NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Aviation Engineering Division
Washington, D.C. 20594

October 26, 2011

AIRWORTHINESS

Group Chairman's Factual Report

CEN11IA341

A. INCIDENT

Operator: Great Lakes Airlines, Flight 5150
Location: Denver, Colorado
Date: May 17, 2011
Time: 0645 Mountain Daylight Time[1]
Aircraft: Beech 1900D, Registration Number: N218YV

B. AIRWORTHINESS GROUP

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Cheyenne, Wyoming

C. SUMMARY

On May 17, 2011, approximately 0645 mountain daylight time, N218YV (UE-218),a Beech 1900D, sustained minor damage when the left main landing gear collapsed during landing roll out on Runway 35L at Denver International Airport (DEN), Denver, Colorado. The airline transport rated captain, commercial rated first officer and the nine passengers were not injured. The airplane was registered to Raytheon Aircraft Credit Corporation, Wichita, Kansas, and operated by Great Lakes Airlines, Cheyenne, Wyoming. An instrument flight plan was filed for flight #5150 that originated at Pueblo Memorial Airport (PUB), Pueblo, Colorado, about 0607, and destined for DEN. Visual meteorological conditions prevailed for the scheduled passenger flight conducted under 14 CFR part 121.

In a written statement, the captain reported that the first officer was the pilot flying. While on approach to DEN, the first officer called for the landing checks to be completed, which included the landing gear to be extended. The captain extended the gear and verified the landing gear down-and-locked lights were illuminated. However, the lights were only illuminated for the

[1] All times are mountain daylight time (MDT) based on a 24-hour clock, unless otherwise noted. Actual time of incident is approximate.

NOSE, RH, and L. The "H" light for the left gear did not illuminate. He also noted that the landing gear in-transit light stayed on and the gear motor continued to run for approximately 16 seconds before the gear-motor relay circuit breaker popped. The captain said he confirmed several times that all three landing gear down-and-locked lights were illuminated prior to landing and stated, "All training tells us that indication is 3 down and locked gear." Upon landing, and after a few seconds during the rollout, the airplane began to "wobble" and the left main gear collapsed.

D. DETAILS OF THE INVESTIGATION

1.0 Incident Aircraft Examination (N218YV)

Manufacturing Serial Number (MSN): UE-218
Total Aircraft Time (TAT): 29,582 hours
Total Aircraft Cycles (TAC): 40,340 cycles

The airplane came to rest on the left side of runway 35L at Denver International Airport about 6,090 feet from the approach end of the runway. The airplane was found resting on the right main landing gear (RMLG), nose landing gear (NLG), and the left wingtip (Figure 1[2]). The left overwing exit was open and the passengers and crew reportedly exited through this door. Examination of the runway revealed gouging of the concrete consistent with propeller strikes beginning about 2,557 feet from the approach end of the runway. The propeller strikes were evident to varying degrees for about 2,500 feet. Small pieces of fiberglass and metal debris from the composite propeller blades were found on the runway from the first propeller strike until the last strike was evident. About 5,815 feet from the approach end of the runway, a metal piece, later identified as the top portion of the NLG actuator end cap, was found on the runway (Figure 2). There was a puddle of hydraulic fluid beneath the NLG where the airplane came to rest. There was no discernable hydraulic fluid found anywhere else on the runway.

The NLG access panel was removed to view the fractured top end of the NLG actuator (Figure 3). Examination of the cockpit revealed that the landing gear handle was in the DN (down) position. The LANDING GEAR RELAY circuit breaker located to the right of the landing gear handle was popped. Both the CKPT VOICE RCDR and FLT DATA RCDR circuit breakers located on the panel to the right of the first officers seat were popped. The flap handle was in the 17° detent, the rudder trim was set to 1 unit left, and the aileron trim was set to almost 2 units right. The parking brake was set.

The airplane was lifted using a crane with slings and the left main landing gear (LMLG) fell to the down position. There was no evidence of any failures to the components on the LMLG so it was pulled into the fully down and locked position. The three landing gears were pinned and the airplane was moved to a hangar for further evaluation. The left removable wingtip with attached winglet had extensive abrasion damage that went through the composite lower skin and partially into the honeycomb core. A small area of the lower wing skin adjacent to the wingtip exhibited some minor abrasion damage that did not penetrate through the lower skin. There was no visible

[2] All figures are presented in Appendix A to this report.

damage to the wing spars. The aileron sustained moderated abrasion damage to the outboard lower skin and trailing edge, but no visible damage to the spar or control hinges. The inboard and outboard flaps had some minor abrasion damage to the lower skin and trailing edge. The nacelle area aft of the LMLG wheel well and LMLG doors had extensive abrasion damage.

