Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

AVIATION INVESTIGATION REPORT
A06Q0190

RUNWAY OVERRUN

CANADIAN GLOBAL AIR AMBULANCE
LEARJET 35A C-GAJS
MONTRÉAL/PIERRE ELLIOTT TRUDEAU INTERNATIONAL AIRPORT, QUEBEC
26 NOVEMBER 2006

Canada

The Transportation Safety Board of Canada (TSB) investigated this occurrence for the purpose of advancing transportation safety. It is not the function of the Board to assign fault or determine civil or criminal liability.

Aviation Investigation Report

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Canadian Global Air Ambulance
Learjet 35A C-GAJS
Montréal/Pierre Elliott Trudeau International Airport, Quebec
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Summary

The Canadian Global Air Ambulance Learjet 35A aircraft (registration C-GAJS, serial number 35-380) departed Brunswick, Georgia, United States, on a medical evacuation flight to Montréal/Pierre Elliott Trudeau International Airport, Quebec. On board the aircraft were two pilots, two flight nurses, and two passengers. At 0507 eastern standard time, the aircraft landed on Runway 06R at Montréal and overran the 9600-foot runway, coming to rest approximately 600 feet off the end of the runway in a grass field. The aircraft sustained damage to the left wing leading edge and the fuselage. There were no injuries.

Ce rapport est également disponible en français.

Other Factual Information

History of the Flight

Canadian Global Air Ambulance operated an air ambulance charter service using four Learjet 35 aircraft serving customers worldwide. The company is operated under Section 704, Commuter Operations, of the *Canadian Aviation Regulations* (CARs).[1] All flight operations were controlled from the company's main base in Winnipeg, Manitoba. Sub-bases were located in Toronto, Ontario, and Vancouver, British Columbia.

The flight was the second and final leg of a medevac flight that began at Toronto/Lester B. Pearson International Airport. The two pilots checked in at the Canadian Global Air Ambulance facility at 2000 eastern standard time[2] on 25 November 2006, where they met the two flight nurses assigned to the flight. The aircraft, a Learjet 35A, arrived at the company hangar from a previous mission at about 2145. The flight from Toronto to Brunswick departed at 2254 and landed at 0045. The flight was routine; however, when the landing gear was lowered on the final approach, the left main gear down-and-locked light did not illuminate. The landing gear lights were turned on, and the crew, seeing the illumination of the landing lights, concluded that the affected landing gear was down and locked, and that the left gear down-and-locked light was burnt out. The aircraft landed without incident.

After embarking a patient and a passenger, the plane took off for Montréal/Pierre Elliott Trudeau International Airport at 0305. The captain was the pilot flying (PF), and the co-pilot was the pilot not flying (PNF). At 0500, the aircraft was cleared for an instrument landing system (ILS) Runway 06R approach; landing reference speed (Vref) was established at 124 knots. At about 10 000 feet during the descent, the aircraft was flying at a ground speed of about 360 knots. The weather at this time was as follows: wind 120° at two knots; visibility 15 miles, and a few clouds at 12 000 feet and 21 000 feet.

About 13 nautical miles (nm) west of the airport, the aircraft was descending through 7000 feet at a ground speed of 350 knots. The spoilers were twice deployed during the descent. At about 6 nm from the runway, the flaps were extended to 8° and then 20°. After it was confirmed that the landing gear was down and locked, the flap selector switch was moved to the DN (down) position to extend the flaps to 40°; the flaps and the position indicator remained at 20°. The first officer informed the captain of the discrepancy by pointing to the indicator and stated that the hydraulic pressure was normal. At that time, the aircraft was abeam the final approach fix, 1000 feet above the glidepath at 150 knots, 26 knots above Vref.

It was established that the runway was sufficiently long for a partial flap landing and the approach was continued. The crew members' intention was to exit at the end of the runway to be near their ground destination, and their plan was to deploy the spoilers and thrust reversers and to delay the use of the brakes after touchdown. At 500 feet above touchdown, the aircraft was about 1 nm from the threshold at approximately 155 knots and slightly above the

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1 See Glossary at Appendix A for all abbreviations and acronyms.

