Australian Government
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ATSB TRANSPORT SAFETY INVESTIGATION REPORT
Aviation Occurrence Investigation – 200600837
Final

Aircraft loss of control
56 km S of Lombadina, WA
15 February 2006

VH-OTV
Viking Air Ltd
DHC-3-T 'Turbo-Otter'

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Abstract

During a charter flight from Broome, WA to Cone Bay, WA, the pilot of an amphibious (float and landing gear equipped) Viking Air Ltd DHC-3-T 'Turbo-Otter' aircraft (VH-OTV) reported an unusual movement within the control system, followed by a sudden downward pitching motion, leading to a rapid and uncontrolled descent. With the assistance of the front seat passenger, the pilot was able to arrest the descent and regain control of the aircraft, before making a precautionary landing at Lombadina Station, WA.

An engineering assessment of the aircraft found that the right elevator servo tab had broken away from the control rod and horn at the outboard end. Damage to the elevator trailing edge and tearing of the tab through the mid-span was consistent with gross oscillatory movement (flutter) of the tab after it had become disconnected from the rod and horn.

Aerodynamic flutter within the elevator trim and servo tabs of the DHC-3 aircraft type had been known since the 1960s, however the development of turboprop engine conversions for the aircraft had resulted in an increased potential for tab failure as a result of the increased airspeeds and control surface loads associated with the re-engined aircraft. A series of engineering solutions to the flutter problem had been subsequently developed, and in April 2004, a US Federal Aviation Administration airworthiness directive (AD) mandated the modification of the DHC-3 elevator tab assembly for US registered aircraft.

At the time of the occurrence, VH-OTV had not undergone the elevator tab modifications. The maintenance organisation stated that it was unaware of the FAA actions and had not received any information as to the availability of flutter prevention modifications from the aircraft type certificate holder or the certificate of registration holder.

Safety action taken by the maintenance provider after the occurrence included the implementation of systems to more adequately alert the organisation to the existence of important safety bulletins and airworthiness directives affecting the aircraft. An airworthiness directive for the elevator tab modifications issued by Transport Canada the month before the occurrence, became effective on 31 March 2006 and, on 1 March 2006, the Civil Aviation Safety Authority (CASA) introduced an AD to mandate the prospective Transport Canada requirements from 31 May 2006.

THE AUSTRALIAN TRANSPORT SAFETY BUREAU

The Australian Transport Safety Bureau (ATSB) is an operationally independent multi-modal bureau within the Australian Government Department of Infrastructure, Transport, Regional Development and Local Government. ATSB investigations are independent of regulatory, operator or other external bodies.

The ATSB is responsible for investigating accidents and other transport safety matters involving civil aviation, marine and rail operations in Australia that fall within Commonwealth jurisdiction, as well as participating in overseas investigations involving Australian registered aircraft and ships. A primary concern is the safety of commercial transport, with particular regard to fare-paying passenger operations.

The ATSB performs its functions in accordance with the provisions of the *Transport Safety Investigation Act 2003* and Regulations and, where applicable, relevant international agreements.

Purpose of safety investigations

The object of a safety investigation is to enhance safety. To reduce safety-related risk, ATSB investigations determine and communicate the safety factors related to the transport safety matter being investigated.

It is not the object of an investigation to determine blame or liability. However, an investigation report must include factual material of sufficient weight to support the analysis and findings. At all times the ATSB endeavours to balance the use of material that could imply adverse comment with the need to properly explain what happened, and why, in a fair and unbiased manner.

Developing safety action

Central to the ATSB's investigation of transport safety matters is the early identification of safety issues in the transport environment. The ATSB prefers to encourage the relevant organisation(s) to proactively initiate safety action rather than release formal recommendations. However, depending on the level of risk associated with a safety issue and the extent of corrective action undertaken by the relevant organisation, a recommendation may be issued either during or at the end of an investigation.

The ATSB has decided that when safety recommendations are issued, they will focus on clearly describing the safety issue of concern, rather than providing instructions or opinions on the method of corrective action. As with equivalent overseas organisations, the ATSB has no power to implement its recommendations. It is a matter for the body to which an ATSB recommendation is directed (for example the relevant regulator in consultation with industry) to assess the costs and benefits of any particular means of addressing a safety issue.

About ATSB investigation reports: How investigation reports are organised and definitions of terms used in ATSB reports, such as safety factor, contributing safety factor and safety issue, are provided on the ATSB web site www.atsb.gov.au.

