



Aviation Investigation Final Report

Location:	Lewiston, Idaho	Accident Number:	WPR18LA215
Date & Time:	August 8, 2018, 18:28 Local	Registration:	N255
Aircraft:	Cessna T337	Aircraft Damage:	Substantial
Defining Event:	Sys/Comp malf/fail (non-power)	Injuries:	2 None
Flight Conducted Under:	Part 91: General aviation - Aerial observation		

Analysis

The pilot reported that he was returning to the airport after an uneventful aerial survey flight. When the pilot extended the landing gear, the system began operating but the gear did not extend. Multiple efforts to extend the gear, including assistance by the passenger and coordination with his company's maintenance personnel, were unsuccessful. The pilot then burned off excess fuel and conducted a gear-up landing at the airport. The airplane sustained substantial damage to the lower fuselage.

Postaccident examination of the airplane revealed that two main landing gear door actuators had hyperextended and allowed all hydraulic fluid to be lost. Detailed examination indicated that the right actuator had hyperextended in flight, while the left one hyperextended due to landing gear door runway contact during the gear-up landing. The actuator rod in each actuator was normally travel-limited and contained by a single internal snap ring, which acted as the mechanical stop and retention device for the rod inside the actuator cylinder. For undetermined reasons, the snap ring was liberated from its groove in the right actuator, which allowed the actuator rod to travel beyond its normal limit, which resulted in the loss of hydraulic fluid and operational failure of the landing gear. Postexamination reassembly and testing of the landing gear system indicated that the hyperextended actuators were the only mechanical deficiencies in the system.

The airplane manufacturer's maintenance manual specified the replacement of the snap rings (retainers) upon rebuild of the actuator. According to the airplane maintenance records, all three main landing gear door cylinders (actuators) were rebuilt with new "O-rings" about 4 years before the accident. The entry did not cite any additional details about the rebuilds, including whether new internal snap rings were installed. Discussions with the operator's director of maintenance indicated that the snap rings likely were not replaced during the actuator rebuild.

Review of industry documents revealed other occurrences of snap ring liberation and consequent landing gear system problems in this model airplane, and at least two different hardware options to prevent recurrence were available. One incorporated a new-design actuator that eliminated the accident

failure mode, and one involved elimination of the subject actuators from the airplane. The operator reported that this modification was installed on the accident airplane when it was repaired after the accident. Either option would ensure against a recurrence of this accident scenario.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be:

The liberation of an internal snap ring from a landing gear door actuator, which resulted in a complete loss of hydraulic fluid and a gear-up landing. Contributing to the accident was the failure of maintenance personnel to replace the snap ring during the last rebuild of the actuator.

Findings

Aircraft	Landing gear door retract sec - Failure
Personnel issues	Scheduled/routine maintenance - Maintenance personnel
Aircraft	Landing gear door retract sec - Design

Factual Information

History of Flight

Approach	Sys/Comp malf/fail (non-power) (Defining event)
Landing	Landing gear not configured

On August 8, 2018, about 1828 Pacific daylight time, a Cessna T337G airplane, N255, was substantially damaged to the lower fuselage during landing at Lewiston Perce Nez Airport (LWS) Lewiston, Idaho. The commercial pilot and his passenger were not injured. The airplane was registered to Northern Air Inc, and was under contract to and being operated by the United States Forest Service as a Title 14 *Code of Federal Regulations* Part 91 aerial survey flight. Visual meteorological conditions existed at the time of the accident and no flight plan was filed. The flight had originated from LWS about 5 hours before the accident.

According to the pilot, the airplane operated normally for the mission, and for most of the landing approach. However, when the pilot selected the landing gear to the extended position, the gear doors opened, the electric motor that pressurized the hydraulic extension system continued to run, but the landing gear failed to extend. The pilot reported that the airplane was at a speed about 20 mph below the maximum landing gear operating speed when he selected the gear down. The pilot pulled the circuit breaker for the pump motor and abandoned the approach. He then flew a short distance away from LWS so that he could attempt to troubleshoot and rectify the problem.

The pilot cycled the landing gear control five or six times, but all efforts to operate the landing gear were unsuccessful. He then employed his passenger to assist him with running the checklists and other troubleshooting activities. The pilot and passenger determined that the landing gear system hydraulic fluid reservoir that was accessible to them in the cabin was empty. The pilot contacted his maintenance personnel by radio, and they assisted in additional attempts to correct the situation; these attempts included replenishing the reservoir with oil and water. Despite those efforts, the landing gear could not be successfully extended. The pilot decided to burn off extra fuel before returning to conduct a gear-up landing.

During the return approach, the pilot secured the front engine, and "bumped" the propeller with the starter to position the blades horizontally, in order to prevent damaging them by runway contact. The occupants unlatched a cabin door in order to enable assured opening after landing. The pilot landed the airplane gear up on runway 30, and the airplane slid to a stop within a few feet of the runway centerline.

