National Transportation Safety Board
Aviation Accident Final Report

Location:	Homer, AK	**Accident Number:**	ANC14LA035
Date & Time:	05/30/2014, 0930 AKD	**Registration:**	N3125N
Aircraft:	DEHAVILLAND DHC-3T	**Aircraft Damage:**	Substantial
Defining Event:	Flight control sys malf/fail	**Injuries:**	3 None
Flight Conducted Under:	Part 91: General Aviation - Personal		

Analysis

The airline transport pilot was conducting an on-demand commercial taxi flight. The pilot reported that, during level cruise flight, he felt a vibration in the airplane that progressed such that the airplane exhibited a nose-down pitch. He also believed that there was a change in the elevator. The pilot reduced the airspeed and applied gradual pitch corrections to avoid excessive aerodynamic loads on the tail. Once the airplane was slowed and recovered from the pitch deviation, the vibration stopped, and the remainder of the flight was uneventful. However, after landing, the pilot and a mechanic examined the airplane and found damage to the elevator servo tab and spar structures inside the right elevator.

Examination revealed that the elevator auxiliary spar and rear spar forward of the servo tab location exhibited fractures and buckling consistent with overload. The servo tab hinge was intact and attached to the elevator, and nearly all of the rivets remained installed through the tab upper skin and hinge; however, the tab lower skin was separated from the hinge along the rivet line of the C-channel such that the tab structure was splayed open. The rivet holes in the C-channel portion of the skin were intact but had some elongation and deformation consistent with the rivets pulling out.

Dark staining was evident around every rivet on the upper servo tab skin. Such staining, commonly known as "smoking rivets," is typically caused by the loosening of one or more rivets, which allows relative movement between the rivet(s) and the underlying structure. However, if the joint is adequately riveted, there should be no movement between the rivet(s) and the underlying structure.

About 100 flight hours before the accident, the elevator servo tab had been disassembled and its hinge replaced. The elevator servo tab uses steel blind rivets to fasten the upper skin, hinge, and upper leg of the C-channel together because there is no access to the lower side of the joint, which is needed for a typical driven rivet. Replacing the hinge required drilling out each of the rivets fastening the tab skin, C-channel, and hinge together; drilling out rivets can enlarge the holes beyond their nominal diameter. In an adequately riveted joint, the rivet expands to fill

the hole and should slightly deform the hole, making each hole diameter slightly larger than the original; however, if the diameter is already larger than required, the rivet may not adequately fill the hole. Postaccident examination of the servo tab skin found that the material used to construct the tab was about 25 percent thinner than the skin material specified in the original servo tab design and that the hinge used was not in accordance with the original servo tab design.

The servo tab is subject to a harsh vibratory environment due to the natural airframe vibration and the propeller wash induced on the airplane's tail. The holes in the servo tab upper skin and upper leg of the C-channel, which had been previously attached to a different hinge, were likely slightly larger than nominal when the new hinge was installed. Based on the dark staining evidence, the rivets installed on the accident servo tab likely did not adequately fill the holes in the tab structure, which allowed them to loosen over a short period of operation.

The airplane was inspected less than 2 flight hours (2 days) before the accident flight as required by an airworthiness directive (AD) that specifically required checks for elevator servo tab condition, fastener security, and tab free-play. Although maintenance personnel found the tab to be compliant with the AD's maximum free-play/trailing edge deflection allowances, the dark staining should have provided maintenance personnel a visual indication that there was a problem with relative movement between the rivets and the underlying structure; however, no maintenance action was taken.

The reported vibration during the accident flight and the overload damage observed on the servo tab and elevator spar structures are consistent with aerodynamic flutter of the elevator servo tab that excited to the point of imposing damaging loads on the servo tab and the elevator spar structures. Both airspeed (airflow) and inadequate structural stiffness are required for a servo tab flutter event to develop. Inadequate stiffness of the servo tab was evident by both the inadequate servo tab skin thickness and the loose rivets. Airspeed information was not obtained for the accident flight. Generally, as airspeed increases, a flutter condition is exacerbated.

Probable Cause and Findings

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

The flutter failure of the right elevator servo tab due to the improper fabrication of the servo tab and maintenance personnel's subsequent failure to detect anomalies with the servo tab.

