NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Aviation Engineering Division
Washington, DC 20594

August 3, 2009

AIRWORTHINESS GROUP CHAIRMAN'S FACTUAL ADDENDUM ENGINES AND THRUST REVERSERS

A. **ACCIDENT:** DCA08MA098

LOCATIONS: Columbia, South Carolina

DATE/TIME: September 19, 2008

AIRCRAFT: Learjet Model 60, N999LJ, S/N 60-314

B. **GROUP MEMBERS:**

Chairman: Robert L. Swaim
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C. SUMMARY:

On September 19, 2008, at about 11:53 p.m. EDT, a Bombardier Learjet Model 60 (N999LJ) operated by Global Exec Aviation as an on-demand passenger flight under 14 CFR Part 135 overran runway 11 while departing Columbia, South Carolina, enroute to Van Nuys, California. The two pilots and two of the four passengers were fatally injured; the other two passengers were seriously injured. The aircraft was destroyed by extensive post-crash fire. Weather was reported as clear with light winds.

The Pratt & Whitney Canada PW305A engines were found with the left thrust reverser in the stowed position and the remnants of the right engine's thrust reverser (T/R) doors (buckets) in the closed locations. When the thrust reversers are open/deployed, the doors have large exposed frontal areas and with the main landing gear not supporting the airplane the lower doors would have been within inches of the ground. The doors had thermal damage consistent with the post-crash fire, but no impact-type damage.

Various members of the group were part of the airworthiness examination on-site, then met twice at Learjet engineering offices in Wichita, Kansas. An on-site topic of discussion was of a January 2001 Troy, Alabama, failure of a Model 60 squat switch on a main landing gear that resulted in an accident after stowage of the thrust reversers during landing.[1] The broader group discussions of October 2008 and January 2009 included the engine and thrust reverser system findings, design, certification, and service history.

This document cites factual observations about the engine and thrust reverser systems in the accident airplane, records from other Learjets, the design of the engine and thrust reversers, changes made, and certification.

D. DETAILS OF THE INVESTIGATION:

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[1] NTSB Case ATL01FA021 is described in further detail in a later section.

D.1 ACCIDENT AIRPLANE

D.1.1 ENGINES AND THRUST REVERSER OBSERVATIONS ON-SCENE

The engines are extensively described in the June 10, 2009 Powerplants Group Chairman's Factual Report, which was developed from the engine examination at the Pratt & Whitney Canada (P&WC) engine services facility in Bridgeport, West Virginia. The examination report does not describe the T/R system that is installed by Learjet after the engines are manufactured by Pratt & Whitney Canada. This section supplements that report by relating observations from the accident site. To assist in visualizing what is shown in the following photographs, the thrust reverser doors were photographed in the deployed positions on a test airplane. (See Figure 1)

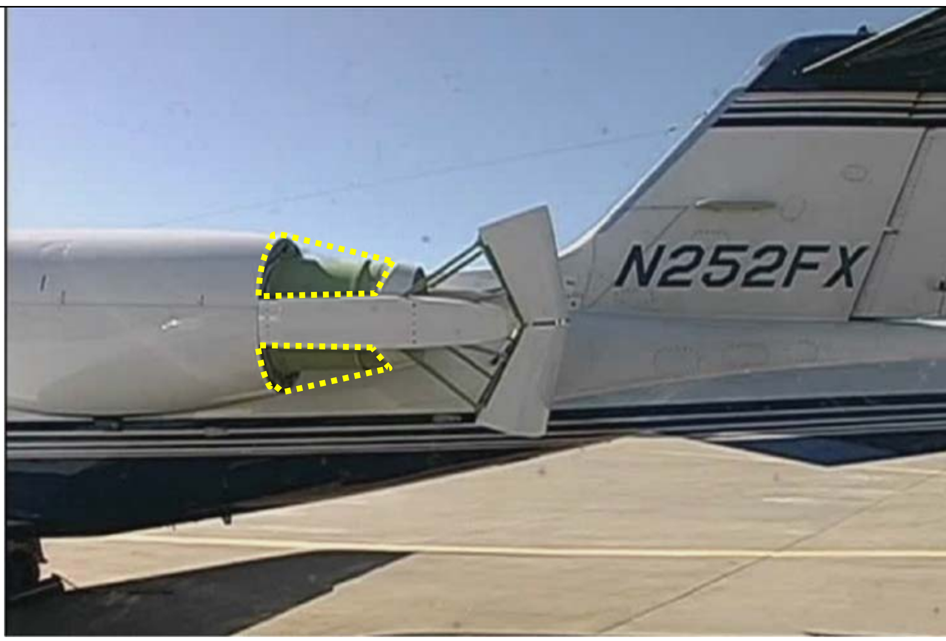

Figure 1. For reference and context of the following photographs, this shows the upper and lower thrust reverser doors in the deployed positions on a test airplane. The dotted lines show the stowed/closed positions for the doors, which can also be seen in Figure 2.

The engines were found loosely attached to the accident airplane and each had been fire damaged. The fire in the airplane center section had destroyed the integrity of the mounting structure and each engine was resting on the ground. The left engine T/R doors were found in the closed positions with external post-accident fire heat-damage. (See Figure 2) The doors had no dents, scuffs, or other damage consistent with impact damage in the open configurations.

Figure 2. Accident airplane left engine, as-found with the thrust reverser doors in the stowed/closed positions. The arrow points to the upper door.

The right engine had received extensively more fire damage than the left engine. The engine had been in the path of fuel leaking from the fuselage fuel tank. (See Figure 3)

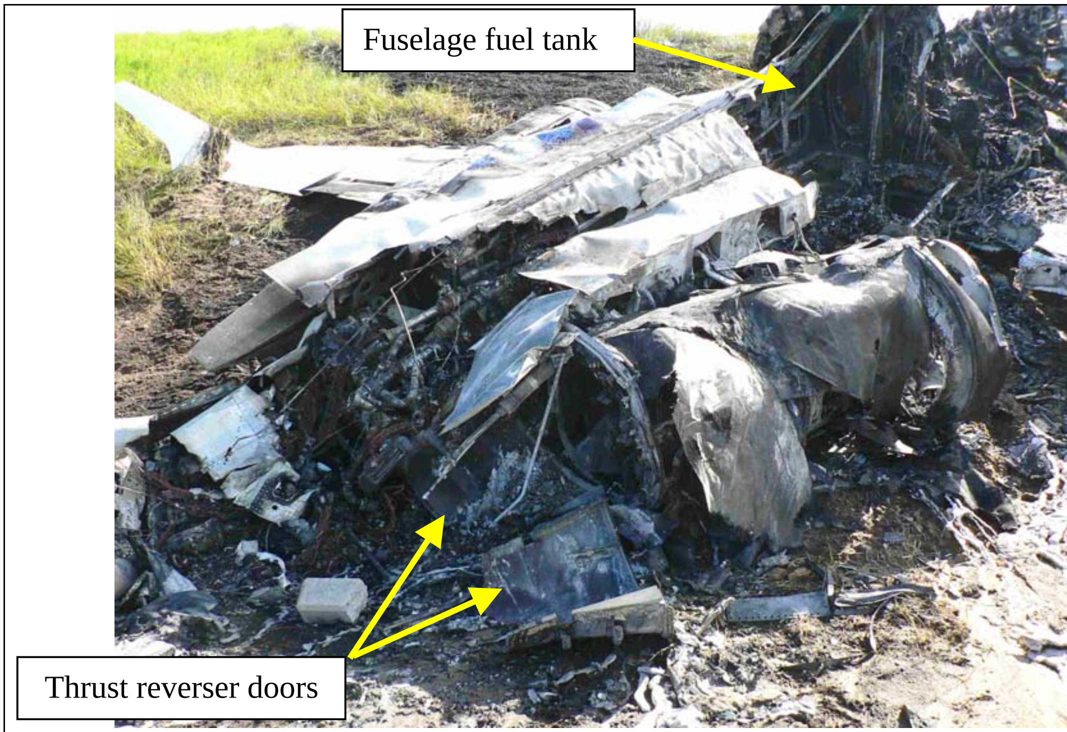

Figure 3. The right engine had substantially more fire damage than the left engine and the thrust reverser doors were found forward, in the stowed position. Note: The light-gray block above the "Thrust reverser doors" caption is the top of the concrete marker post from the west side of Highway 302.

The lower T/R door was found in the stowed/forward orientation and the leading edges had no damage to indicate that the door had been open when the airplane passed through the ILS antenna array, or when it struck the hillside. The upper door was also found in the stowed/forward position, lying loosely next to the bottom door and the leading edges were also undamaged.

The fire had exposed the inlet guide vanes (IGV) of the right engine and the control ring in the left engine showed that the left IGVs were also open. This orientation was consistent with both high power and with the engines not operating. The engines were removed and sent to the Pratt & Whitney Canada (P&WC) engine services facility in Bridgeport, West Virginia for further examination.[2] The engine cores were able to rotate at the engine services facility and found to have ingested dirt and organic material; consistent with operation at impact. Leading edge damage was found to some compressor blades in each engine, also consistent with operation, but providing no indications about power setting at impact. No other indications regarding power setting at impact were found.[3]

[2] See the June 10, 2009 Powerplants Group Chairman's Factual Report for details about each engine and the individual tear-down results.

[3] The left engine IGV were not exposed by the accident circumstances.

D.1.2 ACCIDENT AIRPLANE COCKPIT CONTROLS AND INDICATIONS

The two thrust levers were found at the forward end of the travel limits and the sheet-metal from forward of each was cut forward. The pedestal assembly in general had been displaced up and to the right and the linkages to the thrust levers had been disrupted. The thrust reverser control (a.k.a. piggy-back) levers were found in the down/stowed positions. (See Figure 4)

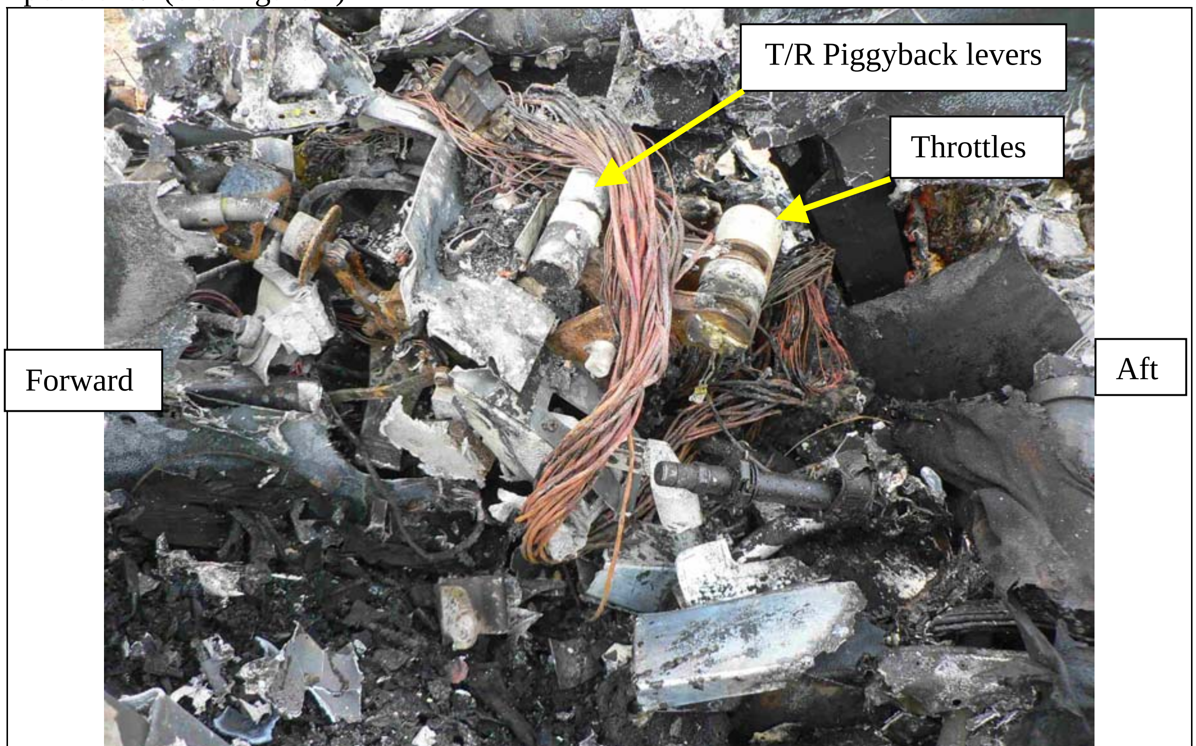

Figure 4. Pedestal assembly as found, shown from the left side.

The six thrust reverser indicator light assemblies were included in a caution and warning panel that was sent to the NTSB Materials Laboratory.[4] The left TR UNLOCK indicator was missing one bulb. None of the bulbs exhibited stretching of the bulb filaments that could be associated with illumination at impact.

The heat of the post-crash fire prevented the group from obtaining data from the on-board Nonvolitile Memory (NVM) memory devices. (See Appendices A and B)

D.2 ENGINE AND THRUST REVERSERS

[4] From the bottom were left and right indications labeled TRA ARM, TR UNLOCK, and TR DEPLOY and each indicator was designed to contain two bulbs. See also Materials Laboratory Factual Addendum Report 08-134AD, dated April 10, 2009. The function of the lights is described in more detail in later sections.

With the above knowledge about the state of the accident airplane, the group investigated the design of the engine and reverser system, changes to the T/R system, T/R failure modes, failure history, and certification requirements.

The Learjet Model 60 is powered by two Pratt & Whitney PW305A high bypass turbofan engines. The PW305A engines in the Model 60 were each rated at a maximum 4,679 pounds of thrust, with a maximum non-transient forward fan (N1) speed of 10820 rpm (102%). The Pratt & Whitney Canada PW305 customer Training Manual showed the PW300 series of engines were also installed in the following airplane models:

Manufacturer and model	Engine variant
Cessna Sovereign	PW306C
Dassault 2000EX	PW308C
Fairchild Dornier 328	PW306B
Hawker 1000	PW305B
Hawker Horizon	PW308A
IAI Galaxy	PW306A
Learjet 60	PW305A

D.2.1 COCKPIT CONTROL

No mechanical or cable-actuated connection exists between the cockpit thrust levers and the engines. Engine thrust is controlled by a dual channel full authority digital electronic control (FADEC) which regulates low pressure rotor fan (called N1) speed in response to the pilot-operated thrust levers. The Model 60 throttles use detented thrust settings and the FADECS vary engine outputs for the selections of cruise, maximum continuous thrust, takeoff power, and automatic power reserve (APR). The pilots can reduce or modulate power through use of the thrust levers at less than the cruise thrust detent. (See Figures 5 and 6)

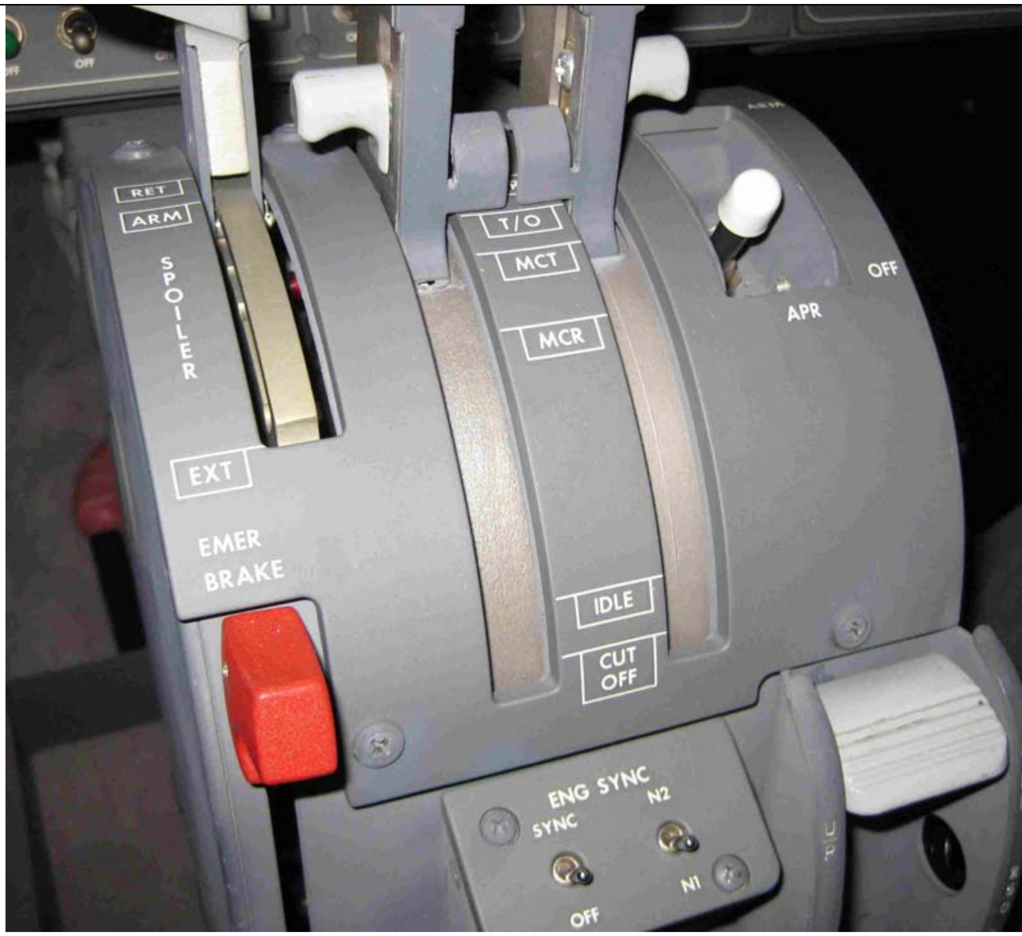

Figure 5. The throttle detent positions marked on the pedestal. The marked positions relate to the ranges shown in the next Figure. (Photo of airplane similar to N999LJ)

The Pratt & Whitney Canada PW305 Customer Training Manual (December 2000, page EEC 11.13) contained charts for the Lear 60 and Hawker 1000 to approximately depict the concept of forward fan (N1) speed (vertical axis) for both forward and reverse thrust lever angle (TLA) on the horizontal axis. (The Learjet 60 chart is shown as Figure 6.) The detented positions shown in Figure 5 relate to flat areas of the forward thrust schedule on the chart. These denote selections of cruise, maximum continuous thrust, takeoff power, and automatic power reserve (APR). Due to the lack of specific data on the vertical axis, this shows the relative relationships only, not actual specific data from an airplane. For example, at the reduced airspeeds consistent with take-off, the change in N_1 between the detents may be less than in the range leading to the first detent.