2 All times are eastern standard time (Coordinated Universal Time minus five hours).

glidepath. At about 200 feet above touchdown, the enhanced ground proximity warning system (EGPWS) produced oral alerts "TOO LOW FLAPS" indicating that the flaps were not in the landing configuration. The captain immediately requested flaps 40, and the co-pilot informed him that the flap indicator was at 20°.

Runway 06R is 9600 feet long by 200 feet wide, and there is an asphalt pad, 200 feet by 200 feet, at each end of the runway. The aircraft touched down about 1000 feet past the threshold at approximately 130 knots. According to the aircraft flight manual (AFM), the landing distance for the aircraft configuration at the time of landing was 3300 feet with a flap setting of 20°. At about 3500 feet from the threshold, the spoiler switch was set to the extend position (EXT), but the spoilers did not deploy, which went unnoticed by the crew. Starting at about 4800 feet, the captain attempted three times, without success, to move the thrust reverser levers beyond the idle/deploy stop. At about 8300 feet, the captain announced that there were no brakes. At the end of the runway, the captain called for the brace position. The aircraft was travelling at approximately 53 knots as it went off the end of the runway.

As the aircraft rolled through the soft ground, the left wing struck three light posts from the first row of approach lights. Shortly after, the nosewheel ran over a manhole after which the left wing struck three light posts from the second row of approach lights. The aircraft came to rest 600 feet past the end of the paved area off the end of the runway. Immediately after the aircraft came to a stop, the captain ordered the evacuation. There was significant damage to the aircraft in the area of the nosewheel, the left wing, and the left side of the fuselage.

The cockpit voice recorder (CVR) is a Collins model number 642C-1, part number 522-4057-010, serial number 2086. It has four channels and a recording capacity of 30 minutes. The P1 and P2 audio channels were excellent quality, better than the air traffic control (ATC) recording, which was missing some data. The recorder was 32 minutes and 15 seconds in length.

The cockpit area microphone (CAM) channel did not work on this aircraft for the majority of the recording. The first 30 minutes and 5 seconds contained no data. A strong 400 hertz (Hz) tone is then heard for 47 seconds, followed by 1 minute and 24 seconds of CAM data. It is possible that a bad connection to the CAM was shaken up during the incident and caused the CAM to work for this short period.

Crew Information

The captain obtained his commercial pilot licence in 1994 and worked for various companies flying propeller aircraft. He held a valid airline transport pilot licence and joined Canadian Global Air Ambulance in June 2006. This was the first time he had been employed to fly jet engine aircraft. He satisfactorily completed a Learjet 35/36 series pilot initial course at FlightSafety International in July 2006. After completing the required training, he was employed as a captain on Learjet 35A aircraft. The captain had flown a total of 7300 flight hours and had accumulated approximately 180 hours on Learjet 35, 100 hours as captain. The captain's duty time on the day of the occurrence was 7.2 hours after a rest period of 34 hours. In the past seven days, his flight time was 22 hours.

The co-pilot possessed a valid airline transport pilot licence and joined the company in July 2006. He successfully completed the Learjet 35/36 series pilot initial course at FlightSafety International in July 2006. He was hired has a co-pilot on Learjet 35A aircraft. The co-pilot had a total of 2475 flight hours, 173 of which were on the Learjet 35. The co-pilot's duty time on the day of the occurrence was 7.2 hours after a rest period of 261 hours.

FlightSafety International provided both flight crew members with formal crew resource management (CRM) training courses. CRM techniques were an integral part of simulator training. The crew's performance was satisfactory during simulator training.

The FlightSafety International flight simulator was certified for all phases of ground and flight operations. Among differences between the accident aircraft and the simulator were that the simulator was equipped with a low hydraulic pressure light and a drag chute, but the aircraft had neither. During training, low hydraulic pressure anomaly was simulated. Illumination of the low hydraulic pressure light alerted the crew to the situation, indicating that the landing gear, flaps, spoilers, and brakes were affected. The pilots were required to execute the procedure specified in the quick reference handbook (QRH). The QRH called for the crew to turn on the auxiliary hydraulic pump before landing. After touchdown, if the hydraulic pressure was not maintained, the crew had to use the emergency brake handle. In addition, the QRH specified that the use of the drag chute or thrust reversers (if installed) was recommended. Unannounced brake failure after touchdown was not simulated during flight crew training. The investigation revealed that both crew members believed that the aircraft was equipped with a low hydraulic pressure light.

