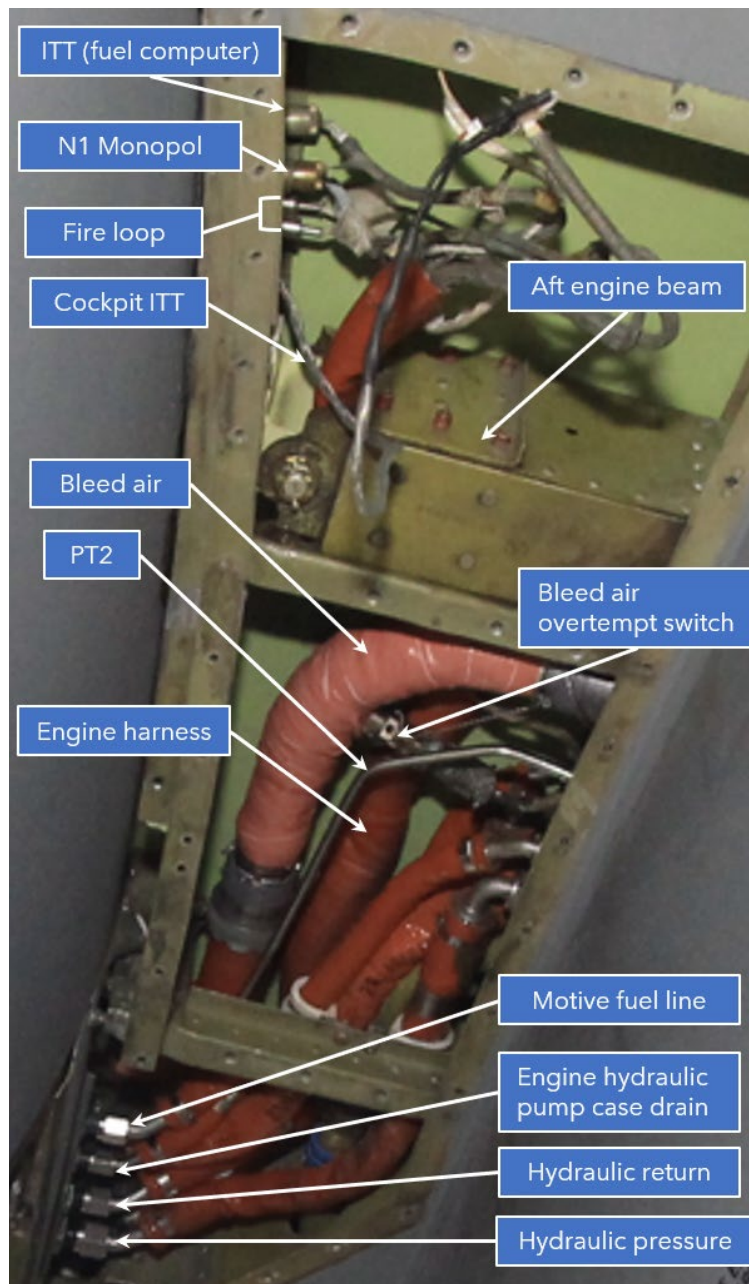


Figure 13. Left pylon engine service connections.

Examination of the left and right rear engine beams showed an asymmetric material condition between the two. The left engine beam exhibited beam deformation, extreme thinning of the upper beam plate, moderate thinning of the forward plate, and unpainted surfaces with corrosive deposits (Figure 14). The thinning of the left engine beam plates presented an eroded appearance with similar characteristics as to what was observed on the upper left portion of the fuselage fuel tank aft bulkhead.

The right engine beam retained its box structure, paint was present on all beam surfaces with minor amounts of corrosive deposits (Figure 15)



Figure 14. Left rear engine mount beam.



Figure 15. Right rear engine mount beam.

2.3.1 Examination of the left pylon engine service connections

The fuel motive flow line was traced from the engine fuel pump to the fuselage fitting. The line enters the aircraft fuselage in the upper left quadrant of the aft equipment bay (tailcone). The fuel line was intact and covered with fire protective sleeve up to the fuselage skin and attached to the fuselage fitting. The fuselage fitting on the aft equipment bay (tailcone) side did not have a b-nut attached nor the line that should extend to the motive flow valve (Figure 16).

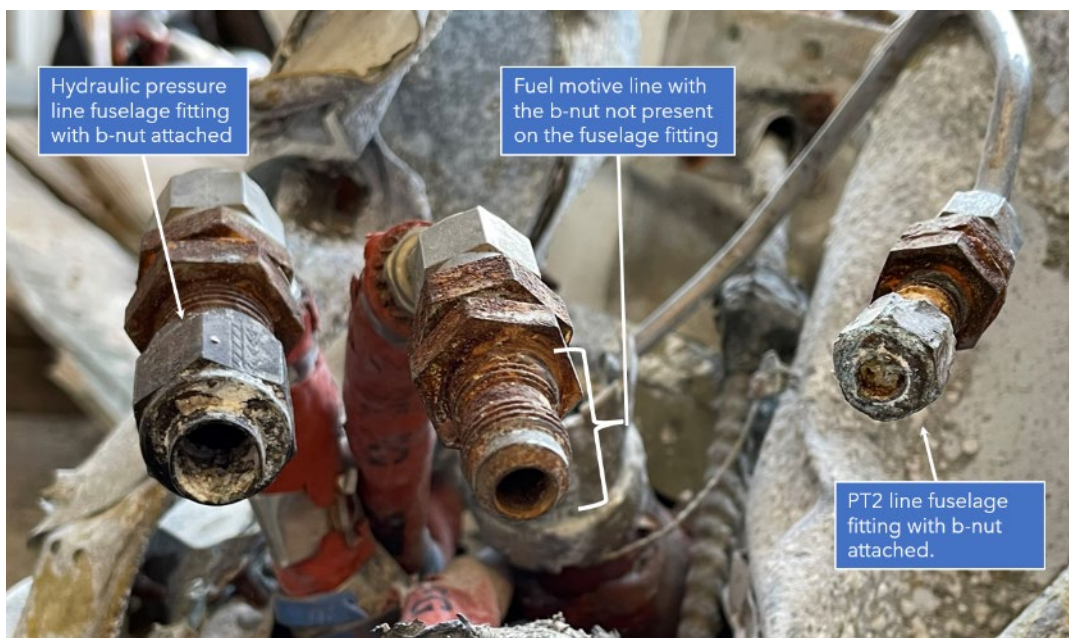


Figure 16. Left engine service connections and fuselage fittings.

The left engine hydraulic pressure line was traced from the engine driven hydraulic pump to the fuselage skin fitting. The line was covered in the fire protective

sleeve. The fuselage fitting enters the fuselage in the upper left quadrant of the aft equipment bay (tailcone). The fuselage fitting on the interior of the aft equipment bay (tailcone) had a b-nut attached and the hydraulic line had sheared off at the end of the b-nut and was not recovered by investigators.

