NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

October 21, 2014

AIRWORTHINESS

Group Chairman's Factual Report

DCA13FA148

A. ACCIDENT: DCA13FA148

Operator:	Great Lakes Airlines, flight 7125
Location:	Telluride, Colorado
Date:	September 1, 2013
Time:	1310 Mountain Daylight Time
Aircraft:	Beechcraft 1900D
Registration Number:	N169GL

B. AIRWORTHINESS GROUP

Chairman: Clinton R. Crookshanks
National Transportation Safety Board
Denver, Colorado

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Member: Ernest Hall
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C. SUMMARY

On September 1, 2013, at about 1310 mountain daylight time (MDT), Great Lakes Airlines flight 7125, a Beech 1900D, N169GL, experienced a left main landing gear collapse during landing on runway 27 at Telluride Regional Airport (KTEX), Telluride, Colorado. The two flight crew members and 10 passengers were not injured and the airplane sustained substantial damage. The scheduled passenger flight was operating under 14 Code of Federal Regulation Part 121 and originated from Denver International Airport (KDEN), Denver, Colorado.

According to statements provided by the captain and first officer, after extending the landing gear, the left main landing gear (LMLG) failed to lock in the down position. The green lights for the LMLG did not illuminate and the red “in-transit” light remained illuminated in the landing gear handle. A visual inspection revealed that the LMLG appeared to be in the down position. The manual extension procedures were performed until the handle felt ‘firm’ but failed to lock the LMLG in the down position. They declared an emergency and performed a normal landing. Around 80 knots on the rollout the LMLG collapsed. All of the passengers were safely evacuated and there were no reported injuries.

D. DETAILS OF THE INVESTIGATION

1.0 Aircraft

Manufacturer's Serial Number (MSN): UE-169
Total Time: 35,184.0 hours
Total Cycles: 43,794 cycles

The Beechcraft 1900D is a twin engine, propeller driven, low wing, pressurized airplane (Figure 1[1]) equipped to carry 19 passengers. The airplane is equipped with a retractable tricycle landing gear system. Extension and retraction of the nose landing gear (NLG) and two main landing gear (MLG) is accomplished by the action of individual hydraulic actuators installed on each landing gear assembly. The MLG actuators retract for gear extension and extend for gear retraction while the NLG actuator extends for gear extension and retracts for gear retraction. Hydraulic pressure for the system is supplied by a hydraulic power pack located in the left wing leading edge inboard of the nacelle and associated plumbing for the normal extend, normal retract, and emergency extend modes. Control of the system is accomplished through the landing gear handle located to the left side of the center pedestal on the pilot's inboard sub panel as shown in Figure 2. The landing gear handle has two detents, UP and DN. When the handle is placed in the UP position, power is supplied to the hydraulic pump motor and to a gear-up solenoid that allows fluid to flow through the normal retract side of the system. When the handle is placed in the DN position, power is supplied to the hydraulic pump motor and to a gear-down solenoid that allows the fluid to flow through the normal extend side of the system to the primary extend ports on the actuators. See Figure 3 for a schematic of the landing gear hydraulic system in the normal extend mode. The system has a nominal operating pressure of 3,000 psi. There is a system relief valve installed in the power pack that will open when the internal system pressure reaches about 3,250 psi to prevent over pressurization and damage to the system. If actuated the system relief valve will route the fluid back to the primary reservoir. There is also a pump check valve that prevents fluid from flowing back to the pump once the pump has shut off. Once the landing gear are fully extended, an internal mechanical lock in each of the actuators holds the landing gear in the down position. The lock will also activate a down-position switch in each actuator that will interrupt current to the hydraulic pump motor once all three landing gear are in the down and locked position. In the event that any landing gear is not down and locked, the hydraulic pump motor will continue to run for about 16 seconds before the LANDING GEAR CONTROL circuit breaker is tripped by the time delay relay and interrupts current to the pump motor to prevent the possibility of damage to the system.

In the event of a system malfunction or failure, the pilots can extend the landing gear manually through the use of a hand pump located in the cockpit. The emergency extension system utilizes a different reservoir and plumbing than the normal system. See Figure 4 for a schematic of the landing gear system in the emergency extend mode. When operated, the emergency system applies hydraulic pressure to the secondary extend port on the actuators which is located adjacent to the primary port, moving a shuttle valve to block the primary port and allow fluid into the actuator.

[1] All Figures are presented in Appendix A to this report.