Findings

Aircraft	Tab structure (on elevator) - Failure (Cause)
	Tab structure (on elevator) - Not serviced/maintained (Cause)
Personnel issues	Fabrication - Maintenance personnel (Cause)
	Scheduled/routine maintenance - Maintenance personnel (Cause)

Factual Information

HISTORY OF FLIGHT

On May 30, 2014, about 0930 Alaska daylight time, N3125N, a de Havilland DHC-3T Otter airplane equipped with a Honeywell TPE331-12JR turboprop engine, experienced an anomalous in-flight vibration and uncommanded nose-down pitch during cruise flight in the vicinity of Homer, Alaska. The personal flight was operated by Alaska Air Taxi, LLC under the provisions of 14 Code of Federal Regulations (CFR) Part 91 with no flight plan filed. The airline transport pilot and the two passengers were not injured, and the airplane sustained substantial damage to the right elevator. Visual meteorological conditions prevailed. The flight departed Seldovia, Alaska, about 0900, en route to Anchorage, Alaska.

According to the pilot, during level cruise flight about 5,000 feet above mean sea level, he felt a vibration in the airplane that at first felt similar to the effects of propeller ice or a problem with the engine, but the engine and systems instruments showed no indications of any problems. The pilot said that the vibration then became worse, and the airplane wanted to pitch nose-down, and he felt certain that there was a change in the elevator. The pilot reduced the airspeed and applied gradual pitch corrections, being mindful that he did not want to impose excessive aerodynamic loads on the tail. The pilot said that, after he slowed the airplane and recovered it from the pitch deviation, the vibration stopped, and he continued the flight to the destination.

After landing, the pilot and a mechanic examined the airplane and found that skin on the right elevator servo tab was separated from the hinge, and spar structures inside the right elevator were fractured.

AIRCRAFT INFORMATION

The de Havilland DHC-3 Otter, as designed in the early 1950s, is a single-engine, propeller-driven airplane originally powered by a reciprocating radial engine. The type certificate for the DHC-3 is currently held by Viking Air Limited, Sidney, British Columbia, Canada. The accident airplane was modified in November 2008 to be equipped with a Honeywell TPE331-12JR turboprop engine, a Hartzell model HC-B4TN-5QL propeller, and other modifications in in accordance with supplemental type certificate (STC) SA09866SC, held by Texas Turbine Conversions, Inc., of Denison, Texas.

The accident airplane was not equipped, and was not required to be equipped, with a modified elevator servo tab and control linkage. (See the "Additional Information" section below for more information.) The original design for DHC-3 servo tab (P/N C3TE13-12) specifies the use of a single piece of 0.016-inch thick 2024 Alclad aluminum formed into a triangular shape with a C-channel incorporated into the forward edge, a continuous hinge (P/N NAS-30-3A-LT) installed at the forward edge of the tab between the upper skin and the upper leg of the C-channel (to attach it to the elevator), and CR-163-4 blind rivets to fasten the hinge and tab skin together. According to design specifications, the NAS-40-3A-LT hinge is made from anodized 61S-T6 aluminum alloy with a width from the hinge centerline to the edge of the flange of 0.625 inch and a flange thickness of 0.045 inch.

A maintenance log entry dated December 1, 2013, documented an annual/100-hour inspection for the airplane and referenced compliance with AD 2011-18-11 (which specified an elevator servo tab inspection) at an airframe total time of 16,299.1 (Hobbs 1513.1). A two-page maintenance worksheet that noted the same Hobbs time contained 11 work items. Item 3 on the worksheet recorded compliance with AD 2011-18-11 and stated "Tabs within tolerance." Item 11 on the worksheet, which was signed off by a different mechanic, noted "R-H Elevator Trim Tab Hinge Worn" and, for work accomplished, noted "R/R Trim Tab Hinge." During an interview, the Alaska Air Taxi director of maintenance (DOM) said that the reason for the hinge replacement at that time was because the AD 2011-18-11 inspection revealed that the servo tab installation exceeded the maximum free-play/trailing edge deflection allowances specified in Viking DHC-3 Otter Maintenance Manual Temporary Revisions 18, 19, and 20. The DOM said that the skin had been assembled to the hinge in accordance with the specifications in the original DHC-3 drawing. The repaired servo tab was reinstalled on the airplane, found to be compliant with the specified allowances, and the airplane was returned to service.