Pilot Information

Certificate:	Commercial	Age:	33,Male
Airplane Rating(s):	Single-engine land; Single-engine sea; Multi-engine land	Seat Occupied:	Left
Other Aircraft Rating(s):	None	Restraint Used:	3-point
Instrument Rating(s):	Airplane	Second Pilot Present:	No
Instructor Rating(s):	None	Toxicology Performed:	No
Medical Certification:	Class 2 Without waivers/limitations	Last FAA Medical Exam:	May 9, 2018
Occupational Pilot:	Yes	Last Flight Review or Equivalent:	May 23, 2018
Flight Time:	4460 hours (Total, all aircraft), 632 hours (Total, this make and model), 3445 hours (Pilot In Command, all aircraft), 82 hours (Last 90 days, all aircraft), 82 hours (Last 30 days, all aircraft), 6 hours (Last 24 hours, all aircraft)		

Federal Aviation Administration (FAA) records indicated that the pilot held a commercial pilot certificate with a airplane single engine, multiengine, and instrument ratings. According to information provided by the pilot, he had approximately 4,460 total hours of flight experience, including approximately 632 hours in the accident airplane make and model. His most recent flight review was completed in May 2018, and his most recent FAA second-class medical certificate was issued in May 2018.

Aircraft and Owner/Operator Information

Aircraft Make:	Cessna	Registration:	N255
Model/Series:	T337 G	Aircraft Category:	Airplane
Year of Manufacture:	1975	Amateur Built:	
Airworthiness Certificate:	Normal	Serial Number:	P3370213
Landing Gear Type:	Retractable - Tricycle	Seats:	4
Date/Type of Last Inspection:	July 9, 2018 Annual	Certified Max Gross Wt.:	4700 lbs
Time Since Last Inspection:	93 Hrs	Engines:	2 Reciprocating
Airframe Total Time:	2848 Hrs at time of accident	Engine Manufacturer:	Continental Motors
ELT:	C126 installed, not activated	Engine Model/Series:	TSIO-360C
Registered Owner:		Rated Power:	225 Horsepower
Operator:		Operating Certificate(s) Held:	None

The airplane was manufactured in 1975, as serial number P3370213. Operator information indicated that the airplane was equipped with two Continental Motors TSIO-360 series engines. The airplane was a centerline thrust configuration, and was equipped with retractable, tricycle-configuration landing gear.

The airframe and both engines had each accumulated a total time (TT) in service of about 2,848 hrs. The engines had each accumulated about 880 hours TT since the most recent overhaul. The most recent annual inspection was completed on July 9, 2018.

The airplane manufacturer's published normal operating speed range for the airplane was 80 to 190 mph, and the caution speed range was from 190 to 230 mph. The maximum landing gear extension speed was 160 mph, and the maximum landing gear extended operating speed was 230 mph.

The landing gear was arranged in a tricycle configuration. All 3 landing gear retracted into the fuselage, and were aerodynamically faired by multiple doors for each wheel well. The aftmost and largest door for each of the two main landing gear wells extended from the fuselage bottom and partially up its respective fuselage side, resulting in an "L"- or bowl-like shape for the door. Due to their shape, these main landing gear doors are sometimes referred to as the "parachute" or "clamshell" doors.

Each main door was opened and closed by a dedicated hydraulic actuator attached to the door and the fuselage. Each actuator was equipped with an internal snap ring (sometimes referred to as a "circlip") that nested in a groove inside the actuator cylinder, functioned as a travel-limiting and retaining stop for the actuator rod in the actuator cylinder.

Each main door was hinged longitudinally along its upper (outboard) edge. The forward and aft door edges were oriented parallel to the airplane lateral axis. The inboard door edges were closest to the airplane centerline. During the landing gear extension cycle, each main door would swing down and then outboard, with a maximum travel of about 90°. When the doors were in transit or fully open, their shape and operating configuration resulted in significant airloads on the doors, and resultant aerodynamic drag on the airplane. These doors return to the closed position when the landing gear extension cycle is complete.

The airplane manufacturer's maintenance manual (MM) specified that after disassembly, the landing gear door actuator should be inspected for "cracks, chips, scoring, wear or surface irregularities which might affect...the overall function of the actuator." In the MM section for actuator re-assembly, the guidance specified to "Install all new packings and retainers." The internal snap rings qualified as retainers, and therefore were to be replaced during re-assembly of the actuators.

According to the airplane maintenance records "all three MG [main landing gear] door cylinders [actuators]" were "rebuilt" with "new O-rings" in July 2014, when the airplane had a TT of about 1,968 hrs. That entry was the most recent entry concerning the landing gear. The entry did not cite any additional details about the rebuilds, including whether new internal snap rings were installed. Discussions with the operator's Director of Maintenance indicated that the snap rings likely were not replaced during the actuator rebuild. The airplane accumulated more than 750 hours of operation between the actuator rebuild and the failure.