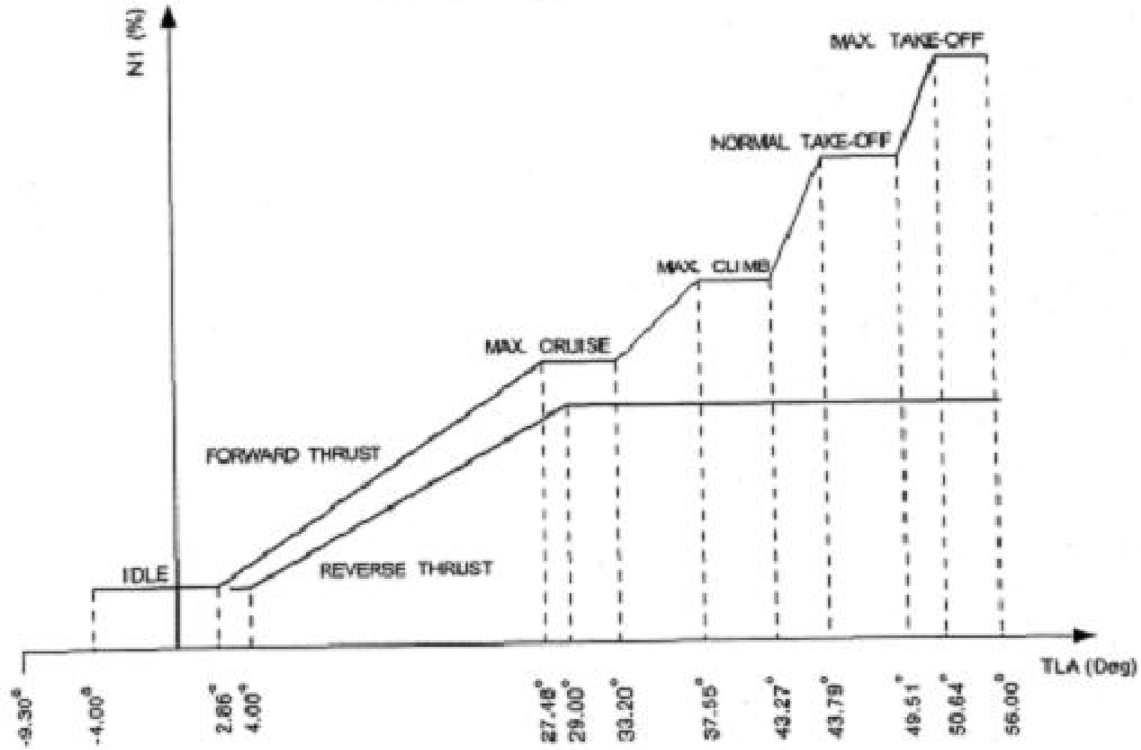

Figure 6. The PW305 Training Manual contained this chart that depicts forward fan (N1) speed (vertical axis) for both forward and reverse thrust lever angle (TLA) on the horizontal axis. The flat areas of the forward thrust schedule denote selections of cruise, maximum continuous thrust, takeoff power, and automatic power reserve (APR). Due to the lack of specific data on the vertical axis, this is not to scale and shows the relative relationships only, not actual specific data from an airplane.

The FADEC is a combination of engine control system components that perform thrust management, compressor surge control, high and low pressure compressor rotor speed control, and overspeed protection. The logic controls for the FADEC system and thrust reverser system are accomplished by an electronic engine control computer (EEC) that is mounted in an aluminum case on each engine, with assorted relays and micro-switches mounted on both the engine and the airframe. (See Figured 7 and 8). The EEC for each engine has dual parallel channels, labeled A and B.

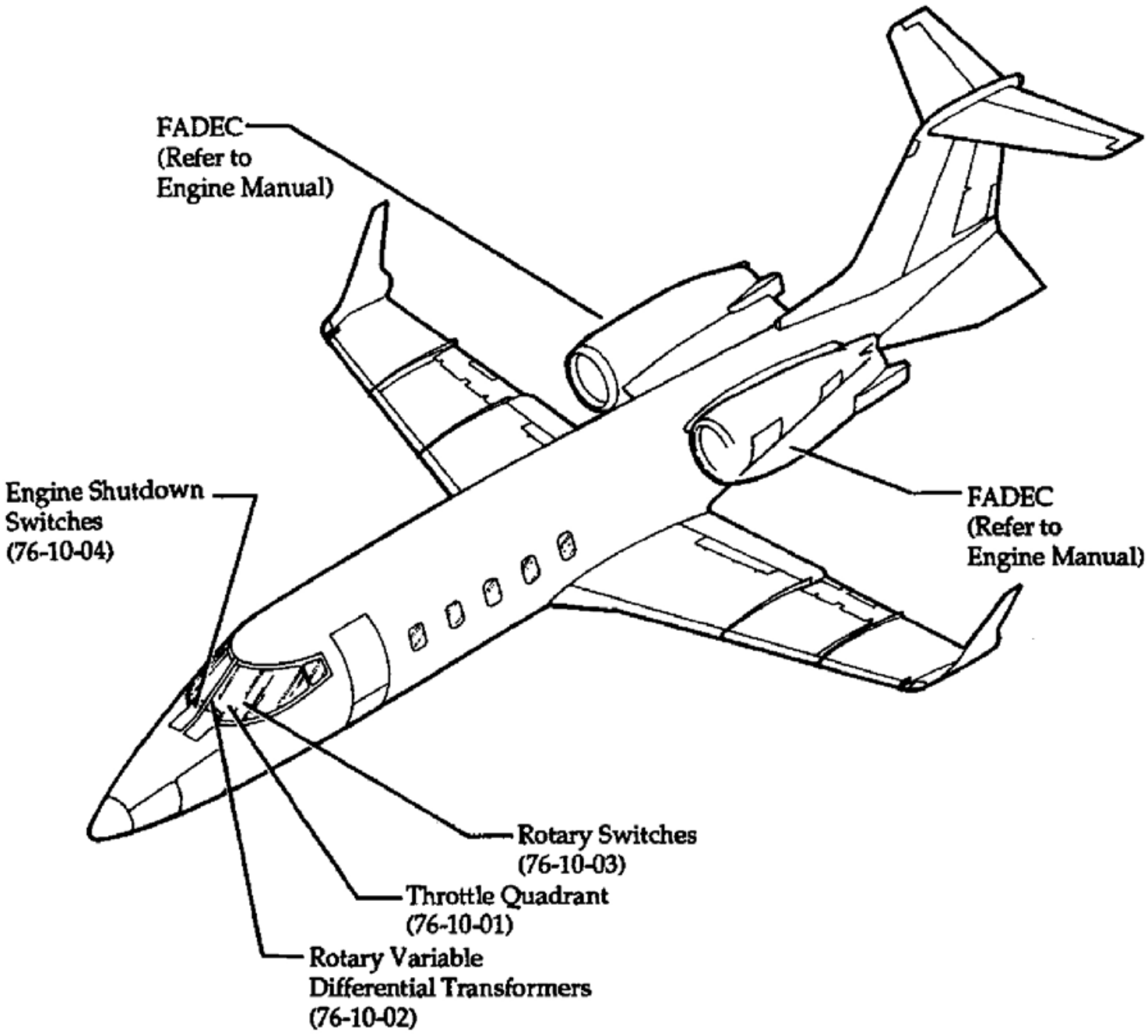

Figure 7. Basic FADEC component locations, per MM 76-10-00, page 2.

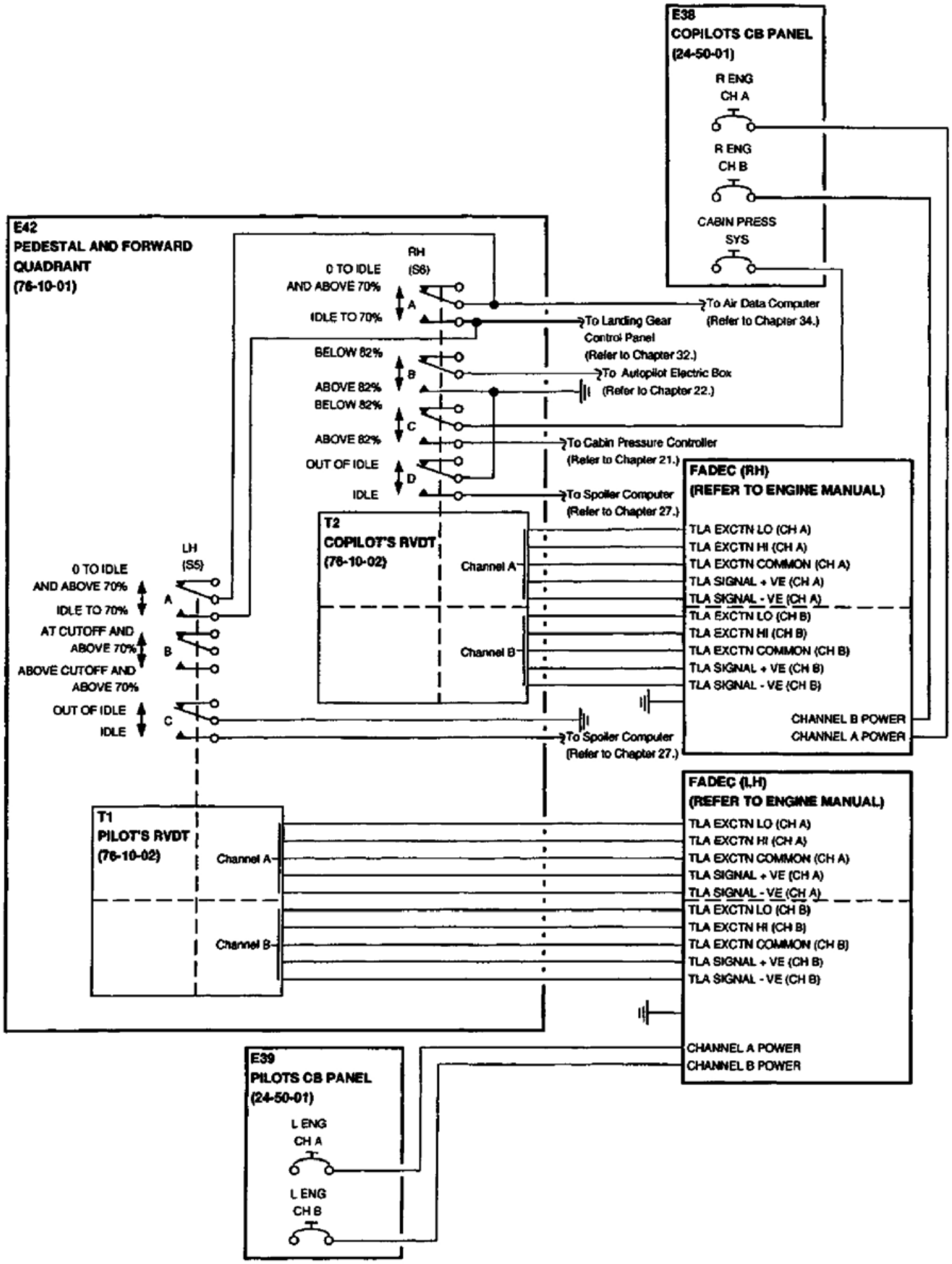

Figure 8. Basic FADEC connections, per MM 76-10-00, page 3.

The position of each thrust lever is established by the angular position of a rotary variable differential transformer (RVDT) in the cockpit pedestal. (See Figure 9)

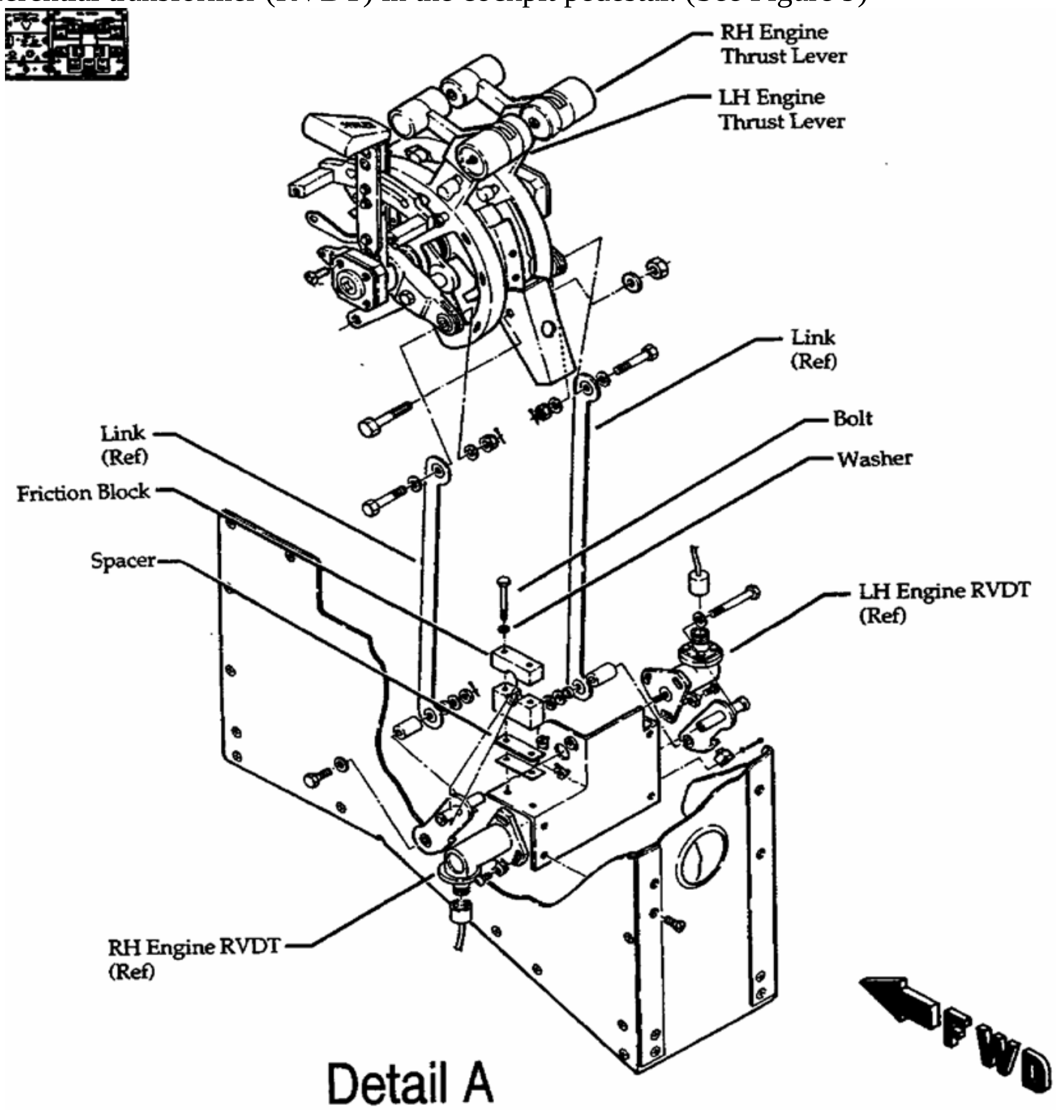

Figure 9. Cockpit thrust lever pedestal with RVDTs, per MM 76-10-00, page 204.

Each RVDT is actually a twin set of RVDT devices in a single housing, to separately provide input data to the EEC channels A and B. The EEC provides excitation at 6 volts and 3906 hertz, as well as interpretation of the RVDT positions, known as the thrust lever angle (TLA). (See Figure 10)

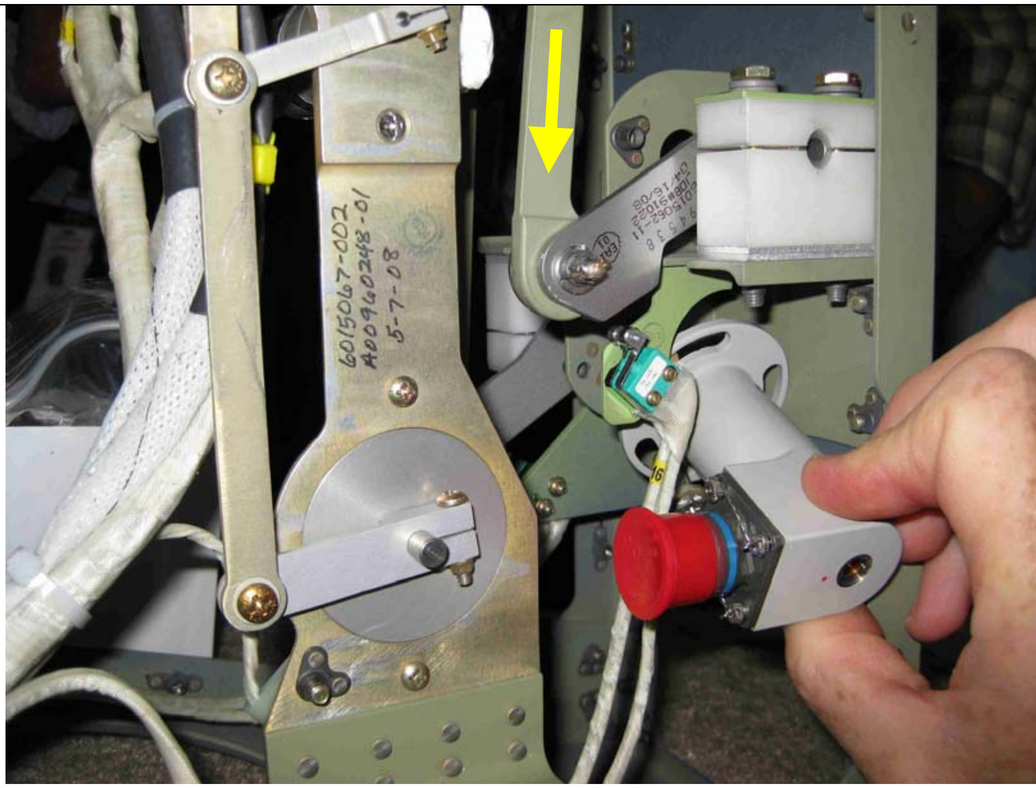

Figure 10. This photo is of a pedestal assembly in the factory. The hand is holding a dual RVDT beneath a dual (green) shut-down microswitch pack in a pedestal. This RVDT is labeled in the previous Figure as the RH Engine RVDT. The forward thrust and the T/R piggyback lever movements share the common vertical bar (yellow arrow) to rotate the input shaft on the far side of the RVDT. The RVDT output signals are the FADEC thrust commands.

The green microswitch is part of determining whether the FADEC will operate in the forward or reverse thrust schedule shown on Figures 6 and 20. The microswitch commands the thrust reverser to deploy when the thrust reverser piggy back lever is lifted to the deploy position. When the thrust reverser is fully deployed, the thrust reverser deploy switch changes state, which is a FADEC input, along with other thrust reverser discrete inputs. When the FADEC reverser deployed logic is met, the FADEC sets power in accordance with the reverse thrust power setting instead of the forward thrust power setting.

Each FADEC has three sources of power. Each engine has an independant permanent magnet alternator and for starting. The airframe also provides 28 VDC power. One channel of each FADEC is in control of the engine functions, with the second channel performing the same calculations on its’ redundant sensor inputs. The channel in command is changed with each engine start; levels of degraded control are provided for each FADEC as part of the system. Each EEC channel also performs health checks on the respective RVDT, such as checking for RVDT signals within the usable range of motion

(-15 degrees to +60 degrees), rate of RVDT motion at 1,000 degrees per second (or less), and comparing the return voltages of the RVDT windings against an expected constant value ($V_A + V_B$). The EEC channels have a cross-channel "read-only" capability to obtain information from sensors used by the other channel, and the RVDT is a sensor that this would apply to. If the channel logic perceives that both sources of RVDT data are invalid, the EEC is programmed to go to the last known "good" TLA and then to idle thrust (0.0 degree TLA) for that engine, over a 10 second period of deceleration.