The left engine PT2 line was traced from the left engine to the fuselage skin fuselage fitting. The fuselage fitting enters the fuselage at the upper left quadrant of the aft equipment bay (tailcone). The fuselage fitting on the aft equipment bay (tailcone) side had a b-nut attached, the line extending from the b-nut was sheared off and not located by investigators.

The two other lines that entered the fuselage from the left engine were the hydraulic pump case drain and the hydraulic return line. Both were in similar condition as the others with b-nuts attached to each fuselage fitting but missing the connecting tubing.

Engine wire circuitry associated with the left engine pylon was found to have a few wires that exhibited beads of resolidified molten copper. No such beads were found on other wiring (Figure 17).

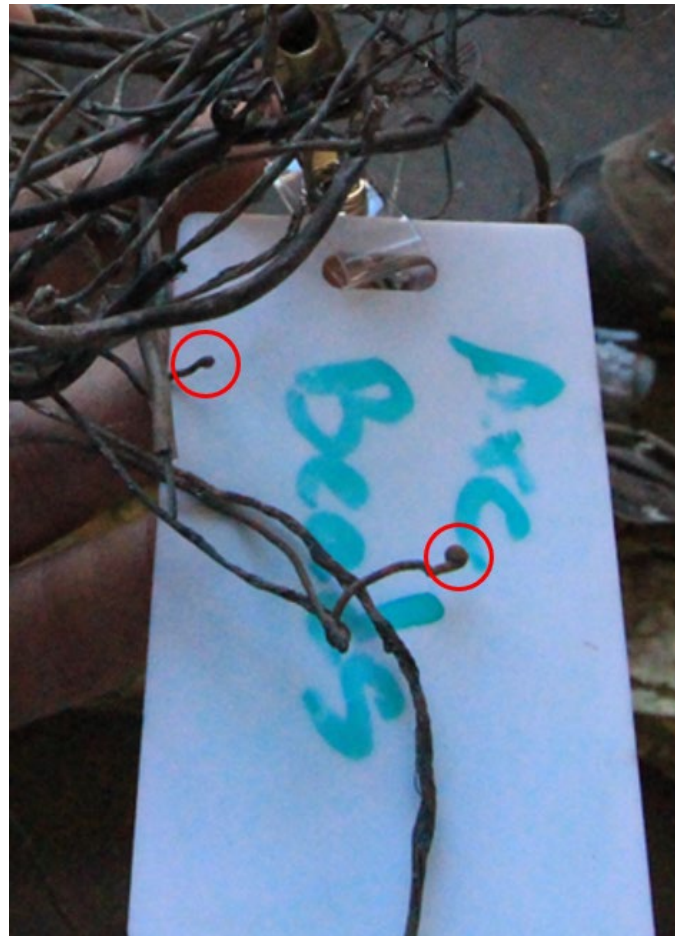


Figure 17. Resolidified molten copper beads circled in red.

2.3.2 Examination of the right pylon engine service connections

The engine service connections were traced from the nacelle side to their fuselage fittings. The corresponding connections in the interior of the equipment bay were not located for examination. The PT2 line with its fuselage fitting had separated from the fuselage skin and was missing the interior side b-nut.

2.4 Hydraulic System⁹

The hydraulic system supplies military standard hydraulic fluid (MIL-H-5606) under pressure of approximately 1,450 psi to the brake, landing gear, flap, and spoiler systems.

Hydraulic fluid for systems operation is supplied from a reservoir through hydraulic supply shutoff valves to the engine-driven hydraulic pumps. The hydraulic reservoir is pressurized to approximately 20 psi by a pressure regulator. The pressure regulator is installed in a line from the bleed air duct to the reservoir. The engine-driven hydraulic pumps supply hydraulic fluid under pressure through check valves and a filter to the hydraulically operated systems upon demand (Figure 18).

⁹ System description extracted from the Learjet 36A Maintenance Manual, 29-00-00

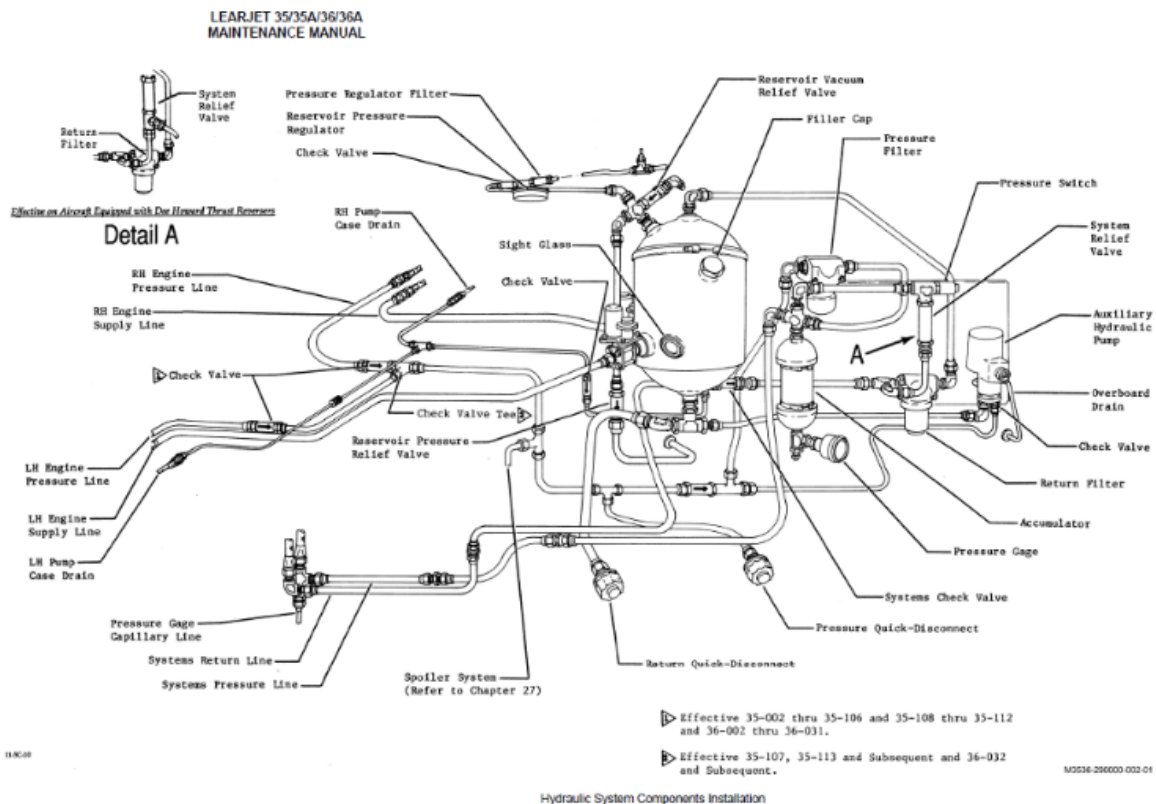


Figure 18. Hydraulic system diagram. (Diagram source: Learjet 35A Maintenance Manual 29-00-00)

2.4.1 Hydraulic System Examination

The main hydraulic system components were examined. The components consisted of the hydraulic reservoir, accumulator, pressure filter, return filter, and auxiliary hydraulic pump (Figure 21). Both the pressure filter and return filter elements were disassembled and examined for metallic particles. Both filters were clear of debris when examined visually. The input ports of both left and right hydraulic shut off valves that were attached to the hydraulic reservoir were probed and found that the left valve was in the closed position and the right valve was in the open position. The reservoir tank was deformed inwards (crushed). The quadrant of the tank that faced inward to the equipment bay compartment exhibited substantial heat damage, while the half that was up against the fuselage and the quadrant that faced aft was undamaged by heat (Figures 19 and 20).



