Aviation Investigation Final Report

Location:	Henderson, Nevada	**Accident Number:**	WPR12FA332
Date & Time:	July 28, 2012, 08:32 Local	**Registration:**	N146SL
Aircraft:	Piaggio P180	**Aircraft Damage:**	Substantial
Defining Event:	Flight control sys malf/fail	**Injuries:**	4 None
Flight Conducted Under:	Part 135: Air taxi & commuter - Non-scheduled		

Analysis

The twin-engine airplane departed 23 minutes behind schedule to pick up passengers at an intermediate airport. During the takeoff roll, the left elevator departed the airplane and was found off the side of the runway 3 days later. The crew arrived at the intermediate airport and quickly boarded the two waiting passengers. They did not perform an adequate preflight inspection and departed about 5 minutes behind schedule. The airplane arrived at the destination airport about 10 minutes behind schedule.

Upon postflight examination by the crew, the left elevator was observed missing from the tail's horizontal stabilizer. An examination of the attachment nuts on the hinges of the right elevator found that they were finger tight. Examination of the hinge fittings on the left elevator and horizontal stabilizer revealed no mechanical damage or deformation to any of the components. Review of airplane maintenance records showed that an airworthiness directive (AD) had been complied with 54 days earlier, which involved both elevators being removed and then reinstalled.

Materials laboratory examination of one of the right elevator attachment hardware bolt-nut combinations revealed that the self-locking nut exhibited run-on torque values well below the acceptable minimum torque. Based on the finger tight condition of the right elevator attachment hardware and the lack of any mechanical damage to the hinge fittings of the left elevator and stabilizer hinge structure, it is likely that all four sets of attachment hardware for both elevators were not properly torqued during the AD maintenance 54 days earlier. Additionally, 26 days before the event, a phase inspection was completed during which the elevator should have been visually inspected and functionally checked. The airplane had flown 158.9 hours with loose elevator attachment hardware before the two sets of bolts on the left elevator had completely worked their way out of the hinges, and the elevator departed the airplane.

The cockpit voice recorder revealed that the flight crew had experienced unusual pitch control responses during each of the departures and landings. The flight crew could have identified the missing elevator during a preflight inspection at the intermediate airport, yet they decided to continue the flight despite the pitch control problems experienced during the takeoffs and landing.

Probable Cause and Findings

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

The failure of maintenance personnel to properly torque the elevator attachment hardware in accordance with the maintenance manual, which led to the detachment of the elevator. Contributing to the accident were maintenance personnel's failure to identify the loose attachment hardware during a scheduled inspection, the flight crew's decision to continue the flight after identifying a flight control problem, and the flight crew's failure to perform an adequate preflight inspection at the intermediate airport.

Findings

Personnel issues	Scheduled/routine maintenance - Maintenance personnel
Aircraft	Elevator control system - Incorrect service/maintenance
Personnel issues	Preflight inspection - Flight crew
Personnel issues	Decision making/judgment - Flight crew
Personnel issues	Scheduled/routine inspection - Maintenance personnel

Factual Information

History of Flight

Takeoff	Flight control sys malf/fail (Defining event)

On July 28, 2012, at 0832 Pacific daylight time, a Piaggio P180, N146SL, arrived at Henderson Executive Airport, Henderson, Nevada, missing its left elevator. The airplane was operated by Avantair under Title 14 Code of Federal Regulation, Part 135. The two crew, both airline transport pilots, and two passengers were unhurt, and the airplane was substantially damaged. Visual meteorological conditions prevailed, and an instrument flight rules (IFR) flight plan had been filed. The flight originated from San Diego, California, about 0735.