As each thrust lever is moved aftward to the idle stop, a roller concealed in the pedestal comes to a mechanical shoulder. A toggle on the side of each thrust lever may be pulled up to lift the toggle over the shoulder, so that the thrust lever can move further aft for idle cut-off of fuel to that engine. (See Figure 11)

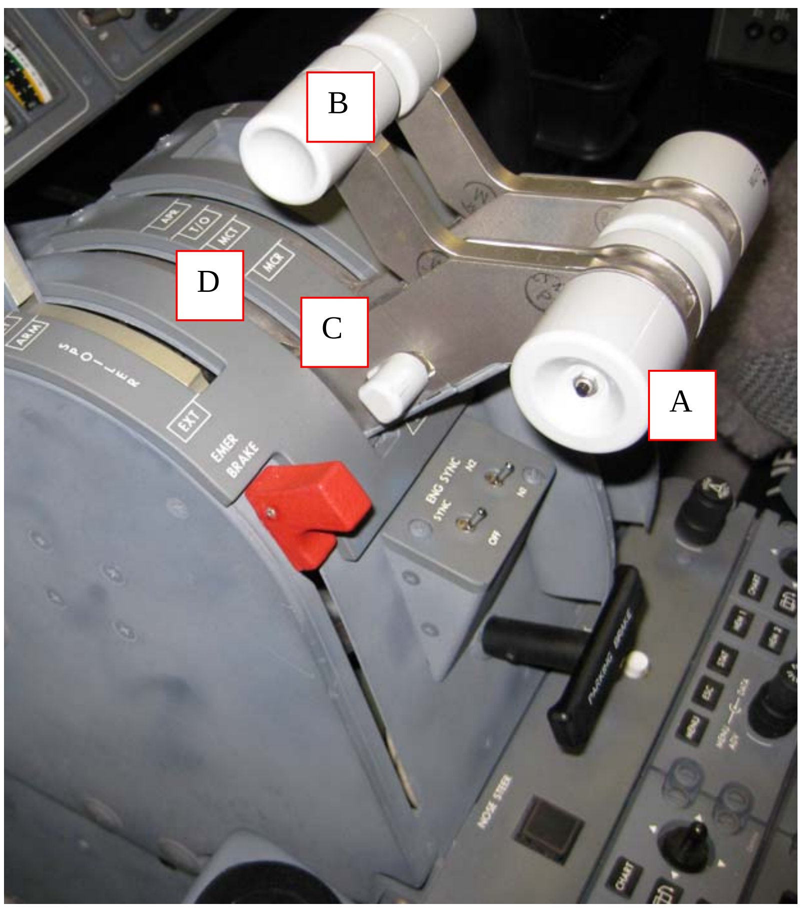

Figure 11. Captain's view of pedestal in an airplane similar to N999LJ. The view shows the thrust levers (A), thrust reverser (piggyback) levers (B), idle/cut-off latches (also known as toggles, shown as C), which must be lifted before the thrust lever can move aft from idle to cut-off, and location of thrust lever detents (D).

The method of fuel cut-off is different in the air and ground modes. On the ground and for each engine, closure of two microswitches (one for each channel) that are mounted adjacent to the RVDT will result in exercising the engine overspeed protection system, resulting in engine shutdown. (The TLA position is also used to provide a fail-safe mechanism against potential microswitch failures, stopping the engine if 5 seconds pass.) This method of engine shutdown is commanded by EEC logic and incorporates a time delay. If the main landing gear squat switches are in the air mode, the TLA cutoff position will command the fuel metering valve (MV) to seat without the time delay. A third method of shutdown is through the position of microswitches in each of the cockpit firewall "FIRE" pull handles.

Although not considered to be part of the FADEC system, the air-ground sensing mentioned with respect to engine shut-down is also used for other aspects of FADEC control. Mounted on the scissors assembly at the bottom of each main landing gear strut is a six-pole switch assembly, known as a squat switch. (See Figure 12)

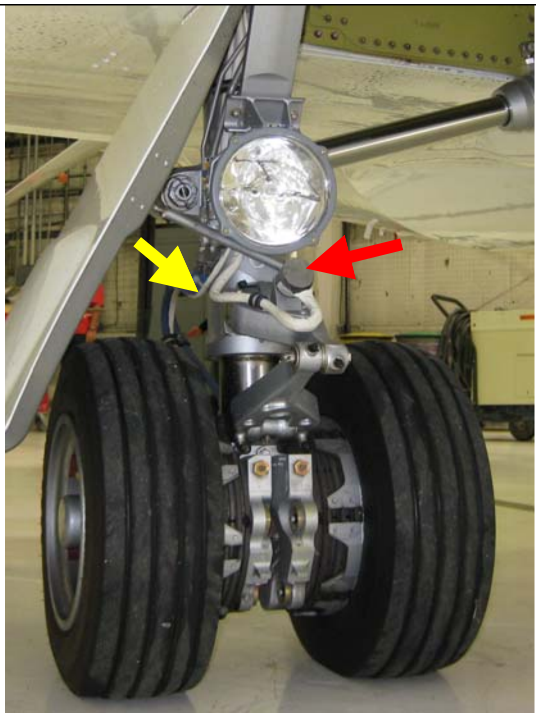

Figure 12. Right main landing gear squat switch (red arrow from right) and electrical harness beneath the landing light. The yellow arrow (from left) points to the wheel speed sensor electrical harness which is routed behind the main landing gear tires with the brake hydraulic hoses. (Photo of airplane similar to N999LJ)

D.2.2 THRUST REVERSER (T/R), GENERAL DESIGN

NOTE: Unless stated otherwise, the descriptions are generally of the thrust reverser for one engine. The control and function of the thrust reversers are the same for each engine and are the same for takeoff and landing.

Each Model 60 engine was equipped with a thrust reverser that deflects exhaust air with two half-shell doors per engine. The thrust reversers are not installed by Pratt &Whitney Canada, as manufacturer of the engines, but by Learjet as part of the airframe installation.

The Learjet Model 60 Maintenance Manual description of the thrust reverser system states:

> Each engine employs a post-exit target type thrust reverser to redirect the flow of the fan air and exhaust gases forward, providing a decelerative force for ground braking. The thrust reverser barrel is attached to the engine outer fan duct and functions as the final nozzle, expelling the fan air and exhaust gases aft when the thrust reverser is not deployed. The thrust reverser doors, when stowed, fair into the external nacelle contour and form the aft portion of the nacelle. Each thrust reverser system consists of two (2) vertically oriented doors, a four-bar linkage system, two (2) linkage support castings with guided driver mechanisms driven by two (2) hydraulic actuators, and a hydraulic control unit. Additional thrust reverser system components include two (2) stow switches, a deploy switch, a secondary latch system, a check valve, and two (2) restrictors.

The hydraulic actuators are retracted when the system is in the deployed position and the hydraulic actuators are extended in the stow position. The stow switches are at the aft end and are actuated at the extension of the actuator, one on each side of the T/R. The deploy switch is located at the aft end of the inboard fairing and is actuated by the lower idler arm depressing the switch. The idler arm is the short steel arm attached to the aft pivot point of the door. (See Figure 13)

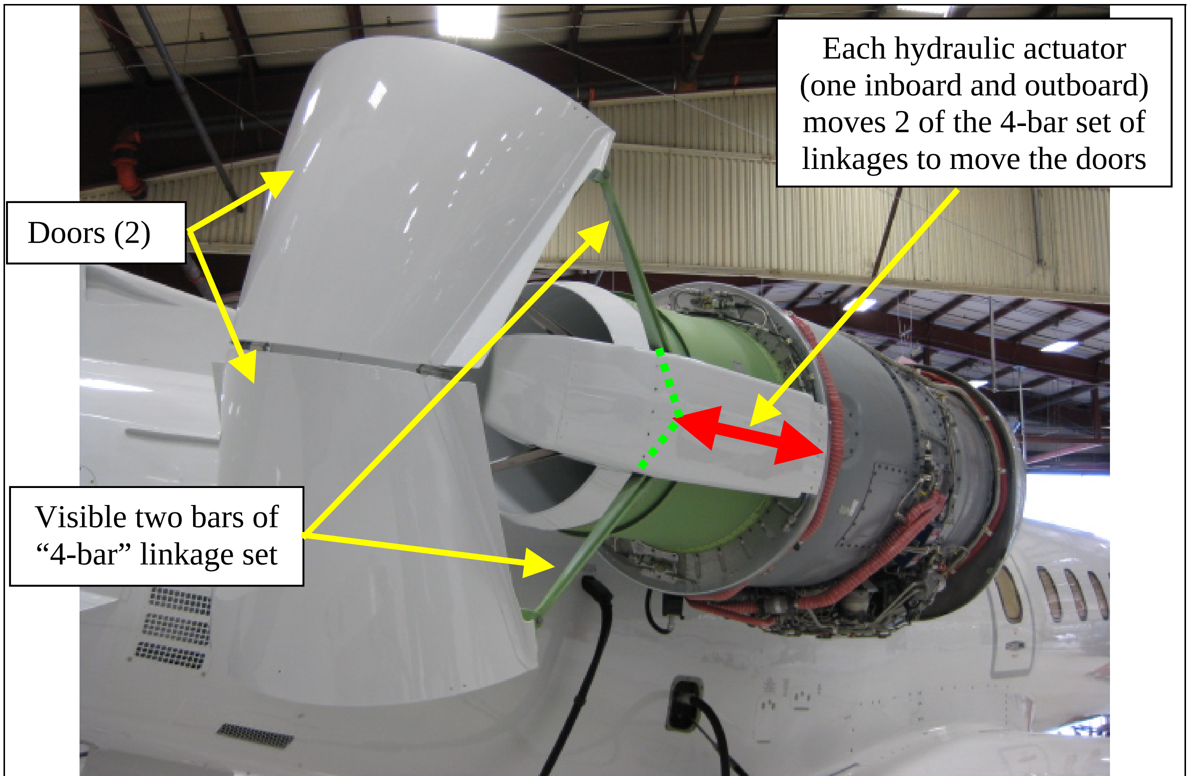

Figure 13. The blockage of the engine exhaust to redirect the air flow can be seen from this angle. (Photo of airplane similar to N999LJ)

Learjet engineering personnel noted that the T/Rs are used for landing and checked before takeoff. Learjet staff is aware that some pilots use the T/Rs to minimize use of the wheel brakes during taxi. As a general estimate (rule of thumb), the engineers related a design assumption that at least one reverser would be deployed about 10 times per flight.

The Model 60 T/R system was built by Rohr and typical of a bucket-style system, actuated by a four-bar linkage set. Learjet engineering personnel related that the thrust reverser system in the Model 60 was similar in design and function to the Rohr system used in the Hawker 1000, but that no other Learjet models used a similar system. The control of the T/R in the Model 60 was the first Learjet thrust reverser system to use a fully electronic control, with no mechanical connections between the cockpit and engine.

The early 30 and 55 series Learjet airplanes that pre-dated the Model 60 each had an Aeronca/Learjet thrust reverser system with cable controls. The Model 30 series originally had the Dee Howard style of thrust reversers that were installed as a supplemental type certificate in the 20-series airplanes, until adopted as a Learjet option. The Model 45 that was certified after the Model 60 uses a similar thrust reverser style. The Dee Howard design was later acquired by Nordam, after Nordam bought Rohr Industries. All of the Learjet designs used a "balk" solenoid (described later) and were generally similar from the standpoint of the pilot raising piggy-back levers to deploy the thrust reversers. None of the cable-based systems were known to have had an uncommanded thrust reverser stowage that was associated with more than idle thrust.[5] Uncommanded stowage of a cable-operated thrust reverser would result in the piggyback levers physically moving out of the reverse range of motion.

The thrust reverser system in each of the Learjet airplanes was designed to protect against uncommanded deployment. Learjet engineering personnel related that the thrust reversers were intentionally designed to fail to the closed position for multiple reasons. First, both Learjet and FAA personnel repeatedly noted that by having the reversers stowed, a pilot would not have to isolate which engine had a fault, correctly increase thrust on the opposing engine to counteract the reverse thrust, and then shut down the engine with the faulty thrust reverser.[6] The potential for identifying and shutting down the wrong engine in airplanes from other manufacturers is a known problem in multi-engine airplanes that has resulted in numerous accidents.

As a result of this fail-safe concept, the thrust reverser system will hydraulically secure the doors in the stowed position if an unlocked condition is sensed. The thrust reverser doors are moved and mechanically secured at the stowed positions by the four-bar over-center door linkage and the secondary latch design.

Another reason for having the T/R system fail to the stowed position related by the Learjet and FAA personnel was that any airplane in the Learjet series may be operated without the thrust reversers. Certification and test flights are conducted without the use of thrust reversers and without thrust reverser credit for calculating takeoff and landing field length.[7] It was noted that the earliest Model 60 airplanes were delivered with inoperable thrust reversers and factory lock-out pins had been installed prior to delivery, because the configuration of the exhaust plumes had not been finalized. The current thrust reversers may be inoperative for 10 days, in accordance with the minimum equipment list and to do so, a maintenance lock-out pin is installed in both reversers to prevent use.

D.2.3 T/R CONTROL AND INDICATIONS

The left and right T/Rs are independent with respect to operation, although there are shared pre-conditions for operation. For example, both T/Rs must both be in the deployed positions before either engine speed can increase to more than idle power. The thrust reversers depend upon many items in the airplane. (See Figure 14)

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[5] One airplane had a translating cowl depart the airplane, resulting in partial forward thrust due to the mechanical failure.
[6] The in-flight deployment of the thrust reverser system, to landing, was demonstrated during certification of the Model 60.
[7] Contaminated runway requirements can allow some credit.

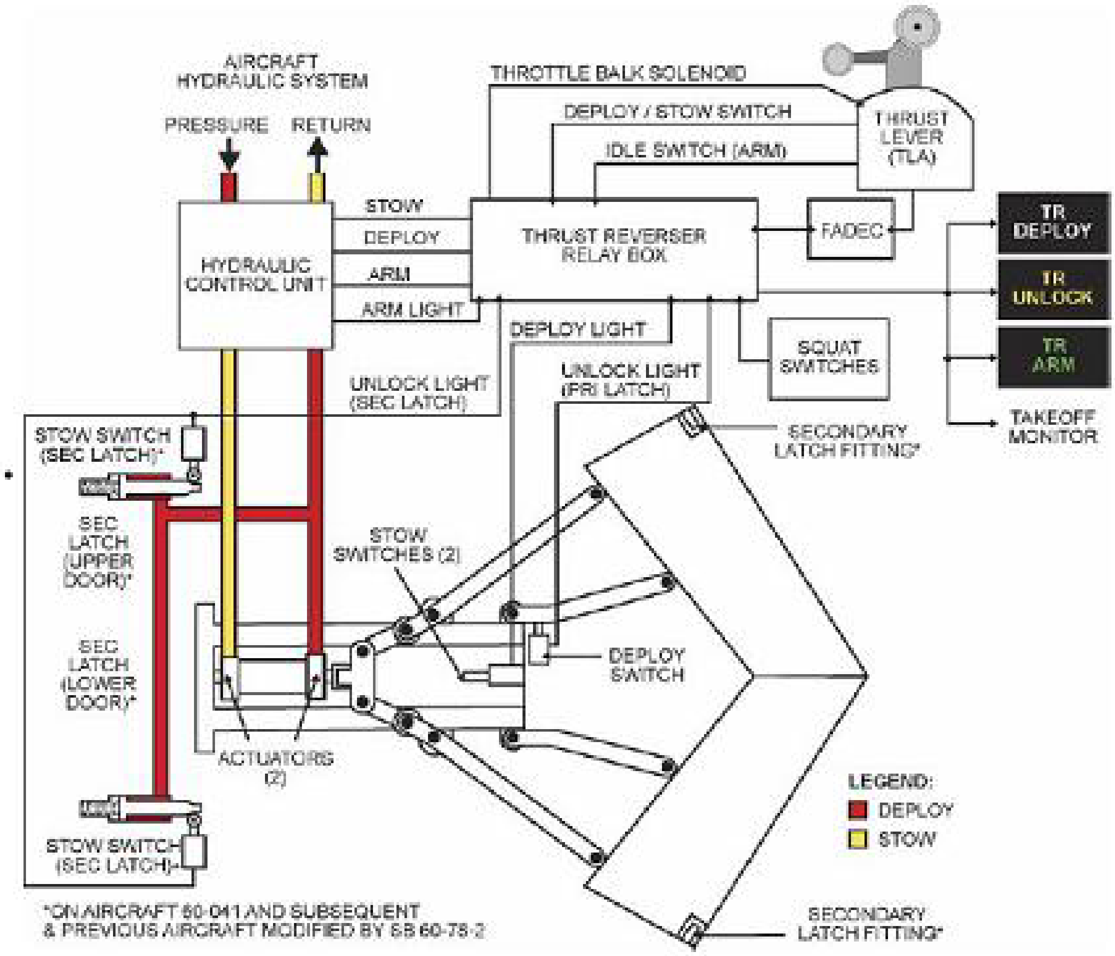

Figure 14. T/R control and indication general schematic. (source: Learjet Pilot Training Guide)

Initiation of T/R deployment requires that both main landing gear squat switches be in the ground mode for at least 0.1 seconds (100 milliseconds).[8] To deploy a given thrust reverser, the thrust lever associated with the given thrust reverser (e.g., left) needs to be in the idle position prior to raising the piggyback lever. (Figure 11 shows the throttles at the idle position.) The upward piggyback lever travel is limited to a position controlled by a “balk” solenoid in the pedestal. If the pilot holds upward pressure on the T/R

[8] Both squat switch assemblies have multiple sets of contacts. Signals directly routed from the switch assemblies go to the landing gear control, anti-skid control, and thrust-reverse control. Some signals go to both weight on wheel relay boxes, one for the left main landing gear and one for the right main landing gear. In a test with one squat switch in the air mode, the engine idle speed increased to flight idle. The squat switch signals are also used for other functions, such as in part of the nose gear steering engage logic. A related nose gear steering warning can alert the crew that the system has abnormally transitioned from an engaged state to a disengaged state when weight is not on the landing gear.

piggybacks to anticipate release of the balk solenoid, concealed serrations prevent the piggyback levers from being raised until the upward pressure is momentarily released.

The condition or logic for raising one or both of the piggyback levers above the baulk solenoid stop position is that the baulk solenoid is energized, which would normally occur when both thrust reversers are in the fully-deployed position. To get a reverser into the fully-deployed position requires left and right squat switches in the ground mode, both thrust levers at idle, both piggybacks lifted to the deploy position, hydraulic power available to both hydraulic control units (HCU), both hydraulic pressure switches in the pressure-sensed position, and the associated isolation valves, deploy valves, and actuators being energized so as to move the buckets to the fully-deployed position.

The thrust reversers are controlled by the T/R relay boxes, which are independent from engine control. The interface between the thrust reverser system and the FADEC is to signal when the FADEC should use the thrust reverse schedule and to respond to the piggyback movement for the amount of thrust reverse, including idle.

The thrust reverser system has three annunciator lights. From bottom to top, the three annunciator lights are T/R ARM in green, T/R UNLOCK in amber, and T/R DEPLOY in white. (See Figure 15) During testing of Model 60 airplanes, none of the T/R lights were illuminated ("black panel") when the throttles were advanced in forward thrust from the idle stop. This lack of annunciations was the as-designed mode for forward thrust.

Figure 15. Three T/R system indicator lights for the left engine (circled), as shown during a test of all annunciator light bulbs in an airplane similar to N999LJ. The T/R captions state TR ARM (bottom green), TR UNLOCK (middle amber), and TR DEPLOY (top white). A similar set of three are located on the first officer side for the right engine.

When the airplane is on the ground, at idle, the TR ARM light illuminates. (See Figure 16) During taxi, the green TR ARM light frequently illuminated and went black, as the throttles were moved in and out of idle. The green T/R ARM light remained illuminated when either the white T/R UNLOCK or amber T/R DEPLOY lights were illuminated.