Figure 19. Hydraulic reservoir, inward facing quadrant.



Figure 20. Hydraulic reservoir outboard and aft facing quadrants.

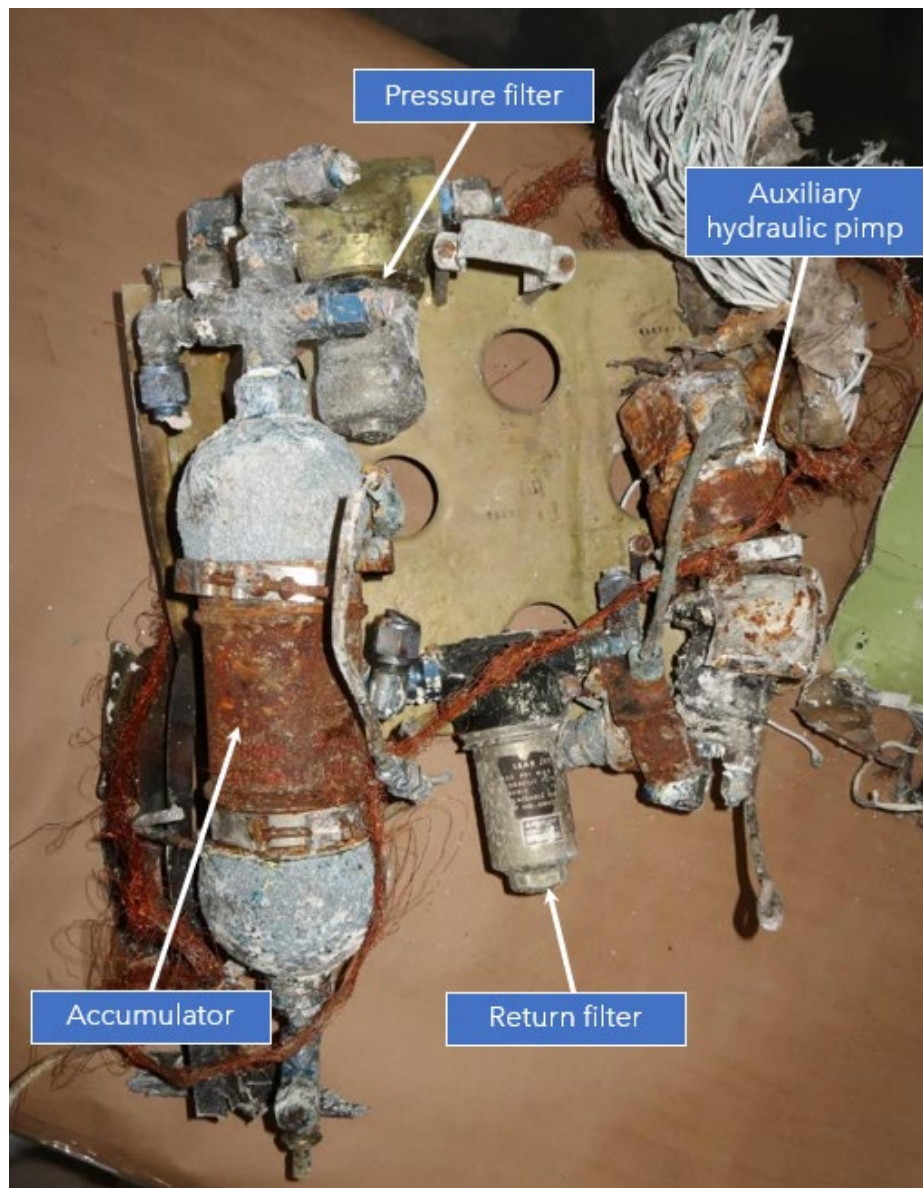


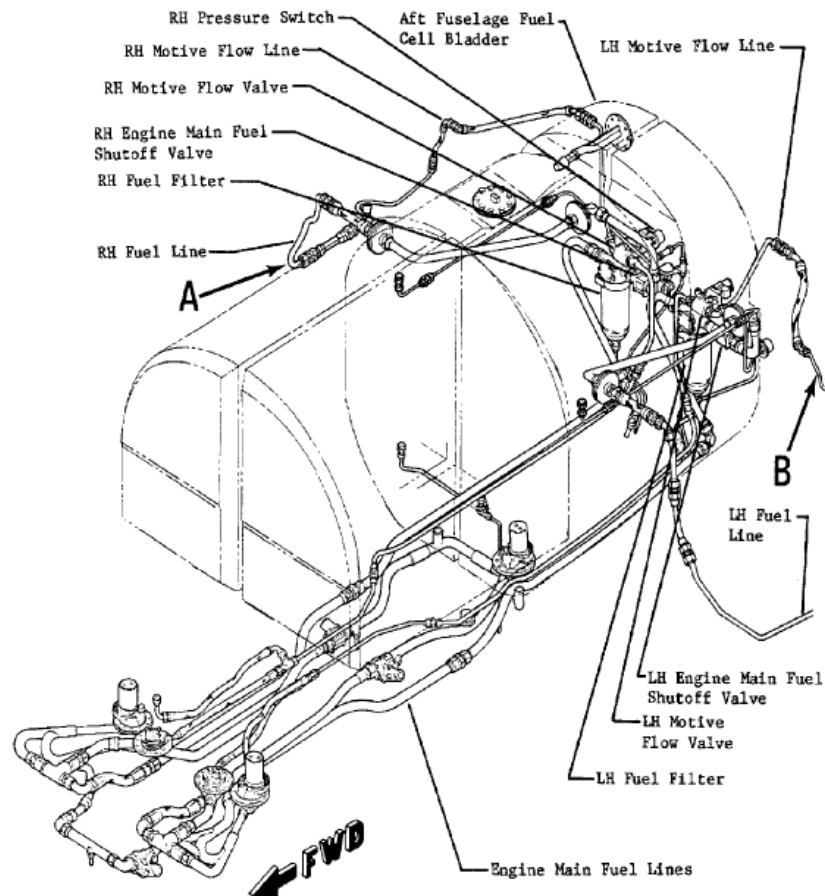
Figure 21. Hydraulic system accumulator, pressure filter, return filter, and auxiliary hydraulic pump.