Visual indication of the landing gear positions is provided by two red lights located in the landing gear handle and six green lights in an annunciator assembly next to the gear handle. Illumination of the red lights in the handle occurs when the landing gear are in-transit and illumination of the green lights occurs when the gear are in a down and locked position. A gear-up indication occurs when none of the lights are illuminated. In addition to the down lock switches internal to the actuators that sense the down lock engagement, there are two position switches located in each wheel well to provide either an up-position or a down-position indication. In order to get either a gear up or gear down and locked indication two of the three switches have to be in the correct position. When the down-position switch on the landing gear drag brace and the down lock switch in the actuator are both closed, current is supplied to the two green down and locked lights in the landing gear position annunciator assembly corresponding to the appropriate landing gear (NOSE, RH, or LH). When the down-position switch on the landing gear drag brace is open and the up-position switch in the wheel well is closed, no current is supplied to any lights. For any other combination of switch positions, current is supplied to the two red in-transit lights in the gear handle.

The Great Lakes Airlines Beech 1900D Quick Reference Handbook (QRH) details the procedures for the crew to follow in the event that the landing gear fails to extend normally, for manual extension of the landing gear, and for landing with one landing gear unsafe. The procedures for landing with one main up or unsafe include pulling the landing gear relay circuit breaker, the landing gear warning horn circuit breaker, and the TAWS circuit breaker and leaving the landing gear handle in the down position. The alternate extension handle should be pumped “until maximum resistance is felt” and the handle should be left at the top of the stroke.

2.0 Accident Aircraft Examination

The airplane came to rest on the runway resting on the NLG, right main landing gear (RMLG), and left wingtip. There was a small pool of hydraulic fluid beneath the LMLG wheel well area. The airplane was lifted with airbags, the LMLG was pulled to the extended position, the landing gear were pinned and the airplane was towed to a hangar for examination. The Airworthiness Group examined the airplane on September 3-4, 2013.

The left wingtip lower skin exhibited abrasion damage but the lower wing skin was not damaged. The left inboard flap was deformed and wrinkled and the trailing edge and aft nacelle were abraded where they contacted the asphalt runway. The left outboard flap was deformed and wrinkled and the trailing edge was abraded where it contacted the runway. The left aileron had abrasion damage to the outboard 2 feet of trailing edge and lower trailing edge skin. The aileron spar was not damaged. The left ventral strake was damaged along its lower edge where it contacted the runway. The left engine inboard machined mount fitting was fractured and portions were separated. The firewall was deformed and bent.

The left landing gear was examined and there were no obvious failures noted. There was some hydraulic fluid present on the actuator and strut. The hydraulic system reservoir, located in the left wing leading edge, fluid level was checked and was between the cold and warm levels on the dip stick. The hydraulic filter was removed and exhibited no obvious evidence of contamination. A sample of hydraulic fluid was retained for analysis. The sample of hydraulic fluid was sent to

AvLab for analysis[2]. The report showed that the fluid was graded as NAS Class 12 due to excessive particles in the 5-15 micron size range. All other particles were at NAS Class 5 or better.

In the cockpit the LANDING GEAR RELAY, the LANDING GEAR WARN, the CKPT VOICE RCDR, the TAWS, and the 26VAC FLT DATA RCDR circuit breakers were popped out. The flap handle was in the 35 degree detent. Ground power was applied and the airplane power was turned on. All three landing gear indicators were green and the in-transit light was extinguished (Figure 2). No other warning lights relating to the landing gear were illuminated. The landing gear control handle was in the down position. The landing gear alternate extension handle was not secured in the stowed position.

The hydraulic system was pressurized with air to about 10 psi and hydraulic fluid began leaking from the LMLG actuator. The leaking appeared to be exiting from a hole between the primary and secondary extend ports in the area where a shuttle valve is installed internally (Figure 5). The pressure was increased to about 18 psi and a steady stream of hydraulic fluid was observed coming from the hole. The air pressure was removed and the emergency extension handle was then pumped and fluid was observed exiting the hole. The retract actuator was removed for further examination. The data tag on the actuator indicated it was manufactured by APPH Wichita, Inc. The HBC (Hawker Beechcraft Corporation) P/N was 114-380041-21, the APPH P/N was 40600-12, and the S/N was not readable. The actuator had a manufacturing date of 9/11. The actuator extension was measured to be 2.3 inches from the edge of the housing to the center of the rod end, 1.75 inches from the actuator side of the jam nut to the center of the rod end, and 1.35 inches from the rod end side of the jam nut to the center of the rod end.