Figure 16. Illuminated right engine TR ARM green annunciation during ground test. (Photo of airplane similar to N999LJ)

Once the thrust lever is pulled back to idle, the second cockpit action to deploy a thrust reverser would be pulling up on the thrust reverser control (a.k.a. piggy-back) lever. (See Figure 17)

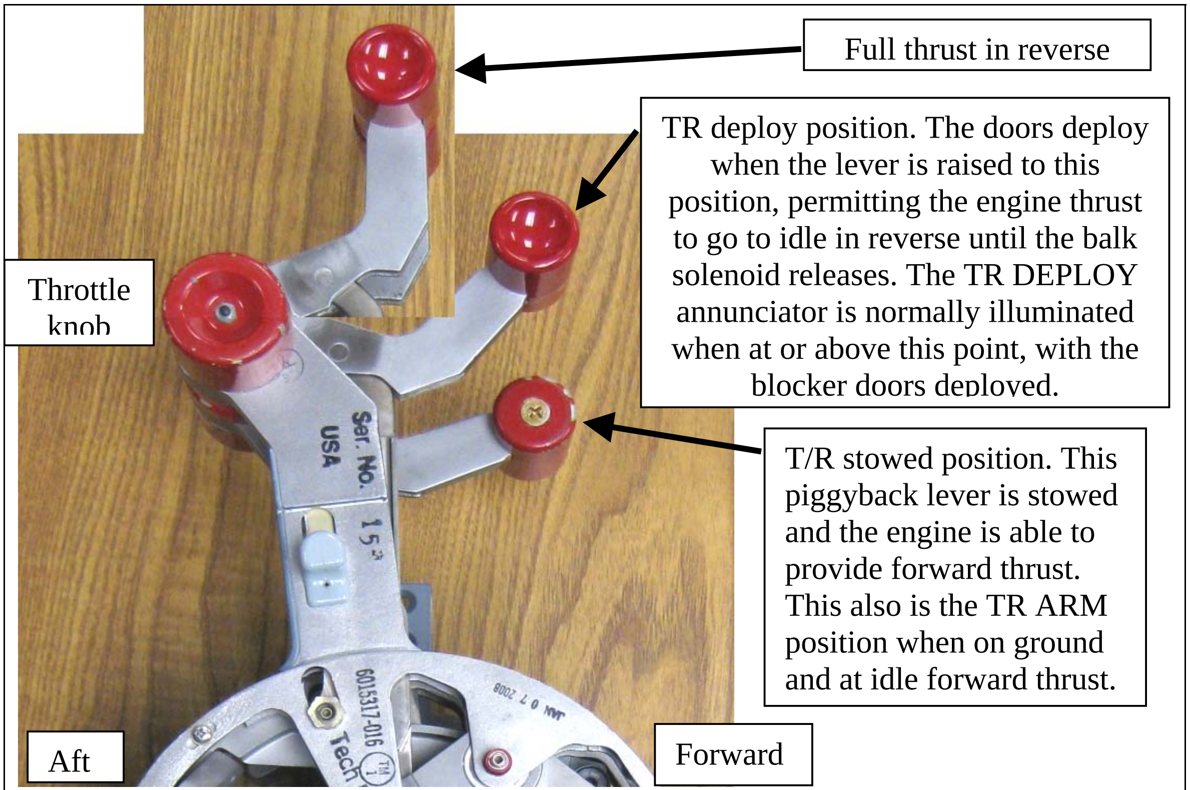

Figure 17. This composite of photographs shows the positions of the thrust reverser piggyback levers. (Photo of uninstalled new assembly at factory.)

With the throttles at idle forward thrust and lifting the piggy-back levers to the T/R deploy position, the piggyback levers would stop until the thrust reverser doors deflect the engine exhaust. During the transition, the TR UNLOCK light would illuminate and the TR ARM light would remain illuminated. (See Figure 18)


Figure 18. Illuminated TR ARM and TR UNLOCK lights during ground test. (Photo of airplane similar to N999LJ)

The middle amber-colored TR UNLOCK annunciator light is intended to illuminate when the system is in transition, not meeting the full criteria of the stowed condition or for the white TR DEPLOY annunciation. If one or more thrust reverser sensors was not in the appropriate stowed position in flight,[9] the TR UNLOCK light could illuminate and remain illuminated. The system is designed so that is it becomes unlocked in flight, an auto-stow function is initiated that will attempt to stow the thrust reverser. Only if the system is unsuccessful in stowing the thrust reverser and the thrust reverser remains unlocked or is sensed to be unlocked will the TR UNLOCK remain illuminated.

With the piggyback levers raised to the deploy position and once the doors fully open, a switch at the aft end of the support casting for the actuator and linkage set would be actuated by the idler link to change state, illuminating the TR DEPLOY annunciator. The TR ARM annunciator should remain illuminated. (See Figure 19)

Figure 19. Illuminated engine TR DEPLOY light during ground test. (Arrow) (Photo of airplane similar to N999LJ)

With actuation of the deploy switches at the aft end of each engine's T/R actuator track, the balk solenoid in the throttle quadrant would release with an audible snap. Both reversers (left and right engine) need to be in the fully deployed positions to release the

[9] The stowed position is engagement of two secondary locks and engagement of the two STOW switches at the forward end of the thrust reverser track.

balk solenoid. Once the balk solenoid released, the piggy-back levers could be pulled from idle-reverse to increasing reverse thrust power settings.

When deploying the thrust reversers there was a delay that was characterized by pulling up on the levers to the solenoid stop, saying “one potato and,” then hearing the snap as the solenoid released the levers. When stowing the thrust reversers, there was a delay of less than a second between the sound of the levers going down and the snap of the solenoid re-engaging.

As each piggyback lever lifts to the raised position, a mechanical linkage to the RVDT rotates the input shaft and actuates microswitches. The position of the microswitches changes the EEC logic to recognize the use of the reverse thrust power schedule, rather than the power schedule which each EEC commands for forward thrust.

Page EEC 11.12 of the Pratt & Whitney Canada PW305 Customer Training Manual shows that with reverse selected and the required discrete sequence confirmed, the EEC target specific N1 speeds or settings. Providing a simplistic description of the thrust reverser system, the Training Manual provided the following as requirements for reverse thrust in the Learjet 60:

> Reverse thrust N1 is a function of thrust lever angle and indicated airspeed (air data computer mach number). The maximum reverse thrust lever angle is 29 degrees. The PW305 Training Manual provided the following relationships for reverse N1 relative to airspeed:

Airspeed	Percent of takeoff N1 speed
0 to 40 knots	50 %
50 knots	60 %
60 knots	65 %
80 knots	75 %
100 knots	85 %

The PW305 Training Manual contains a chart that depicts forward fan (N1) speed for both forward and reverse thrust lever angle (TLA). The microswitch in the throttle quadrant at the RVDT take part in determination of which thrust schedule is in use. (See Figures 6 and 10)

D.2.4 UNCOMMANDED T/R STOWAGE

Once a reverser is deployed, loss of signal for any of the green TR ARM light prerequisites, as well as loss of the deployment requirements, should result in the thrust reverser moving to the stowed position. Loss of signal from a landing gear weight on wheels (squat) switch would remove one of the pre-requisite for the TR ARM signal and during ground tests the two thrust reversers would move to the stow positions. Engineering review revealed that detection of a T/R failure while in-flight would cause the TR UNLOCK annunciator to illuminate, the hydraulic system would pressurize on the stow side of the reverser actuators, and the full authority digital engine control (FADEC) would command that engine's thrust to flight idle for the time that the reversers were in transit.

Ground tests were performed with test equipment that could change the landing gear squat switch state to the air mode. The tests were begun with the T/R in reverse at idle thrust. When the squat switch changed to the air mode, the T/R doors would move toward the stowed positions and the TR DEPLOY light would extinguish. The TR UNLOCK light would illuminate and the TR ARM light would flash for less than two seconds, as the doors moved to the stowed positions, and then all annunciator lights would extinguish. There would be no audible thrust lever configuration alert warning if the blocker doors were to close. The N1 indicators each have a FADEC "command" target which would move as the EEC shifted logic from the state of reverse thrust to that of forward thrust and the engine thrust would change from ground idle speed to flight idle speed.[10]

With respect to thrust reverser inadvertent deployment, the PW305 Training Manual states on page EEC 11.12 that "to prevent spurious occurrences, the EEC control will switch to the other channel. In the event of inadvertent deployment, the controlling EEC channel reduces power to idle. If an inadvertent deployment is not confirmed, the engine will maintain thrust."

With the thrust reversers transitioning to the stow position, the engineering review found that the EECs would transition from the reverse thrust N1/TLA schedule to the forward thrust N1/TLA schedule, within about a 2 second transition through idle power. At this point, the T/R piggyback levers would be in the positions normally used for full reverse thrust.[11] The engines would be applying forward thrust according to the RVDT angle and the conditions of the day per the thrust schedule. (See Figure 20)

---

[10] The airplane has a white master CAUTION annunciator and red master WARNING annunciator. The cited condition would not pose the level of risk that the airplane design requires to illuminate the red WARNING annunciator. A normal pre-takeoff checklist item calls for inhibiting the white master CAUTION light for takeoff to prevent nuisance annunciations. The inhibition is reset 10 seconds after the airplane leaves the ground.

[11] The piggyback levers could alternatively be in any other position within the reverse power modulation range.

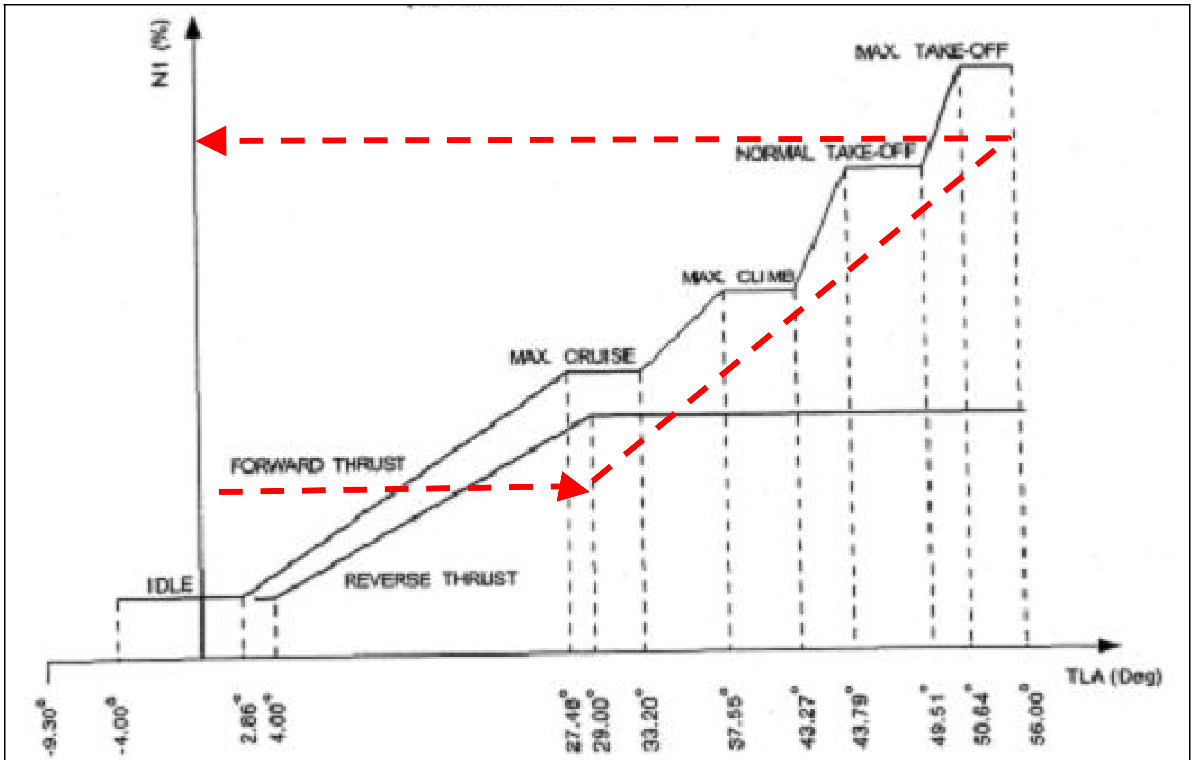

Figure 20. Modified from Figure 6 during the group meeting at the Learjet factory in Wichita from October 6-10, 2008. The red arrow drawn from maximum reverse TLA (horizontal axis) shows how a shift in between the reverse and forward thrust schedules could affect N1 (vertical axis), due to removal of the 29 degree TLA restriction. The chart is graphic in nature and the vertical proportions are not to scale. On the ground at airspeeds less than V_1, only minor differences in N_1 would exist through the detents.[12]

To reduce the forward thrust, the pilot would need to move the piggyback lever to the stowed position, which would not be how pilots normally bring the airplane to a stop. Learjet personnel noted that this scenario (uncommanded stow) pertains to an abnormal situation that is in the Emergency section of the Airplane Flight Manual, and that in an emergency condition, trained pilots should follow the AFM procedure, not follow their intuition.

In mechanical engine control systems and some T/R systems that use electronic control (including the Model 45), the piggyback levers are physically moved to the stowed positions when the reverser doors stow. This feature is not a regulatory requirement. The

[12] As noted in the earlier use of this chart, the illustration is not to scale and little N1 change would exist between detents at less than V_1 airspeed. An FAA engineer familiar with the engines who commented on this chart related that to be more precise when the piggyback levers were fully up and the blocker doors stowed "In this case the RVDT is in approximately the Max Climb flat range of TLA and the RVDT does not rotate during the transition. I.e. extend the lower arrow's arrow end to ~40 degrees TLA, make the transition to the upper arrow's tail end vertical, and truncate the upper arrow's tail end at ~40 degrees."

Model 60 electronic engine control has no solenoid or other mechanism that moves the piggyback levers down if an abnormal condition leads the reverser doors to move to the stowed position while the piggyback levers are above the relaxed flight idle orientations. A Learjet engineer summarized the reason for not having the mechanism as: "Nobody was looking at the piggyback lever positions as a feedback to the crew."

D.2.5 AIRPLANE FLIGHT MANUAL CHANGES

In March 2009, Learjet published a FAA-approved temporary flight manual change in procedures, which described improved methods for quickly recognizing and responding to uncommanded T/R stowage. Prior to the change, the Airplane Flight Manual (AFM) had an Auto-Stow procedure that was printed inside of a box, denoting that it should be a memorized procedure. The procedure stated that in the event of an uncommanded T/R stowage, the piggy-back levers should be stowed. The procedure did not cite how to recognize conditions that should result in use of the procedure.

The thrust reverser stow procedure was originally an ABNORMAL procedure, which was moved to the EMERGENCY section of the AFM following a Model 60 accident in Troy, Alabama, in 2001.[13] In that accident, the airplane struck deer and the landing gear squat switch was broken, resulting in uncommanded thrust reverser stowage. FAA and Learjet personnel in October 2008 who took part in the N999LJ accident investigation related that the FAA originally accepted this (moving the T/R stow procedure from the ABNORMAL to the EMERGENCY section of the AFM) as a sufficient change to prevent a recurrence. Learjet internally decided to add a redundancy for the squat switches, through incorporation of wheel speed sensing that already existed for the spoiler system. The change added the level of redundancy, although wiring for each of the systems is routed in close proximity along the main landing gear struts.

Dates found in October 2008 that related to the design change were:

January 14, 2001	Accident at Troy, Alabama.
April 2, 2004	Report 60-D1175, Titled: Thrust Reverser Aircraft Electrical Safety And Failure Mode And Effect Analysis
February 21, 2005	Release of Service Bulletin SBT 60-78-7, Titled: Exhaust – Installation of Thrust Reverser Interface Box

The change to add the wheel speed sensor redundancy was created for the landing condition. Takeoffs do not need the thrust reversers and rejected takeoffs generally

[13] NTSB Accident report ATL01FA021 is described in more depth in a later section

receive no field-length credit for having thrust reversers during certification.[14] To keep the system as simple as possible and due to the lack of perceived need for the change to be applied to takeoffs, the redundancy was not added for the takeoff condition.

D.3 RECORDS FROM OTHER AIRPLANES

Records were found from Model 60 Learjets that had TR stowage, in which the stowage had not been intentionally caused by the pilots. The records follow in chronologic order.

D.3.1 FLIGHT TEST ACCIDENT OF APRIL 6, 1994

A test-flight accident took place on April 6, 1994, involving a landing gear and squat switch that may have affected the thrust reversers. The test airplane (N60XL) was a Model 55 that had been modified to be the prototype of the Model 60 (Serial 55-001). The following narrative was in the preliminary notification for the accident:

> After landing with a suspected flat tire, and unsuccessful application of thrust reversers, brakes were applied but no deceleration experienced. Air brakes were tried also. Both tires on right side were flat – aircraft went off north end of runway … and stopped. Nose gear folded and right main strut damaged. Crew secured airplane and exited with no injuries.

D.3.2 TAKEOFF INCIDENT AT WASHINGTON DULLES, JUNE 1998

According to a pilot report submitted to the National Aeronautics and Space Administration Aviation Safety Reporting System (ASRS), a Learjet Model 60 experienced failure of both right main landing gear tires while departing from Washington Dulles International Airport, in Chantilly, Virginia. The failures of the tires and the brake assembly led to severing the hydraulic brake lines and electrical wiring to the squat switch. The thrust reversers stowed and the airplane departed the end of the runway before coming to a stop.

D.3.3 DEER STRIKE ACCIDENT OF JANUARY 14, 2001 (ATL01FA021)

On, January 14, 2001 at 1:45 pm, Central Standard time, a Learjet Model 60 (N1DC, S/N 60-035) collided with deer during landing and ran off the end of runway 7 at the Troy Municipal Airport, in Troy, Alabama. The two pilots were critically injured and the airplane was destroyed by impact and post-crash fire damage. According to witnesses,

---

[14] Contaminated runway requirements can allow some credit.

the airplane collided with deer shortly after touchdown and continued down the runway with the tires smoking, veered from the side of the runway, impacted a ditch, and burst into flames. Two fragmented deer carcasses were found and deer fur was found lodged in the broken squat switch of the left main landing gear. According to the pilots, the thrust reversers failed to operate when engaged and both thrust reversers were subsequently found in the stowed positions.

The NTSB factual report noted that with the loss of the squat switch on the left main landing gear, the thrust reverser relay box deenergized the deploy solenoid and the thrust reversers go to the stow position. The electronic engine control commands the engine speed to go to idle. As the thrust reversers complete the stow cycle, the unlock switches open, signaling the thrust reverser relay box to remove the discrete signals. The EEC's switch to the forward thrust schedule and within 2.6 seconds estimated, and if the piggybacks remain at the max reverse position the engines rpm begins to increase to near takeoff power.

The Statement of Probable Cause assigned to the accident stated:

> The National Transportation Safety Board determines the probable cause(s) of this accident as follows. On ground collision with deer during landing roll.

D.3.3.1 CHANGES AFTER ACCIDENT OF JANUARY 14, 2001

The Learjet 60 Airplane Flight Manual moved a procedure from the ABNORMAL section of the Airplane Flight Manual to the EMERGENCY PROCEDURES section on November 20, 2003. This followed an accident in which at least one main landing gear squat switch circuit was damaged by a deer strike during landing. The Emergency Procedure is shown in a hatched box to denote it as a memory item, and states:

> INADVERTENT STOW OF THRUST REVERSER AFTER A CREW-COMMANDED DEPLOYMENT
>
> 1. Maintain control with rudder, aileron, nose-wheel steering, and brakes.
> 2. Both Thrust Reverser Levers - Stow
>
> NOTE: Failure to move the thrust reverser levers to stow will result in forward thrust ranging from idle to near takeoff power, depending upon the position of the thrust reverser levers.

The thrust reverser logic was changed following the 2001 accident. (See Figure 21) Since the deployment of the thrust reversers required a ground signal from each of the squat switches, a redundant ground path was provided for each. The path selected incorporated the signals from the wheel speed detection box that was already installed as part of the spoiler system. This was incorporated on February 21, 2005 (revised May 2, 2006) as Service Bulletin 60-78-7, with effectivity for serial numbers 60-002 through –276, and into production at airplane serial number 60-277.