2.5 Fuel System¹⁰

The fuel distribution system (Figure 22 and 23) consists of two independent systems, one for each engine. Each distribution system consists of a jet pump, an electric standby pump, a fuel filter, a shutoff valve, a motive flow valve, a pressure switch, a relief valve, relays in the fuel control relay panel, and fuel supply line check valves. The motive fuel line is pressurized between 250 psi and 300 psi depending on altitude and engine power setting. The jet pumps operate from the high pressure motive fuel flow directed through a nozzle in the jet pump, which then draws fuel from the tank. A jet pump is installed in each distribution system. The jet pump is

¹⁰ System description extracted from Learjet 36A Maintenance Manual 28-20-00.

located near wing station rib station 0.0 so that it will be submerged in fuel until the tanks are practically empty. An electric standby pump is installed in each distribution system. The pump is located adjacent to the jet pump. A low-pressure fuel filter is installed in each main fuel line within the tail cone. Each distribution system incorporates a fuel shutoff valve. The shutoff valves are located adjacent to the fuel filters. The shutoff valves are two-position (open and closed) ball-and-seat type and are electrically operated. Each distribution system incorporates a motive flow valve. The valve is installed on the aft fuselage fuel tank wall above the fuel filters. The valves are two-position (open and closed) rotary actuator type and are electrically operated. The fuel control relay panel is located on the right-hand electrical equipment tray. The electrical equipment tray is located on the right-hand side of the tail cone. The fuselage tank consists of four bladder-type cells located in cavities between fuselage frames 18 and 25. The cavity incorporates four drain ports; two are located in the forward cavity area and two in the aft cavity area.



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Distribution System Locator

Figure 22. Fuselage fuel tank and system components diagram. (Diagram source: Learjet 35A Maintenance Manual 28-20-00)

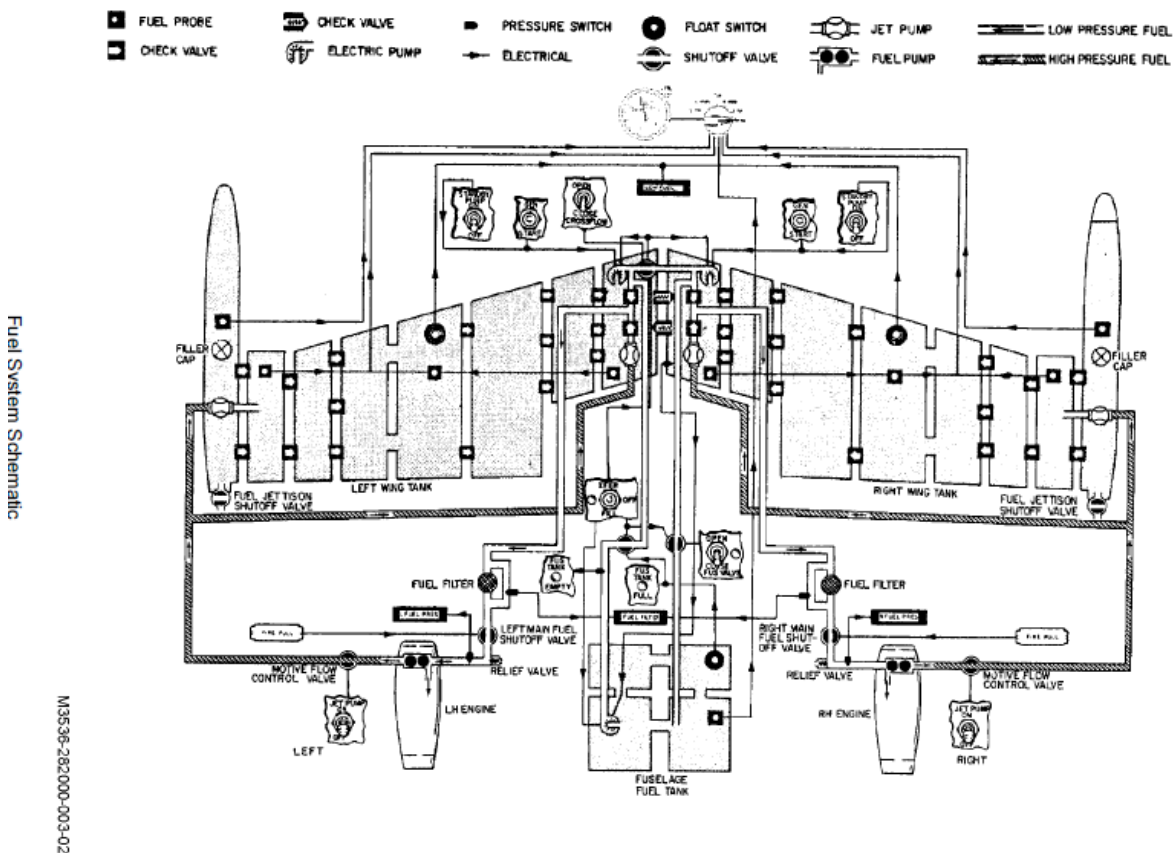


Figure 23. Diagram of the fuel distribution system diagram. (Diagram source: Learjet 35A Maintenance Manual 28-20-00)

2.5.1 Fuel System Examination

Fuel tanks outboard of the flaps (including tip tanks) were not present with the wreckage. Both left and right inboard sections of the wing fuel tanks were breached, with the lower wing panels having been separated in overload from the upper wing structure. The fuselage fuel tank was fragmented, with portions of the fuel bladder material attached to the aft pressure bulkhead, fuel tank divider panels, and fuel tank aft bulkhead. The fuselage fuel tank aft area, up against the aft bulkhead, and aft area bladder portions appeared to have heat damage. The forward section of the fuselage fuel tank up against the pressure bulkhead had no heat damage.

The right-side fuel filter (Figure 24) with attached fuel lines was recovered with the wreckage, the input fuel line was sooted. The soot stopped at the connection to the fuel filter manifold. The fuel shutoff valve on the other side of the filter was impact damaged but did not appear to have heat or soot damage, and the valve was in the open position. The left side fuel filter and shutoff valve were not found.

