National Transportation Safety Board
Office of Aviation Safety
Washington, DC 20594

DCA22MA193

AIRWORTHINESS

Group Chair's Factual Report

March 30, 2023

A. ACCIDENT

Location:	Freeland, Washington
Date:	September 4, 2022
Time:	1509 Pacific Daylight Time (PDT) 2209 Coordinated Universal Time (UTC)
Airplane:	Viking Air Limited DHC-3 Otter, N725TH

B. AIRWORTHINESS GROUP

Group Co-Chair	Adam Huray National Transportation Safety Board Washington, DC
Group Co-Chair	Clinton R. Crookshanks National Transportation Safety Board Aurora, CO
Group Co-Chair	Van S. McKenny IV National Transportation Safety Board Los Angeles, CA
Group Member	Bobbie Kroetch Federal Aviation Administration Wichita, KS
Group Member	Rod Ziegler Federal Aviation Administration Seattle, WA
Group Member	Jim Lambert Northwest Seaplanes Renton, WA
Group Member	Dennis Pollard De Haviland Aircraft of Canada Calgary, AB

C. DETAILS OF THE INVESTIGATION

The group responded to the accident location and was on site September 5-12, 2022. The first several days were spent examining recovered floating debris, visiting Northwest Seaplanes, collecting maintenance records, and working with various local, state, and federal agencies to locate the airplane in the waters of Mutiny

Bay. See the Search and Recovery Factual Report in the public docket for the details of the search and recovery.

The group returned to the accident location to recover the airplane wreckage from the water from September 26 through October 3, 2022. The group examined the recovered wreckage at the AvTech facility in Auburn, WA October 4-6, 2022.

A portion of the group met at the NTSB Materials Lab in Washington, DC, October 18-19, 2022, to examine the stabilizer trim actuator from the accident airplane. A portion of the group met at the NTSB Materials Lab January 10-12, 2023, to examine the elevators from the accident airplane.

The investigator-in-charge and one of the group co-chairs examined the wreckage a final time March 14-15, 2023, at the AvTech facility in Auburn, WA. They also visited Kenmore Air in Kenmore, WA, on March 16 to examine an intact DHC-3 Otter and gather details on maintenance practices and STC modifications to their Otter airplanes.

D. FACTUAL INFORMATION

1.0 Airplane Overview

The Viking Air Limited DHC-3 Otter is a single engine, propeller driven, single pilot, high wing, short take-off and landing (STOL) airplane originally designed in the early 1950's (Figures 1 and 2). The airplane is equipped with a cruciform tail and can be configured with conventional wheel landing gear, wheel skis, spring skis, straight floats, or amphibious floats. The airplane is 41 feet, 10 inches long, 16 feet high at the tail (on floats) and has a wingspan of 58 feet. The original airplane was powered by a single reciprocating radial engine but could be converted to turbine engine power by Supplemental Type Certificate (STC). The turbine conversion extends the nose of the airplane 4 feet for a total length of 45 feet, 10 inches. The accident airplane was powered by a GE BGS Turboprops H80-200 (Formerly Walter M601E-11) turboprop engine in accordance with Stolaris Aviation, Inc. STC SA19857SC and equipped with Edo 7170 floats. The accident airplane was equipped with 1 pilot seat and 10 passenger seats. The type certificate for the airplane is currently owned and maintained by Viking Air Limited, Sidney, British Columbia, Canada, also known as De Havilland Aircraft of Canada.