FACTUAL INFORMATION

History of the flight

At approximately 0830 Western Standard Time[1] (WST) on 15 February 2006, an amphibious (float and landing gear equipped) Viking Air Ltd DHC-3-T 'Turbo-Otter' aircraft, registered VH-OTV, departed Broome WA, for a charter flight to Cone Bay, WA. The flight was a single-pilot operation with 5 passengers.

Shortly after commencing a planned descent from the 9,500 ft cruising altitude, the pilot reported feeling an unusual movement within the elevator control system. Electing to continue the descent at a reduced rate, the pilot monitored the 'feel' of the control system until, at approximately 6,500 ft, the aircraft suddenly and rapidly pitched downward. Initial attempts by the pilot to arrest the ensuing descent by pulling back on the control column were unsuccessful, however after enlisting the assistance of a passenger seated in the right front seat, the pilot was able to regain sufficient authority over the elevator to arrest the descent and return the aircraft to near level flight. During the descent, the pilot declared a 'Mayday[2]' condition on the West Kimberly common traffic advisory radio frequency (CTAF). A nearby Coast Watch aircraft responded to the Mayday call and subsequently advised air-traffic control at Brisbane Centre of VH-OTV's difficulties.

After regaining control of the aircraft, the pilot discontinued the flight to Cone bay, electing to proceed to the Lombadina Station authorised landing area (ALA) for an immediate landing. To alleviate the fatigue resulting from the sustained control back-pressure needed to maintain level flight, the pilot instructed another passenger to take the right front seat for the descent and landing. The aircraft was then flown through what was described as a 'high but otherwise normal' approach to the Lombadina ALA airstrip. With the additional assistance of the front seat passenger during the flare, the pilot was able to land the aircraft normally and taxi clear of the airstrip.

Aircraft examination

Inspection of the aircraft by the pilot and the operator's maintenance personnel, revealed that the right elevator servo tab[3] had disconnected from the control horn and actuator rod. The tab itself had fractured and torn in a span-wise manner through the central region and the lower elevator skin had separated along the rivet line between the skin and the tab mounting panel. The upper surface of the tab had sustained severe mechanical impact and indentation damage in the vicinity of the separated control horn. There was no other reported damage to the aircraft.

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1 Western Standard Time (WST) was Universal Coordinated Time (UTC) + 8 hours.

2 Internationally recognised call for urgent assistance.

3 A servo tab is a secondary control surface, typically located at the trailing edge of the primary surface and rigged such that when the primary surface is moved, the tab moves to generate an aerodynamic force that assists in moving the primary surface.

Figure 1. Depiction of the DHC-3 elevator assembly, showing the servo tab (yellow) and control rod and horn (orange)