According to the Aventair trip sheet, the planned schedule for the Piaggio P180 crew was to depart Camarillo, California, at 0552, arrive at San Diego at 0642, then depart San Diego at 0730, and arrive at Henderson at 0822. The crew arrived at Camarillo at 0500, preflighted the airplane, and took off at 0615. The Piaggio P180 arrived at San Diego at 0715. The Captain went to the fixed base operator (FBO) to sign for services then did a walk around on one side of the airplane. The First Officer met the two passengers, loaded the baggage, and stayed with the passengers who were upset about the delay. The First Officer stated that he did not perform the required walk around prior to departing San Diego, and that, per the Aventair general operating manual, both pilots are required to do an airplane walk around on every leg. The airplane departed San Diego at 0735 (5 minutes behind schedule), and arrived at Henderson Executive Airport at 0832 (10 minutes behind schedule). When the crew performed a post flight walk around, they noticed that the left elevator was not present on the tail. The crew reported that they had a non-eventful departure and flight from San Diego, and that the captain noticed that more back pressure on the flight controls was required for a normal landing upon arrival at Henderson.

On July 31, 2012, at 1720, personnel at the Camarillo Airport located an airplane flight control surface lying in the grass off the north side of runway 8 near the intersection of taxiway C. The flight control surface was identified by personnel at the Avantair fixed base operator (FBO) as an elevator from a Piaggio P180. An FAA inspector collected the elevator from airport personnel, and delivered it to the NTSB investigator-in-charge (IIC) on August 1, 2012.

Pilot Information

Certificate:	Airline transport	**Age:**	31
Airplane Rating(s):	Multi-engine land	**Seat Occupied:**	Left
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 1 Without waivers/limitations	**Last FAA Medical Exam:**	April 16, 2012
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	June 30, 2011
Flight Time:	5037 hours (Total, all aircraft)		

Co-pilot Information

Certificate:	Airline transport	**Age:**	34
Airplane Rating(s):	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 1 Without waivers/limitations	**Last FAA Medical Exam:**	April 11, 2012
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	July 7, 2012
Flight Time:	5624 hours (Total, all aircraft)		

The Captain, age 31, held an Airline Transport Pilot certificate with ratings for multiengine land and instrument airplane, and held a first-class medical certificate issued April 16, 2012, with no limitations. The pilot reported in the NTSB Pilot Accident Report Form 6120.1 that he had 5,037 hours of total flight time.

The First Officer, age 34, held an Airline Transport Pilot certificate with multiengine land and instrument airplane ratings, and held a first-class medical certificate with no limitations issued on April 11, 2012. He reported in the NTSB Pilot Accident Report Form 6120.1 that he had 5,624 hours of total flight time.

Aircraft and Owner/Operator Information

Aircraft Make:	Piaggio	**Registration:**	N146SL
Model/Series:	P180	**Aircraft Category:**	Airplane
Year of Manufacture:	2004	**Amateur Built:**	
Airworthiness Certificate:	Normal	**Serial Number:**	1091
Landing Gear Type:	Retractable - Tricycle	**Seats:**	11
Date/Type of Last Inspection:	July 2, 2012 Continuous airworthiness	**Certified Max Gross Wt.:**	12150 lbs
Time Since Last Inspection:		**Engines:**	2 Turbo prop
Airframe Total Time:	8352 Hrs at time of accident	**Engine Manufacturer:**	P&W
ELT:	Installed, not activated	**Engine Model/Series:**	PT6A SER
Registered Owner:	AVANTAIR INC	**Rated Power:**	850 Horsepower
Operator:	AVANTAIR INC	**Operating Certificate(s) Held:**	Commuter air carrier (135), Fractional ownership

The 10-seat, twin turboprop, business airplane, serial number 1091, was manufactured in 2004. It was powered by two Pratt & Whitney PT6A-66 850-hp engines, and equipped with two Hartzell HC-E5N-3A controllable pitch propellers. The airplane was in a continuous airworthiness program utilizing the manufacturer's inspection criteria. Review of the airplane maintenance records show that the total airframe time was 8,351.9 hours when it landed at Henderson. The most recent maintenance inspection was a 150-hour "A" inspection completed on July 2, 2012, at total aircraft time (TAT) of 8,269.4 hrs. The "A" phase inspects the engines, propellers, flight controls, and landing gear. Part of the inspection includes a visual inspection and functional check of the elevator.