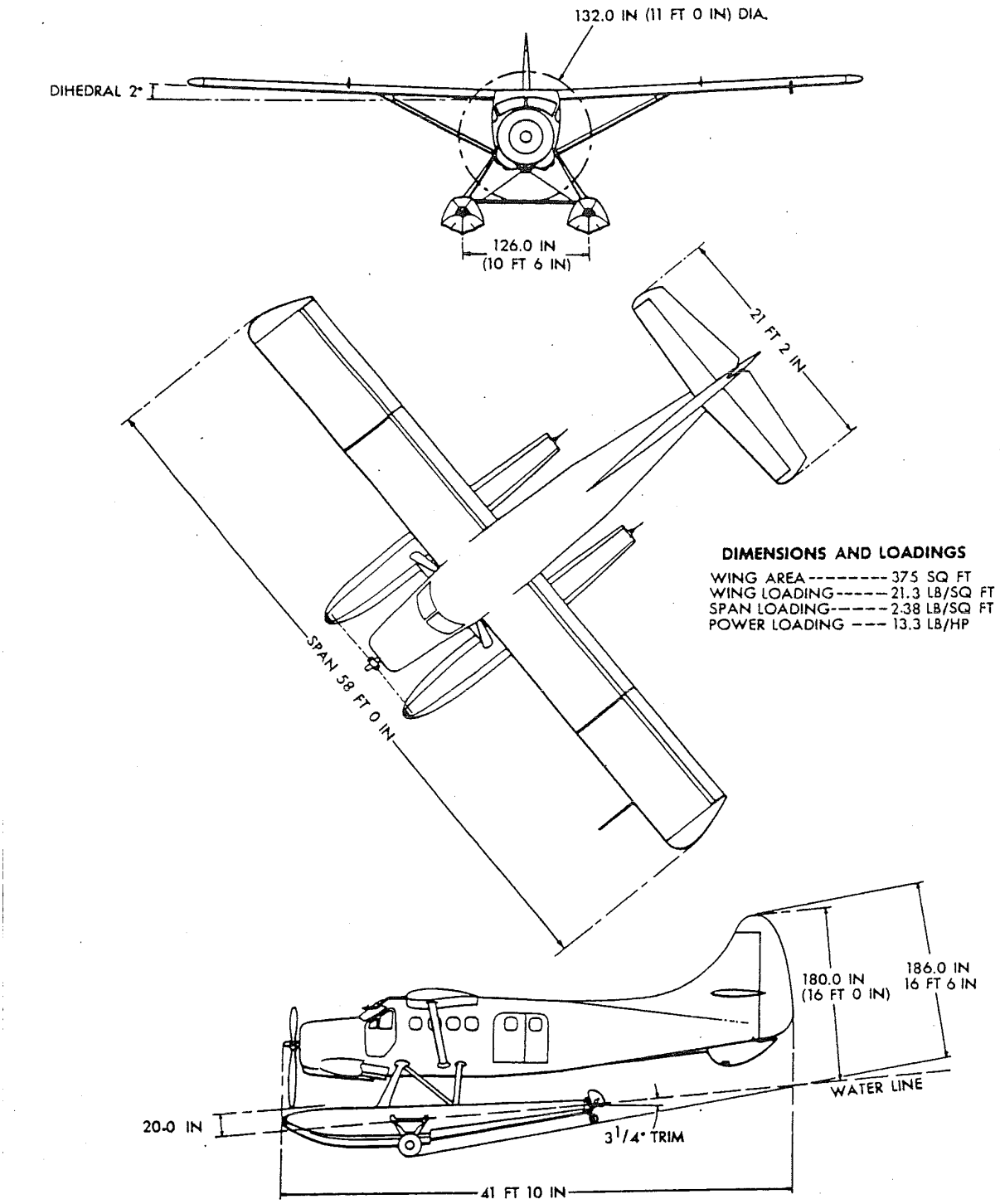

Figure 1. Viking Air Limited DHC-3 Otter 3-view drawing with original radial engine (provided by Viking)

Figure 2. Photo of accident airplane, N725TH (provided by operator)

The airplane manufacturer defines the location of parts of the airplane longitudinally, laterally, and vertically using station locations measured in inches from a datum as shown in Figure 3. The fuselage station (FS) datum for the Otter is located 60 inches forward of the firewall. The wing station (WS) and horizontal stabilizer station (HSS) datums are located at the centerline of the airplane with locations measured outboard to the end of each wing or stabilizer. The vertical stabilizer station (VSS) datum is located below the bottom of the airplane with distance measured up from the datum.