A replacement LMLG actuator (P/N 114-380041-15) was installed and the landing gear system was cycled several times. The system operated normally with three green lights in both the normal and alternate extension mode and there were no hydraulic fluid leaks noted.

The L3 Model FA2100 CVR, P/N 2100-1020-00, S/N 000694648 was retained and shipped to the NTSB lab. The Fairchild F1000, P/N S703-1000-00, S/N 01318 was retained and shipped to the NTSB lab. The ULBs were removed and installed on the new recorders.

3.0 Maintenance Records[3]

The LMLG actuator removed from the accident airplane (P/N 114-380041-21, APPH P/N 40600-12, S/N 120A) was purchased by Great Lakes Aviation (GLA) in August 2011 and sent to APPH for overhaul. The purchased unit was a P/N 114-380041-9 (APPH P/N 40600-8) and came from a Colgan Air Beech 1900D (S/N UE-24). GLA issued purchase order R54914 to APPH to inspect and overhaul the purchased unit. APPH initiated the repair under work order 631010 and provided GLA with a tear down report and repair estimate on August 31, 2011. The estimate stated that the unit would be upgraded to an APPH P/N 40600-10 (P/N 114-380041-17) during overhaul and required several replacement parts including an end cap and Lee plug in addition to the standard overhaul parts. The repair estimate was approved by GLA on August 31,

[2] See Attachment 1 for the hydraulic fluid analysis report.
[3] See Attachment 2 for the pertinent maintenance records.

2011, and in a subsequent email on September 9, 2011, APPH informed GLA that the unit would be upgraded to an APPH P/N 40600-12 (P/N 114-380041-21) since APPH did not have the correct housing for the -10 configuration. The APPH purchase order was originally issued with P/N 40600-10 but had two hand written notations changing it to P/N 40600-12. All of the other internal shop paperwork for the overhaul listed the unit as P/N 40600-10. The overhauled actuator was released by APPH on an FAA Form 8130-3 on September 19, 2011, with P/N 40600-12.

The overhaul paperwork indicated that the P/N 25719 lock slide was not replaced during the overhaul. The actuator assembly drawing requires a P/N 25719-4 lock slide for the P/N 40600-8 actuator and a P/N 25719-6 lock slide for the P/N 40600-10/-12 actuator. There was a note in the overhaul work order stating "NOTE: SLIDE REPLACEMENT IS REQUIRED IF CUSTOMER IS REQUESTING AN UPGRADE TO A -10 ACTUATOR. (Slide Lock is shoter [sic] than 1.105". There was a note on the purchase requisition form in the overhaul paperwork that stated "Slide lock meets specs for -12". The FAA Form 8130-3 airworthiness approval in the overhaul package indicated that the P/N 25719-4 lock slide from the purchased actuator was non-destructively inspected with no defects found. The length of the P/N 25719-4 lock slide should be 1.100-1.105 inches per the drawing. The length of the P/N 25719-6 lock slide should be 1.110 ±0.005 inches per the drawing.

The LMLG actuator was received by GLA on September 26, 2011, from APPH after overhaul and installed on the accident airplane, N169GL, on March 14, 2012, at a total aircraft time of 31,818.9 hours under log page 046024. The LMLG, P/N 114-380041-12, S/N 120A, was removed from the airplane after the accident with 3,365.1 hours and 3,929 cycles since installation.

The most recent landing gear system inspection was performed on July 17, 2012, and the hydraulic primary return line on the LMLG was replaced due to the outer cover being frayed. No other discrepancies were noted with the system. The landing gear hydraulic line filters were inspected and/or cleaned during this time also. The most recent detailed inspection (5^{th} detail) of the airplane was performed on April 24, 2013, with no discrepancies noted on the landing gear system.

The group noted three instances where landing gear problems were annotated in the aircraft logs in June 2012, September 2012, and July 2013. The most recent write-ups involved three separate instances where the landing gear would not retract when commanded from July 4-6, 2013. Maintenance was performed on the landing gear safety switches and the discrepancy was finally signed off on July 6, 2013. There were no noted issues with the landing gear system between July 6, 2013, and the accident.

4.0 Tests and Research

The LMLG actuator from the accident airplane was examined under the supervision of the group at APPH Wichita on December 11, 2013.