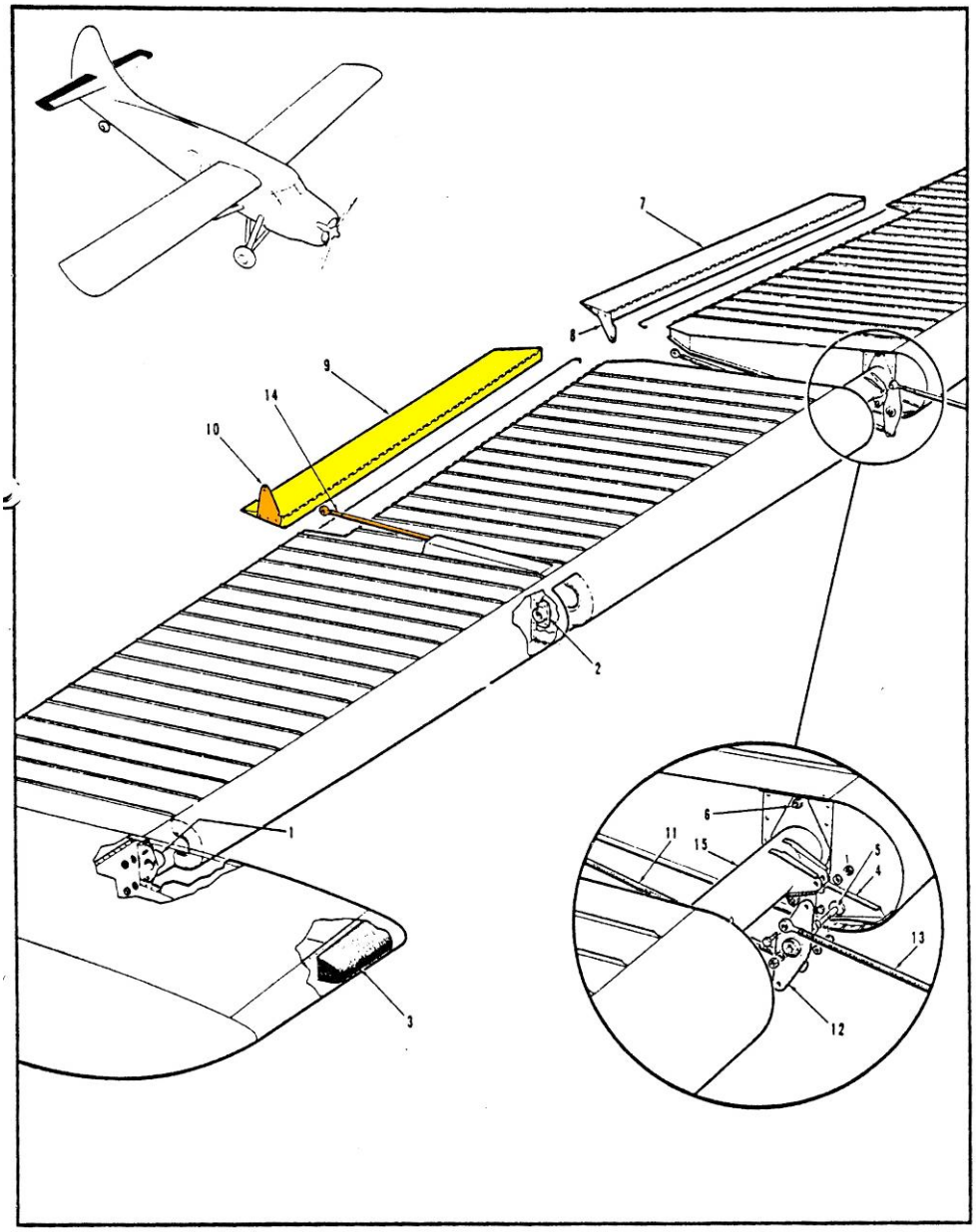

Figure 1 originally from the DHC-3 Group Assembly Part List, Part 2, Figure 12.

Servo tab examination

The damaged servo tab, hinge, control horn and actuator rod (Figure 2) were retained by the ATSB for laboratory examination to ascertain the reasons for the damage sustained.

Figure 2. Servo tab removed from the VH-OTV right elevator after the event

The DHC-3 servo tab was an unbalanced[4] secondary control surface, hinged along the full length of its forward upper edge, and interconnected with a single rigid actuator rod via an upward facing control horn (Figure 1). The tab design had the control horn affixed directly to the outboard-facing end of the section with three solid-section rivets. The rivets extended through a composite filler block and were affixed to an internal flange plate.

Two of the three rivets securing the control horn to the servo tab had failed through the central cylindrical section, in a manner consistent with mechanical overload (Figure 3). The third (forward-most) rivet had failed by pulling through the control-horn hole, with remnants of the rivet head remaining around the periphery. The corresponding rivet holes in the control horn all presented prominent elongation and wear damage, consistent with looseness and repeated oscillatory movement in service. Wear and material loss from the inside surface of the control horn was also consistent with repeated movement, as was the accumulation of fine grey wear debris over the joint interfacial surfaces.

Adjacent to the control horn connection, the servo tab upper surface skin presented severe mechanical indentation and puncture marks, consistent with repeated impacting against the edges and corners of the control horn after it had separated from the tab (Figure 4). The horn remained connected to the control rod, which had slightly bent about its mid-span. Approximately 60 cm from the outboard end, the servo tab had torn and fractured in a chord-wise manner, with the irregular fractures suggesting the loss of some pieces of skin and tab structure from around the point of failure. Slight downward buckling of the tab trailing edge was also noted, approximately 5 cm outboard from the main fracture.

4 A control surface is ‘balanced’ if it is weighted or configured in such a way as to place the longitudinal centre of gravity coincident with the axis of rotation or movement. An ‘unbalanced’ surface carries no such weighting.