The maintenance records showed no other maintenance to the servo tab between its replacement and the time of the accident. A maintenance record documented that a 100-hour inspection, including the AD 2011-18-11 elevator servo tab inspection, was performed May 28, 2014, at an airframe total time of 16,398.0 hours.

The review of airframe logs did not locate a record for compliance with AD 2011-12-02 (which specified revised airspeed limitations and airspeed indicator markings); however, the AD compliance record for the airframe showed it was complied with on July 15, 2011. The airplane's airspeed indicator had red radial markings at 134 mph and 144 mph, consistent with the specifications in AD 2011-12-02.

WRECKAGE EXAMINATION

The airplane had been repaired and returned to service on June 3, 2014, before the NTSB was notified of the event. (See the "Postaccident Repair and Return to Service" subsection under the "Additional Information" section below for more information.) Examination of photographs of the damaged components provided by the operator showed that a majority of the servo tab remained attached to the right elevator. Most of the servo tab upper skin was attached to the hinge by its rivets, but the lower skin was separated from the rivets such that the tab structure was splayed open. Sections of both the upper and lower skin were separated and not recovered. The upper tab skin showed dark staining around every rivet, and the staining extended aft along the airflow direction from many of the rivets.

The operator provided the NTSB IIC the damaged servo tab, hinge, and elevator auxiliary and rear spar components for further examination by an NTSB structures engineer. While meeting with the NTSB IIC, both the pilot and the DOM expressed their concerns that complying with the AD could potentially introduce a new problem. Both the pilot and the DOM noted that previously replacing the hinge required the removal of blind rivets from the servo skin. The DOM noted that when a rivet is drilled out, the holes could become "hogged out," or elongated. He noted that, in a blind rivet situation, a person cannot tell if the holes are clean or not, and a person cannot tell how much material is there for the new rivets to grip into.

TESTS AND RESEARCH

Elevator Servo Tab and Hinge

NTSB examination of the elevator servo tab and hinge components revealed that the inboard 3 to 4 inches of the tab upper skin was separated and not recovered; the remaining upper skin portion was mostly intact. All of the rivets with the exception of the inboard-most rivet remained installed through the tab upper skin and hinge; however, the tab lower skin was separated from the hinge along the rivet line of the C-channel such that the tab structure was splayed open. The inboard 9.5 inches of tab lower skin and the inboard 14 inches of the C-channel portion of the tab were separated and not recovered. Examination of the remaining C-channel portion found that the rivet holes were intact but had some elongation and deformation.

The C-channel was fractured about 3.5 inches inboard of the outboard end, and the fracture extended aft on the lower skin about 2.25 inches. The outboard filler and control horn remained attached to the tab upper skin at the outboard end. Fractures in the tab lower skin were coincident with the location of the fractures in the upper skin.

Skin thickness measurements of the servo tab skin pieces were performed at several locations (the paint was not removed before the measurements were taken). All measurement readings were between 0.012 and 0.013 inch. Examination of the hinge found it was marked with "MS 20001-2" along its length. Specifications for the MS 20001-2 hinge indicate that it is made from anodized 2024-T3511 aluminum alloy with a width from the hinge centerline to the edge of the flange of 0.531-inch and a flange thickness of 0.044-0.056 inch.

Elevator Auxiliary and Rear Spar Structures

Examination of the elevator auxiliary spar (installed between the upper and lower elevator skins in the area forward of the servo tab) found that it was fractured about 20.75 inches outboard of the inboard end. Twelve rivets installed on the lower elevator skin were found still attached to the skin but pulled through (separated) from the auxiliary spar in the area of the spar fracture and outboard. The auxiliary spar had identification and inspection stamps consistent with the original manufacture. Examination of the elevator rear spar revealed buckling damage on the inboard 25 inches with fractures through the upper flange about 18 inches from the inboard end (at the third lightening hole location) and through both the upper and lower flanges about 25 inches from the inboard end (at the fourth lightening hole location).

See the Airworthiness Group Factual Report in the public docket for more detailed information.