The LMLG was visually examined prior to performing any work. The serial number 120A was stamped on one of the housing arms and on the end cap. The 3 torque seals on the end cap, the 3 torque seals on the housing, and the torque seal on the retainer cap were all intact. The safety wire between the end cap and housing, on the shuttle valve, on the retainer cap, on the return line, and on the switch were all intact and had ends indicating they were the original wire installed by APPH. The safety wire on the jam nut was intact. The tab washer on the rod end was intact and the jam nut on the rod end was loose. There was no obvious wear or damage on the exterior of the actuator. The shuttle valve appeared to be in its normal position in the end cap. The piston extension was measured to be 0.55" from the land of the end cap to the end of the piston and 2.3" from the land of the end cap to the center of the rod end. The wire harness and connector were intact with no obvious damage. The harness was connected to an electrical test fixture and indicated the actuator was in the locked position. The lock indication was verified with a multimeter on pins A to E.

According to APPH, the hole between the return ports facilitates the manufacturing of the end cap and should be plugged with a P/N PLGA2180010A Lee plug after manufacturing. The diameter of the plug hole was measured to be 0.2206" and there was some damage to the outboard half of the hole as annotated by the red arrow in Figure 6. The diameter of the hole per the drawing should be 0.2187-0.2212 inch. There was no obvious damage to the inboard half of the hole. The plug was missing from the actuator and the overhaul paperwork indicated that the correct part number plug was installed. The specifications for the Lee plug in Figure 7 show that the plug is a Class 1 with a proof pressure of 8000 psi.

The distance between the P/N 40610-2 locking rings was measured to be 3.28". The P/N 40603-8 end cap was removed. There was no fluid in the actuator. The o-rings appeared intact and there was no obvious damage to the internal portions of the end cap and actuator. The anodize layer appeared intact. The end cap was disassembled and there was no obvious damage on the internal portions. The surface finish of the interior was measured to be 5 RMS[4] in the shuttle valve bore and 9 RMS elsewhere.

A new end cap was built up and installed on the actuator for functional testing. The actuator unlocked at about 265 psi initially, and was cycled several times. It then consistently required about 250 psi to unlock and about 50 psi to lock. A full functional test in accordance with Functional Test Bulletin 40600 was then performed with no anomalies.

The actuator was disassembled. The P/N 1EN51-6 downlock switch and P/N AS20009 ball appeared normal. The P/N 40617-1 inner slide moved freely within the P/N 40616-1cup. The P/N 25719 lock slide had no obvious damage. The outer surface of the P/N 40616-1 cup had axial score marks concentrated in a square area. The P/N 25719 lock slide moved freely over the cup. There was minor scratching on the surfaces of the 7 P/N AS20009 lock balls. The P/N 40604-2 piston was removed and exhibited only normal indications of wear. The P/N 40616-1 cup and P/N 40617-1 inner slide were disassembled and showed only normal indications of wear. The 3 P/N AS20009 lock balls had minor scratching on the surfaces.

[4] Root mean square average of the microscopic profile height deviations from an established mean recorded along the evaluation length. Lower values represent a smoother surface.

The following measurements were obtained. All dimensions are in inches. Red indicates measurements outside the drawing limits.

