



AVIATION



HIGHWAY



MARINE



RAILROAD



PIPELINE

Aviation Investigation Final Report

Location:	Eugene, Oregon	Accident Number:	WPR12FA193
Date & Time:	April 27, 2012, 14:30 Local	Registration:	N101PG
Aircraft:	Cessna 560XL	Aircraft Damage:	Substantial
Defining Event:	Landing gear collapse	Injuries:	3 None
Flight Conducted Under:	Part 91: General aviation - Executive/Corporate		

Analysis

The pilot-in-command (PIC) reported that, during the visual approach to the airport, he and the second-in-command (SIC) lowered the landing gear and verified that all cockpit indications showed that the landing gear were in the down-and-locked position. The airplane touched down smoothly on the main landing gear (MLG) and then touched down on the nose landing gear (NLG). The PIC had his hand on the thrust reversers when he and the SIC heard the landing gear unsafe horn; the left MLG then collapsed followed immediately by the collapse of the right MLG and the NLG. The airplane slid on its belly for about 1,500 ft before it came to rest on the runway. Cockpit voice recorder data confirmed that the unsafe landing gear configuration warning did not occur before touchdown as reported by the PIC.

Postaccident examination revealed that, although the landing gear handle was in the down-and-locked position, all of the landing gear were fully retracted and engaged in their respective uplocks. Extensive testing of the airplane's hydraulic and electrical systems did not reveal any malfunctions that would have resulted in an uncommanded gear retraction. Some small, fine particulate matter was observed within the hydraulic manifold assembly; however, testing was unable to determine if these particles contributed to the uncommanded landing gear retraction.

Probable Cause and Findings

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

An uncommanded landing gear retraction after touchdown for reasons that could not be determined because postaccident examination did not reveal any mechanical malfunctions or failures that would have precluded normal operation.

Findings

Not determined	(general) - Unknown/Not determined
Aircraft	Gear extension and retract sys - Malfunction

Factual Information

History of Flight

Landing-landing roll	Landing gear collapse (Defining event)
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On April 27, 2012, about 1430 Pacific daylight time, a Cessna Citation 560XL, N101PG, sustained substantial damage to the left wing and front pressure bulkhead following an uncommanded landing gear retraction while landing at Mahlon Sweet Field Airport (EUG), Eugene, Oregon. The airline transport pilot, commercial pilot, and one passenger were not injured. The airplane was registered to and operated by Pape Group Inc., as a cross country corporate transportation flight under the provisions of 14 Code of Federal Regulations Part 91. Visual meteorological conditions prevailed, and an instrument flight plan had been filed. The flight originated from Cleveland-Hopkins International Airport (CLE), Cleveland, Ohio, with an intermediate stop at Centennial Airport (APA) in Denver, Colorado.

The pilot in command (PIC) reported that the flight from APA was uneventful. During the visual approach into EUG, the PIC called for full flaps and final landing configuration. The flight crew both verified that all cockpit indications showed the landing gear in the down and locked position. The airplane touched down smoothly on the main landing gear followed by the nose gear. The PIC had his hand on the thrust reversers (he was unsure if he started to deploy them or not) when the flight crew heard the landing gear unsafe horn; the left main landing gear collapsed followed immediately by the right and nose gears. The airplane slid on its belly for about 1,500 feet before it came to rest on the runway.

Pilot Information

Certificate:	Airline transport; Flight instructor	Age:	44
Airplane Rating(s):	Single-engine land; Multi-engine land	Seat Occupied:	Left
Other Aircraft Rating(s):	None	Restraint Used:	
Instrument Rating(s):	Airplane	Second Pilot Present:	Yes
Instructor Rating(s):	Airplane single-engine; Instrument airplane	Toxicology Performed:	No
Medical Certification:	Class 2 With waivers/limitations	Last FAA Medical Exam:	April 13, 2012
Occupational Pilot:	Yes	Last Flight Review or Equivalent:	September 11, 2011
Flight Time:	5600 hours (Total, all aircraft), 250 hours (Total, this make and model), 3500 hours (Pilot In Command, all aircraft), 100 hours (Last 90 days, all aircraft), 35 hours (Last 30 days, all aircraft), 0 hours (Last 24 hours, all aircraft)		

