Aviation Investigation Final Report

Location:	Hays, Kansas	**Incident Number:**	ENG12IA024
Date & Time:	March 12, 2012, 20:55 Local	**Registration:**	N178YV
Aircraft:	Beech 1900D	**Aircraft Damage:**	Minor
Defining Event:	Sys/Comp malf/fail (non-power)	**Injuries:**	N/A
Flight Conducted Under:	Part 121: Air carrier - Scheduled		

Analysis

During a post flight inspection the pilot discovered a hydraulic leak on the nose landing gear that was emanating from a crack in the nose landing gear end cap. The end cap was examined and found to have failed in fatigue that initiated from multiple origins at an internal diameter. The fatigue had propagated significantly into the wall thickness of the end cap and through the thickness at one location. The striation count revealed that the fatigue crack had initiated and been growing in the end cap for at least 22,563 cycles. The end cap had been inspected using an ultrasonic method recommended by the manufacturer 3 cycles prior to the incident. The crack was present at the time of the inspection which indicated that the inspection method was ineffective in detecting the crack. The timing of the end cap inspection was in compliance with the manufacturer's recommendation. The crack was also present at the time of the last overhaul. Examination of the microstructure of the material revealed that the longitudinal grain direction was oriented parallel to the shuttle valve bore in the end cap. Resistance to fatigue can be improved by aligning the principle tension stresses in the end cap with the longitudinal grain direction. It is probable that the manufacturer had determined that the grain direction was a contributing factor to fatigue failure in the end cap and revised the end cap drawing to require a grain direction along the longitudinal axis of the end cap in February 2010. No engineering data to support the drawing revision was made available.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this incident to be: A failure of the nose landing gear end cap due to fatigue. Contributing to the failure were the ineffective inspection and the unknown effect of grain direction on fatigue life.

Findings

Aircraft	Nose/tail landing gear - Failure
Organizational issues	Adequacy of policy/proc - Manufacturer

Factual Information

History of Flight

Standing	Aircraft inspection event
Other	Sys/Comp malf/fail (non-power) (Defining event)

HISTORY OF FLIGHT

On March 12, 2012, about 2055 central daylight time, the pilot of a Beechcraft 1900D airplane, N178YV, discovered a hydraulic leak on the nose landing gear (NLG) during a post flight inspection. The airplane was registered to Raytheon Aircraft Credit Corporation and operated by Great Lakes Airlines as a 14 Code of Federal Regulations, Part 121 scheduled passenger flight. The airplane had just completed a flight from Denver, Colorado, to Hays, Kansas.

DAMAGE TO AIRPLANE

The pilot's inspection of the NLG revealed a crack in the NLG actuator end cap, part number (P/N) 25703-4. The end cap, serial number (S/N) 512, was removed from the actuator and shipped to the NTSB.

AIRCRAFT INFORMATION

The NLG actuator had accumulated 29,308.7 hours and 39,838 cycles since new. The NLG actuator had been overhauled in 2009 and had accumulated 3,509.9 hours and 4,083 cycles since overhaul. Great Lakes Airlines performed an ultrasonic inspection in accordance with the instructions in the Model 1900D Airliner Maintenance Manual 3 cycles prior to the incident.

TESTS AND RESEARCH

The NLG end cap was examined in the National Transportation Safety Board (NTSB) Materials Laboratory. A visible crack extended circumferentially from the primary extend port on one side of the end cap, around the diameter of the end cap, to the secondary extend port on the other side. The intact portion of the end cap between the ports was cut toward the center line of the shuttle valve bore, and the two pieces were separated to examine the fracture faces. Examination of the fracture faces revealed a relatively flat, smooth zone and ratchet marks originating at the intersection of a radius with an inner diameter of the end cap, consistent with fatigue. The fatigue zone extended outwards almost uniformly through the wall thickness of the end cap, with a preference to the shuttle valve bore, and had propagated entirely through the thickness near the aft side (as installed with the landing gear extended) of the end cap. The fracture face outside of the fatigue zone displayed a rough, grainy surface consistent with an overload event. Samples were removed from the end cap and metallurgically mounted,

polished, and etched in order to display the material microstructure at different orientations. The etchant revealed a longitudinal grain structure that was oriented parallel to the shuttle valve bore. The surface finish and machined radius were found to satisfy the drawing requirements.

The fatigue zone was examined in the scanning electron microscope in order to assess and count the individual fatigue striations which are individual crack arrest features left on a fatigue fracture as a result of one load application. A location near the shuttle valve bore that contained the longest length of fatigue propagation was chosen to perform the count. Near the beginning of the crack it was determined that there were 28 individual striations in a measured crack length of 11.25 micrometers. Near the end of the crack it was determined that there were 28 individual striations in a measured length of 22.5 micrometers. It was then calculated that there were approximately 22,563 striations along the length of the crack propagation at this location. Since the full crack length could not be determined due to the fatigue zone propagating into the shuttle valve bore, the striation count is an approximate and minimum value.

According to the Metals Handbook Desk Edition, 2nd Edition, 1998, wrought aluminum products such as the end cap generally exhibit differences in tensile properties and in resistance to fatigue stresses in the three orthogonal grain directions (longitudinal, long-transverse, and short-transverse) with the longitudinal direction being superior. Typically, fatigue loading in the longitudinal grain direction can provide a 5 to 10 percent improvement in fatigue strength according to the Metals Handbook, 8th Edition, Volume 1, 1961. The principal tensile stresses in the end cap are in the longitudinal direction and result from hydraulic pressure.