ADDITIONAL INFORMATION

Aerodynamic Flutter

Flutter is an aeroelastic phenomenon that can occur when an airplane's natural mode of structural vibration couples with the aerodynamic forces to produce a rapid periodic motion, oscillation, or vibration. The vibration can be somewhat stable if the natural damping of the structure prevents an increase in the vibratory forces and motions. The motions can become dynamically unstable if the damping is not adequate, resulting in increasing self-excited

destructive forces being applied to the structure. Flutter can range from an annoying "buzz" of a flight control or aerodynamic surface to a violent and destructive failure of the structure in a very short period of time. Aircraft speed and structural stiffness are two inputs that govern flutter; as speed increases or structural stiffness decreases, the susceptibility to flutter will increase. (Source: NTSB Aircraft Accident Brief, NTSB/AAB-12/01, "Pilot/Race 177, The Galloping Ghost, North American P-51D, N79111, Reno, Nevada, September 16, 2011.")

Summary of Related Elevator Servo Tab Safety Activity, including ADs

The FAA, Transport Canada (TC), the Civil Aviation Authority of Australia, the Civil Aviation Authority of New Zealand, Viking Air Limited, and various STC holders have a history of activity (spanning several years) related to elevator servo tab safety for a variety of configurations of the DHC-3 airplane, including original and STC-modified (turbine) powerplant configurations. A summary of the items that applied to the accident airplane's configuration for U.S. operations at the time of the accident is provided below. A detailed history of various ADs for other DHC-3 configurations, an optional Viking Air Limited flutter-prevention modification kit STC (with its own related ADs and a service bulletin), and additional requirements from TC for DHC-3 airplanes in Canada, are contained in the Airworthiness Group Factual Report in the docket for this investigation.

In June 2011, the FAA issued AD 2011-12-02 to impose limitations on the airspeed of DHC-3 airplanes equipped with a Honeywell TPE331-10 or -12JR turboprop engine per STC SA09866SC. The AD required inserting limitations into the airplane flight manual to specify a maximum operating airspeed limitation of 144 mph for a land/ski airplane and 134 mph for a seaplane and modifying the airspeed indicator to include a red radial line at 144 mph for a land/ski airplane and/or a red radial line at 134 mph for a seaplane.

In August 2011, the FAA issued AD 2011-18-11 requiring repetitive inspections of the elevator servo tab, correcting all discrepancies, and reporting results to the FAA for all DHC-3 airplanes. (The AD superseded AD 2011-05-02 issued in February 2011, retaining all of the requirements and changing the applicability to include all DHC-3 airplanes.) The AD requires operators to inspect the elevator servo tab every 100 hours in accordance with Viking DHC-3 Otter Maintenance Manual Temporary Revisions No. 18, No. 19, and No. 20.

In March 2004, the FAA issued an AD that initially mandated the installation of an STC for a modified elevator servo tab and redundant control linkage on all turbine-powered DHC-3 airplanes (including Honeywell [STC SA09866SC], Walter M601E-11 [Canada Turbine Conversions, Inc., STC SA09857SC], and Pratt & Whitney PT6A-34 or -135 [A.M. Luton STC SA3777NM]turbine engine installations). According to Federal Register Vol. 69, No. 40, Monday, March 1, 2004, page 9523, in which the FAA announced the original AD, the FAA referenced "several reports of situations where pilots of…DHC-3 airplanes with installed turbine engines have experienced buffeting of the elevators." The FAA noted that, in all cases, the airplanes had been modified with a Pratt & Whitney engine per STC SA3777NM. In April 2004, the FAA issued a revised AD 2004-05-01R1 to remove the mandate for the Honeywell- and Walter-equipped airplanes. The FAA stated that it decided to remove the applicability to the Honeywell- and Walter-modified airplanes after it evaluated the concerns, comments, and technical information related to all three STC configurations.

An NTSB review of available records found no previous documented instances of an in-flight failure of an elevator servo tab on a DHC-3 airplane equipped with a Honeywell TPE331-10 or -12JR turboprop engine.

Postaccident Repair and Return to Service

Following this accident, the airplane was repaired and returned to service. A maintenance record dated June 3, 2014, documented repairs to the elevator rear spar, replacement of the false spar, and fabrication of a new servo tab. According to the DOM, the new servo tab was built in accordance with the drawing for the original P/N C3TE13-12 servo tab. He pointed out that the original drawing specified the use of CR163 blind rivets to fasten the tab and hinge together. The DOM used CR9163 rivets, the modern equivalent of CR163 rivets (which were no longer available), for the repair.