Co-pilot Information

Certificate:	Commercial	Age:	45
Airplane Rating(s):	Single-engine land; Multi-engine land	Seat Occupied:	Right
Other Aircraft Rating(s):	None	Restraint Used:	
Instrument Rating(s):	Airplane	Second Pilot Present:	Yes
Instructor Rating(s):	None	Toxicology Performed:	No
Medical Certification:	Class 2 Without waivers/limitations	Last FAA Medical Exam:	
Occupational Pilot:	No	Last Flight Review or Equivalent:	February 15, 2011
Flight Time:	2519 hours (Total, all aircraft), 15 hours (Total, this make and model), 190 hours (Pilot In Command, all aircraft), 30 hours (Last 90 days, all aircraft), 16 hours (Last 30 days, all aircraft)		

Pilot in Command (PIC)

The PIC, age 44, held an airline transport pilot certificate with ratings that included airplane single- and multi-engine land, and instrument airplane. At the time of the accident, he had accumulated about 5,600 hours of flight experience, about 250 of which were in the accident airplane. His most recent FAA second-class airman medical certificate was issued on April 14, 2012, with the restriction that he must wear corrective lenses.

Second Pilot

The second pilot, age 45, held a commercial pilot certificate with ratings that included airplane single- and multi-engine land, and instrument airplane. At the time of the accident, he had accumulated about 2,519 hours of flight experience, about 15 of which were in the accident airplane. He also held a FAA second-class medical with no limitations or waivers.

Aircraft and Owner/Operator Information

Aircraft Make:	Cessna	Registration:	N101PG
Model/Series:	560XL	Aircraft Category:	Airplane
Year of Manufacture:		Amateur Built:	
Airworthiness Certificate:	Normal	Serial Number:	560-5590
Landing Gear Type:	Retractable - Tricycle	Seats:	11
Date/Type of Last Inspection:	December 21, 2011 Continuous airworthiness	Certified Max Gross Wt.:	20400 lbs
Time Since Last Inspection:		Engines:	2 Turbo fan
Airframe Total Time:	1937 Hrs at time of accident	Engine Manufacturer:	P&W CANADA
ELT:	Installed, not activated	Engine Model/Series:	PW545 SER
Registered Owner:	PAPE GROUP INC	Rated Power:	3952 Lbs thrust
Operator:	PAPE GROUP INC	Operating Certificate(s) Held:	None

The airplane was a Cessna Citation 560XL, serial number 560-5590, and was manufactured in 2005. The airplane was maintained under a manufacturer's inspection program and its most recent maintenance occurred on December 21, 2011. At the time of the accident, the airplane had a total time of 1,937 hours.

The airplane has a tricycle landing gear system that is controlled electrically and actuated hydraulically.

The landing gear control panel in the cockpit contains a landing gear handle, three gear indicator lights, a red gear unlocked indicator, and an audible warning system. The landing gear handle can be positioned either up or down, with the two positions separated by a detent. Therefore, if the handle is in the up position the pilot must pull the handle out to clear the detent before positioning it in the down position. There is also a locking solenoid within the gear handle that physically restricts the handle from being moved while the airplane is on the ground. This solenoid is activated by a squat switch on the left main landing gear, which indicates if there is 'weight on wheels' or 'no weight on wheels'.

The hydraulic system contains a bypass valve, a manifold assembly that houses the control valves for all hydraulic components, and landing gear actuators. The bypass valve opens and closes on command to pressurize and depressurize the system. The landing gear control valve, which is secured to the manifold assembly, receives an electrical signal to either an extend or retract solenoid, which directs fluid through an internal spool to either the extend or retract side of the hydraulic system. When the control valve is not in use, it is spring loaded to a neutral position. Finally, the landing gear actuators, one at each gear, raise and lower the gears. When the gear is retracted, mechanical uplocks hold the gear in place; and when the gear is extended, an internal lock within the actuators hold the gear into the extended position.