Figure 3. Detail of the control horn separation from the servo tab outer end

Figure 4. Damage to the upper surface of the servo tab resulting from repeated impact against the separated control horn

Aircraft history

The DHC-3 'Turbo-Otter' aircraft (serial number 250), was manufactured in 1958 by de Havilland Canada[5]. The aircraft was originally fitted with a Pratt & Whitney R-1340-S1H1-G 'Wasp' radial piston engine, however in 1997, at an aircraft total time in service (TTIS) of 7,600 hours, that engine was replaced with a Pratt & Whitney Canada PT6A-135A turboprop engine and Hartzell HC-B3TN-3DY propeller. The turbine engine retrofit operation was carried out in accordance with supplementary type certificate (STC) SA3777NM, issued by the US Federal Aviation Administration (FAA). In late 1997, the aircraft was imported into Australia and entered onto the Australian civil aircraft register as VH-OTV.

Elevator trim/servo tab flutter

The history of relevant airworthiness directives (Table 1, Appendix A) suggested that the potential for aerodynamic flutter[6] of the elevator trim or servo tabs of the DHC-3 aircraft had been known since the late 1960's. In July 1968, Transport Canada published an airworthiness directive (CF-68-13) restricting the maximum speed of the aircraft until such time as the aircraft was modified to reduce the potential for elevator-tab flutter. In 2002, the in-flight failure of an elevator servo-tab assembly, after the installation of an approved flutter prevention modification, prompted a revision of that modification, including the complete re-design of the servo-tab assembly. Investigations had found that the elevator tabs on aircraft retrofitted with turbine engines were sustaining greater levels of vibration and aerodynamic stress, which could lead to the premature failure of the trim and servo-tab attachments, thus allowing the tabs to flutter. Follow-up directives from the US FAA in 2004 required the installation of the new design servo-tab on both unmodified aircraft, and those aircraft that already had the earlier flutter prevention modification implemented. On 24 January 2006, Transport Canada released airworthiness directive CF-2006-02 (effective 31 March 2006) that mandated the modification of turbine engine powered DHC-3 aircraft to incorporate the re-designed elevator servo tab and redundant control linkages prescribed by FAA supplementary type certificate (STC) SA01059SE or Transport Canada STC SA03-99. Effective on 13 April 2006, CASA AD/DHC-3/40 mandated the requirements of that Transport Canada AD for Australian Registered aircraft.

Modification detail

The published modifications to the DHC-3 elevator trim and servo tab assemblies incorporated two separate changes to the original tab design – both intended to reduce the potential for the onset of flutter while the aircraft was in flight.

- Incorporation of arm-mounted mass-balance weights into the tabs. Both servo and trim tabs thus become balanced[4] control surfaces, and as such would be significantly less likely to flutter should they become detached from the control rod assembly.

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5 In 2006, Viking Air Ltd, Canada, accepted the transfer of the type certificate for the DHC-3 aircraft design.

6 Flutter is an aerodynamically induced and often forceful oscillatory movement of a control surface or aerofoil.

- Incorporation of a second, redundant servo tab control rod assembly. The tab would thus remain connected and functional in the event of the separation of the primary control horn or rod from the servo tab.

Maintenance information

The documentation for VH-OTV indicated that it was being maintained in accordance with a system approved by the Civil Aviation Safety Authority (CASA). That system of maintenance, outlined within the aircraft maintenance log-book, included a statement directing that:

All applicable Airworthiness Directives applicable to this aircraft must be complied with;

and a note directing that:

Airworthiness Directives take precedence over the manufacturer's instructions.

As an Australian registered aircraft, the requirement for airworthiness directive compliance extended only to those directives issued under Civil Aviation Safety Regulation (1998) part 39-105, or related Australian legislation. Following the acceptance of the aircraft onto the Australian register in 1998, there was no legal requirement for the maintenance organisation responsible for VH-OTV to have acted on the directives issued by the FAA, Transport Canada or other international regulator.

An examination of the aircraft maintenance records found no evidence that the elevator assembly had undergone any modifications for the purposes of flutter prevention. Examination of the failed servo tab from VH-OTV, and of several photographs of the elevators of the aircraft taken immediately after the occurrence, confirmed that the servo tab assembly was of the original design.

Discussions with the maintenance provider for VH-OTV found that at the time of the occurrence, the organisation was unaware of any of the service bulletins or service kits available for reducing the risk of flutter within the DHC-3 elevator tabs. The organisation stated that the normal procedure for notification and awareness of any relevant service information, was that the certificate of registration (C of R) holder would receive any alert or service bulletins from the type certificate holder, which would then be forwarded to the maintenance organisation for action where necessary. The maintenance organisation reported to the ATSB that it had not received any notification, service bulletin or communication of any sort regarding the flutter modification or the international directives that dealt with the matter.