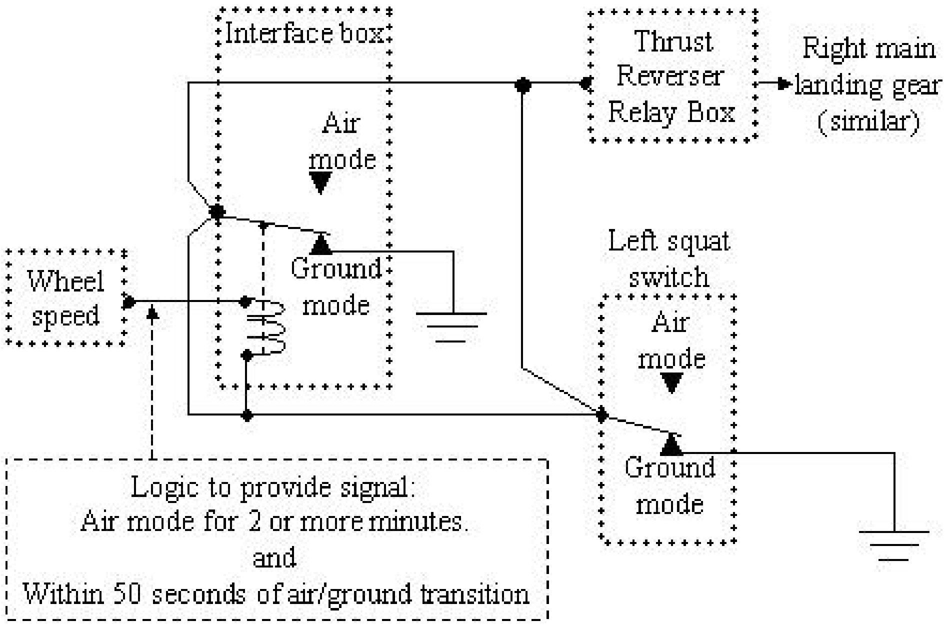

Figure 21. An illustration of the change to the logic for the left redundant ground feature. The interface box and associated circuits were added after the January 14, 2001 accident. The right thrust reverser interface is similar. (Simplified diagram and not all components are shown.)

This change protected against inadvertent stowage of the thrust reversers after landing and selecting reverse thrust. Damage to a squat switch or other required circuit prior to the selection of reverse thrust would still prevent the thrust reversers from going to the doors deployed and idle thrust positions. The design change would not be applicable to inadvertent reverser stowage in a takeoff situation, because the airplane had not been in the air for two minutes.

D.3.4 INCIDENTS AND EXPERIENCE CITED BY FAA MANAGER OF FLIGHT TEST

> NOTE: This captured certain parts of a conversation with the FAA manager of flight test and is placed here due to the conversation about the 2001 accident in Troy, Alabama, and this person's experience with this model of airplane, including the development of the flight reverser system.

> The conversation took place during the meetings of January 2009 and was not a comprehensive transcript of an interview.[15]

During the original tire certification of the Model 55, he was involved in an incident involving loss of all four main landing gear tires. He was in the first officer seat during a gross weight Model 55 takeoff at Orlando, Florida, with a Learjet company pilot in the captain's seat.

The airplane had a very long taxi and a high energy stop before their subsequent takeoff was delayed by arriving traffic. During the takeoff, the wheel fuse plugs burst on the takeoff roll. The tires failed when the airplane was beyond the V_1 speed. He and the Captain heard the tires coming apart and he watched fragments passing forward of the cockpit. Although faster than V-one, the takeoff was aborted due to the concern that tire fragments could be ingested by the engine. It took about 9,300 feet to stop the airplane on a 12,000 foot runway. He has trained extensively in simulators and feels that simulators are usually realistic, but does not feel that a simulator would accurately portray the tire failure event.

The manager had been involved with the development of the Model 55 Learjet and noted some differences, such as flight characteristics. The Model 55 seemed to him to have more pitch-up with an in-flight reverser deployment than the Model 60. The Model 55 did not have "throttle snatchers" (an automated system that moves the throttles to idle). The Model 60 throttle snatchers and the automated (FADEC) reduction in engine speed (N-one) made it a better thrust reverser system in his opinion. In-flight thrust reverser deployments in the Model 55 were not a problem, although there was the pitch-up.

This is the first Model 60 fatal accident that he is aware of. With respect to the 2001 Model 60 accident at Troy, Alabama, he was not involved in the investigation or changes that followed. The FAA worked with Learjet on the AFM change to move the procedure for an uncommanded thrust reverse stowage, and then to approve the design change that incorporated the wheel speed sensors. He was surprised that no design changes were made for the takeoff mode and feels that nobody in any organization recognized the significance of the failure in the procedure for an uncommanded stowage. It would be odd to not think a deer could do the same damage on a takeoff.

The manager noted that typical pilots do not fly in the manner that the airplanes are flown to obtain performance data. The published performance data is accurate, but pilots in general are not aware of how widely they may miss this data. When slightly too fast or high in not using the baselines that had been used to establish the performance data, there could be a potential for going off the end of a runway. It concerns him that most pilots have minimal or no training for minimum field length landings in high performance airplanes, where altitude and speed control can be critical.

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15 The date of this particular conversation during the period was not recorded.

The Manager is aware of the investigation into the accident at Columbia, SC, and that there is an interest in checking tire pressures and an interest in the thrust reversers. He knows that there is an interest in potential changes to procedures and that Learjet had proposed changes. The FAA and Learjet are in the process of discussing the potential changes and working on differences.

The Manager did not remember anything unusual about the development or certification of the wheel/tire brake systems in the Model 60. He feels that a pilot is able to check tire pressures. He has been working with Learjet airplanes since 1978 and has never heard that the tire pressures were as critical as is now being learned. He repeated this at another point in the conversation. For Part 135, checking tire pressures is something that will need to be a change to the Operation Specifications at each individual operator.

There was early post-accident discussion about prohibiting use of the thrust reversers in rejected takeoffs. However, the prohibition could be a negative in some situations, so the policies regarding the use of reverse thrust on takeoff is still in discussion.

The Manager was asked what he felt he would have experienced if he were the pilot involved with the N999LJ accident. His first reaction was that there would be no time to troubleshoot an untrained problem, especially as the airplane reaches V_1 speed. It would have been hard to detect and react to, even if he had seen the thrust reverser lights. He feels that if he were to pull the piggy-back levers, miss the second of lights while looking outside the airplane, and hear the thrust increase, he would assume that he was getting reverse thrust due to both the positions of the levers and the increase in sound.
As the end of the runway would come, he would probably pull harder on the thrust reverser piggy-back levers. Notable comments that he made with respect to these thoughts included:

> "You are trained to do things that come natural to you."
>
> "This is the type of thing that supposedly can't happen, like the Lauda thrust reverser."
> [In the early 1990's, a Lauda Air 767 had an uncommanded thrust reverser deployment while climbing from Bangkok, control was lost, and the airplane crashed.]
>
> "This needs a procedure as an interim fix and then an engineering fix to be permanent."

He learned of the potential for uncommanded reverser stowage to result in the three annunciators to be dark. In his terms, this type of a black panel is not an optimal situation, because pilots are trained for specific procedures and are not trained to recognize items that do not happen. He strongly feels that pilots need a cue for the abnormality. There ought to be some type of annunciation for uncommanded thrust reverser stowage. When he flies the airplane, his training is to divide duties with the First Officer, so that he is focusing on the environment outside of the cockpit and the First Officer is monitoring the instruments and annunciators.

An FAA Model 60 Aircraft Evaluation Group pilot reported that he tried the inadvertent stowage scenario in a simulator, after the N999LJ accident. He went off the end of the runway until his third attempt at the rejected takeoff. A Learjet person with eight years of working with various Learjet simulator models was part of the conversation and added that he had never performed the uncommanded thrust reverser stowage procedure.

This ends the notes from discussion with the FAA Manager of Flight Test.

APPENDIX A, NONVOLATILE MEMORY (NVM) FROM ENGINE ELECTRONIC CONTROL (EEC):

The airplane incorporated full authority digital engine controls (FADEC) and had no physical push/pull control cables to connect the cockpit controls and the engines. Solid state memory devices from the engine electronic control (EEC) units and an engine data recording system exhibited severe damage from exposure to fire. Each unit was removed from the engines at the crash site for memory extraction.

The EECs were sent to the Federal Aviation Administration office in Hartford, Connecticut in an attempt at obtaining any nonvolatile memory at the manufacturer, Hamilton Sundstrand. The EECs were extensively fire damaged and no data was obtained from the memory of either EEC. The following are identification data for each of the full authority digital engine control (FADEC) units that was recorded in Columbia, SC:

Left Engine CA 0484	
Pratt & Whitney P/N:	30B3200-06
Serial Number	SN 06044823
Hamilton Standard P/N:	822821-6-004
Right Engine CA0487	
Pratt & Whitney P/N:	30B3200-06
Hamilton Standard P/N:	822821-6-004

The following text has been copied from the Hamilton Sundstrand test report:

FACTUAL NOTES, ELECTRONIC ENGINE CONTROLS, IN SUPPORT OF THE INVESTIGATION OF LEAR 60 EVENT, SEPTEMBER 2008 IN SOUTH CAROLINA.

Rev. 0 – Base, 19 November 2008

1.0 **INVESTIGATION**

A Lear 60 event occurred in September 2008 in South Carolina. The aircraft (Lear 60, N999LJ) was taking off and apparently blew one or more tires, which prompted the crew to attempt to abort the takeoff. The aircraft exited the end of the runway, hitting several approach lights, went through a fence and over a road, hitting the ground on an opposite embankment. Severe post crash fire occurred. 4 of the 6 persons on board were killed. The Lear 60 aircraft is powered by 2 Pratt & Whitney Canada (PWC) PW305A engines. The electronic engine controls (EEC) removed from the PW305A engines, Hamilton Sundstrand (HS) model EEC400-1, were shipped to the HS repair facility in Windsor

Locks, Connecticut from the crash site by the NTSB and were quarantined until the investigation on 18 November 2008. The investigation was witnessed by local FAA Inspectors per the request of the NTSB.

The part numbers and serial numbers of the EECs are shown below:

EEC Identification
Part Number: 822821-x-yyy (full part number unknown as the ID plate was destroyed)
Serial Number: Unknown. Information obtained from the NTSB and PWC investigators at the site of the event shows that SN 06044823 EEC was reported to be on the engine when shipped from PWC, but it is unknown if this was still on the engine at the time of the crash. This unit was reportedly from the left hand engine. For shop processing of the unit, it was given a serial number of UNK-L

Part Number: 822821-x-yyy (full part number unknown as the ID plate was destroyed)
Serial Number: Unknown. Information obtained from the NTSB and PWC investigators at the site of the event shows that SN 06072639 EEC was reported to be on the engine when shipped from PWC, but it is unknown if this was still on the engine at the time of the crash. This unit was reportedly from the right hand engine. For shop processing of the unit, it was given a serial number of UNK-R

2.0 **General Background Information**

The EEC400-1 is a dual channel (channel A and channel B) digital Electronic Engine Control. In conjunction with a Mechanical Fuel Control (MFC), it monitors and adjusts fuel flow to the engine.

3.0 **Model Designation EEC400-1**

This model EEC400-1 Electronic Engine Control is used on the PW305A, PW306A, and PW306C engines.

4.0 **Electronic Engine Control Receiving**

The shipping container that the EECs were shipped in was opened in the receiving inspection area and external visual inspections were performed.

External Inspection results:

Serial Number: UNK-L

External visual inspection of the unit showed severe physical damage to the chassis and connectors. In addition to the physical damage, the unit had severe heat damage by fire. A large “L” was written on the top cover of the unit.

Serial Number: UNK-R
External visual inspection of the unit showed severe physical damage to the chassis and connectors. In addition to the physical damage, the unit had severe heat damage by fire. A large "R" was written on the top cover of the unit.

5.0 Electronic Engine Control Disassembly/Fault Data

Disassembly and Internal Inspection:

From the severely damaged condition of the units, it was not possible to use the test rig to power the units and download the fault data. The units were disassembled to review the condition of the circuit card assemblies (CCA) and to remove the memory devices to download the fault data via a Data I/O reader. Internal inspection of the CCAs and chassis's showed that the units had experienced extreme temperatures, damaging them beyond repair. Several devices (electronic chips) and other components from the CCAs had become unsoldered from the board assemblies. The flex tape on each unit that connects the two channels was melted and needed to be cut so the CCAs from channel A and B in each unit could be separated.

Removal of memory devices;

Once the CCAs were removed, the memory devices on 3 of the 4 CCAs (UNK-L channel A UNK-L channel B and UNK-R channel A) were identified and removed by unsoldering them from the CCA. The memory device for the remaining CCA (UNK-R channel B) had become unsoldered from the board from the heat during the event and was found inside the chassis. Visual inspection of the memory devices showed that they were also heat damaged and their condition was questionable for reading via the Data I/O reader. The memory devices were cleaned as best as possible so they could be read by a Data I/O reader.

Reading of the memory devices by a Data I/O reader;

An attempt was made to read all the memory devices using the Data I/O reader. None of the memory devices were able to be read. The indication from the Data I/O reader showed that it could not communicate with the memory device, indicating that the memory device was damaged internally. Partial communication with one of the memory devices was possible, but because not all internal leads were intact, data could not be downloaded. Additional attempts to retrieve the data contained on the memory devices can be made using different methods. However, that is beyond the scope of this investigation and at the discretion and direction of the NTSB.

6.0 Closing

The EEC units are currently in quarantine at Hamilton Sundstrand awaiting further direction by the NTSB.

These factual notes are based on observations made 18 November 2008 at the Hamilton Sundstrand Worldwide Repair Center in Windsor Locks, Connecticut. This document may be amended on the basis of further information.

HAMILTON SUNDSTRAND

Scott J. Ashworth
Sr. Service Engineer, Customer Support
19 November 2008

APPENDIX B, NONVOLATILE MEMORY (NVM) FROM EDU:

The EEC memories in the Model 60 were not designed to retain a substantial number of fault records, as the fault records were to be centrally recorded by the engine diagnostic Unit (EDU). The EDU was recovered from the aft fuselage of the airplane and the design contained non-volatile memory to collect and record an extensive amount of engine operational and fault data. When recording the engine parameters, the EDU was designed to also capture numerous airframe parameters. (See Figure B-1)

Figure B-1. The engine data unit was recovered with extensive fire damage. Following removal of the outer case, this shows the condition of the internal electronics.

The EDU was partially consumed by fire at one end. The opposite end had the remnant of a RS-232 connector and had gotten hot enough that the pins of the connector were missing. The EDU box rattled when it was shaken. The part number of the EDU was 9-361-06 and the manufacturer was the ELDEC Division of Crane. The Control Display Unit has no non-volatile memory and a 31B5424-02, also identified by the ELDEC part number of 9-362-03.

Because an extensive amount of data about the airplane and engines could potentially be collected, the Safety Board contracted Analytical Solutions Incorporated, a laboratory with specialty expertise in recovery of nonvolatile data and reverse engineering of microelectronics. The following is the summary of their report, regarding the work required and finding that heat from the post-crash fire had cleared the NVM:

> A flight recorder box with eight (8) Intel Flash 28F010 NVM chips was received for analysis in an attempt to retrieve the memory contents from the individual devices; U3-U10. Upon initial inspections of the box and NVM chips on the PWB, exterior fusing of the devices in the form of carbonized epoxy on was observed, an indication that these devices were exposed to temperatures in excess of 400C. The box was carefully disassembled for removal of the NVM chips from the PWB, no additional heating or damage to the devices was caused by this process. All devices were subjected to detailed inspections and documentation at this time; again, severe overheating damage was observed on all devices. Real time X-ray inspections in conjunction with pin to pin testing indicated internal opens on all devices due to lifted or broken wires, once again due to the severe overheating of these devices. At this time all devices were decapsulated using a mechanical parallel lapping process where the packages were lapped down to the level of the bonds to the die. Two die (U4 and U9) exhibited mechanical damage which could not be repaired. The remaining die exhibited a thin film of carbonized epoxy, yet another indication of overheating. A test setup was generated and a custom probe card was designed and built to accommodate internal electrical testing and data extraction via a probe station. This was a laborious process presenting many challenges to obtained proper continuity to all bond pads on each device. Several instances required FIB cleaning or deposition for proper continuity. U3 was successfully read out. All remaining, undamaged devices (U5-8, U10) were successfully read and identified to be erased due to the extreme heat. This was concluded from the fact that the programmed device ID was erased as well, which indicates the memory contents were lost, most likely due to the severe heating the devices were subjected to.

APPENDIX C, LEARJET SERVICE BULLETIN 60-78-7

The SB was titled EXHAUST – INSTALLATION OF THRUST REVERSER INTERFACE BOX, with the BASIC release date as February 21, 2005, and revised twice, with Rev 2 issued May 1, 2006.

BOMBARDIER

SERVICE BULLETIN
REVISION TRANSMITTAL SHEET

This page transmits Revision 2 to Service Bulletin 60-78-7, "Installation of Thrust Reverser Interface Box."

Rework:

No rework is required for aircraft which have complied with previous issues of this Service Bulletin.

Reason:

Revised the planning information as follows:

In paragraph 1.H., moved the wheel speed detect box assembly information from the material required table to the other materials necessary table.

In paragraph 1.H., moved T/R interface box information from the material required table to the other materials necessary table.

Added paragraph 1.H.(1), other material/parts necessary to do this service bulletin table.

In paragraph 1.H.(1), added wheel speed detect box assembly information to the table.

In paragraph 1.H.(1), added T/R interface box information to the table.

In paragraph 1.H.(1), revised the note to add the phone number for customers outside of North America.

In paragraph 1.H.(1), added a note for the alternate part number for the wheel speed detect box assembly.

Revised the accomplishment information as follows:

In Figure 1, sheet 1 of 3, added the alternate part number for the wheel speed detect box.

In Figure 1, sheet 1 of 3, changed the ground plug callout from 148C to 148E.

In Figure 2, sheet 1 of 2, changed the ground plug callout from 148C to 148E in wire diagram.

In Figure 2, sheet 1 of 2, changed the electrical code from 148C to 148E in flagnote 5.

In Figure 2, sheet 2 of 2, changed the ground plug callout from 148C to 148E in wire diagram.

Revised material information as follows:

In paragraph 3.A.(1), changed wire specification for C98B22 wire from M27500-22SD-3T23 to M27500-22SD-2T23.

In paragraph 3.B., added alternate part number for the wheel speed detect box assembly to the parts removed list table.

Filing Instructions:

This is a COMPLETE revision. Remove and discard all pages of the prior issue and replace with pages of Revision 2.

Record of Revisions:

ISSUE	DISTRIBUTION DATE
Basic	Feb 21/05
Revision 2	May 1/06

BOMBARDIER

SERVICE BULLETIN

To ensure proper compliance with this Service Bulletin, owners and operators of affected aircraft modified by STC should contact the STC holder or their regional FAA office for additional information and disposition.

CONTACT INFORMATION	DISTRIBUTION DATE	REV. NO.
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EXHAUST - INSTALLATION OF THRUST REVERSER INTERFACE BOX

1. Planning Information

A. Effectivity

(1) Learjet 60-002 thru 60-276.

NOTE: On applicable aircraft, Learjet Service Bulletin 60-27-6, "Installation of Autospoiler-Wheel Speed Detection System" must be performed prior to or in conjunction with this Service Bulletin. Owners and operators should check the Service Bulletin effectivity against their aircraft serial number to determine if their aircraft is impacted.

B. Reason

(1) To install a wheel speed input to the thrust reverser system to reduce the possibility of inadvertent stowing during thrust reverser operation.