The DOM stated that following the June 3, 2014, repair, an FAA inspector had inspected the airplane and wanted to ground the airplane because CR3243 Cherry Max rivets were not used to fasten the tab together. The DOM said that the FAA inspector was incorrect and that, per the drawing, he had used the correct rivets. The DOM noted that the Cherry Max rivets were used only for DHC-3 airplanes that were equipped with an optional flutter kit, which the accident airplane had not incorporated. The DOM provided a copy of the service bulletin that applied to modified airplanes for reference. A maintenance record for the airplane dated June 5, 2014, showed that the CR9163 rivets were removed from the servo tab hinge, CR3243 Cherry Max rivets were installed, and the airplane was returned to service.

Before this accident investigation was completed (and before the results of the component examinations were known), the airplane experienced another anomalous event involving the elevator servo tab. See NTSB accident ANC15LA037 for more information about that event.

History of Flight

Prior to flight	Aircraft maintenance event Aircraft inspection event
Enroute-cruise	Flight control sys malf/fail (Defining event)

Pilot Information

Certificate:	Airline Transport; Commercial	**Age:**	67, Male
Airplane Rating(s):	Multi-engine Land; Single-engine Land; Single-engine Sea	**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 With Waivers/Limitations	**Last FAA Medical Exam:**	03/28/2014
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	
Flight Time:	16000 hours (Total, all aircraft)		

Aircraft and Owner/Operator Information

Aircraft Make:	DEHAVILLAND	**Registration:**	N3125N
Model/Series:	DHC-3T	**Aircraft Category:**	Airplane
Year of Manufacture:	1960	**Amateur Built:**	No
Airworthiness Certificate:	Normal	**Serial Number:**	394
Landing Gear Type:	Tailwheel	**Seats:**	
Date/Type of Last Inspection:		**Certified Max Gross Wt.:**	
Time Since Last Inspection:		**Engines:**	1 Turbo Shaft
Airframe Total Time:		**Engine Manufacturer:**	Honeywell
ELT:		**Engine Model/Series:**	TPE331
Registered Owner:	KATMAI AIR LEASING LLC	**Rated Power:**	
Operator:	On file	**Operating Certificate(s) Held:**	On-demand Air Taxi (135)

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual Conditions	**Condition of Light:**	Day
Observation Facility, Elevation:	PAHO, 64 ft msl	**Distance from Accident Site:**	
Observation Time:	0853 AKD	**Direction from Accident Site:**	
Lowest Cloud Condition:	Clear	**Visibility**	10 Miles
Lowest Ceiling:	Broken / 6000 ft agl	**Visibility (RVR):**	
Wind Speed/Gusts:	4 knots /	**Turbulence Type Forecast/Actual:**	/
Wind Direction:	110°	**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:	29.66 inches Hg	**Temperature/Dew Point:**	13°C / 6°C
Precipitation and Obscuration:	No Precipitation		
Departure Point:	SELDOVIA, AK (PASO)	**Type of Flight Plan Filed:**	None
Destination:	Anchorage, AK (PANC)	**Type of Clearance:**	None
Departure Time:	0900 AKD	**Type of Airspace:**	

Airport Information

Airport:	Ted Stevens Anchorage Intl (PANC)	**Runway Surface Type:**	N/A
Airport Elevation:	151 ft	**Runway Surface Condition:**	Unknown
Runway Used:	N/A	**IFR Approach:**	None
Runway Length/Width:		**VFR Approach/Landing:**	Unknown

Wreckage and Impact Information

Crew Injuries:	1 None	**Aircraft Damage:**	Substantial
Passenger Injuries:	2 None	**Aircraft Fire:**	None
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	3 None	**Latitude, Longitude:**	59.643333, -151.548611 (est)

Administrative Information

Investigator In Charge (IIC):	Catherine Gagne	**Adopted Date:**	01/18/2017
Additional Participating Persons:	Darren K Vaughn; FAA - Anchorage FSDO; Anchorage, AK		
Publish Date:	01/18/2017		
Investigation Docket:	http://dms.ntsb.gov/pubdms/search/dockList.cfm?mKey=89350		

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