Aircraft Condition

The impact with the light posts left several dents to the fuselage and left wing. The light posts are built with a frangible portion close to ground, which helped reduce the severity of the impacts. The nosewheel rim was deformed and the axle arm slightly bent as a result of hitting and displacing the protruding manhole cover. Examination of the aircraft showed that the flaps were at 20° and the spoilers were retracted. There were droplets of hydraulic fluid on the tail's lower fin, with streaks originating from the aircraft belly. Other dust–covered, very light hydraulic streaks emanating from the nosewheel well area were also visible on the lower right-hand side of the fuselage. The hydraulic fluid level in the reservoir was not visible through the sight gauge.

The anchorage area of the nose oleo was torn and a hydraulic connector was broken while retrieving the aircraft. This damage precluded the possibility of cycling the gear during the ensuing tests. The origin of hydraulic seepage from the nosewheel well area could not therefore be identified. The broken connector was blanked to allow testing of the remaining hydraulic system components, which confirmed the proper operation of the brakes, flaps, spoilers, and thrust reversers. The left main gear down-and-locked light was confirmed being burnt out. Without cycling the gear, no actual leakage was noted. However, the relatively small size of the streaks under the fuselage was not representative of a large leak depleting the hydraulic fluid in the last two hours. Once the access panel located forward of the main gear was removed, a

"B" nut connecting the nose gear retract hydraulic line to a one-way valve (part number 1R3665-035) was found slightly loose. Review of the recent maintenance records did not show any maintenance having been performed in that area.

For the occurrence flight, the aircraft was not being operated with item limitations. The flight from Brunswick to Montréal was operated with the left landing gear down-and-locked light inoperative. A main gear down-and-locked light is not a minimum equipment list (MEL) item. Dispatch of the aircraft with this unserviceable item was thus not permitted by Canadian Global Air Ambulance's Transport Canada (TC)–approved Learjet 35 MEL.

The aircraft maintenance records indicate that it had been maintained in accordance with the company's maintenance control manual. Because the aircraft are flying more than 1000 hours annually, the operator can use the manufacturer's High Utilisation Maintenance Program (HUMP). This program outlines that a Service & Condition Check be done as often as practical and recommends every 15 days minimum. It had been performed on November 21, five days before the occurrence. The aircraft had flown 19.5 hours and 20 cycles since the check. Before this last check, the aircraft had flown 103.2 hours and 27 cycles during the previous 13-day period. The check sheet, HUMP-M35/36 Revision 5, outlines the requirements to verify the aircraft hydraulic system for leaks and adequate fluid level. Even though it does not address or refer to the thrust reverser system, the Dee Howard[3] 150/200-hour inspection was carried out jointly with the last HUMP check. The aircraft was operated with an MEL. The MEL states that all defects will be entered in the aircraft journey log book. Any defect may be deferred provided it is included in the approved MEL, and the aircraft must be operated in accordance with any conditions or limitations specified therein. If any doubt exists as to the deferral of an item, consultation between operations and maintenance is required.

Hydraulic System

The aircraft hydraulic system supplies hydraulic pressure for operation of the aircraft landing gear, brakes, flaps, spoilers, and thrust reversers. During normal operations, the hydraulic pressure is assured by the engine-driven pumps, one on each engine. Both pumps draw fluid from the same port on the hydraulic reservoir. That port is about one-third up from the bottom of the reservoir and slightly below a sight gauge. The fluid must be visible through the sight gauge to ensure an acceptable operating level.

A second port, located at the bottom of the tank, allows the remaining fluid to be available to an auxiliary electrically driven hydraulic pump in the event of a malfunction of the hydraulic system. This pump is controlled by the HYD PUMP switch located on the instrument panel and cycles automatically by a pressure switch when there is a low hydraulic pressure condition. Pump operation is limited to 3 minutes with 20-minute intervals. A capillary line runs to the cockpit and transmits the hydraulic pressure to the crew via a small direct reading gauge, about 1 ¾ inches in diameter, located below the glare shield under the annunciator panel. The gauge is partly behind the CVR area microphone and is in direct view from the co-pilot's seat. Reading it from the captain's seat requires some head movement. The heading "Abnormal Procedures" under Section IV of the approved AFM for the occurrence aircraft describes the procedure to be

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[3] This aircraft is equipped with Dee Howard thrust reversers.

followed in case of the illumination of the low hydraulic pressure light. However, the occurrence aircraft was not fitted with such a warning light and the crew would have had to refer to the procedure for "Hydraulic System Failure Landing."