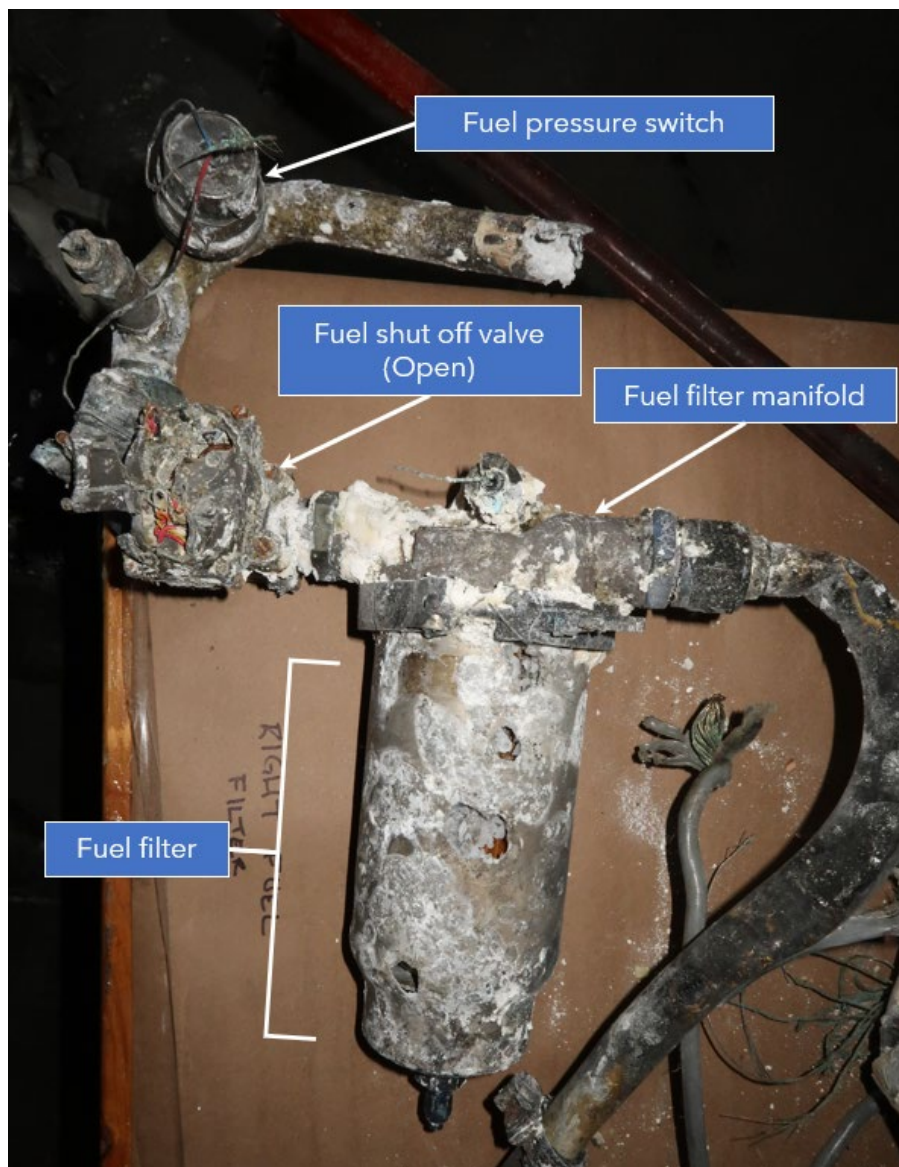


Figure 24. Right side fuel filter and shutoff valve.

The fuselage fuel tank fuel quantity indicator tube was found to have soot deposits on it (Figure 25).

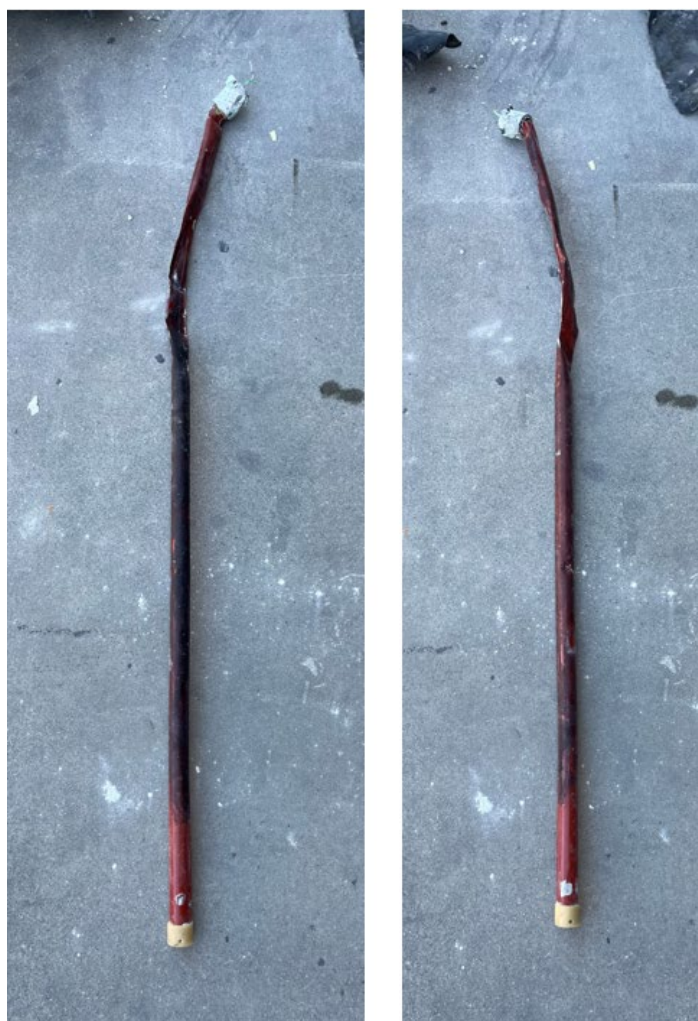


Figure 25. View of both sides of the fuselage fuel tank fuel quantity indicator tube.

2.6 Flight Control System¹¹

Dual cockpit control wheels operate the elevator and ailerons mechanically through a system of pulleys, push-pull tubes and bell cranks. Switches, controlling trim functions, microphone keying and autopilot release/nose steering, are installed on each control wheel. The rudder pedals operate the rudder for directional control through a system of cables, pulleys, and bell cranks. Nose wheel steering is electronically controlled by the pedals. Brakes are applied by pressing on top of the pedals.

The flap control switch is located on the center pedestal and labeled UP-FLAP-DN [down]. The switch controls a solenoid which positions the flap control valve to direct hydraulic fluid to the up or down ports of the flap actuators. The actuators rotate sectors which are mechanically connected to the flaps to raise or lower the flaps. Interconnecting cables attached to the flap sectors synchronize flap travel. An

¹¹ System description extracted from the Learjet 35/36 Pilot's Manual, Section 2.

aural warning system is connected to the flaps and landing gear. With flaps extended 20° to 25° an aural warning will sound until the landing gear is down and locked.

The flap control valve is a hydraulic, solenoid activated, 4-way, 2 position valve, that is mounted on the upper surface of the wing spar carry through. It receives hydraulic pressure from the aircraft's hydraulic system and is commanded electrically from the cockpit. When the valve solenoids are de-energized the valve is in the closed position. The o-ring seals (packing) internal to the valve seals the various interior chambers within the valve. The o-rings material specification is Military Standard (MS) MS28774. MS28774 is a rubber butadiene-acrylonitrile class NBR (nitrile butadiene rubber) with a designed operating temperature range between - 65°F to 275°F.

Spoilers are used for aileron augmentation anytime flaps are extended 25° or more and the spoiler switch is set to RET. At flap extension of 25° or more the spoileron computer amplifier actuates the spoiler-control valve and the spoiler servo valve. As one aileron moves up, the servo valves are actuated and the spoiler on the same wing as the raised aileron will rise at a 1:1 ratio with the aileron to a spoiler limit of 15°. The spoiler switch will override the spoileron mode of operation and the augmentation mode is automatically disengaged when flaps are retracted above 25 degrees.