On 24 January 2006 (22 days before the occurrence), Transport Canada had issued airworthiness directive CF-2006-02, mandating a flutter prevention modification for the turboprop converted DHC-3. That directive became effective on 31 March 2006 and required compliance by 30 April 2006. At the time of the occurrence, there was no equivalent Australian airworthiness directive, however CASA AD/DHC-3/40 was subsequently issued on 1 March 2006 and became effective from 13 April 2006, with compliance required by 31 May 2006.

ANALYSIS

The temporary loss of control of the DHC-3 aircraft reported by the pilot was a direct consequence of the onset of aerodynamic flutter and subsequent structural failure of the servo tab located at the trailing edge of the aircraft's right elevator. The flutter event was precipitated by the separation of the control horn from the outboard end of the tab, allowing the unbalanced tab to immediately and violently oscillate (flutter) within the airflow across the elevator surface. The strong nose-down pitching tendency of the aircraft reported by the pilot was likely to have been a consequence of the loss of longitudinal trim resulting from the disconnection of the servo tab, and the subsequent damage to the tab and elevator trailing edge from the flutter behaviour.

Evidence of localised wear and movement between the servo tab control horn, rivets and mounting surfaces suggested the horn had been progressively loosening over an indefinite period. That behaviour was consistent with exposure to the elevated aerodynamic stresses resulting from turboprop engine operation.

The potential for failures within the trim and servo tab control systems of the DHC-3 aircraft, allowing tab flutter and hence threatening the aircraft safety, has been known for several decades. Modifications in the form of service kits and redesigned components have been certificated and available since 2002 and had been mandated by the US FAA since April 2004.

At the time of the occurrence, the DHC-3 aircraft VH-OTV had not had any form of modification carried out on the elevator trim or servo tabs, for the purposes of reducing the risk of flutter following control-linkage failure. Despite the US FAA mandating such modification since April 2004, Transport Canada had only introduced a similar airworthiness directive in January 2006, with a CASA equivalent following in March 2006.

While the modification of the aircraft was not legally mandated by airworthiness directive at the time of the occurrence, there had been commercial publications and service bulletins issued that could have alerted the maintenance organisation to the potential for elevator tab flutter and failure. The ATSB investigation found evidence of poor communication between the certificate of registration holder and the maintenance organisation, with the maintenance organisation noting that it relied on the C of R holder to notify them of the existence of any directives, service bulletins and other maintenance information applicable to the aircraft under their control.

FINDINGS

From the evidence available, the following findings are made with respect to the events surrounding the loss of control sustained by DHC-3 aircraft VH-OTV, and should not be read as apportioning blame or liability to any particular organisation or individual.

Contributing safety factors

- The Viking Air Ltd DHC-3 'Turbo-Otter' aircraft type had a history of elevator trim / servo tab aerodynamic flutter events.
- The elevated aerodynamic stresses and higher airspeeds associated with the conversion of the aircraft type to turbine engine operation increased the susceptibility of the elevator trim and servo tabs to premature failure, resulting in tab flutter.
- VH-OTV was converted to Pratt & Whitney Canada PT6A-135A turboprop engine operation in 1997.
- Despite the April 2004 release of a unique US FAA airworthiness directive to mitigate the risks of elevator tab flutter in the DHC-3-T type, regulators in Canada and Australia had not announced mandatory modifications until early 2006 – insufficient time to have provided for the modification of VH-OTV before the incident. *[Safety Issue]*
- The organisation responsible for the maintenance of VH-OTV reported that it had not received any information regarding modifying the aircraft for flutter prevention. The organisation reported that it relied upon the certificate of registration holder for the aircraft to advise them of the existence of any applicable service bulletins or airworthiness directives. *[Safety Issue]*
- At the time of the occurrence, VH-OTV had not been modified to reduce the risk of elevator tab flutter and failure.
- The elevator servo tab control horn separated from the tab surface during flight, allowing the tab to immediately and violently flutter and precipitating the temporary loss of control reported by the pilot.

SAFETY ACTIONS

The safety issues identified during this investigation are listed in the Findings and Safety Actions sections of this report. The Australian Transport Safety Bureau (ATSB) expects that all safety issues identified by the investigation should be addressed by the relevant organisation(s). In addressing those issues, the ATSB prefers to encourage relevant organisation(s) to proactively initiate safety action, rather than to issue formal safety recommendations or safety advisory notices.