The hydraulic system for the thrust reversers incorporates a hydraulic accumulator, which is basically a cylinder with a floating piston. According to the maintenance manual, one side of the cylinder is charged with dry air or nitrogen to 600 ±50 pounds per square inch (psi). During operation, the normal hydraulic pressure of 1250 to 1500 psi pushes the floating piston, causing the air pressure to match hydraulic pressure. The accumulator fluid is isolated from the rest of the hydraulic system via a one-way valve, thereby reserving the trapped fluid under pressure for the operation of the thrust reversers in case of lost hydraulic pressure. The pre-charge pressure indicated in the pilot's manual differs from the maintenance manual; it indicates an accumulator pre-charge of 900 to 1000 psi. The accumulator can provide one full thrust reverser cycle. After the event, the accumulator's air pressure was found to be at 250 psi. The right thrust reverser was stowed and the left thrust reverser was cracked open.

The thrust reverser accumulator air pressure gauge is co-located in the tail cone with the main hydraulic system accumulator, which is serviced at 850 psi. With the hydraulic system in operation, the air pressure in the accumulator will rise to match the system pressure; at rest, the pressure will drop back to the pre-charge pressure of 850 psi. However, on the thrust reverser accumulator gauge, because of the one-way valve, the pressure will remain at the system operating pressure unless the thrust reversers are cycled several times to bleed off the trapped pressure. The gauges are similar in appearance, they are not identified to their respective system, and the green bands on the scales outline the system's normal operating pressure. There are no placards to remind the correct pre-charge pressure for each gauge, or in the case of the thrust reversers, a warning that the thrust reversers must be activated to relieve the hydraulic pressure.

By design, hydraulic actuators need a larger amount of fluid in the extend motion than during retraction due to the volume occupied by the actuating rod. The landing gear actuators, being the largest actuators on the aircraft, cause the hydraulic reservoir level to decrease during gear extension. The AFM instructs that, in case of a loss of hydraulic pressure, the gear must be lowered via the emergency mode before selecting the electric hydraulic pump. The emergency mode uses air pressure, thereby saving the remaining fluid at the bottom of the hydraulic reservoir and enabling the electric pump to operate the flaps or the spoilers, which have no emergency system. After lowering of the gear, the flaps remained inoperative at 20°, neither the spoilers nor the thrust reversers deployed, and the brakes did not respond in the normal mode. Emergency braking, which is air-operated, was not attempted.

Company Operating Procedures

According to the company standard operation procedures manual (SOP), the PF will deploy the spoilers and gently lower the nose after touchdown. If sufficient runway exists and there is no special requirement to stop short, the aircraft should be stopped with minimum braking action. However, it states that "In all cases however, pilots should check their brakes right after landing. It is not the time to discover a problem at the end of a runway." The SOP further indicates that, if the aircraft is equipped with Dee Howard thrust reversers, they should be used

on every landing to reduce brake wear. The PF will first deploy the spoilers, lower the nose gently to the runway, and then smoothly pull back the thrust reverser handles and apply wheel brakes consistent with conditions.

The AFM landing procedure after touchdown calls for immediate extension of the spoilers, application, as required, of the wheel brakes and thrust reversers or deployment of the drag chute (if installed) as desired.

The partial flap landing procedure is stipulated in the AFM, QRH, and SOP. The procedure is based on the crew having recognized the flap anomaly before landing. To summarize, it establishes the final approach speed and the landing distances according to the flap position. The documentation does not remind the crew to check the hydraulic pressure in the event of a discrepancy between flap position and flap setting.

If the normal brake system fails, an emergency (pneumatic) system can be used to stop the aircraft. The emergency brake handle, located on the pilot side of the pedestal, must be pulled out and pushed downward for brake pressure. No attempt was made to use the emergency brake system during this occurrence.