In summary, if the pilot wants to retract the landing gear: with weight off of the left landing gear squat switch, the landing gear handle solenoid unlocks, and the pilot can move the handle to the up (retract) position. The pilot then receives a GEAR UNLOCKED indicator light; an electrical signal is sent to close the bypass valve, and to energize the landing gear control valve. The hydraulic fluid pressurizes and routes through the landing gear control valve to the retract side of the hydraulic system. The fluid

then flows to the landing gear actuators which raise and mechanically lock the gear. Once all three gears are in the up position the bypass opens to reduce pressure, the control valve is positioned to neutral, and the GEAR UNLOCKED indicator light extinguishes.

To extend the landing gear, the system works identical with the exception that the landing gear control valve routes fluid through the uplocks to release them before going to the extend side of the actuating cylinders. Also, when the landing gear is down and locked the pilot will get three green gear safe lights.

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	Condition of Light:	Day
Observation Facility, Elevation:	EUG,374 ft msl	Distance from Accident Site:	0 Nautical Miles
Observation Time:	14:41 Local	Direction from Accident Site:	
Lowest Cloud Condition:	Scattered / 3300 ft AGL	Visibility	10 miles
Lowest Ceiling:	Broken / 5000 ft AGL	Visibility (RVR):	
Wind Speed/Gusts:	9 knots / None	Turbulence Type Forecast/Actual:	/
Wind Direction:	200°	Turbulence Severity Forecast/Actual:	/
Altimeter Setting:	30.31 inches Hg	Temperature/Dew Point:	13°C / 6°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	Denver, CO (APA)	Type of Flight Plan Filed:	IFR
Destination:	Eugene, OR (EUG)	Type of Clearance:	IFR
Departure Time:	13:30 Local	Type of Airspace:	

At 1441, the weather reported at EUG was wind from 200 degrees at 9 knots, 10 statute miles of visibility, scattered clouds at 3,300 feet above ground level (agl) and 4,300 feet agl, broken clouds at 5,000 feet agl, temperature 13 degrees C, dewpoint 6 degrees C, and an altimeter setting of 30.32 inches of mercury.

Airport Information

Airport:	Mahlon Sweet Field Airport EUG	Runway Surface Type:	Asphalt
Airport Elevation:	374 ft msl	Runway Surface Condition:	Dry
Runway Used:	16R	IFR Approach:	Visual
Runway Length/Width:	8009 ft / 150 ft	VFR Approach/Landing:	Full stop

The Mahlon Sweet Field Airport (EUG) is located about 7 miles northwest of Eugene, Oregon and has a field elevation of 374 feet. The airport has two runways, runway 16R/34L and 16L/34R both of which are grooved asphalt runways and in good condition. The accident occurred on runway 16R, which is 8,009 feet long and 150 feet wide; the pilot reported that the runway was dry at the time of the accident.

Wreckage and Impact Information

Crew Injuries:	2 None	Aircraft Damage:	Substantial
Passenger Injuries:	1 None	Aircraft Fire:	None
Ground Injuries:	N/A	Aircraft Explosion:	None
Total Injuries:	3 None	Latitude, Longitude:	44.121387,-123.207221(est)

Flight recorders

Review of the cockpit voice recorder (CVR) revealed that the flight crew read through the landing checklists. The recording also captured the sound of the landing gear extending and the flight crew verifying "three green." After touchdown, a thump and another thump was heard followed immediately by the gear warning horn. The airplane rolled down the runway for a few seconds and the recording captured the landing gear collapse, followed by the sound of the airplane sliding. [Additional information can be found in the CVR group chairman's report located in the public docket.]