The spoiler control switch is located on the center pedestal and is labeled SPOILER with two positions EXT [extend] and RET [retract]. When in the EXT position a solenoid operated valve opens and extends both spoilers to 40°. Anytime the spoilers are released from their retracted position, the red SPOILER light on the readout panel will light.

2.6.1 Flight Control Examination

The severe fragmentation of the airplane prevented the thorough confirmation of control continuity for all control surfaces. However, all control cables that were examined had overload separations, the aileron sector cables were attached, and cable runs/guides in the tail section for the elevator showed deformation consistent with the cables being present at the time of aircraft fragmentation.

The hydraulic flap control valve was not located in the wreckage. The flap control valve mount on the upper surface of the center wing spar showed an outline of where the control valve had been attached. The flap actuator extension¹² on each wing was measured from the center of the cylinder body attachment bolt to the center of the piston rod end bolt. The left flap actuator measured about 13.5 inches, and the right flap actuator measured about 13.4 inches. Per the maintenance manual,

¹² The flap actuator is hydraulic, and its position could be affected by impact forces or post-accident wreckage movement.

full retract of the actuator is 12.95 ± 0.010 inches, full extension is 19.12 ± 0.010 inches.

The spoiler control valve remained attached to the upper surface of the center wing spar. It was sooted and heat damaged. The control valve was removed from the wing spar. Low pressure air was passed through the valve via the 'PRES' [pressure]port and observed to exit the 'CYL 1' [cylinder 1]port.

2.7 Electrical System¹³

The direct-current (DC) generator system consists of a 30-volt 400-ampere, air-cooled, brushless-type generator installed on each engine. Additional components are a generator control box, two voltage regulators, two voltage regulator control relays, a paralleling protection assembly, two 10-ampere current limiters, two DC ammeters, a DC voltmeter, two system switches, two generator reset switches, two generator caution lights and a generator warning control box. The paralleling protection assembly is installed in the aft equipment bay (tailcone). The 10-ampere current limiters are installed on each generator. The DC generator system also consists of two system switches and two generator reset switches located on the instrument panel. Two amber generator caution lights are located on the glareshield in the cockpit.

The generator control box (Figure 26, installed in the tailcone on the left-hand side, serves as the central control unit for the DC electrical system. The generator control box incorporates the battery, external power, right and left starter and generator control, overvoltage control, warning light, and paralleling control relays. Battery, external power, starter, and generator outputs are connected to the generator control box from which DC power is distributed through current limiters and circuit breakers to the various electrical systems. Two solid state voltage regulators are installed in the tailcone. The regulators maintain a constant output voltage under varying engine speeds and load conditions by automatically adjusting the generator field current.

An alternating-current (AC) generation system is installed to provide 115-VAC [voltage AC] 400-hertz to various using systems. Two autotransformers provide 26 VAC for various using systems. The system consists of two static inverters, a paralleling control box, two overload sensors, two power relays, an AC voltmeter and switch, two control switches, and two red warning lights.

2.7.1 Electrical System Examination

The electrical distribution system was highly fragmented. The generator control panel (Figure 26) was recovered with the wreckage. The panel was deformed

¹³ System description extracted from Learjet 36A Maintenance Manual, 24-20-00 and 24-31-00

by impact forces and had evidence of exposure to high heat. The generator control panel exhibited thermal damage and charring of the phenolic backer board it was comprised of. On the forward section of the phenolic board the thermal damage was more severe. The power distribution panel would be located on the left side adjacent to the access hatch. Figure 27 depicts the generator control panel as found in the wreckage.

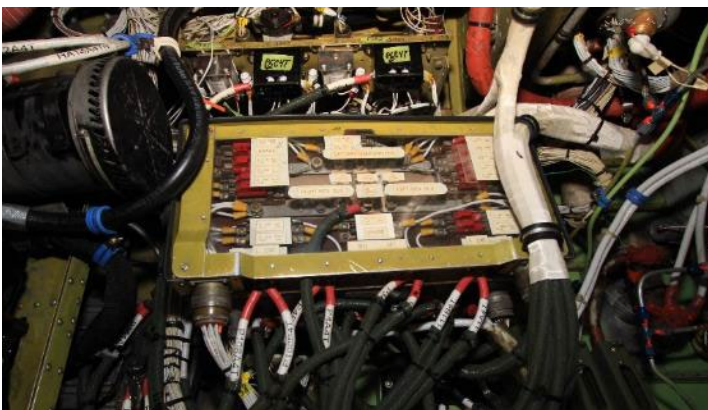


Figure 26. Exemplar photo of the generator control box/panel.



Figure 27. Recovered generator control panel.

2.8 Mission Equipment

The airplane was equipped with under wing external stores hardpoints, supplemental type certificate (STC) SA1670CE, and the installation of the RM-30A Reeling Machine Target Tow System and other underwing stores (STC ST00102WI). Mission equipment power is provided by the 30-volt 400-ampere aircraft DC electrical system to the J-box (Figures 28 and 29), located immediately forward of the aft pressure bulkhead and tied into the generator control box in the aft equipment bay (tailcone).



Figure 28. Exemplar photo of the mission equipment J-box located in the very aft area of the airplane cabin. (Source: Phoenix Air Group)

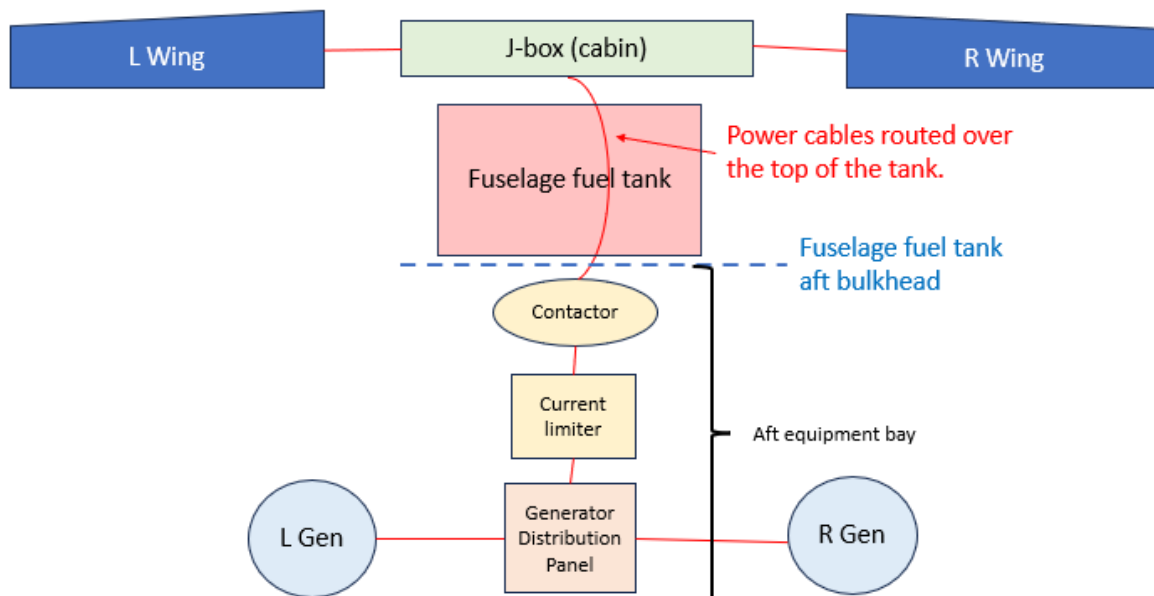


Figure 29. Mission equipment basic power distribution diagram.