The most recent maintenance was performed on July 27, 2012, at TAT 8,350.3 hours. The crew had repositioned the airplane from Van Nuys, California, to Camarillo, in order to have the right main landing gear door rod assembly and the navigation lights repaired.

Airplane maintenance records show that on June 4, 2012, TAT 8,191.5 hours, Avantair complied with airworthiness directive AD 2010-23-01, which required the left and right elevators be removed, the elevator hinges be inspected for corrosion between the elevator hinge fittings (metal) and the horizontal stabilizer (carbon fiber), and replaced if necessary. The elevators were then reinstalled.

Examination of the hinge fittings by the NTSB IIC of the left horizontal stabilizer and the corresponding hinge fitting on the left elevator revealed no damage, deformation, or witness marks. The two sets of bolts, nuts, and straight bushings that attached the left elevator to the horizontal stabilizer were not located.

The airframe and powerplant (A&P) mechanic who removed the right elevator reported that the self-locking nuts on the right elevator were loose, and could be loosened and removed with his fingertips. The mechanic took photos to document the loose nuts before he removed the elevator.

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Day
Observation Facility, Elevation:	KHND,2402 ft msl	**Distance from Accident Site:**	0 Nautical Miles
Observation Time:	16:56 Local	**Direction from Accident Site:**	
Lowest Cloud Condition:	Clear	**Visibility**	10 miles
Lowest Ceiling:	None	**Visibility (RVR):**	
Wind Speed/Gusts:	6 knots /	**Turbulence Type Forecast/Actual:**	/ None
Wind Direction:	270°	**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:	30 inches Hg	**Temperature/Dew Point:**	33°C / -12°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	San Diego, CA (KSAN)	**Type of Flight Plan Filed:**	IFR
Destination:	Henderson, NV (KHND)	**Type of Clearance:**	IFR
Departure Time:	09:00 Local	**Type of Airspace:**	

Airport Information

Airport:	Henderson Executive Airport KHND	**Runway Surface Type:**	Asphalt
Airport Elevation:	2402 ft msl	**Runway Surface Condition:**	Dry
Runway Used:	17R	**IFR Approach:**	None
Runway Length/Width:	6501 ft / 100 ft	**VFR Approach/Landing:**	Traffic pattern

Wreckage and Impact Information

Crew Injuries:	2 None	**Aircraft Damage:**	Substantial
Passenger Injuries:	2 None	**Aircraft Fire:**	None
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	4 None	**Latitude, Longitude:**	35.972778,-115.134445(est)

Flight recorders

The airplane was equipped with an L-3/Fairchild FA2100-1010 cockpit voice recorder (CVR), which records 30 minutes of digital audio stored in solid-state memory modules. The CVR was removed, and sent to the NTSB's Audio Laboratory for readout. The CVR contained 30 minutes of excellent quality recording from the captain's and first officer's audio panels, and 30 minutes of good quality recording from the cockpit area microphone (CAM). A CVR Group was not convened. The recording was audited by the NTSB's Vehicle Recorder Laboratory, and a summary report prepared. The Cockpit Voice Recorder Specialist Factual Report is located in the official docket of this investigation.

The majority of the conversation between the Captain and First Officer between 0815 and 0825 pertained to airplane operations. At 0825, air traffic control (ATC) cleared the airplane for a visual approach to runway 17R at Henderson. At 0829, the crew lowered the landing gear, and performed landing checks. One minute later, the CAM starts recording a rattling sound that continues all the way to touchdown. At 0831:24, an automated voice announced "five hundred above, sink rate, sink rate." The Captain replied "correcting". At 0831:53, the Captain said "ha ha," the First Officer replies "crazy isn't it?" and the Captain said "yeh, its really bad at the end there." As the crew taxied the airplane, they continued to discuss the unusual feel of the airplane in the flare and landing. The First Officer said he had the same unusual feel landing in San Diego.