Normal Learjet pre-flight procedures must be accomplished before take-off at the original departure point of a flight. Some items on the checklist are marked with diamond bullets. These refer to "Through-Flight" checklist and only these items need to be done if there has been no change in flight crew personnel, no maintenance has been performed on the aircraft, no more than three hours have elapsed between engine shutdown and engine start, and there have been no extreme weather conditions that would change the pre-flight status of the aircraft. Part of Item 17 of the normal pre-flight checklist, which requires that the hydraulic system reservoir fluid level and accumulator pressure be checked, is not included in the "Through-Flight" checklist. There is no indication in the checklist reminding the user to refer to the AFM supplement for the thrust reverser system. The supplement does not provide any information on how to check the accumulator pre-charge pressure. In Toronto, as well as in Brunswick, the co-pilot accomplished the "Through-Flight" procedure. Both pre-flights were performed outside, at night, with a flashlight. The co-pilot was not aware of the criteria for the use of the "Through-Flight" checklist.

Analysis

The absence of hydraulic fluid in the nosewheel well and the dust-covered streaks from that area indicate a minor seepage. Thus, seepage from the nosewheel did not contribute significantly to the depletion of hydraulic fluid. The hydraulic leak at the "B" nut resulted in the depletion of the hydraulic fluid. The magnitude of the leak could not be established due to the damage to the nose gear. However, the size of the hydraulic fluid streaks under the belly was not representative of a rate of loss sufficient to deplete the hydraulic reservoir within a few hours. Because no recent maintenance in the area of the "B" nut had been recorded, it can be assumed that the "B" nut had been inadequately tightened, thus allowing it to loosen over time. The last inspection carried out 19.5 hours before the accident did not reveal any hydraulic

system anomalies. It can therefore be concluded that the leak developed during that period. Because the magnitude of the leak was not established, the time required to deplete the hydraulic reservoir could not be determined.

The Service & Condition Check carried out at intervals of 15 days may not assure proper fluid level between these checks. Therefore, confirmation of proper servicing rests on the completeness of the pre-flight inspection by the crew. The flight crew's adopted practice of doing a "Through-Flight" checklist when a normal pre-flight was required allowed dispatching of the aircraft without ascertaining a proper fluid level in the hydraulic reservoir.

Neither the pre-flight checklist nor the Dee Howard thrust reverser AFM supplement indicates how to verify the thrust reverser pre-charged hydraulic accumulator. As a consequence, the crew did not know how to properly check the actual thrust reverser accumulator pre-charge pressure. Even if the crew members had checked the thrust reverser accumulator gauge, it is unlikely that they would have detected the low air pressure condition and the inappropriate servicing.

Because the original departure point of the flight was Toronto, a normal pre-flight check should have been accomplished by the crew. Nonetheless, unaware of this requirement, the co-pilot completed the "Through-Flight" checklist. Therefore, the hydraulic oil level was not verified. The exterior inspections of the aircraft in Toronto and Brunswick were performed at night with a flashlight. These conditions may have rendered detection of an oil leak more difficult.

During the approach to Brunswick, the left main gear down light did not illuminate. The captain used a workaround to confirm that the gear was effectively locked. Since the light is not an MEL item, the defect should have been fixed before the aircraft took off. Also, the crew did not enter the defect in the journey log book, as required.

During the approach to Montréal, the spoilers and flaps functioned normally until the gear was lowered. The volume of fluid required to extend the gear lowered the level of hydraulic fluid in the reservoir below the engine-driven pump delivery port. Without hydraulic supply, the hydraulic pressure was immediately lost. From that point on, the flaps, spoilers, landing gear, and thrust reversers were affected.

When the flaps were selected to 40°, the co-pilot indicated to the captain that the flaps remained at 20° and erroneously stated that hydraulic pressure was normal. It is likely that the co-pilot misread the hydraulic pressure gauge, seeing what he was expecting to see rather than the actual reading of the gauge. The fact that 12 minutes earlier, as part of the descent check, he noted the hydraulic pressure being normal and that the spoilers and flaps operated normally up to the time the gear extended may have biased the co-pilot's perception.