2.8.1 Mission Equipment Examination

The mission equipment wiring was traced. Power for the mission equipment comes from the generator control box. Two heavy gauge insulated cables (white) come from the generator control box to a current limiter and a contactor. The contactor is controlled by the crew. When in the engaged (ON) position, power is routed to the J-Box in the main cabin. When in the open (OFF) position, power stops at the contactor. The mission equipment power cables were traced back from the J-Box to a location in the aft equipment bay (tailcone) and were a few inches from the contactor. There was no evidence of arcing or melting of the power cables that would be indicative of them being energized. The current limiter, contactor, and the mission wiring go from the generator control box to the current limiter and the contactor, were not located within the wreckage. The equipment and wire bundles in the J-box were undamaged by fire and exhibited no evidence of arcing. Wire bundles from the J-box are routed out to each wing. There was evidence of fire damage to the portions of wire bundles that were outside the pressurized fuselage in the wheel well area. The entire wheel well area had evidence of fire damage with black soot, heat deformed metal, and burned and melted wiring.

2.9 Fire Detection and Extinguishing System¹⁴

Engine fire detection sensing element assemblies (Figure 30) consist of three elements each. One element is secured around the tailcone with hinge-type clamps, another element is secured to a support tube on the accessory gear box with hinge-type clamps, and the third element is secured to the firewall with hinge-type clamps. The outer part of the element is constructed of Inconel metal tubing which encloses a thermistor core (a ceramic material) containing internal wires. The ceramic material has a negative coefficient of resistance with respect to temperature. The electrical resistance decreases as temperature increases. During normal ambient temperature, the core resistance is relatively high and there is small current flow across the core. An increase in heat produces a decrease in resistance of the ceramic material, allowing increased current flow. The control unit energizes the FIRE PULL warning light when the temperature in the accessory gearbox or firewall areas is approximately 410°F. The tail cone element temperature must reach approximately 890°F before the control unit energizes the FIRE PULL warning light due to normally higher temperatures in the area.

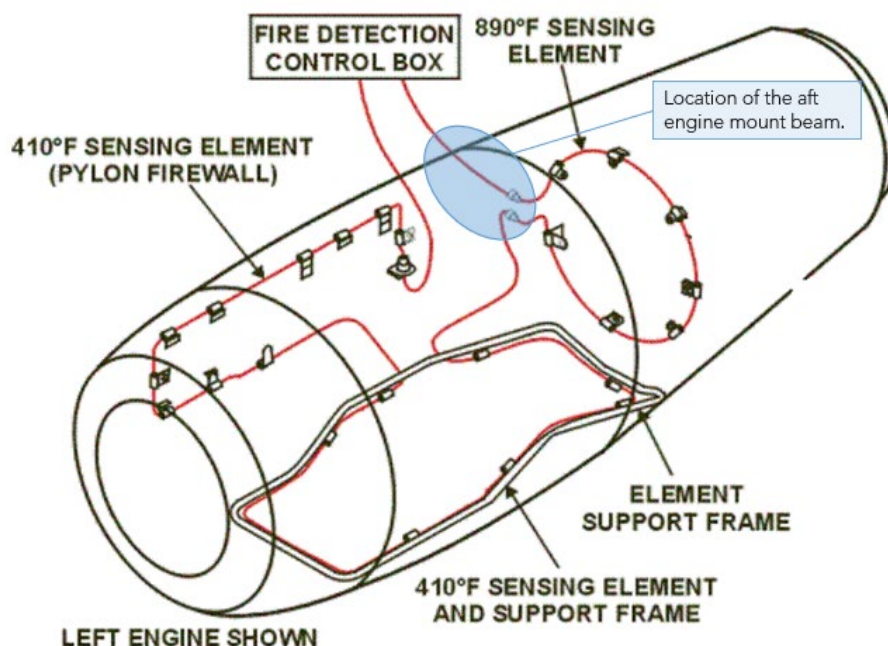


Figure 30. Fire detection loop positions within the engine nacelle. (Source: Phoenix Air Group)

The engine fire extinguishing system, installed in the tailcone equipment section, provides fire extinguishing capabilities for each engine nacelle. The system consists of the following: two bottles a thermal discharge indicator, a manual discharge indicator,

¹⁴ System description extracted from the Learjet 36A Maintenance Manual, 26-20-00 and 26-10-00

push-button type switches, pull-type fire switches, and two two-way check valves. Two engine fire extinguisher bottles are installed in the tail cone equipment bay. The bottles are charged with CF₃Br (monobromotrifluoromethane) extinguishing agent to a pressure of 600 psi. Pulling the left FIRE PULL Tee-Handle Switch closes the left engine main fuel shutoff valve, the left hydraulic shutoff valve, and the left bleed air shutoff and pressure regulator valve and lights the two ARMED switches just above the FIRE PULL Switch. Operation of the system for the right nacelle controlled by the copilots inboard and outboard ARMED Switches is the same. Figure 31 depicts the fire bottles as found within the wreckage.

2.9.1 Examination of the fire extinguishing system



Figure 31. Fire extinguishing bottles.

Both extinguishing agent bottles (Figure 31) were located within the wreckage. Both bottles were empty of contents, the pressure gages were damaged and unreadable, and both had some extent of mechanical deformation (crushing). When comparing the two bottles the left bottle appeared to have more extensive heat damage than the right bottle. Other components of the extinguishing system were not located or identified.

2.10 Powerplants¹⁵

The Gates Learjet 35 and 36 are powered by two Honeywell TFE 731 turbofan engines. The engines are two-spool geared transonic-stage, front-fan, jet engines rated at approximately 3,500 pounds thrust. A spinner hub and an axial flow fan, located at the forward end of the engine, are gear-driven by the low-pressure spool. The low-pressure spool consists of a four-stage low pressure axial flow compressor and a three-stage low pressure axial flow turbine, both mounted on a common shaft. The high-pressure spool consists of a high-pressure single stage centrifugal flow compressor and a high-pressure single-stage turbine. The high-pressure compressor and turbine are mounted on a common shaft. The high-pressure spool drives the accessory section. The spool shafts are concentric, and the low-pressure spool shaft passes through the high-pressure shaft. Engine hydromechanical fuel control is provided by an electronic fuel computer which responds to movements of the thrust lever to meter fuel to the engines. During normal operation, the fuel computer performs functions of speed governing and acceleration and deceleration limiting through electrical control inputs to the fuel control.