Tests and Research

Examination at Mahlon Sweet Field Airport in Eugene, Oregon

Initial examination of the airplane revealed the left wing sustained scrape damage, which punctured the left wing fuel tank. In addition, a communications antenna was pushed through the pressure vessel. A cockpit inspection revealed the landing gear handle was in the down position, the anti-skid was on, and the flaps were fully extended. All of the circuit breakers were engaged with the exception of the CVR and AHRS AUX BATT CHG, which were intentionally pulled after the accident as directed by the National Transportation Safety Board investigator in charge. The landing gear handle was intentionally bumped numerous times to ensure that it could not be accidentally bumped into the retract position.

Examination of the landing gears revealed that all were fully retracted and engaged in their respective uplocks. The right wing skin and gear assembly sustained black circular marks. The sidewall of the tire showed a circular abrasion around the perimeter of the sidewall, which also extended slightly around the perimeter of the rim. There were no black circular marks on the left wing skin, tire, and gear assembly; however, there were linear abrasions on the rim and tire sidewall. The nose landing gear doors were

damaged and would not open by hand. When the landing gear was manually released from inside the cockpit all gears dropped, but did not lock in the down position. It was noted that the nose landing gear uplock was heard releasing prior to the wheel dropping.

The CVR, enhanced ground proximity warning system (EGPWS), landing gear handle, gear control printed circuit board (PCB), gear monitoring PCB, and all three landing gear actuators were removed from the airplane for further examination. The airplane was repaired to accommodate a ferry flight to the Citation Service Center in Wichita, Kansas.

Examination at Honeywell Aerospace in Redmond, Washington.

Review of data obtained from the EGPWS did not reveal any warnings or abnormalities prior to touchdown. [Additional information can be found in the 'Component Examination – EGPWS' document located in the public docket.]

Examination at the Citation Service Center in Wichita, Kansas

Once back at the Citation Service Center, the landing gear handle was tested to acceptance test procedures (ATP) standards and passed. The front knob was removed followed by the face plate. The internal components were examined and one of the three screws securing the PCB was loose; however, no anomalies were noted that would have affected the outcome of the flight.

The landing gear actuators were functionally tested to ATP standards and passed. All three landing gear actuators fully extended and retracted, and there were no indications of internal or external leaks. The unlock and extend pressures were tested, and were within specification requirements. The actuators were later taken to the manufacturer for disassembly, and no anomalies were noted. [Additional information can be found in the 'Component Exam - Nabtesco Aerospace Inc' document located in the public docket.]

Additional testing was conducted on the airplane; the electrical wiring was visually inspected. All lines were continuous and remained intact with the exception of some electrical wires that appeared to be chewed by a rodent. Those wires were later determined to not be associated with the landing gear system. Some aircraft wiring and connectors were found installed in the tailcone in an area that might collect water from the outside elements. These connectors were filled with tap water, and no shorts were observed within the connectors.

The landing gear control PCB and gear monitoring PCB were visually inspected with no anomalies noted. Both PCB's were tested to ATP standards and passed with the exception of a hard failure on the gear monitoring PCB. The hard failure was noted on a transistor that internally shorted to ground; however, this failure was not noted during prior testing.

The hydraulic lines were visually inspected; all lines were continuous and remained intact. Pressure was added to the hydraulic system and no failures were observed. The cockpit warning lights and sounds were tested and functioned normally. The landing gear handle system was tested and responded normally. Instrumentation was added to the airplane to record system inputs, outputs, and responses during testing.

The airplane's hydraulically operated equipment was activated in many normal and abnormal ways. The hydraulic system operated as designed, even when the airplane received simultaneous signals from different components. [Additional information can be found in the 'Airframe Exam – Wichita, Kansas' document located in the public docket.] The check valve was removed from the airplane and functioned normally when tested. The return system filter was removed, examined, and was clear of debris. The manifold assembly, which houses a relief valve and the control valves for all hydraulic actuated systems, was removed from the airplane and taken to the manufacturer for further examination.