C. Description

(1) This bulletin modifies the aircraft as follows.

(a) Installs brackets to secure thrust reverser interface box.

(b) Installs thrust reverser interface box.

(c) Modifies wiring for the new thrust reverser interface box.

D. Compliance

(1) Recommended - It is recommended that this Service Bulletin be complied with no later than the next 600 flight hours or within 12 months from the original distribution date of this Service Bulletin, February 21, 2005.

E. Approval
(1) FAA approval has been obtained on technical data in this publication that affects airplane type design.
(2) EASA approval has been obtained on technical data in this publication that affects airplane type design.

F. Labor Hours - Estimated Accomplishment Time

-801 KIT	TASK
5.0	Labor hours to gain access to affected area.
25.0	Labor hours to modify aircraft.
20.0	Labor hours to functional test/operational check.
15.0	Labor hours to restore aircraft to airworthy status.
65.0	Total Labor Hours

NOTE: The above labor hour estimate is for planning purposes only. Facility and/or personnel capabilities may cause actual accomplishment time to vary significantly.

G. Expense Coverage
(1) Labor Coverage
(a) *Aircraft in service 0-5 years* - 100% coverage.
(b) *Aircraft in service years 6 thru 8* - 50% coverage.
(c) *Aircraft in service years 9 thru 12* - 25% coverage.
(2) Material Coverage
(a) *Aircraft in service 0-5 years* - 100% coverage.
(b) *Aircraft in service years 6 thru 8* - 50% coverage.
(c) *Aircraft in service years 9 thru 12* - 25% coverage.
(3) Smart Parts - Smart Parts Plus does not pay for the materials during or after the free period for those aircraft in service 0-5 years at the time of service bulletin distribution. For those aircraft in service greater than 5 years at the time of service bulletin distribution Smart Parts Plus pays for the chargeable portion of the materials in accordance with the above prorated table applicable to the aircraft at the time of service bulletin distribution.

H. Material Required to Accomplish Service Bulletin.

PART NUMBER	QTY	NOMENCLATURE	PRICING
6081046-801	1	Service Bulletin Kit	$ 1,154.00

NOTE: The above selling price is subject to change without notice.

(1) Other material/parts necessary to do this service bulletin.

PART NUMBER	QTY	NOMENCLATURE	NOTES
6018366-005 *	1	Box Assembly, Wheel Speed Detect (E410)	(** See Note Below)
6018003-001	1	T/R Interface Box (E465)	(** See Note Below)

NOTE: * 6081044-805 is a spare for 6018366-005.

** The wheel speed detect box assembly and T/R interface box are rotatable components. Contact Bombardier Aerospace Parts Logistics Business Aircraft Customer Service at 1-888-222-1428 in North America or 1-316-946-2377 outside North America for information for availability and pricing.

To place an order for these parts, please call Bombardier Aerospace Parts Logistics Business Aircraft Customer Service at 1-888-222-1428 in North America or 1-316-946-2377 outside North America for information.

I. Tooling
(1) Acquire the necessary tools and equipment.

NAME	PART NUMBER	QTY	MANUFACTURER	USAGE
External Hydraulic Power Source (1500 PSI)		1	Obtain Locally	Drive T/Rs and Spoilers
Squat Switch Simulator Sticks		2	Fabricate	Close squat switch.
Ground Power Unit	GPU	1		
Spoiler Cage	TN61341	2	Learjet Inc. Wichita, KS	Protect personnel from spoilers.
Stopwatch		1	Commercially Available	General
Spin Adapter	2571004-1	1	Learjet Inc. Wichita, KS	To adapt the drill to the transducer.
Drill Motor (two [2] Reqd.)(Speeds of 1700 to 2000 rpm.)		2	Commercially Available	To simulate aircraft ground speed.

J. Weight and Balance

(1) Change in basic weight and moment.

CHANGE IN BASIC WEIGHT	CHANGE IN BASIC MOMENT
Plus (+) 1.35 pounds	Plus (+) 488.2 inch-pounds

K. References

(1) Learjet Maintenance Manual, Chapters 7, 12, 24, 25, 27, and 29.

(2) Learjet Wiring Manual, Chapter 20.

L. Other Publications Affected

(1) Learjet Illustrated Parts Catalog, Chapter 27.

(2) Learjet Wiring Manual, Chapters 27, 32, and 78.

2. Accomplishment Instructions

A. Gain Access

(1) Jack the aircraft so that the landing gear clears the ground. (Refer to Learjet Maintenance Manual, Chapter 7.)

(2) Set battery switch(es) off and disconnect aircraft batteries.

(3) Open aft cabin baggage compartment closet door.

NOTE: If removal of closet door is preferred, refer to Learjet Maintenance Manual, Chapter 25.

(4) The aft cabin baggage compartment floor liner panel is secured by hook and loop fasteners on all edges.

(5) Pull to release hook and loop fasteners and remove floor liner panel from aircraft.

(6) Remove all attaching hardware from left side liner panel assembly.

(7) Remove left side liner panel assembly from aircraft.

B. Modification of Aircraft

(1) Remove the wheel speed detect box assembly (E410) from the aircraft. Retain attaching hardware. (Refer to Learjet Maintenance Manual, Chapter 27.)

(2) Return wheel speed detect box assembly (E410) to Learjet. (Refer to paragraph 3.B for return shipping information.)

(3) Install new wheel speed detect box assembly (E410) to aircraft with retained hardware.

(4) Determine location of 6018004-803 bracket to stringer 10L as follows:

(a) Position and clamp bracket to stringer 10L. (See Figure 1.)

(b) Using a 0.1250 inch [3.18 mm] drill bit, drill six (6) fastener holes through bracket and stringer 10L.

(5) Determine location of 6018004-804 bracket to stringer 11L as follows:

(a) Position and clamp bracket to stringer 11L. (See Figure 1.)

(b) Using a 0.1250-inch [3.18 mm] drill bit, drill six (6) fastener holes through bracket and stringer 11L.

(6) Position the T/R Interface box on 6018004-803 and 6018004-804 brackets and clamp in place. (See Figure 1.)

(7) Mark T/R Interface box mounting hole pattern on the 6018004-803 and 6018004-804 brackets.

(8) Ensure proper edge distances and that locations are not in bend radius of brackets.

(9) Remove T/R Interface box from brackets.

(10) Remove 6018004-803 and 6018004-804 brackets from stringers.

(11) Drill No. 12 (.189 diameter) hole at marked location on 6018004-803 and 6018004-804 brackets.

(12) Deburr holes on both sides of the brackets.

(13) Deburr holes drilled in stringers 10L and 11L.

(14) Install nutplates to new 6018004-803 and 6018004-804 brackets as follows.

(a) Position nutplate to bracket and mark nutplate fastener hole locations.

(b) Drill fastener holes in brackets.

(c) Electrically bond nutplate to brackets, (Refer to Learjet Wiring Manual, Chapter 20.)

(d) Install nutplate to bracket using MS20426AD3-2 rivets.

(15) Install 6018004-803 bracket to stringer 10L as follows.

(a) Electrically bond all holes drilled. (Refer to Learjet Wiring Manual, Chapter 20.)

(b) Clean stringer 10L and the 6018004-803 bracket using MPK or equivalent and cheesecloth.

(c) Wipe remaining MPK from stringer 10L and bracket using lint-free cloth.

(d) Secure the 6018004-803 bracket to stringer 10L using MS20470AD4-3 rivets. (See Figure 1.)

(16) Install 6018004-804 bracket to stringer 11L as follows.

(a) Electrically bond all holes drilled. (Refer to Learjet Wiring Manual, Chapter 20.)

(b) Clean stringer 11L and the 6018004-804 bracket using MPK or equivalent and cheesecloth.

(c) Wipe remaining MPK from stringer 11L and bracket using lint-free cloth.

(d) Secure the 6018004-804 bracket to stringer 11L using MS20470AD4-3 rivets. (See Figure 1.)

(17) Install T/R Interface box to bracket with MS27039-0806 screws. (See Figure 1.)

(18) Modify aircraft wiring. (See Figure 2.)

NOTE: Route the new wiring with the existing wire bundle.

Permissible to secure new wiring to existing wiring using tie wraps at each clamp location. (See Figure 2.)

C. Perform Functional Test/Operational Check

(1) Functional Test - Model 60 Thrust Reverser with Wheel Speed Detect Interface - Ground Test

(a) PRE-TEST PROCEDURE FOR T/R GROUND TESTS ENGINES NOT RUNNING

1) Place the aircraft on jacks. (Refer to Learjet Maintenance Manual, Chapter 7)

2) Release the parking brake.

3) Connect the electrical ground power cart. (Refer to Learjet Maintenance Manual, Chapter 24.)

4) Connect the hydraulic ground power cart. (Refer to Learjet Maintenance Manual, Chapter 29.

NOTE: The following thrust reverser operating checks are performed with the engines not running and system hydraulic power supplied by a hydraulic mule. A suitable AC outlet must be available to power the Hydraulic Mule.

5) Insert squat switch simulator sticks into the right and left squat switches (S1 thru S4) to simulate ground mode (weight on wheels).
6) Set the T/R Cont, Auto Stow, Warn. Lts., EEC and Squat Switch Circuit Breakers.

(b) RT SQUAT SWITCH FIRST OFF GROUND

1) Deploy one thrust reverser at a time, waiting for the hydraulic power cart to re-stabilize at full pressure between T/R deployments.
2) With both thrust reversers deployed, set the right squat switch to the flight mode and verify the following.
   a) Assure that a major engine fault (amber lamp) for each engine is set.
   b) The amber engine fault lamps will remain ON through step 2.C.1.(e).5).
   c) Assure that both thrust reversers stow and that the armed lamps flash until both thrust reversers are stowed, and extinguish when the thrust reversers are stowed.
3) Set the left squat switch to the flight mode.
4) Assure that a minor engine fault (white lamp) for each engine is set.
5) The white engine fault lamps will also remain ON through step 2.C.1.(e)5).

(c) RT SQUAT SWITCH FIRST LANDING

1) Set the left thrust reverser lever to STOW.
2) Set the right squat switch to ground mode.
3) Assure that both thrust reversers remain stowed.
4) Set the left squat switch to ground mode.
5) Verify that the right thrust reverser deploys.

(d) LT SQUAT SWITCH FIRST OFF GROUND

1) With the right thrust reversers deployed, set the left squat switch to the flight mode.
2) Assure that the right thrust reverser stows and that the armed lamp flashes until the thrust reverser is stowed, and extinguish when thrust reverser is stowed.
3) Set the right squat switch to the flight mode.

(e) LT SQUAT SWITCH FIRST LANDING

1) Set the left squat switch to ground mode.
2) Verify that both thrust reversers remain stowed.
3) Set the right thrust reverser lever to STOW.
4) Set the left thrust reverser lever to DEPLOY.
5) Set the right squat switch to ground mode.
6) Verify that the left thrust reverser deploys.
7) Set the left thrust reverser lever to STOW.
8) Verify that the left thrust reverser begins to stow.
9) Verify the left TR DEPLOY annunciator extinguishes and the left engine T/R UNLOCK annunciator illuminates during transition.
10) Verify after the left thrust reverser is fully stowed, that the left engine T/R UNLOCK annunciator extinguishes and both T/R ARM annunciators remain illuminated.

(f) THRUST REVERSER WHEEL SPEED INTERFACE GROUND TEST ENGINES NOT RUNNING.

1) Verify the aircraft is on jacks with the nose and main gear clearing the ground in the DOWN position.
2) Verify the parking brake is in the released position.
3) Set BATTERY 1 and BATTERY 2 switches OFF.

4) If not previously accomplished remove the hubcap from each wheel, exposing each wheel speed transducer.
5) Verify the left and right squat switches are set to the ground mode.

WARNING: KEEP CLEAR OF THE THRUST REVERSERS AT ALL TIMES. THE THRUST REVERSERS MAY OPEN OR CLOSE AT ANY TIME WITHOUT WARNING, WHEN HYDRAULIC POWER IS AVAILABLE.

6) Apply electrical ground power to the aircraft. (Refer to Learjet Maintenance Manual, Chapter 24.)
7) Apply hydraulic ground power to the aircraft. (Refer to Learjet Maintenance Manual, Chapter 29.)
8) Verify hydraulic pressure is normal (1500 - 1550 PSI).
9) Set both throttles to the idle position.
10) Verify both green T/R ARM annunciators are illuminated and the SPOILER MON annunciator is extinguished.
11) Set the spoiler lever to the ARM position.
12) Verify the green SPOILER ARMED annunciator is illuminated.
13) Set both squat switches to the flight mode.
14) Verify both green T/R ARM annunciators extinguish.
15) Rotate the SYSTEM TEST switch to the SPOILER RESET position and press the TEST button. Upon release verify the left and right T/R ARM annunciators do not illuminate.
16) Allow the left and right squat switches to remain in flight mode for 3 minutes minimum.
17) Set the Left and Right squat switches to ground mode.
   a) Start the stopwatch when the switches are set.
   b) Set both squat switches to ground mode as close to the same time as possible.
18) Move the left thrust reverser lever to DEPLOY.
19) Verify that when the left thrust reverser is fully deployed, the left T/R DEPLOY annunciator illuminate and the left T/R UNLOCK annunciator extinguishes.
20) Spin the left outboard and right outboard wheel speed transducers to fast drill speed.

NOTE: Fast drill speed range is from 1100 RPM to 2000 RPM.

21) Within 40 seconds after setting the squat switches to ground mode, set the right squat switch to flight mode and stop the stopwatch while continuing to spin the left outboard and right outboard wheel speed transducers.
22) Verify the left thrust reverser remains deployed.
23) Stop spinning the left outboard wheel speed transducer.
24) Verify the left thrust reverser remains deployed.
25) Stop spinning the right outboard wheel speed transducer.
26) Verify after a 2 ± 1 second delay, the left thrust reverser begins to stow.
27) Verify the left thrust reverser is fully stowed.
28) Set the left thrust reverser lever to STOW.
29) Allow the left and right squat switches to remain in flight mode for 3 minutes minimum.

30) Set the left and right squat switches to ground mode.
   a) Start the stopwatch when the switches are set.
   b) Set both squat switches to ground mode as close to the same time as possible.
31) Set the right thrust reverser lever to DEPLOY.
32) Verify that when the right thrust reverser is fully deployed, the right T/R DEPLOY annunciator illuminates and the right T/R UNLOCK annunciator extinguishes.
33) Spin the left outboard and right outboard wheel speed transducers to fast drill speed.

NOTE: Fast drill speed range is from 1100 RPM to 2000 RPM.

34) Within 40 seconds of setting the squat switches to ground mode set the right squat switch to flight mode and stop the stopwatch while continuing to spin the left outboard and right outboard wheel speed transducers.
35) Verify the right thrust reverser remains deployed.
36) Stop spinning the left outboard wheel speed transducer.
37) Verify the right thrust reverser remains deployed.
38) Stop spinning the right outboard wheel speed transducer.
39) Verify after a 2 ± 1 second delay, the right thrust reverser begins to stow.
40) Verify the right thrust reverser fully stows.
41) Set the right thrust reverser lever to STOW position.
42) Set the left squat switch to flight mode. Maintain flight mode with both squat switches for 3 minutes minimum.
43) Set the left and right squat switches to ground mode.
   a) Start the stopwatch when the switches are set.
   b) Set both squat switches to ground mode as close to the same time as possible.
44) Move the left thrust reverser lever to DEPLOY.
45) Verify that when the left thrust reverser is fully deployed, the left T/R DEPLOY annunciator illuminates and the left T/R UNLOCK annunciator extinguishes.
46) Spin the left outboard and right outboard wheel speed transducers to fast drill speed.

NOTE: Fast drill speed range is from 1100 RPM to 2000 RPM.

47) Within 40 seconds of setting the squat switches to ground mode, set the right squat switch to flight mode and stop the stopwatch while continuing to spin the left outboard and right outboard wheel speed transducers.
48) Verify the left thrust reverser remains deployed.
49) Stop spinning the right outboard wheel speed transducer.
50) Verify the left thrust reverser remains deployed.
51) Stop spinning the left outboard wheel speed transducer.
52) Verify after a 2 ± 1 second delay, the left thrust reverser begins to stow.
53) Verify the left thrust reverser fully stows.
54) Set the left thrust reverser lever to STOW.
55) Set the left squat switch to flight mode. Maintain flight mode with both squat switches for 3 minutes minimum.

56) Set the Left and Right squat switches to ground mode.
   a) Start the stopwatch when the switches are set.
   b) Set both squat switches to ground mode as close to the same time as possible.
57) Move the right thrust reverser lever to DEPLOY.
58) Verify that when the right thrust reverser is fully deployed that the right T/R DEPLOY annunciator illuminates and the right T/R UNLOCK annunciator extinguishes.
59) Spin the left outboard and right outboard wheel speed transducers to fast drill speed.

NOTE: Fast drill speed range is from 1100 RPM to 2000 RPM.

60) Within 40 seconds of setting the squat switches to ground mode set the right squat switch to flight mode and stop the stopwatch while continuing to spin the left outboard and right outboard wheel speed transducers.
61) Verify the right thrust reverser remains deployed.
62) Stop spinning the right outboard wheel speed transducer.
63) Verify the right thrust reverser remains deployed.
64) Stop spinning the left outboard wheel speed transducer.
65) Verify after a 2 ± 1 second delay, the right thrust reverser begins to stow.
66) Verify the right thrust reverser is fully stowed.
67) Set the right thrust reverser lever to STOW.
68) Set the right squat switch to flight mode. Maintain flight mode with both squat switches for 3 minutes minimum.
69) Set the left and right squat switches to ground mode.
   a) Start the stopwatch when the switches are set.
   b) Set both squat switches to ground mode as close to the same time as possible.
70) Set the right thrust reverser lever to DEPLOY.
71) Verify that when the right thrust reverser is fully deployed that the right T/R DEPLOY annunciator illuminates and the right T/R UNLOCK annunciator extinguishes.
72) Spin the left inboard and right inboard wheel speed transducers to fast drill speed.

NOTE: Fast drill speed range is from 1100 RPM to 2000 RPM.

73) Within 40 seconds of setting the squat switches to ground mode, set the left squat switch to flight mode and stop the stopwatch while continuing to spin the left inboard and right inboard wheel speed transducers.
74) Verify the right thrust reverser remains deployed.
75) Stop spinning the left inboard wheel speed transducer.
76) Verify the right thrust reverser remains deployed.
77) Stop spinning the right inboard wheel speed transducer.
78) Verify after a 2 ± 1 second delay, the right thrust reverser begins to stow.
79) Verify the right thrust reverser is fully stowed.
80) Set the right thrust reverser lever to STOW.
81) Set the right squat switch to flight mode. Maintain flight mode with both squat switches for 3 minutes minimum.

82) Set the left and right squat switches to ground mode.
   a) Start the stopwatch when the switches are set.
   b) Set both squat switches to ground mode as close to the same time as possible.
83) Set the left thrust reverser lever to DEPLOY.
84) Verify that when the left thrust reverser is fully deployed, that the left T/R DEPLOY annunciator illuminates and the left T/R UNLOCK annunciator extinguishes.
85) Spin the left inboard and right inboard wheel speed transducers to fast drill speed.

NOTE: Fast drill speed range is from 1100 RPM to 2000 RPM.