Electrical power was applied to the airplane in the hangar and all the landing gear annunciator lights (6 bulbs) were illuminated green (Figure 4). The in-transit light was not illuminated but was checked and illuminated red.

The LMLG actuator was removed from the airplane for further testing.
P/N 114-3800-41-15 (Beech)
P/N 1FA10043-3 (Manufacturer-Frisby Airborne Hydraulics)
S/N 0987A

The NLG actuator was removed from the airplane for further testing.
P/N 112-380022-23 (Beech)
P/N 25700-22 (Manufacturer-APPH)
S/N 583

After the airplane was ferried to the Great Lakes maintenance base the group decided to have some additional components removed for examination, as listed below.

LMLG Drag Leg Assembly
P/N 114-810023-1
S/N GLA544

LMLG Upper Drag Leg Bolt
P/N 101-810089-1
S/N None

LMLG Middle Drag Leg Bolt
P/N 101-810090-3
S/N None

LMLG Lower Drag Leg Bolt
P/N 101-810090-1
S/N None

LMLG Drag Leg Actuator Attach Bolt
P/N 130909B163
S/N None

LMLG Switch Assemblies and wiring harness
P/N 114-361044-1
S/N None

2.0 Landing Gear Operation

The Beech 1900D is equipped with a retractable tricycle landing gear system. Extension and retraction of the NLG and two 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 4. 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 5 for a schematic of the normal extend mode. Once the landing gears 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 gears 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 RELAY circuit breaker pops 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 manual extension system utilizes a different reservoir and plumbing than the normal system. When operated, the manual system applies hydraulic pressure to the secondary extend port which is located adjacent to the primary port, moving a shuttle valve to block the primary port and allow pressure into the actuator.

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-position switches internal to the actuators, 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. See Figure 6 for a wiring diagram of the switch and indication circuit. When the down-position switch on the landing gear drag brace and the down-position 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. Based on the wiring, there are no combinations of switch positions that can supply current to both the in-transit and down and locked lights simultaneously. Each individual landing gear indication and the in-transit indication have 2 bulbs installed in a parallel circuit for redundancy. If one bulb should burn out, the pilot will still see the correct indication.

According to the Model 1900D Illustrated Parts Catalog, Chapter 31-10-00-03, the landing gear position annunciator assembly (P/N 40-42291-2) is composed of three different lamp modules; P/N 90-42292-001 for the NOSE indication, P/N 90-42292-002 for the L and R indications, and P/N 90-42292-003 for the H and H indications. See Figures 7 and 8 for photos of the assembly and the three modules with the face plates removed. The lamp module part number is stamped on the top of each module by the manufacturer. According to Hawker Beechcraft, the lamp modules are sold complete and there are no provisions in their manuals for replacing or changing the face plates. The individual light bulbs can be changed from the rear of the module without removing the face plate.

3.0 Airplane Maintenance Records

The Group convened at the Great Lakes Airlines facility in Cheyenne, Wyoming on June 1, 2011, to examine the maintenance records for the accident airplane. See Attachment 1 to this report for all of the referenced maintenance records.

Great Lakes maintained the airplane under a continuous airworthiness maintenance program (CAMP) approved by the FAA. The Great Lakes Aircraft Inspection Manual volume IX, Chapter 3 details the inspection requirements for the airplane. The inspection program consists of Routine Inspections that should be performed every 60 hours and Detailed Inspections that should be performed every 220 hours. There are 6 Detailed Inspections performed in sequence to ensure that the entire airplane is inspected every 1,320 hours.

The incident airplane, UE-218, was leased by Great Lakes Airlines from Raytheon Aircraft Credit Corporation on December 30, 2008. The most recent Routine Inspection[3] was performed on May 11, 2011 at a total aircraft time (TAT) of 29,562.5 hours and total aircraft cycles (TAC) of 40,314. Item 21 of the Routine Inspection calls for a check of the main and nose landing gear struts for leaks and was signed off. There were no non-routine work cards for the landing gear generated as a result of this inspection.