ADDITIONAL INFORMATION

The fatigue cracking evident on the NLG end cap is similar to cracking found on the end caps of three different Beechcraft 1900D airplanes operated by Great Lakes Airlines. The details are documented in NTSB investigations CEN11IA341, ENG12IA013, and ENG12IA014.

As a result of some previous NLG end cap fractures and the preliminary findings from the CEN11IA341 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 (AMM) 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 within 15 months after the August 1 revision. On May 1, 2011, a section was added to the AMM to include instructions for inspecting the NLG actuator end cap for cracks using an ultrasonic inspection method. Additionally, on May 1, 2011, the AMM was revised to add a recommended repetitive ultrasonic inspection of the NLG actuator every 1,200 cycles once the actuator had accumulated 8,000 cycles since new or newly overhauled. On November 1, 2011, a Temporary Revision to the AMM was released to change the NLG ultrasonic inspection time in order to deal with some supplier issues. If the actuator

could not be overhauled or replaced by November 1, 2011, the revision allowed the actuator to remain in operation as long as the ultrasonic inspection had been performed within the last 1,200 cycles and recommended repeat ultrasonic inspections every 600 cycles.

The end cap is produced according to the details of Airight, Inc. (now called APPH, Inc.) drawing 25703 which is currently at revision P. Revision N to the drawing was approved in February 2010 and added a specified longitudinal 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. No engineering data or other information was supplied to support the change. APPH also informed the NTSB 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.

On February 13, 2013, the NTSB issued recommendations A-13-04, 05, and 06 to Hawker Beechcraft Corporation to address fatigue cracking of NLG end caps on Beechcraft 1900D airplanes.

Information

Certificate:		**Age:**	Male
Airplane Rating(s):		**Seat Occupied:**	Left
Other Aircraft Rating(s):		**Restraint Used:**	
Instrument Rating(s):		**Second Pilot Present:**	Yes
Instructor Rating(s):		**Toxicology Performed:**	No
Medical Certification:		**Last FAA Medical Exam:**	
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	
Flight Time:			

Information

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Other Aircraft Rating(s):		**Restraint Used:**	
Instrument Rating(s):		**Second Pilot Present:**	Yes
Instructor Rating(s):		**Toxicology Performed:**	No
Medical Certification:		**Last FAA Medical Exam:**	
Occupational Pilot:		**Last Flight Review or Equivalent:**	
Flight Time:			

Aircraft and Owner/Operator Information

Aircraft Make:	Beech	**Registration:**	N178YV
Model/Series:	1900D	**Aircraft Category:**	Airplane
Year of Manufacture:		**Amateur Built:**	
Airworthiness Certificate:	Normal	**Serial Number:**	UE-178
Landing Gear Type:	Retractable - Tricycle	**Seats:**	19
Date/Type of Last Inspection:	March 12, 2012 Continuous airworthiness	**Certified Max Gross Wt.:**	17230 lbs
Time Since Last Inspection:		**Engines:**	2 Turbo prop
Airframe Total Time:	33249 Hrs as of last inspection	**Engine Manufacturer:**	P&W
ELT:	Installed, not activated	**Engine Model/Series:**	PT6A-67D
Registered Owner:	RAYTHEON AIRCRAFT CREDIT CORP	**Rated Power:**	750 Horsepower
Operator:	Great Lakes Aviation	**Operating Certificate(s) Held:**	Flag carrier (121), Supplemental
Operator Does Business As:	Great Lakes Airlines	**Operator Designator Code:**	GLBA

Meteorological Information and Flight Plan

Conditions at Accident Site:		**Condition of Light:**	
Observation Facility, Elevation:		**Distance from Accident Site:**	
Observation Time:		**Direction from Accident Site:**	
Lowest Cloud Condition:		**Visibility**	
Lowest Ceiling:		**Visibility (RVR):**	
Wind Speed/Gusts:	/	**Turbulence Type Forecast/Actual:**	/
Wind Direction:		**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:		**Temperature/Dew Point:**	
Precipitation and Obscuration:			
Departure Point:	Denver, CO (KDEN)	**Type of Flight Plan Filed:**	IFR
Destination:	Hays, KS (KHYS)	**Type of Clearance:**	Unknown
Departure Time:	19:45 Local	**Type of Airspace:**	

Airport Information

Airport:	Hays Regional Airport KHYS	**Runway Surface Type:**	
Airport Elevation:		**Runway Surface Condition:**	
Runway Used:		**IFR Approach:**	Unknown
Runway Length/Width:		**VFR Approach/Landing:**	Unknown

Wreckage and Impact Information

Crew Injuries:	N/A	**Aircraft Damage:**	Minor
Passenger Injuries:		**Aircraft Fire:**	None
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	N/A	**Latitude, Longitude:**	38.869361,-99.310516(est)

Administrative Information

Investigator In Charge (IIC):	Crookshanks, Clinton
Additional Participating Persons:	
Original Publish Date:	August 8, 2013
Last Revision Date:	
Investigation Class:	Class
Note:	
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=83805