Examination at PneuDraulics in Rancho Cucamonga, California

Upon arrival at PneuDraulics, the manifold assembly was tested to ATP standards; during which, the test bench return flow was restricted to obtain appropriate pressures. Initial results showed normal indications with the exception of an internal leakage at the flap control valve. Continued testing showed that the flap valve was slow to respond. When cycled various times with the extend solenoid energized, the valve would either respond slowly or move to the retract position, which is a reverse command. During one of the reverse commands, the valve was tapped with a rubber mallet and the valve slowly transitioned from the retract to extend position.

The manifold relief valve was removed and debris was noted within the fluid drained. The relief valve was tested to ATP standards and it did not pass due to lower than acceptable cracking pressure, pressure drop at rated flow, reseal pressure, and reseal leakage. The pressure relief valve was disassembled; all fluid and debris was flushed. Unusual wear marks were noted on some of the internal components; however, these components do not contact other components within the system. No other damage was noted on the seals or other internal parts.

A new relief valve, which tested to ATP standards, was installed onto the manifold and the flap control valve still showed a slow response. The flap control valve was removed from the manifold for further testing and examination.

The flap control valve was tested to, and passed, ATP standards with the exception of two internal leakage requirements when solenoid A (extend solenoid) was energized. Both the extend and retract control solenoids were removed for further examination. When tested, the extend solenoid passed the ATP; however a failed pressure drop test revealed too much backpressure to the return when de-energized. The extend solenoid was disassembled and there were no visual anomalies. Solenoid B (retract solenoid) was also tested to ATP standards and had a higher leakage than normal when energized. The retracted solenoid was disassembled and there were no internal visual anomalies. Some small debris was noted within the solenoid. The remainder of the flap control valve was disassembled and some scoring was noted along the spool surface, however that is not uncommon. Otherwise, there were no anomalies noted with the control valve spool and chamber.

The gear control valve was also removed from the manifold assembly. After ensuring a proper test bench setup the gear control valve was tested and passed all components of the ATP. The gear and flap control valves, and the manifold assembly were dimensionally tested; no blockages or burrs were noted throughout any of the units.

The flap control valve and manifold were reassembled near original configuration to facilitate additional testing and examination. During testing, the spool position, high pressure solenoid ball, and the return ball were manipulated in an attempt to recreate the command reversal that was previously witnessed. Despite testing in various configurations, the reversal was not duplicated; however, it was found that if the spool is not centered (when the system is not energized) it can favor either the retract or extend side of the system.

Additional Information

On April 15, 2008 a Cessna 560XL, N613QS was substantially damaged during an uncommanded gear retraction while landing at the Westchester County Airport in White Plains, New York [NTSB accident number NYC08LA162]. The subsequent investigation was not able to determine the cause of the gear collapse. This investigation differed in the fact that a landing gear extend hydraulic line was compromised consistent with overpressure.

Administrative Information

Investigator In Charge (IIC): Link, Samantha

Additional Participating Persons: Curt Cowley; Federal Aviation Administration; Hillsboro, OR
Andrew Hall; Cessna Aircraft Company; Wichita, KS
Matthew Glugla; Nabtesco Aerospace, Inc.; Kirkland, WA , WA

Original Publish Date: July 7, 2015

Last Revision Date:

Investigation Class: [Class](#)

Note:

Investigation Docket: <https://data.nts.gov/Docket?ProjectID=83542>

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The NTSB does not assign fault or blame for an accident or incident; rather, as specified by NTSB regulation, “accident/incident investigations are fact-finding proceedings with no formal issues and no adverse parties ... and are not conducted for the purpose of determining the rights or liabilities of any person” (Title 49 *Code of Federal Regulations* section 831.4). Assignment of fault or legal liability is not relevant to the NTSB’s statutory mission to improve transportation safety by investigating accidents and incidents and issuing safety recommendations. In addition, statutory language prohibits the admission into evidence or use of any part of an NTSB report related to an accident in a civil action for damages resulting from a matter mentioned in the report (Title 49 *United States Code* section 1154(b)). A factual report that may be admissible under 49 *United States Code* section 1154(b) is available [here](#).