The crew did not investigate the flap discrepancy. Normally, after recognizing the anomaly, the crew should have consulted the "Partial Flap Landing" checklist of the QRH. Regardless, consultation of the "Partial Flap Landing" checklist would not have led the crew to identify the problem because the checklist does not refer to a possible hydraulic malfunction.

Neither crew associated the abnormal flap position with a low hydraulic pressure condition. As in the simulator, the crew expected to be forewarned of a hydraulic malfunction by the illumination of a low hydraulic pressure light, which they believed was present in the aircraft. The crew's lack of knowledge of onboard systems indicates a training deficiency in the differences familiarization of company aircraft. Since the aircraft was not equipped with such a warning light and the co-pilot misread the hydraulic pressure gauge, the crew never anticipated the loss of hydraulic pressure. The fact that the aircraft QRH and AFM refer to the low hydraulic pressure warning light illumination to signal a loss of hydraulic system pressure may have reinforced the crew's belief that the aircraft was equipped with such a system.

Once aware of the flap anomaly, the flight crew continued the approach, knowing that the runway length was adequate for a partial flap landing. The decision to land did not take into consideration a low hydraulic condition. A go-around would have enabled the crew to complete all applicable checklists and plan a possible normal braking system failure landing.

Based on the published landing chart, the immediate use of the brakes after touchdown would have stopped the aircraft within approximately 4300 feet of the threshold and 3000 feet short of the exiting taxiway.

The aircraft landed in darkness about 1000 feet down the runway, and, unbeknownst to the crew, there was no hydraulic oil pressure. As planned, the spoilers and thrust reversers were selected before the brakes were used. The crew was following the SOP procedure for landing with thrust reversers. Even though the SOP emphasizes that brakes should be checked immediately following touchdown, compliance is expected but not mandatory. Furthermore, the landing procedure for aircraft equipped with Dee Howard thrust reversers promotes brake wear reduction thus possibly enticing crews to delay all brake application.

The lack of hydraulic oil pressure prevented the spoilers from extending. Had the co-pilot been aware of the spoiler malfunction, he may have associated the spoiler malfunction with the flap discrepancy, the low hydraulic pressure condition, and subsequent brake malfunction.

The thrust reversers would have deployed had the pre-charged hydraulic accumulator been charged with air in accordance with the manufacturer's specifications. Had the thrust reversers deployed when selected, the pilot might have tested the brakes in accordance with normal procedures and recognized the brake failure earlier than he did. Early detection of the brake failure may not have assured correct crew reaction; however, it would have provided more time to identify and execute the appropriate procedure.

The captain became conscious of the brake failure about 2300 feet from the end of the runway. The investigation could not establish why the emergency brake was not used.

According to their training records, both crew members demonstrated successful proficiency in the use the emergency brake system during the initial Learjet flight course at FlightSafety International. However, unexpected brake failure on the runway was not simulated. The brake failures were always followed by the loss of hydraulic pressure that was evidenced by the illumination of the low hydraulic light. When the captain realized that the brakes had failed, the

crew was caught completely by surprise, with little runway left and travelling at relatively high speed. It is possible that the rehearsal of a similar scenario during training may have attuned the crew to follow the emergency braking procedure.

This occurrence was the result of a combination of factors, not a single omission or error. The loosening of a "B" nut produced a slow leak that depleted the hydraulic oil level. The 15-day interval between Service & Condition Checks was not conducive to early detection of a low fluid level. Also, the lack of maintenance instructions for the thrust reversers on the Service & Condition Check checklist did not assure their proper servicing. The incorrect use of the "Through-Flight" checklist by the co-pilot may have prevented detection of the low hydraulic oil level condition before the flight. The absence of a procedure to correctly check the air pressure in the thrust reverser accumulator precluded the flight crew from detecting its actual air pressure state; therefore, the thrust reversers could not be deployed in case of a loss of hydraulic system pressure. The crew's lack of knowledge of the aircraft's hydraulic system contributed to an erroneous belief that the loss of hydraulic pressure would be signalled by the illumination of a low hydraulic pressure light. The failure of the crew to use the emergency braking procedure contributed to the aircraft runway overrun.