Description	P/N	Location	Measurement	Drawing Requirement	Tolerance
Ball (inner lock)	AS20009	Diameter	0.31255	0.3125	+/-0.0001
Ball (inner lock)	AS20009	Diameter	0.31245	0.3125	+/-0.0001
Ball (inner lock)	AS20009	Diameter	0.31250	0.3125	+/-0.0001
Ball (outer lock)	AS20009	Diameter	0.31250	0.3125	+/-0.0001
Ball (outer lock)	AS20009	Diameter	0.31255	0.3125	+/-0.0001
Ball (outer lock)	AS20009	Diameter	0.31250	0.3125	+/-0.0001
Ball (outer lock)	AS20009	Diameter	0.31250	0.3125	+/-0.0001
Ball (outer lock)	AS20009	Diameter	0.31245	0.3125	+/-0.0001
Ball (outer lock)	AS20009	Diameter	0.31255	0.3125	+/-0.0001
Ball (outer lock)	AS20009	Diameter	0.31255	0.3125	+/-0.0001
Cup	40616-1	OD[A]	1.24685	1.248	+0.000/-0.002
Cup	40616-1	OD[B]	1.24655	1.248	+0.000/-0.002
Cup	40616-1	OD[C]	1.24680	1.248	+0.000/-0.002
Cup	40616-1	ID	0.87496	0.875	+0.002/-0.000
Lock Slide	25719	OD	1.49640	1.496-1.498	NA
Lock Slide	25719	ID	1.2502	1.250-1.252	NA
Lock Slide	25719	ID	1.2500	1.250-1.252	NA
Slide	40617-1	OD	0.87220	0.873	+0.000/-0.002
Slide	40617-1	OD	0.87245	0.873	+0.000/-0.002
Slide	40617-1	OD	0.87240	0.873	+0.000/-0.002
Slide	40617-1	Length	1.0495	1.035	+/-0.010
Piston	40604-2	OD[D]	0.6241	0.6250	+/-0.0005
Piston	40604-2	OD[D]	0.6245	0.6250	+/-0.0005
Piston	40604-2	OD[E]	0.6239	0.6250	+/-0.0005
Piston	40604-2	Length[F]	0.5667	0.565	+/-0.001
Piston	40604-2	OD[G]	0.87280	0.873	+0.000/-0.001
Piston	40604-2	OD[G]	0.87285	0.873	+0.000/-0.001
Housing	40602-8	ID	1.5015	1.500	+0.002/-0.000
Housing	40602-8	ID	1.5015	1.500	+0.002/-0.000
Housing	40602-8	Length[H]	1.4680	1.469	+/-0.005
End Cap	40603-8	ID[I]	0.3773	0.3760	+0.0003/-0.0000
End Cap	40603-8	ID[J]	0.3773	0.3760	+0.0003/-0.0000
Shuttle	25714-4	OD[K]	0.3770	Note M	NA
Shuttle	25714-4	OD[K]	0.3770	Note M	NA
Shuttle	25714-4	OD[L]	0.37725	Note M	NA
Shuttle	25714-4	OD[L]	0.37725	Note M	NA
Lock Spring	25716-1	Length	1.932	2.060	+/-0.060
Lock Spring	25716-1	Wire diameter	0.2178	0.218	+/-0.005
Retainer	40605-3	Depth	1.200	1.200	+/-0.005
Washer	25720-2	Thickness	0.06260	0.0625	+/-0.0005

Washer	25720-2	Thickness	0.06250	0.0625	+/-0.0005
Washer	25720-3	Thickness	0.09125	0.0915	+/-0.0005
Washer	25720-3	Thickness	0.09130	0.0915	+/-0.0005
A – measured forward of o-ring B – measured aft of o-ring C – measured at machining mark D – measured with micrometer at bottom of radius E – measured with comparator at bottom of radius F – measured between head of piston and centerline of groove G – shaft diameter, straightness and roundness of shaft was less than 0.001 at each location and less than 0.002 between locations H – measured between washer lands I – shuttle valve bore on primary side J – shuttle valve bore in secondary side K – measured on primary side L – measured on secondary side M – diameter within 0.003 of shuttle valve bore on corresponding side					

Utilizing the measured dimensions the available space for the lock spring was calculated to be 1.59". Using the measured free length of the spring, the spring was compressed 0.34" as installed with the actuator in the locked position. The drawing specified spring rate was 262 lbs/in. The spring was compressed 0.34" and the spring force measured about 90 lbs.

The measurement of the length of the P/N 25719 Slide Lock was not obtained during the tear down at APPH but was obtained later. The length of the slide was measured at several locations around the circumference and all measurements were between 1.104-1.105 inches.

5.0 FAA oversight of APPH

FAA oversight of APPH and its Repair Station after the incident led to Repair Station Manual revisions to comply with Title 14 CFR Part 145. One of the significant improvements to the Repair Station process was the development of Component Maintenance Manuals for use in overhauling components. Component Maintenance Manuals were developed with the guidance and oversight of the FAA Flight Standards District Office and the Aircraft Certification Office Small Airplane Directorate in Wichita. APPH revised their Quality Control Manual to include initial receiving inspections, hidden damage inspections and other inspections throughout the overhaul process. APPH improved their procedures and Work Orders to clearly specify the steps and corrective actions taken when overhauling a component. APPH originated an actuator overhaul drawing to assist repair station personnel in the overhaul of different model number actuators. FAA oversight identified and accepted the level of risk at APPH through proper risk mitigation of incorporating changes to the Repair Station Manual.

Submitted by:
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