2.10.1 Engine Examination

Left Engine: Model TFE731-2C-2B, SN P-74358 (Figures 32 and 33).



Figure 32. Left engine side view



Figure 33. Left engine front view.

No evidence of fire damage was found. Several fan blades had separated at the blade root, while others had shifted aft in the fan disk. At least half of the fan blades were missing, and those present were bent in the opposite direction of rotation, with damage visible on the leading edges. Multiple slots in the fan disk were also damaged. The spinner and bypass vanes were missing. The compressor inlet vanes were damaged, with some sections entirely missing.

¹⁵ System description extracted from Learjet 35/36 Pilot's Manual, Section 1.

A borescope inspection of the first-stage compressor revealed leading-edge damage and bending of the blades opposite to the direction of rotation, along with the presence of earthen debris. The containment ring was deformed and detached from the front frame, no punctures or penetrations were identified. The front frame itself was fractured, with most of its material missing, and it had separated from the mount ring. The mount ring was deformed, with a 45°- arc separated from its flanges.

The bypass duct was severed aft of the forward flange, with half of its circumference missing. The air/oil cooler was intact and appeared undamaged, though covered in earthen debris. The aircraft engine mount points had separated from the aircraft mount structure and showed signs of corrosion. Portions of the aircraft mount structure, including a section of the engine beam, were detached from the engine but loosely connected by cables.

The airframe exhaust was crushed and deformed. During the wreckage examination, it was partially removed and cut to allow observation of the third-stage turbine and a section of the fuel manifold. The fuel manifold appeared intact and undamaged in the visible areas, though the fuel nozzles showed signs of corrosion. The third-stage low-pressure turbine (LPT) stator and rotor were intact and undamaged, though earthen debris was present. The turbine could not be manually rotated. The turbine housing remained intact but showed evidence of corrosion.

The accessory gearbox was not present. The fuel control and fuel pump remained assembled as a unit. The accessory housings were cracked and covered in earthen debris.

Right Engine: Model TFE731-2C-2B, SN P89674C (Figures 34 and 35).



Figure 34. Right engine side view.



Figure 35. Right engine front view.

Two fan blades remained installed but were bent in the opposite direction of rotation and showed leading-edge damage. Several fan blades had separated at the blade root, and most were missing. Some fan blade dovetails had shifted aft in the disk, and multiple fan disk slots were damaged. The spinner had separated

approximately two inches forward of the mounting flange. The bypass vanes were missing.

The compressor inlet vanes were crushed and deformed, with about 180° arc absent. Debris was present in the compressor. A borescope inspection of the first-stage compressor revealed the blades were damaged, with leading-edge wear and bending opposite the direction of rotation. Earthen debris was also observed. The containment ring was deformed and detached from the front frame, which was fractured, with most of its material missing.

The bypass duct had a circumferential crack over about 180°, just aft of the forward flange, and material was missing over approximately 120° near the aft flange. The aft flange itself was separated. The air/oil cooler was intact and appeared undamaged, though it was covered in earthen debris.

The aircraft engine mount points had separated from the aircraft mount structure and showed signs of corrosion. The mount structure remained attached to the fuselage. The airframe exhaust was crushed and deformed. During the wreckage review, it was partially removed and cut to facilitate observation of the third-stage turbine and a section of the fuel manifold. The fuel manifold appeared intact and undamaged in the visible portions, though the fuel nozzles showed signs of corrosion.

The third-stage LPT stator and rotor were intact and appeared undamaged, though earthen debris was present. The turbine could not be rotated manually, but the turbine housing remained intact. The bleed duct was crushed. The accessory gearbox was missing. However, the fuel control and fuel pump were still assembled and located in the aft fuselage section.

2.10.2 Digital Electronic Engine Control (DEEC)

The N1 Digital Electronic Engine Control (N1 DEEC) is a closed loop control that uses power turbine speed (N1) as the controlling parameter. The DEECs provide engine speed control through metering of the fuel flow via the torque motor of the fuel control unit (FCU). The controls also provide an automatic start sequence, over temperature, and speed protections. Surge free acceleration and deceleration are provided through the control of the surge valve. There are several controller interfaces. Electrical inputs from the engine and airframe come into the controller through the DEEC J1 connector. A PT2 port provides for pneumatic plumbing of inlet air pressure. Self-diagnostics transfer control to manual mode (hydromechanical fuel metering) if internal or external circuit fault is detected. A grounding circuit provides cockpit indication of the controller operation status. Each engine has a dedicated DEEC mounted in the tailcone of the airplane.

2.10.2.1 DEEC Examination

During the ocean recovery of the airplane wreckage, one N1 DEEC unit, S/N 105-CM0005, was recovered and was placed in deionized water for shipping to Honeywell, Phoenix, Arizona for data recovery.

The download of the incident recorder data and fault history data from the N1 DEEC was completed successfully. The DEEC data indicated that the subject N1 DEEC was associated with engine SN P74358. The engine was operating and responding to power lever angle (PLA) inputs and under N1 DEEC control until the PLA Circuit Failure fault occurred. The engine then appears to be operating in manual mode. The DEEC data ends prior to a recorded engine shut down. It is unknown if the end of the dataset corresponds with loss of N1 DEEC power prior to or corresponding to aircraft impact.

Data Summary:

1. The data recorded 5,120 seconds of data (about 85 minutes). The plot shows the cruise, descent, and landing from the flight prior to the accident and the full data recorded from the accident flight.
2. The accident flight dataset appears to start at approximately time stamp 1,980 seconds, determined by comparison with the Data File Chronology.
3. Throughout the accident flight until the fuel control unit (FCU) PLA Circuit Failure Fault (at approximately time stamp 50 seconds), the engine appears to be operating and correctly responding to PLA movements.
4. At time stamp 50 seconds through the remainder of the dataset, the N2 and PLA parameters indicate N2 Signal Fail and No Valid Data respectively. This coincides with faults indicating a failure of the FCU PLA circuit and the N2 Monopole Circuit being open or shorted.
5. When a FCU PLA Circuit Failure Fault occurs, the computer switches to manual mode (time stamp 50 seconds). When in manual mode, fuel is being metered solely by the FCU. Metering is based on fuel, P3, PLA input, and N2 speed. The PLA input is a mechanical connection to the fuel control through push/pull links and flexible cables. The mating of the fuel control to the fuel pump provides for the fuel supply and return and the mechanical N2 speed. The FCU PLA circuit and N2 monopole circuit faults would not prohibit engine operation in manual mode.

The slow scan event data was reviewed. The ITT datapoints are consistent with the expected ITT values for the recorded N1 speeds. The PLA and N2 data are

consistent with the expected values for the recorded N1 speeds up until the final twenty seconds of data, consistent with the introduction of circuit faults.

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