The most recent Detailed Inspection performed was the Third and was accomplished on May 11, 2011. See below for the times and cycles for the most recent occurrence of all 6 Detailed Inspections.

Inspection	Date	TAT (hours)	TAC
First	March 12, 2011	29,197.6	39,912
Second	April 12, 2011	29,385.3	40,119
Third	May 11, 2011	29,562.5	40,314
Fourth	December 3, 2010	28,640.6	39,261
Fifth	December 30, 2010	28,808.4	39,446
Sixth	February 1, 2011	28,990.2	39,676

The Fifth Detailed Inspection[4] included provisions to inspect the main and nose landing gears on the airplane as well as performing a detailed lubrication of the landing gear components. Step 6 called out the visual inspection of the main landing gear actuators for cracks, corrosion, damage, and leaks and instructed the technician to “Pay particular attention to the end caps.” Step 22 called out the visual inspection of the nose landing gear actuator but did not include a note regarding the end cap. There were no non-routine work cards for the landing gear generated as a result of this inspection.

The Airworthiness Directive Compliance list for the incident airplane was examined and all applicable AD’s had been complied with. FAA AD 2009-23-01 requires repetitive ultrasonic

[3] See Attachment 1, pages 2-5.
[4] See Attachment 1, pages 6-18

inspections of the MLG actuators on Beech 1900D airplanes for cracks. Great Lakes complied with the AD on the incident MLG actuators on January 24, 2011[5].

The aircraft logbook was examined for any write-ups on the landing gear system. On July 31, 2010, a pilot wrote up the landing gear annuciators (Item 2) "Light bulbs on down 3 green for landing gear need replace. The maintenance corrective action stated "R&R bulb P/N 327. Performed ground ops ck. Ops ck good. R&R MM 33-10-01 & 33-10-00."[6]

On March 24, 2011, a pilot made the following write up concerning the landing gear (Item 2): "Upon extending landing gear in Denver left main gear took an excessive amount of time to extend. All green lights illuminated normally except for "H" light for left main gear. In transit light stayed on & pump ran for about 15 seconds, then "H" light on left main finally illuminated & pump shut off. Left main took about 10 seconds longer to extend than the nose and right main." The maintenance corrective action stated "Performed landing gear swing IAW AIM CH10 Sec. 32-01. Performed multiple gear swings. All gears retracted & extended normally. Couldn't duplicate discrepancy. No defects noted at this time."[7]

On April 19, 2011, a pilot wrote up the landing gear annuciators (Item 2) "'SE' bulb inop in NOSE gear annunciator." The maintenance corrective action stated "R&R one bulb 'NOSE' landing gear annun. P/N 327. Ops check good. Ref MM 33-10-05."[8]

3.1 Landing Gear Maintenance

According to the records examined at Great Lakes, the NLG actuator (P/N 25700-22, S/N 583) was delivered new on airplane UE-255. The actuator was removed from this airplane on January 23, 2007. The reason for removal was identified as "LG CB pops" in the airplane logbook. At the time of removal, the actuator had accumulated 21,287.5 hours and 24,948 cycles. It was sent to APPH Wichita for overhaul and was completed in August 2008. The overhaul paperwork[9] indicated that the actuator components were inspected using either fluorescent penetrant or magnetic particle by A-1 NDI Services in Wellington, KS. There were no discrepancies noted and the parts, including the end cap, were released on an FAA Form 8130-3 on August 5, 2008. The NLG actuator, S/N 583, was installed on airplane UE-218 on July 10, 2009. At the time of the incident, the actuator had accumulated 29,533 cycles since new and 4,585 cycles since overhaul.

According to the records the LMLG Actuator (P/N 114-380041-15, S/N 0987A), was installed on airplane UE-218 on February 16, 2010. It had been removed from UE-218 on December 28, 2009 due to leaking. The unit was sent back to Professional A/C Accessories for repair and was repaired under warranty. At the time of the incident, it had accumulated 2,955 cycles since install and 706 cycles since the AD inspection.

[5] See Attachment 1, pages 19-20
[6] See Attachment 1, page 21
[7] See Attachment 1, page 22
[8] See Attachment 1, page 23
[9] See Attachment 1, pages 24-34

According to the records, the RMLG Actuator (P/N 114-380041-15, S/N 0135A) was installed on airplane UE-218 on October 23, 2009. At the time of the incident, it had accumulated 3,796 cycles since install, and 706 since the AD inspection.