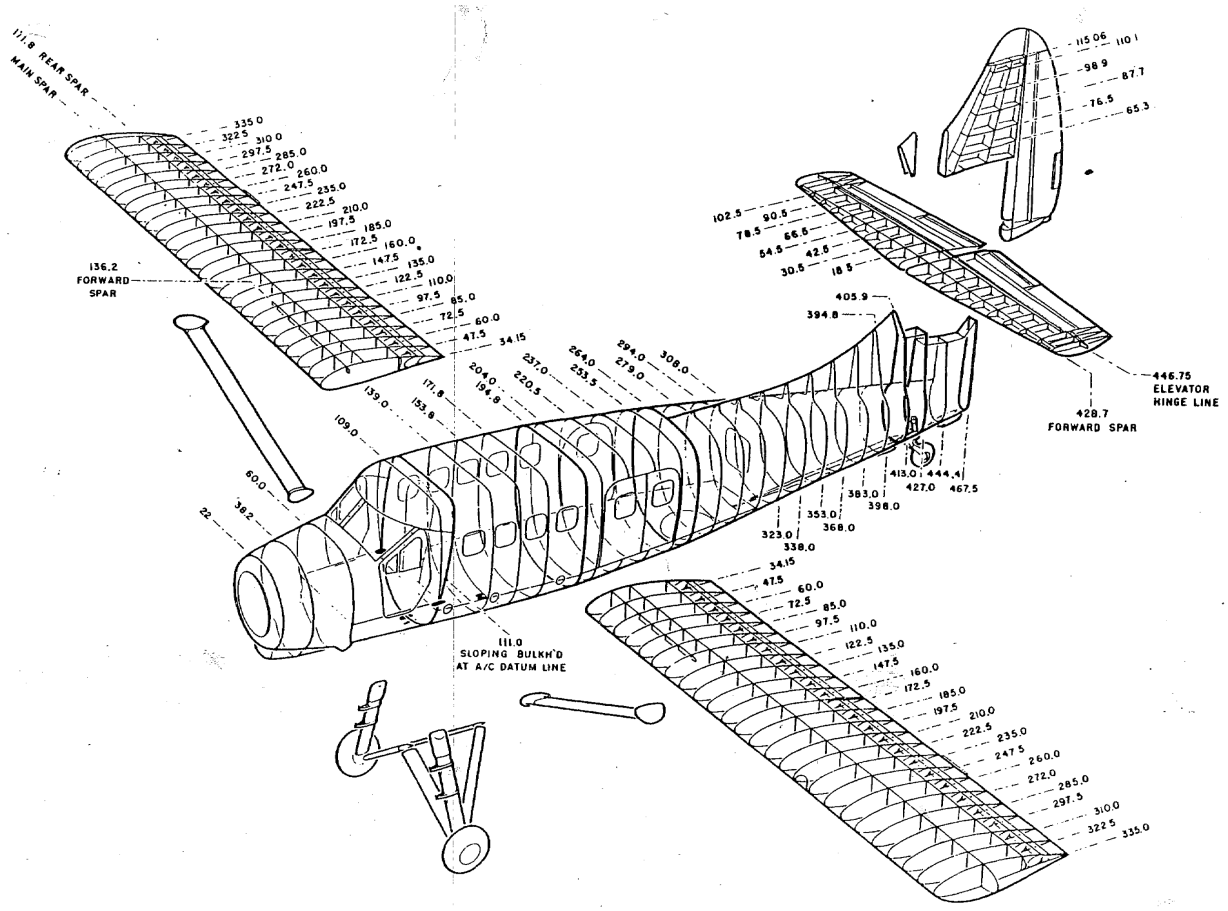

Figure 3. Viking Air Limited DHC-3 Otter station diagram with original radial engine (provided by Viking)

The pitch of the airplane is controlled by the positions of the horizontal stabilizer and the elevators. The elevators are controlled by the pilot using the control column in the cockpit, and the elevator control surfaces are mounted to hinges on the aft spar of the horizontal stabilizer. The horizontal stabilizer's incidence is controlled through use of the trim handwheel located on the right side of the pilot's seat in the cockpit. The horizontal stabilizer trim handwheel is connected by cables to the horizontal stabilizer actuator (screw jack) which serves as the horizontal stabilizer rear mounting point. The forward mounting point of the horizontal stabilizer consists of two hinge assemblies riveted to the fuselage bulkhead at FS 427 and to the stabilizer forward spar. The actuator will lower or raise the rear mounting point and thereby change the stabilizer incidence (Figure 4).