All of the responsible organisations for the safety issues identified during this investigation were given a draft report and invited to provide submissions. As part of that process, each organisation was asked to communicate what safety actions, if any, they had carried out or were planning to carry out in relation to each safety issue relevant to their organisation.

Depending on the level of risk of the safety issue, the extent of corrective action taken by the relevant organisation, or the desirability of directing a broad safety message to the aviation industry, the ATSB may issue safety recommendations or safety advisory notices as part of the final report.

Maintenance organisation

As immediate post-incident remedial work, the elevator assembly of VH-OTV was repaired and modified to incorporate the flutter prevention requirements promulgated by CASA AD/DHC-3/40.

Lack of awareness in regard to issue of maintenance information and airworthiness directives

Safety issue

The organisation responsible for the maintenance of VH-OTV reported that it had not received any information regarding modifying the aircraft for flutter prevention. The organisation reported that it relied upon the certificate of registration holder for the aircraft to advise them of the existence of any applicable service bulletins or airworthiness directives.

Action taken

The maintenance organisation responsible for VH-OTV reported that they have adopted a policy of directly monitoring the public website of the organisation that carried out the turbine engine conversion and have a subscription service with the type certificate holder for all documentation applicable to the DHC-3.

Transport Canada / Civil Aviation Safety Authority

No equivalent Transport Canada or CASA directives for the mitigation of elevator tab flutter

Safety issue

Despite the April 2004 release of a unique US FAA airworthiness directive to mitigate the risks of elevator tab flutter in the DHC-3-T type, regulators in Canada and Australia had not announced mandatory modifications until early 2006 – insufficient time to have provided for the modification of VH-OTV before the incident.

Action taken

Airworthiness directive CF-2006-02 was issued by Transport Canada on 24 January 2006, 22 days prior to the VH-OTV occurrence. While the AD pre-dated the event, it was not effective until 31 March 2006 and compliance was required by 30 April 2006. The AD required the installation of an elevator tab flutter prevention kit on all turbine-powered DHC-3 aircraft.

Transport Canada AD CF-2006-02 was mirrored by the release of CASA AD/DHC-3/40 on 1 March 2006, 16 days following the VH-OTV event. AD/DHC-3/40 became effective on 13 April 2006 and required compliance by 31 May 2006.

APPENDIX A

Table 1. Airworthiness directives relating to DHC-3 trim/servo tab flutter issues (date order)

Airworthiness Directive No.	Issuing Authority	Date Effective	Summary of requirement/s
CF-68-13	Transport Canada	30 Jul 1968	To preclude elevator tab flutter, incorporate modification 3/909 prescribed by de Havilland Canada. Install placard limiting airspeed to 130 knots IAS until modification is carried out.
AD/DHC-3/23	CASA	6 Sep 1968	Unless modified to DHC 3/909, install placard in cockpit limiting aircraft indicated airspeed to 130 knots.
CF-2002-48	Transport Canada	30 Dec 2002	To address the potential for failure of the elevator servo tab balance assembly after installation of the STC SA99-219 flutter prevention modification kit, incorporate the redesigned elevator servo tab introduced by Viking Air Ltd retro kit No. V3MK1151, in accordance with Viking Air Ltd service bulletin No. V3/01.
AD/DHC-3/39	CASA	20 Mar 2003	As per Transport Canada airworthiness directive CF-2002-48
2004-05-01	FAA	20 Apr 2004	For all DHC-3 Otter aircraft retrofitted with a turbine engine – install a new elevator servo-tab and redundant control linkage as per STC SA1059SE.
2004-05-01 R1	FAA	25 May 2004	Re-issue of AD, restricting applicability to only those aircraft with a PT6A-34/-135 turbine engine retrofit (per STC SA3777NM).
2004-24-01	FAA	28 Dec 2004	For those aircraft fitted with a flutter prevention modification kit to STC SA01243NY or ST01243NY, replace the elevator servo tab assembly in accordance with Viking Air Ltd service bulletin V3/01
CF-2006-02	Transport Canada	31 March 2006	For all DHC-3 Otter aircraft retrofitted with a turbine engine – install Viking Air Ltd flutter prevention kit V3MK1148 Issue 3 or equivalent
AD/DHC-3/40	CASA	13 April 2006	As per Transport Canada airworthiness directive CF-2006-02

FAA – United States Federal Aviation Administration
CASA – Australian Civil Aviation Safety Authority