Findings as to Causes and Contributing Factors

1. A "B" nut loosened, resulting in a leak and depletion of the hydraulic fluid and preventing normal operation of the flaps, spoilers, thrust reversers, and wheel brakes.

2. The crew did not notice that there was a loss of hydraulic pressure and therefore did not plan for a landing without normal stopping systems or for the use of the emergency brake system.

3. When the aircraft landed, the flaps were extended to only 20°, the spoilers did not deploy because there was no hydraulic or backup air pressure, the thrust reversers did not deploy, normal braking did not work, and the emergency brake system was not used. Consequently, the aircraft overran the runway.

Findings as to Risk

1. The Service & Condition Check carried out at intervals of 15 days may not assure proper fluid level. Therefore, confirmation of proper servicing rests on the completeness of the pre-flight inspection by the crew.

2. The flight crew's adopted practice of performing the "Through-Flight" checklist, when a normal pre-flight was required, allowed dispatching of the aircraft without confirming a proper fluid level in the hydraulic reservoir.

3. The pre-charged thrust reverser accumulator was not serviced according to the manufacturer's specifications, and there was insufficient air pressure to deploy the thrust reversers.

4. The aircraft flight manual (AFM) supplement for the thrust reverser does not provide guidelines on how to verify the accumulator air pressure. Consequently, the crew did not know how to properly check the thrust reverser accumulator pre-charge pressure.

5. The crew erroneously thought that the aircraft was equipped with a low hydraulic pressure light that would warn them in case of a loss of hydraulic system pressure.

6. The AFM and the quick reference handbook (QRH) indicate that the low hydraulic pressure light illuminates to indicate loss of hydraulic system pressure, although, in this aircraft, there was no low pressure hydraulic light.

Other Finding

1. The aircraft departed for Montréal with an identified and undocumented defect that required maintenance action.

Safety Action Taken

As a result of the accident, the Canadian Global Air Ambulance initiated an administrative investigation. The following actions have been taken:

- All company aircraft underwent extensive inspections of their hydraulic systems.

- Placards have been installed on hydraulic system accumulators indicating pressures and conditions that must be met prior to checking. Checking hydraulic accumulator pressure as well as thrust reverser accumulator pressure (if applicable) is mandatory during the normal exterior pre-flight and exterior post-flight inspections.

- The company Director of Human Resources, the Aviation Safety Officer, and the Chief Pilot discussed the accident with Canadian Global Air Ambulance employees.

- Exterior pre-flight inspections have been expanded beyond the manufacturer's approved procedures.

- Abnormal/emergency exercises that replicate this event have been incorporated into the company initial and recurrent flight training program.

- A review of the manufacturer's normal, abnormal, and emergency procedures is ongoing.

- Pilots have undergone additional training on the following:

    - Standard operating procedures (SOPs)
    - Learjet 35 differences training
    - Emergency braking operating procedures

  - enhanced ground proximity warning system (EGPWS) operation, alerts, and warnings
  - requirements of the normal exterior pre-flight inspection, "Through-Flight" inspection, and post-flight inspection
  - use of the minimum equipment list as well as defect reporting and recording procedures
  - enhanced crew resource management training with a focus on in-flight situation awareness and recognition of impending failures during all phases of flight

- A review of the cockpit checklists is ongoing.

- The company Aviation Safety Officer has been tasked to accelerate the development of the company Safety Management System program.

- A significant restructuring of the company was undertaken.

- Operational Coordination Centre procedures were reviewed and refined to enhance operational control and technical dispatch procedures.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 27 November 2007.

Appendix A – Glossary

AFM	aircraft flight manual
ATC	air traffic control
CAM	cockpit area microphone
CARs	*Canadian Aviation Regulations*
CRM	crew resource management
CVR	cockpit voice recorder
DN	down (flap position)
EGPWS	enhanced ground proximity warning system
EXT	extend (spoiler position)
HUMP	High Utilisation Maintenance Program
Hz	hertz
ILS	instrument landing system
MEL	minimum equipment list
nm	nautical miles
PF	pilot flying
PNF	pilot not flying
psi	pounds per square inch
QRH	quick reference handbook
SOP	standard operating procedure
TC	Transport Canada
Vref	landing reference speed
°	degrees