After the airplane engines were shut down and the passengers disembarked, the CAM recorded a 2 1/2-minute cell phone call made by the Captain. The Captain described to the person on the other end of the phone that he and the First Officer were not getting normal elevator control at rotation and landing, and that he had no real control during the landing flare. He described the takeoff out of San Diego where he had the control yoke all the way back at rotation speed of 106 kts, but the airplane didn't rotate until 120 kts. On the departure out of Camarillo the First Officer said the controls felt strange, and he saw him pull the yoke all the way back. The Captain also said that at that point they were in a hurry, and that was why he hadn't called in the problem after departing Camarillo. The Captain then noted that that he had not experienced the unusual control response yesterday when departing out of Van Nuys.

TESTS & RESEARCH

The left elevator command lever with attached fractured torque tube and the two sets of right elevator attachment hardware were examined by the NTSB Materials Laboratory. On the attachment fittings, the elevator rotates about bushings that are held in place by two ¼-28 bolts, washers, and self-locking nuts. In order to measure the wear on the in service elevator attachment hardware, new OEM (exemplar) attachment hardware was also tested in the same manor. The complete Materials Laboratory Factual report is located in the official docket of this investigation.

The left elevator torque tube remained bolted to the left elevator bellcrank. The attachment fitting was observed to be fractured through a flange where it transitioned out of a cylindrical section. The top part of the flange was bent in the outboard direction, and the lower part of the flange was bent in the inboard direction. Using a stereomicroscope, the fracture surfaces were examined, and were found to have a smeared appearance. The deformation and fracture features were consistent with an overstress failure caused by downward bending of the left elevator about the attachment fitting.

The attachment hardware of the right elevator (2 bolts & 2 self locking nuts) were examined for thread wear and functionality. The running torque of the right attachment fitting self-locking nuts was

measured using a calibrated torque wrench with 0.1 in-lbs precision. A stack of washers was placed over each right attachment fitting bolt shank such that three bolt threads were exposed when the nut was turned onto the bolt and tightened to a wrenching torque of 115 in-lbs in accordance with the P180 maintenance manual (Piaggio, 1991) and MS21043 (NASC, 2003). The wrenching torque was measured using a calibrated torque wrench with 1 in-lbs precision. The running torque was measured while turning the nut onto the bolt (on-running torque) and while turning the nut off of the bolt (off-running torque). For the first bolt/nut combination, the on- and off-running torque was 1.2 in-lbs and 1.5 in-lbs, respectively. For the second bolt/nut combination, the on- and off-running torque was 8.5 in-lbs and 9.0 in-lbs, respectively. According to the P180 maintenance manual, self-locking nuts should be discarded when the running torque (called breakaway torque in the manual) falls below 3.5 in-lbs for ¼-28 nuts.

The change in running torque and breakaway torque with sequential torque cycles was measured using exemplar hardware. Two A286 bolts were used in conjunction with silver-plated self-locking nuts and gray-anodized aluminum washers. The A286 bolts, nuts, and washers were the same material types as the accident attachment hardware. The results for the A286 bolts show an on-running torque between 6.1 and 7.0 in-lbs, and off-running torque between 6.8 and 8.8 in-lbs.

Additional Information

On August 7, 2012, Avantair initiated a fleet wide inspection of all their Piggio P180 airplanes. The focus of the action was to inspect and replace as necessary all elevator mounting hardware. The Executive Vice President of Avantair confirmed on December 6, 2012, that as a precaution, all elevator self-locking nuts had been replaced with new hardware for their fleet of P180's.

Administrative Information

Investigator In Charge (IIC):	McKenny, Van
Additional Participating Persons:	Mark Keefer; Federal Aviation Administration; Tampa, FL Gary Rucker; Federal Aviation Administration; Las Vegas, NV Dave Duncan; Piaggio Aero; Flat Rock, NC James Rue; Avantair; Clearwater, FL
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