4.0 Landing Gear Indication

The operator performed an examination of the incident airplane landing gear position annunciator assembly due to ongoing questions about the indications present during the incident landing. A lamp module marked with P/N 90-42292-001 and with an L and R face plate was installed in the center position of the annunciator assembly (Figure 9). A search of the maintenance records for the incident airplane in ATA chapters 31 Indicating, 32 Landing Gear, and 33 Lights revealed only two individual lamp (bulb) replacements since the airplane has been in operation with Great Lakes Airlines. An additional search of the maintenance records was also performed using the annunciator assembly and lamp module part numbers with nothing found. The operator performed a fleet inspection on the rest of the airplanes in their fleet to examine the annunciator assemblies and lamp modules. In 15 of their remaining 31 airplanes discrepant annuciators were discovered that had part numbers inconsistent with the physical part, missing light dams between the bulbs, or incorrect face plates. All of the discrepant parts were replaced with the correct parts.

5.0 Testing and Research

5.1 NLG Actuator

The NLG actuator was removed from the airplane and sent to the NTSB Materials Laboratory for examination. See NTSB Materials Laboratory Factual Report 11-100 in the public docket for the details of this examination.

The group met with Hawker Beechcraft and the NLG actuator manufacturer, APPH, Inc., in Wichita, KS, on August 10, 2011, to discuss the end cap failure. Hawker Beechcraft informed the group of 5 previous NLG actuator end cap failures that they had some knowledge of. Airight, Inc. (which later became APPH) was the original manufacturer of the actuator. The actuator was designed to Beech specifications and is only manufactured by APPH but is not currently in production. Hawker Beechcraft has purchased 6 NLG actuators as spare replacements since 2009 and they currently have 4 units on order. APPH has not distributed any technical information on the actuator, authorized any other company to overhaul them, or does not sell any spare parts so they are the only approved overhaul facility for the actuator. They currently overhaul the actuators to the drawing specifications and are in the process of developing a component maintenance manual. During overhaul, the end caps are subjected to a dye penetrant inspection performed by a sub-contractor. After disassembly the component parts remain together as a set unless there is a need to replace individual components.

The end cap is produced according to the details of Airight, Inc. drawing 25703 which is currently at revision P. Revision N to the drawing that was approved in February 2010 added a specified grain direction along the longitudinal axis of the end cap. Prior to this revision there was no requirement for a grain direction. According to APPH, the change was initiated by the supplier of the raw material through the purchasing department and had nothing to do with the

fatigue failures of the end caps. Revision P to the drawing, approved in January 2011, added a requirement to stamp "APW" on the top of the end cap. APPH informed the group that the actuator S/N that the end cap was installed on would also be stamped on the top of the end cap. APPH also informed the group that their standard practice was to stamp the actuator serial number in the recessed area between the ports on the end cap for every overhauled actuator since at least 2004. See Figure 10 for the serial number stamped on the incident end cap. Due to the fatigue failures and the possibility of more cracks, APPH initiated the manufacturing of 50 end caps in early 2011 to be used as spare replacements.

5.2 LMLG Actuator

The LMLG actuator, P/N 114-380041-15, S/N 0987A, was examined by the group at the Hawker Beechcraft facilities on August 9, 2011. A visual inspection was performed first. All the safety wire was intact and all the bushings appeared normal with no abnormal wear evident. The dimension from the center of the rod end to the end of the piston measured 1-5/8 inches and from the actuator rig face to the end of the piston measured 1/2 inch. The rod end was free to move with no binding evident. The actuator was connected electrically and hydraulically to the test bench and the orange light was illuminated indicating the switch was in the lock position. Hand pump pressure was applied to the extend side to verify the actuator was in the lock position. Hand pump pressure was then applied to the retract side. The switch changed to unlocked and the piston began extending when the pressure reached about 400 psi. Hand pump pressure was then applied to the extend side. The piston began retracting and the switch changed to locked when the pressure reached about 80-85 psi. A functional test was performed per Hawker Beechcraft Test Procedure H-3835. The piston stroke was measured as 6.23 inches, the pressure on the unlock test was 225 psi, and there was no external leakage noted. The internal leakage test yielded 2 drops per minute. Per the test procedure the stroke should be 6.23 ±0.03 inches, the pressure to unlock should be 200-500 psi, and the leakage should be less than 10 drops per minute.