86) Within 40 seconds of setting the squat switches to ground mode, set the left squat switch to flight mode and stop the stopwatch while continuing to spin the left inboard and right inboard wheel speed transducers.
87) Verify the left thrust reverser remains deployed.
88) Stop spinning the left inboard wheel speed transducer.
89) Verify the left thrust reverser remains deployed.
90) Stop spinning the right inboard wheel speed transducer.
91) Verify after a 2 ± 1 second delay, the left thrust reverser begins to stow.
92) Verify the left thrust reverser is fully stowed.
93) Set the left thrust reverser lever to STOW.
94) Set the left squat switch to flight mode. Maintain flight mode with both squat switches for 3 minutes minimum.
95) Set the left and right squat switches to ground mode.
   a) Start the stopwatch when the switches are set.
   b) Set both squat switches to ground mode as close to the same time as possible.
96) Set the right thrust reverser lever to DEPLOY.
97) Verify that when the right thrust reverser is fully deployed that the right T/R DEPLOY annunciator illuminates and the right T/R UNLOCK annunciator extinguishes.
98) Spin the left inboard and right inboard wheel speed transducers to fast drill speed.

NOTE: Fast drill speed range is from 1100 RPM to 2000 RPM.

99) Within 40 seconds of setting the squat switches to ground mode set the left squat switch to flight mode and stop the stopwatch while continuing to spin the left inboard and right inboard wheel speed transducers.
100) Verify the right thrust reverser remains deployed.
101) Stop spinning the right inboard wheel speed transducer.
102) Verify the right thrust reverser remains deployed.
103) Stop spinning the left inboard wheel speed transducer.
104) Verify after a 2 ± 1 second delay, the right thrust reverser begins to stow.
105) Verify the right thrust reverser is fully stowed.
106) Set the right thrust reverser lever to STOW.
107) Set the left squat switch to flight mode. Maintain flight mode with both squat switches for 3 minutes minimum.

108) Set the left and right squat switches to ground mode.
   a) Start the stopwatch when the switches are set.
   b) Set both squat switches to ground mode as close to the same time as possible.
109) Set the left thrust reverser lever to DEPLOY.
110) Verify that when the left thrust reverser is fully deployed that the left T/R DEPLOY annunciator illuminates and the left T/R UNLOCK annunciator extinguishes.
111) Spin the left inboard and right inboard wheel speed transducers to fast drill speed.

NOTE: Fast drill speed range is from 1100 RPM to 2000 RPM.

112) Within 40 seconds of setting the squat switches to ground mode set the left squat switch to flight mode and stop the stopwatch while continuing to spin the left inboard and right inboard wheel speed transducers.
113) Verify the left thrust reverser remains deployed.
114) Stop spinning the right inboard wheel speed transducer.
115) Verify the left thrust reverser remains deployed.
116) Stop spinning the left inboard wheel speed transducer.
117) Verify after a 2 ± 1 second delay, the left thrust reverser begins to stow.
118) Verify the left thrust reverser is fully stowed.
119) Set the left thrust reverser lever to STOW.

(2) Functional Test of the Spoiler System
   (a) Perform the following test to check thrust reverser interface box operations with the spoiler system.
      1) Verify the aircraft is on jacks with the nose and main gear clearing the ground in the DOWN position. (Refer to Learjet Maintenance Manual, Chapter 7.)
      2) Install the spoiler cages over the spoilers.
      3) Connect an external electrical power source to the aircraft. (Refer to Learjet Maintenance Manual, Chapter 24.)
      4) Connect external hydraulic power source to aircraft. (Refer to Learjet Maintenance Manual, Chapter 24.)
      5) Set the battery switches on.
      6) Set the inverter switches on.
      7) Pressurize hydraulic system to 1,500 (± 50) psi [10,342 (±345) kPa].
      8) Ensure both squat switches are in flight mode.
      9) Extend flaps to 20 degrees and set both throttles above IDLE.
      10) Set squat switches to ground mode and start stopwatch when squat switches are set. Set both squat switches to ground mode as close to the same time as possible.
      11) Within 45 seconds after performing step 2.C.(2)(a)10), set both throttles to IDLE and set spoiler lever to ARM.
      12) Verify that Spoilers extend, SPOILER ARM and SPOILER EXT annunciators shall illuminate.
      13) Wait for 20 seconds after the completion of step 2.C.(2)(a)10).
      14) Set both throttles above IDLE for 5 seconds and return throttles to IDLE.
      15) Spoilers shall retract, SPOILER ARM annunciator shall remain illuminated, and SPOILER EXT annunciator shall extinguish.

16) Using drill motors, spin LH inboard and RH outboard wheels to fast drill speed.

NOTE: Fast drill speed is between 1100 to 2000 rpm. If identical drill motors are not available, regulate the fast motor to match the slower motor using a strobe light.

17) Spoilers shall extend, SPOILER ARM annunciator shall remain illuminated, SPOILER EXT annunciator shall illuminate, and SPOILER MON annunciator shall be extinguished.
18) Reduce wheel speed to zero (0).
19) Advance both throttles above IDLE.
20) Spoilers shall retract.
21) Return both throttles to IDLE.
22) SPOILER ARM annunciator shall remain illuminated, SPOILER EXT annunciator shall extinguish, and SPOILER MON annunciator shall be extinguished.
23) Repeat steps 2.C.(2)(a)16) thru 22), except spin the LH outboard and RH inboard wheels to fast drill speed.
24) Set squat switches to flight mode.

NOTE: Perform steps 2.C.(2)(a)24) thru 30) within 1.5 minutes of setting squat switches to flight mode.

25) Spin left outboard and right inboard wheels to fast drill speed.
26) Verify that spoilers are retracted, SPOILER ARM annunciator is illuminated, and SPOILER EXT and SPOILER MON annunciators are extinguished.
27) Push the spoileron Reset/Test Switch.
28) Verify that spoilers do not extend upon release of switch.
29) Verify SPOILER ARM annunciator is illuminated, and SPOILER EXT and SPOILER MON annunciators are extinguished.
30) Reduce wheel speed to zero (0).
31) Wait 2 minutes, 15 seconds after starting step 2.C.(2)(a)24).
32) Spin the outboard wheels to fast drill speed.

NOTE: Fast drill speed is between 1100 to 2000 rpm. If identical drill motors are not available, regulate the fast motor to match the slower motor using a strobe light.

33) Verify that spoilers are not extended, SPOILER ARM annunciator is illuminated, and SPOILER EXT and SPOILER MON annunciators are extinguished.
34) Reduce wheel speed to zero (0).
35) Advance both throttles above IDLE and return to IDLE.
36) Spin inboard wheels to fast drill speed.
37) Verify that spoilers are not extended, SPOILER ARM annunciator is illuminated, and SPOILER EXT and SPOILER MON annunciators are extinguished.
38) Reduce wheel speed to zero (0).
39) Advance both throttles above IDLE and return to IDLE.

40) Spin the left inboard and outboard wheels to fast drill speed.
41) Verify that spoilers extend, SPOILER ARM and SPOILER EXT annunciators illuminate, and SPOILER MON annunciator is extinguished.
42) Reduce wheel speed to zero (0).
43) Advance both throttles above IDLE and verify that spoilers retract.
44) Return throttles to IDLE.
45) Verify SPOILER ARM annunciator is illuminated, and SPOILER EXT and SPOILER MON annunciators are extinguished.
46) Spin right inboard and outboard wheels to fast drill speed.
47) Verify that spoilers extend, SPOILER ARM and SPOILER EXT annunciators are illuminated, and SPOILER MON annunciator is extinguished.
48) Reduce wheel speed to zero (0).
49) Advance both throttles above IDLE and verify that spoilers retract.
50) Return throttles to IDLE.
51) Verify that SPOILER ARM annunciator is illuminated, and SPOILER EXT and SPOILER MON annunciators are extinguished.
52) Spin the right inboard and left outboard wheels to fast drill speed.
53) Verify that spoilers extend, SPOILER ARM and SPOILER EXT annunciators are illuminated, and SPOILER MON annunciator is extinguished.
54) Reduce wheel speed to zero (0).
55) Advance both throttles above IDLE and verify that spoilers retract.
56) Return throttles to IDLE.
57) Verify that SPOILER ARM annunciator is illuminated and the SPOILER EXT and SPOILER MON annunciators are extinguished.
58) Set right squat switch to ground mode.
59) Within 45 seconds, spin left inboard wheel to fast drill speed.
60) Verify that spoilers extend, SPOILER ARM and SPOILER EXT annunciators are illuminated, and SPOILER MON annunciator is extinguished.
61) Reduce wheel speed to zero (0).
62) Standby for 56 seconds after performing step 2.C.(2)(a)58), advance both throttles above IDLE and verify that spoilers retract.
63) Return throttles to IDLE.
64) Verify SPOILER ARM annunciator is illuminated, and SPOILER EXT and SPOILER MON annunciators are extinguished.
65) Standby for one minute after step 2.C.(2)(a)58), spin the left outboard wheel to fast drill speed.
66) Verify spoilers do not extend, SPOILER ARM annunciator is illuminated, and SPOILER EXT and SPOILER MON annunciators are extinguished.
67) Reduce wheel speed to zero (0).
68) Advance both throttles above IDLE and return throttles to IDLE.
69) Spin left inboard wheel to fast drill speed.
70) Verify spoilers do not extend, SPOILER ARM annunciator is illuminated, and SPOILER EXT and SPOILER MON annunciators are extinguished.
71) Reduce wheel speed to zero (0).
72) Advance both throttles above IDLE and return throttles to IDLE.

73) Spin both left inboard and left outboard wheels to fast drill speed.
74) Verify that spoilers extend, SPOILER ARM and SPOILER EXT annunciators are illuminated, and SPOILER MON annunciator is extinguished.
75) Reduce wheel speed to zero.
76) Complete the following steps within 45 seconds.
   a) Set left squat switch to ground mode.
   b) Set right squat switch to flight mode.
   c) Advance both throttles above IDLE.
   d) Verify spoilers retract.
   e) Return both throttles to IDLE.
   f) Verify the SPOILER ARM is illuminated.
   g) Verify the SPOILER EXT is extinguished.
   h) Verify the SPOILER MON is extinguished.
   i) Spin both right inboard and right outboard wheels to fast drill speed.
   j) Verify spoilers remain retracted.
   k) Verify the SPOILER ARM is illuminated.
   l) Verify the SPOILER EXT is extinguished.
   m) Verify the SPOILER MON is extinguished.
77) Reduce wheel speed to zero.
78) Standby 2 minutes, fifteen seconds after step 2.C.(2)(a)76).
79) Advance both throttles above IDLE and then back to IDLE.
80) Spin both the left inboard and left outboard wheels to fast drill speed.
81) Verify that spoilers extend.
82) Verify that the SPOILER ARM and SPOILER EXT annunciators are illuminated.
83) Verify that the SPOILER MON annunciator is extinguished.
84) Reduce wheel speed to zero (0).
85) Set right squat switch to ground mode.
86) Within 45 seconds of setting the right squat switch to ground mode, advance throttles above IDLE.
87) Verify spoilers retract.
88) Set both throttles to IDLE.
89) Verify that the SPOILER ARM annunciator is illuminated, and SPOILER EXT and SPOILER MON annunciators are extinguished.
90) Set spoiler lever to RET.
91) Verify that the SPOILER ARM, SPOILER EXT and SPOILER MON annunciators are extinguished.

(3) Functional Test of the Asymmetric Squat Switch Monitor
   (a) Perform the following test to check the asymmetric squat switch monitor system operation.
      1) Set the right squat switch to flight mode.
      2) Advance both throttles above IDLE and return to IDLE.
      3) Wait 3 minutes and set spoiler lever to ARM.
      4) Verify the SPOILER ARM annunciator is extinguished.
      5) Set the right squat switch to ground mode.
      6) Verify that spoilers extend, and the SPOILER ARM annunciator is illuminated.
      7) Wait 18 seconds, set both throttles above IDLE, and verify spoilers retract.

      8) Return both throttles to IDLE.
      9) Set the spoiler lever to RETRACT, and verify the SPOILER ARM annunciator is extinguished.
      10) Set the left squat switch to flight mode.
      11) Advance both throttles above IDLE and return to IDLE.
      12) Wait 3 minutes and set spoiler lever to ARM.
      13) Verify the SPOILER ARM annunciator is extinguished.
      14) Set the left squat switch to ground mode.
      15) Verify that spoilers extend, and the SPOILER ARM annunciator is illuminated.
      16) Wait 18 seconds, set both throttles above IDLE, and verify spoilers retract.
      17) Return both throttles to IDLE.
      18) Set the spoiler lever to RETRACT.

(4) Functional Test of the Wheel Speed Mode Engagement
   (a) Perform the following test to check the wheel speed mode engagement.
      1) Set the spoiler lever to ARM.
      2) Verify that spoilers extend, and the SPOILER ARM annunciator is illuminated.
      3) Advance both throttles above IDLE and verify spoilers retract.
      4) Return both throttles to IDLE.
      5) Set spoiler lever to RETRACT, and verify the SPOILER ARM annunciator is extinguished.
      6) Set the spoiler lever to ARM.
      7) Verify that spoilers extend, and the SPOILER ARM annunciator is illuminated.
      8) Set the spoiler lever to RETRACT.
      9) Verify spoilers retract and SPOILER ARM annunciator is extinguished.

(5) Functional Test of the Spoiler Reset System
   (a) Perform the following test to check the spoiler system in the SPOILER RESET position.
      1) Set both throttles to IDLE.
      2) Set spoiler lever to ARM and verify the spoilers extend within 2 seconds.
      3) Verify the SPOILER ARM and SPOILER EXT annunciators are illuminated.
      4) Rotate the SYSTEM TEST switch to SPOILER RESET, and depress and hold the TEST switch.
      5) Verify the spoilers retract within 1 second.
      6) Verify the SPOILER MON annunciator is illuminated, and the SPOILER ARM and SPOILER EXT annunciators are extinguished.
      7) Release the TEST switch.
      8) Verify that spoilers extend, SPOILER ARM and SPOILER EXT annunciators are illuminated, and SPOILER MON annunciator is extinguished.
      9) Depress and release the TEST switch.

         NOTE: Upon depressing the TEST switch, the spoilers will retract.

      10) Verify the spoilers are extended and the SPOILER EXT annunciator is illuminated.
      11) Set the left throttle above IDLE.
      12) Verify the spoilers retract, the SPOILER ARM annunciator is illuminated, and the SPOILER EXT annunciator is extinguished.
      13) Return the left throttle to IDLE and verify the spoilers remain retracted.

14) Repeat steps 2.C.(5)(a) 9) thru 13) for the right throttle.
15) Set the right throttle to the MCR detent.
16) Extend the spoilers, and verify the takeoff aural warning horn sounds.
17) Retract the spoilers.
18) Depressurize the hydraulic system. (Refer to Learjet Maintenance Manual, Chapter 29.)
19) Remove the aircraft from jacks (Refer to Learjet Maintenance Manual, Chapter 7.)
20) Disconnect external hydraulic power source from aircraft. (Refer to Learjet Maintenance Manual, Chapter 29.)
21) Check hydraulic reservoir fluid levels. (Refer to Learjet Maintenance Manual, Chapter 12.)
22) Set inverter switches off.
23) Set battery switches off.
24) Disconnect external electrical power.
25) Remove spoiler cages.

D. Restore Aircraft to Airworthy Status
(1) Install left side liner panel assembly to aircraft.
(2) Install floor liner panel to aircraft.
(3) Close aft cabin baggage compartment closet door.

E. Complete the attached Compliance Response Form and return as soon as possible.

F. Complete aircraft maintenance records in accordance with FAR 43.9.

3. **Material Information**

A. Parts Required

NOTE: The 6081046-801 Kit contains the following parts.

PART NUMBER	QTY	NOMENCLATURE	NOTES
D-436-36	2	Splice	
D-142-51	3	Solder Sleeve	
MS27039-0806	4	Screw	
MS21075L08N	4	Nutplate	
M85049/38-S13N	1	Backshell (P1131)	
MS20470AD4-3	12	Rivet	
MS20426AD3-2	8	Rivet	
M39029/58-363	4	Pin	Used on J5.
M39029/56-351	14	Socket	Used on P5 and P1131.
M39029/32-259	4	Socket	Used on P718 and P719.
D38999/26KC98SN	1	Plug (P1131)	

PART NUMBER	QTY	NOMENCLATURE	NOTES
6018004-804	1	Bracket	
6018004-803	1	Bracket	
6081046-803	1	Wire Kit	

NOTE: The actual quantity for hardware contained in the kit may be greater than the quantity shown in the parts list as hardware may be supplied in pre-packaged quantities.

(1) The 6081046-803 wire kit contains the following parts.

PART NUMBER OR WIRE CODE	QTY	NOMENCLATURE OR WIRE SPECIFICATION	NOTES
C249A22N	5 FT.	M22759/34-22-9	
C250A22N	5 FT.	M22759/34-22-9	
K304A22	10 FT.	M22759/34-22-9	
K305A22	10 FT.	M22759/34-22-9	
K306A22	10 FT.	M22759/34-22-9	
K307A22	10 FT.	M22759/34-22-9	
K304B22	25 FT.	M22759/34-22-9	
K305B22	25 FT.	M22759/34-22-9	
K306B22	25 FT.	M22759/34-22-9	
K307B22	25 FT.	M22759/34-22-9	
C98B22	10 FT.	M27500-22SD-2T23	

NOTE: The actual quantity for hardware contained in the kit may be greater than the quantity shown in the parts list as hardware may be supplied in pre-packaged quantities.

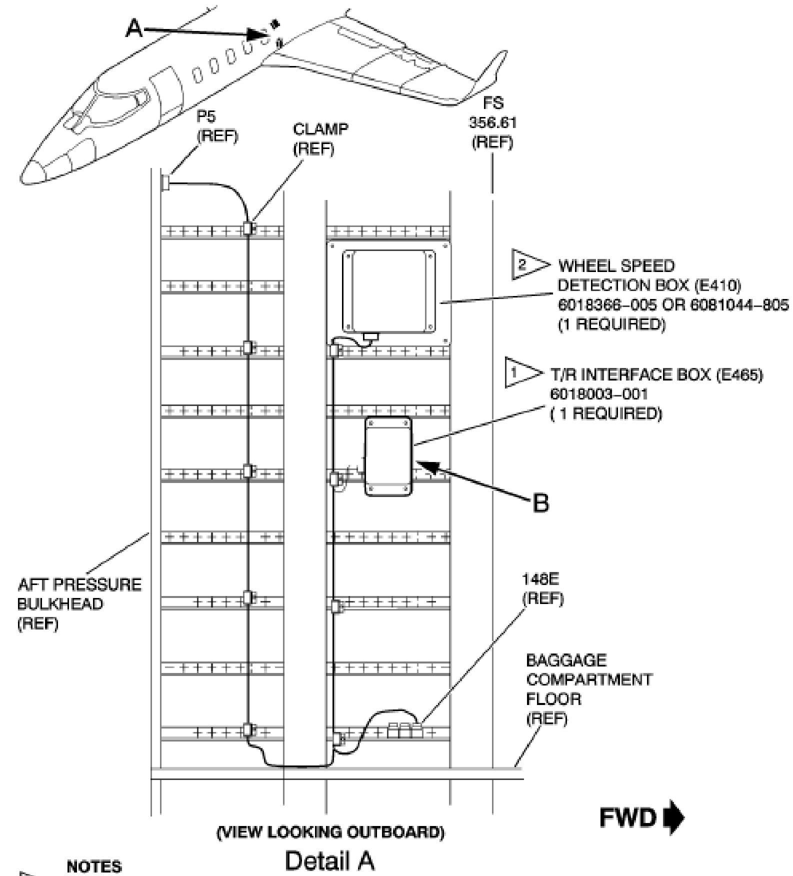
B. Parts Removed List

PART NUMBER	QTY	NOMENCLATURE	DISPOSITION	EFFECTIVITY	REPLACED BY
6018367V1-001 or 6018367V2-001 or 6018366-004 or 6081044-801	1	Wheel Speed Detect Box (E410)	Return to Learjet	60-002 thru 60-276	6018366-005 or 6081044-805

(1) Parts Identified in the "Parts Removed List" with a return to Learjet disposition must be returned within 20 days to avoid late penalty fees. Contact Bombardier Aerospace Parts Logistics Business Aircraft Customer Service at 1-888-222-1428 to obtain a Material Return Authorization.