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	Condition of Light:	Day
Observation Facility, Elevation:	LWS,1442 ft msl	Distance from Accident Site:	0 Nautical Miles
Observation Time:	18:42 Local	Direction from Accident Site:	0°
Lowest Cloud Condition:	Clear	Visibility	10 miles
Lowest Ceiling:	None	Visibility (RVR):	
Wind Speed/Gusts:	5 knots /	Turbulence Type Forecast/Actual:	/
Wind Direction:	90°	Turbulence Severity Forecast/Actual:	/
Altimeter Setting:	29.85 inches Hg	Temperature/Dew Point:	39°C / 5°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	Lewiston, ID (LWS)	Type of Flight Plan Filed:	Unknown
Destination:	Lewiston, ID (LWS)	Type of Clearance:	None
Departure Time:	13:00 Local	Type of Airspace:	Class D

The 1842 automated weather observation at LWS included winds from 090° at 5 knots, visibility 10 miles, clear skies, temperature 39°C, dew point 5°C, and an altimeter setting of 29.85 inches of mercury.

Airport Information

Airport:	Lewiston Nez Perce County LWS	Runway Surface Type:	Asphalt
Airport Elevation:	1442 ft msl	Runway Surface Condition:	Dry
Runway Used:	30	IFR Approach:	None
Runway Length/Width:	5000 ft / 100 ft	VFR Approach/Landing:	Unknown

Wreckage and Impact Information

Crew Injuries:	1 None	Aircraft Damage:	Substantial
Passenger Injuries:	1 None	Aircraft Fire:	None
Ground Injuries:	N/A	Aircraft Explosion:	None
Total Injuries:	2 None	Latitude, Longitude:	46.375,-117.010002(est)

The airplane came to rest near the runway 30 centerline, about 100 ft prior to taxiway F. All three

landing gear were retracted in their wells, but the landing gear doors were in varying positions of transit. All airframe damage was confined to the airplane belly skins and structure, and the landing gear doors. The tips of the rear propeller blades displayed minor grinding damage consistent with runway contact with the engine operating. Post accident examination revealed that the runway slide had ground through several of the lower skin panels and structural members, substantially damaging the airplane.

Examination of the landing gear system revealed that the same failure had occurred in both the left and right main landing gear door actuators, but for different reasons. In each case, the single internal snap ring that functioned as the travel stop and retaining device for the actuator rod in each actuator cylinder had been liberated from its retention groove in the cylinder, but remained captive on the actuator rod. Liberation of the snap ring enables hyper-extension (overtravel) of the actuator rod, which then permits most or all of the hydraulic fluid to exit the hydraulic system via the actuator. The landing gear hydraulic system was not equipped with any hydraulic fuses, and the reservoir was found to be empty. Loss of most or all of the hydraulic fluid renders the landing gear system inoperative in both the normal and emergency modes. No damage to the snap rings or the actuator cylinders from either door was observed.

Both main doors were found open about 90°, so that their inboard free edges, which were closest to the airplane centerline when the doors were closed, had translated outboard and down. Because the MLG remained in their respective wheel wells, these door edges contacted the runway on touchdown. The inboard edge of the right door was only slightly damaged by runway contact, but according to a technician who examined the airplane shortly after the accident, the left door was "missing about 3-4 inches of material" along its inboard edge, due to abrasion by runway contact. This door-damage evidence was consistent with the liberation of the snap ring from the right actuator occurring first, followed by significant loss of hydraulic fluid, and subsequent disabling of the landing gear system. The left actuator was hyperextended (and its snap ring liberated) by door loading due to runway contact.

Subsequent to the examination, the actuator rods and internal snap rings were re-inserted into their respective actuators, and the hydraulic system was replenished with fluid. The landing gear system was operationally tested while the airplane was supported by jacks. The system performed normally; the landing gear was able to be retracted and extended multiple times with no anomalies or failures. No other mechanical deficiencies with the landing gear system were detected.

Additional Information

Snap Ring Problems and Alternatives

The operator reported that a Canadian operator with 18 Cessna 337 airplanes had 3 occurrences of snap ring liberation and landing gear failure since 1980. A search of FAA Service Difficulty Reports (SDRs) revealed additional snap ring liberation occurrences.

The airplane manufacturer offered an alternate-design actuator that could be installed as a direct replacement (no other changes) on the accident model airplane. The alternate design actuator replaced the snap ring with a threaded cap on the end of the actuator cylinder; this design afforded a more secure retention system for the actuator rod.

At least one aftermarket company, RT Aerospace, developed an alternative for the airplane manufacturer's main landing gear doors. This alternative was approved via an FAA supplemental type certificate (STC). This design replaced the moving doors and their actuation systems with fixed panels that had cutouts for the landing gear. The company website stated that this hardware reduced the "high drag" due to the original door configuration, and improved reliability and safety by eliminating 2 actuators and 4 hydraulic lines. This STC modification was not installed on the accident airplane at the time of the event, but the operator reported that they installed it when the airplane was repaired after the accident.

Administrative Information

Investigator In Charge (IIC):	Huhn, Michael
Additional Participating Persons:	David R Hartson; FAA; Helena, MT
Original Publish Date:	June 3, 2020
Note:	The NTSB did not travel to the scene of this accident.
Investigation Docket:	https://data.nts.gov/Docket?ProjectID=98028

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