5.3 LMLG Drag Brace and Hardware

The LMLG Drag Brace (P/N 114-810023-1, S/N GLA544), attachment hardware, and the downlock switch were examined by the group at the Hawker Beechcraft facilities on August 9, 2011. The drag brace lock plate appeared flat and undamaged. There was some minor wear at the stop plate contact point. The actuator attach point had minor wear. The switch pin appeared in good condition with some worn plating. The brace appeared in good condition with very little wear. The lower bushing appeared in good condition. The diameter measured 0.624-0.630 inch and should be 0.6245 to 0.6265. The upper bushings appeared good with minimal wear. The diameters measured were all less than the maximum of 0.640 inch. The drag brace arm upper hole appeared good with minimal wear and the diameter measured above the 0.500 inch minimum. There was a bushing installed indicating it had been repaired in the past, since it does not have a bushing per the drawing. The drag brace measured 0.003 inch under center and should be in the range ± 0.006 inch.

The upper bolt (P/N 101-810089-1) exhibited 4 wear bands coincident with the locations of the edges of the bushings. The diameter was measured at several locations and all measurements were above the minimum of 0.622 inch.

The lower bolt (P/N 101-810090-1) exhibited minor wear at locations where the spacers were in contact. The diameter was measured at several locations and all measurements were at or above the minimum of 0.622 inch.

The actuator attach bolt (P/N 130909B163) appeared in good condition with minimal wear. The diameter was measured at several places and all measurements were above the minimum of 0.4970 inch.

The downlock switch contact pin exhibited wear about 0.009 inch deep. The continuity through the switch was checked with it both activated and normal. All positions activated as designed.

6.0 Service Information

As a result of some previous NLG end cap fractures and the preliminary findings from this investigation, Hawker Beechcraft instituted some changes to their recommended maintenance program for the NLG actuator.

On August 1, 2010, the Model 1900D Airliner Maintenance Manual[10], Chapter 05-10-00, Time Limited Inspections – General, Section 1 K Chapter 32 – Landing Gear, Item 9[11], was revised to add a recommended overhaul of the NLG assembly (including actuator) every 10,000 cycles or 5 years, whichever occurs first. This new requirement was to be complied with 15 months after the August 1 revision.

On May 1, 2011, the Model 1900D Airliner Maintenance Manual[12], Chapter 32-30-14, Nose Landing Gear Actuator - Maintenance Practices, Section 1D Nose Landing Gear Actuator Ultrasonic Inspections[13], was added to include instructions for inspecting the NLG actuator end cap for cracks using an ultrasonic inspection method.

On May 1, 2011, the Model 1900D Airliner Maintenance Manual[14], Chapter 05-10-00, Time Limited Inspections – General, Section 1K Chapter 32 – Landing Gear, Item 9[15], was revised to add a recommended repetitive ultrasonic inspection of the NLG actuator every 1,200 cycles once the actuator has accumulated 8,000 cycles since new or newly overhauled.

On November 1, 2011, Temporary Revision 05-1 was released for the Model 1900D Airliner Maintenance Manual[16] to change the NLG ultrasonic inspection time in order to deal with some supplier issues. Section 1K Chapter 32 – Landing Gear, Item 9[17], added the following temporary requirements.

> If the actuator cannot be overhauled or replaced by November 1, 2011 the actuator may remain in operation with the following requirements:

[10] Part Number 129-590000-15 Revision B3
[11] See Attachment 1, pages 35-45
[12] Part Number 129-590000-15 Revision B5
[13] See Attachment 1, pages 46-64
[14] Part Number 129-590000-15 Revision B5
[15] See Attachment 1, pages 65-74
[16] Part Number 129-590000-15
[17] See Attachment 1, pages 75-85

a. The NOSE LANDING GEAR ACTUATOR ULTRASONIC INSPECTION must have been performed within the last 1,200 cycles. If not, perform the inspection within the next 100 cycles.
b. Perform the NOSE LANDING GEAR ACTUATOR ULTRASONIC INSPECTION every 600 cycles (Ref. Chapter 32-30-14)

As of October 2011, Hawker Beechcraft had no plans to issue a service bulletin or additional guidance to operators for the inspection of the NLG actuator end cap or for the replacement of the end cap at a specified time in service.

Submitted by:
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