(2) Parts identified in the "Parts Removed List" with a return to Learjet disposition, may be shipped to the following address:

RETURN SHIPPING ADDRESS
Bombardier Aerospace 251-A Wille Road Des Plaines, IL 60018 USA

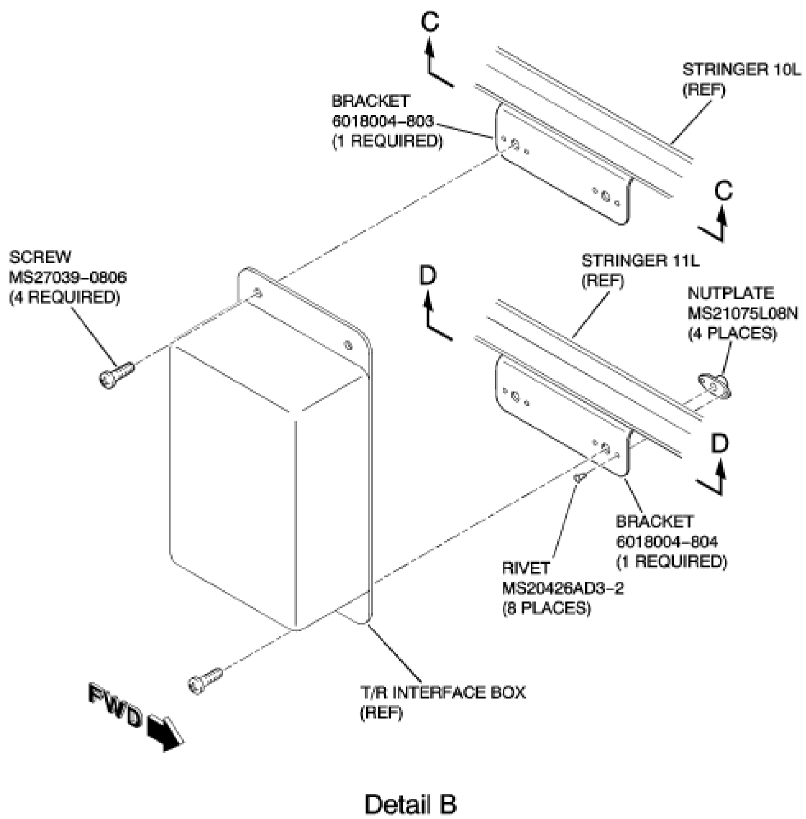


NOTES

1. Electrically bond per Learjet Model 60 wiring manual.
2. If correct part number wheel speed detect box (E410) is installed, it is not required to remove and replace unit.

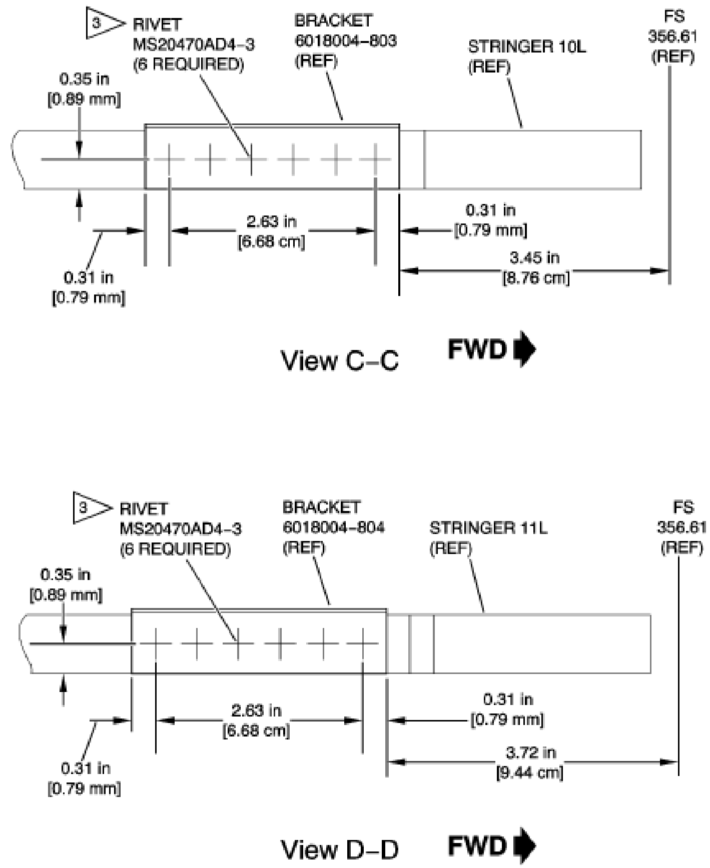
K60-607807-001-01

Wiring Modification of Circuit Breaker Panel Connectors
Figure 1 (Sheet 1 of 3)



K60-607807-001-02

Wiring Modification of Circuit Breaker Panel Connectors
Figure 1 (Sheet 2 of 3)

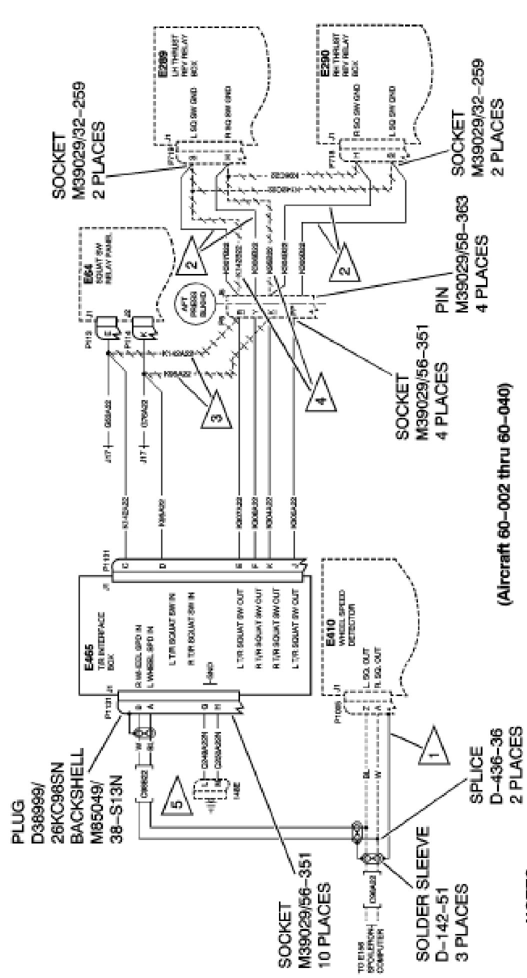


NOTE

3 Drill holes through bracket and stringer together.

K60-607807-001-03

Wiring Modification of Circuit Breaker Panel Connectors
Figure 1 (Sheet 3 of 3)



(Aircraft 60-002 thru 60-040)

LEGEND

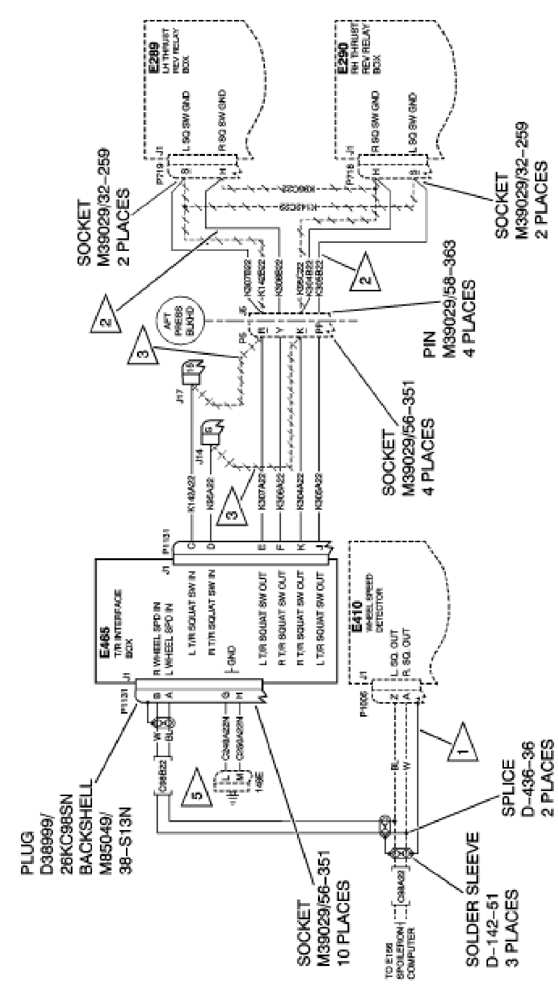
- Represents new or rerouted wires
- Represents existing components and/or wires
- Represents deleted components and/or wires
- Represents continued wires
- Represents a splice location

NOTES

1. Unshielded portion of wire and shield termination not to exceed 3 inches.
2. Route installed wiring with existing bundle from P719 and P718 to J5. Ensure that new wiring is routed through all clamps and sleeving.
3. Permissable to disconnect wiring from P5, reidentify and reroute to P1131, E465 T/R Interface box instead of routing new wiring.
4. Permissable to reterminate and reidentify existing wiring in lieu of running new wires as long as sufficient wire lengths exist to eliminate splice.
5. On plug 148E, it is permissable to use different pin locations if specified pin locations are already filled.

K60-607807-002-01

Wiring Diagram
Figure 2 (Sheet 1 of 2)



(Aircraft 60-041 thru 60-276)

LEGEND

- Represents new or rerouted wires
- Represents existing components and/or wires
- Represents deleted components and/or wires
- Represents continued wires
- Represents a splice location

K60-607807-002-02

Wiring Diagram
Figure 2 (Sheet 2 of 2)

SERVICE BULLETIN COMPLIANCE RESPONSE

BOMBARDIER

It is necessary that Bombardier Learjet record aircraft having complied with this Service Bulletin. Please fill in the Service Bulletin and aircraft information below, sign and date the form in the space provided, fold on dotted lines, seal with tape, and mail completed form to Bombardier Learjet Maintenance Engineering. If mailed within the United States, this form may be mailed to Bombardier Learjet Maintenance Engineering using business reply mail (see reverse). This form may be faxed or e-mailed if preferred. (See mailing information provided.)

WARRANTY - Completion of this response form is required in order to process the warranty claim. Therefore, if a warranty allowance is provided in the Service Bulletin, return a copy of this form with the warranty claim.

SMART PARTS - Completion of this response form is required in order to remain, enroll, or re-enroll in the Smart Parts Program.

Mailing Information:

Bombardier Learjet
Maintenance Engineering
(MS #78) (FAX 316 946-2305)
fracas_usa@aero.bombardier.com
Customer Support
Learjet, Inc.

Service Bulletin Information

Service Bulletin No. 60-78-7

Rev No. 2 Date May 1, 2006

Service Facility Information

Facility Incorporating Bulletin ____________

Aircraft Information

Model ____________

Serial No. ____________

Flight Hours ____________

Landings ____________

Compliance Information

The above referenced Service Bulletin was complied with on the referenced serial number aircraft at the listed aircraft flight hours/landings:

Actual hours to accomplish Service Bulletin: Access ______ SB ______ Test(s) ______ Restore ______

Signature ____________ Title ____________ Date ____________

Comments ____________

▼ FOLD HERE FIRST ▼

BOMBARDIER

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BUSINESS REPLY MAIL
FIRST-CLASS MAIL PERMIT NO. 2928 WICHITA KS
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LEARJET INC
PO BOX 7707
WICHITA KS 67277-9801

▲ FOLD HERE LAST, SEAL WITH TAPE. DO NOT STAPLE ▲

APPENDIX D, LEARJET TFM

TEMPORARY FLIGHT MANUAL CHANGE

Publication Affected: Learjet 60 AFM (FM-123)
Learjet 60XR AFM (FM-133)

Description of Change: Added table to Tires Limitation Section with allowable tire pressure range based on maximum certified takeoff weight. Revises Exterior Preflight procedure by adding an additional check for proper tire pressure inflation.

Revised step 4, added new step, added NOTE and WARNING to ABORTED TAKEOFF procedure.

Revised NOTE to a WARNING to INADVERT-ENT STOW OF THRUST REVERSER AFTER A CREW-COMMANDED DEPLOYEMENT procedure.

Filing Instructions: This document consists of 9 pages. Insert the individual pages in accordance with the following filing instructions and retain until further notice. Record this temporary change in the “Log of Temporary Flight Manual Changes” at the front of the AFM.

TFM 2008-09 page number	Insert adjacent to FM-123 page number	Insert adjacent to FM-133 page number
page 2 of 9	1-25	1-33
page 3 of 9	2-3	2-3
page 4 of 9	2-4	2-4
page 5 of 9	2-7	2-7
page 6 of 9	3-32	—
page 7 of 9	3-32	—
page 8 of 9	—	3-33
page 9 of 9	—	3-37

FAA APPROVED ______________________________ **DATE** ____________

for MARGARET KLINE, MANAGER
AIRCRAFT CERTIFICATION OFFICE
FEDERAL AVIATION ADMINISTRATION
WICHITA, KANSAS

Filing Instructions: Insert this page adjacent to the TIRES Limitation under SYSTEM LIMITS in the affected manual.

Add the following to the TIRES limitation under SYSTEM LIMITS:

The nose and main tire pressures must be checked within 96 hours (not flight hours) prior to takeoff using the procedures listed in Chapter 12 of the Learjet 60 Maintenance Manual.

NOTE

- Aircraft parked for extended periods (10 or more consecutive days) will have tire pressure checked periodically in accordance with Chapter 12 of the Learjet 60 Maintenance Manual.
- The following table is provided for reference only.

AIRCRAFT WITH THE FOLLOWING MAXIMUM CERTIFIED TAKEOFF WEIGHT	ALLOWABLE TIRE PRESSURE RANGE	
All	Nose Gear	104 - 114 psig (718 - 785 kPa)
22,750 Pounds (10,319 kg) 23,100 Pounds (10,478 kg)	Main Gear	205 - 215 psig (1413 - 1481 kPa)
23,500 Pounds (10,660 kg)	Main Gear	209 - 219 psig (1441 - 1508 kPa)

Filing Instructions: Insert this page adjacent to page containing Exterior Preflight, area 2 in the affected manual.

Added additional step within the Exterior Preflight procedure:

2 Nosewheel Tire Pressure — Check (refer to Limitations Section).

Filing Instructions: Insert this page adjacent to page containing Exterior Preflight, area 5 in the affected manual.

Added additional step within the Exterior Preflight procedure:

5 Right Main Tire Pressure — Check (refer to Limitations Section).

Filing Instructions: Insert this page adjacent to page containing Exterior Preflight, area 23 in the affected manual.

Added additional step within the Exterior Preflight procedure:

23 Left Main Tire Pressure — Check (refer to Limitations Section).

Filing Instructions: Insert this page adjacent to page containing ABORTED TAKEOFF in the affected manual.

Added NOTE and WARNING , revised step 4 and added new step to Aborted Takeoff procedure:

Thrust Reversers — Deploy, if necessary. Check for TR DEPLOY lights illuminated.

If none of the TR lights are illuminated, both Thrust Reverser Levers — Stow.

NOTE

The normal sequence of each engine's annunciators are as follows:

- Green TR ARM — Thrust Reverser ready to deploy.
- Green TR ARM and Amber TR UNLOCK — Thrust Reverser in transit.
- Green TR ARM and White TR DEPLOY — Thrust Reverser fully deployed (reverse thrust greater than idle is possible when both engine's thrust reversers have been fully deployed).

WARNING

- A damaged squat switch (or other failures) may cause the thrust reverser auto stow system to activate (both engine's clamshell doors will stow), resulting in **FORWARD** thrust, ranging from idle to near takeoff power, depending on thrust reverser **LEVER** position. If this occurs, thrust reversers **LEVERS** must be stowed immediately.
- Squat switch failure with the thrust reversers deployed will be indicated by the white TR DEPLOY lights extinguishing and the amber TR UNLOCK lights illuminating for several seconds, then extinguishing. The green TR ARM lights will flash during the transition, then extinguish. **In summary, the absence of any TR lights indicates forward thrust**. There may also be a change in acceleration as the engines transition from reverse thrust to forward thrust.

Filing Instructions: Insert this page adjacent to page containing INADVERTENT STOW OF THRUST REVERSER AFTER A CREW-COMMANDED DEPLOYMENT in the affected manual.

Changed the NOTE to a WARNING in INADVERTENT STOW OF THRUST REVERSER AFTER A CREW-COMMANDED DEPLOYMENT procedure:

WARNING

- A damaged squat switch (or other failures) may cause the thrust reverser auto stow system to activate (both engine's clamshell doors will stow), resulting in **FORWARD** thrust, ranging from idle to near takeoff power, depending on thrust reverser **LEVER** position. If this occurs, thrust reversers **LEVERS** must be stowed immediately.
- Squat switch failure with the thrust reversers deployed will be indicated by the white TR DEPLOY lights extinguishing and the amber TR UNLOCK lights illuminating for several seconds, then extinguishing. The green TR ARM lights will flash during the transition, then extinguish. **In summary, the absence of any TR lights indicates forward thrust**. There may also be a change in acceleration as the engines transition from reverse thrust to forward thrust.

Filing Instructions: Insert this page adjacent to page containing ABORTED TAKEOFF in the affected manual.

Added NOTE and WARNING , revised step 4 and added new step to Aborted Takeoff procedure:

Thrust Reversers — Deploy if necessary. Check for DEP indications on the EIS page.

If none of the TR lights are illuminated, both Thrust Reverser Levers — Stow.

NOTE

The normal sequence of each engine's annunciators are as follows:

- Green REV — Thrust Reverser ready to deploy.
- Amber UNL — Thrust Reverser in transit.
- White DEP — Thrust Reverser fully deployed (reverse thrust greater than idle is possible when both engine's thrust reversers have been fully deployed).

WARNING

- A damaged squat switch (or other failures) may cause the thrust reverser auto stow system to activate (both engine's clamshell doors will stow), resulting in **FORWARD** thrust, ranging from idle to near takeoff power, depending on thrust reverser **LEVER** position. If this occurs, thrust reversers **LEVERS** must be stowed immediately.
- Squat switch failure with the thrust reversers deployed will be indicated by the white DEP extinguishing and the red UNL annunciation illuminating on the EIS for several seconds, then extinguishing. An amber REV annunciation may flash momentarily. **In summary, the absence of any thrust reverser annunciations indicates forward thrust**. There may also be a change in acceleration as the engines transition from reverse thrust to forward thrust.

Filing Instructions: Insert this page adjacent to page containing INADVERTENT STOW OF THRUST REVERSER AFTER A CREW-COMMANDED DEPLOYMENT in the affected manual.

Changed the NOTE to a WARNING to Inadvertent Stow of Thrust Reverser After a Crew-Commanded Deployment procedure:

WARNING

- A damaged squat switch (or other failures) may cause the thrust reverser auto stow system to activate (both engine's clamshell doors will stow), resulting in **FORWARD** thrust, ranging from idle to near takeoff power, depending on thrust reverser **LEVER** position. If this occurs, thrust reversers **LEVERS** must be stowed immediately.
- Squat switch failure with the thrust reversers deployed will be indicated by the white DEP extinguishing and the red UNL annunciation illuminating on the EIS for several seconds, then extinguishing. An amber REV annunciation may flash momentarily. **In summary, the absence of any thrust reverser annunciations indicates forward thrust**. There may also be a change in acceleration as the engines transition from reverse thrust to forward thrust.