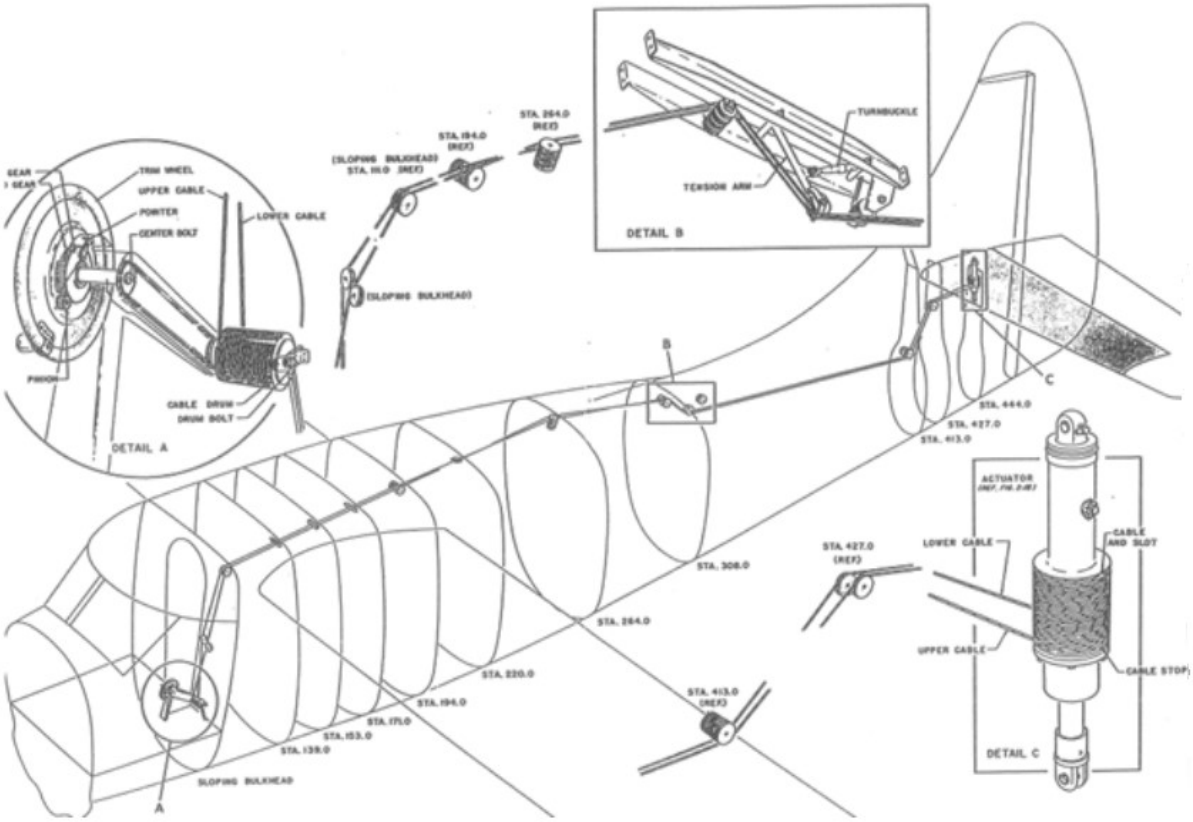

Figure 4. Schematic of the horizontal stabilizer control system. The horizontal stabilizer trim actuator is shown in detail C (provided by Viking).

2.0 Recovered Floating Debris

On September 5, two of the group co-chairs, visited the Island County Southern Precinct Sherriff's office on Whidbey Island, WA. The Sherriff's office was acting as the collection point for any debris found by other agencies (US Coast Guard, Washington Department of Fish and Wildlife) or the public. The following debris was held in a secure room. The debris was transferred to AvTech after the wreckage was recovered.

- Personal effects
- Three sections of aluminum honeycomb panel that was used as flooring in the passenger cabin, each about 6 feet long
- 1 seat cushion and a seat belt
- Small broken sections of foam that were part of a modification to the floats
- Aircraft Maintenance Logbook containing aircraft irregularity and corrections records, an aircraft release document, and a "Cycle and TIS Tracking" sheet. The aircraft irregularity and corrections records started at record #1 and all were blank. The aircraft release document was dated 9/4/22 and contained mandatory inspection compliance information. The Cycle and TIS tracking sheet

had two entries. The first entry was on 9/2/22 and listed 9 starts, 7 takeoffs, 7 landings, starting Hobbs of 2162.2, and ending Hobbs of 2166.2. The second entry was on 9/3/22 and listed 5 starts, 4 takeoffs, 4 landings, starting Hobbs of 2166.2, and ending Hobbs of 2168.8.

3.0 Wreckage Examination

The airplane wreckage was examined at the AvTech facility after it was recovered. The airplane was highly fragmented and suffered significant damage. Most of the fuselage and floats were connected together by various flight control cables, float struts, and flying wires when recovered. These were cut during recovery to facilitate transport of the wreckage. The recovered wreckage was laid out on the floor and examined. The main items recovered included the main nose fuel tank, engine mount and engine, propeller hub and blades, forward fuselage (FS 0 to FS 204), center fuselage (FS 170 to FS 308), tail section (FS 323 to FS 467), right wing, floats, some sections of flaps, and the left and right elevators. The left wing was identified on the seafloor separated from the fuselage and the right horizontal stabilizer was identified partially attached to the empennage using underwater photography prior to recovery but they were not recovered. Major portions of 11 seats were recovered. Figure 5 highlights the parts of the airplane recovered and conclusively identified.

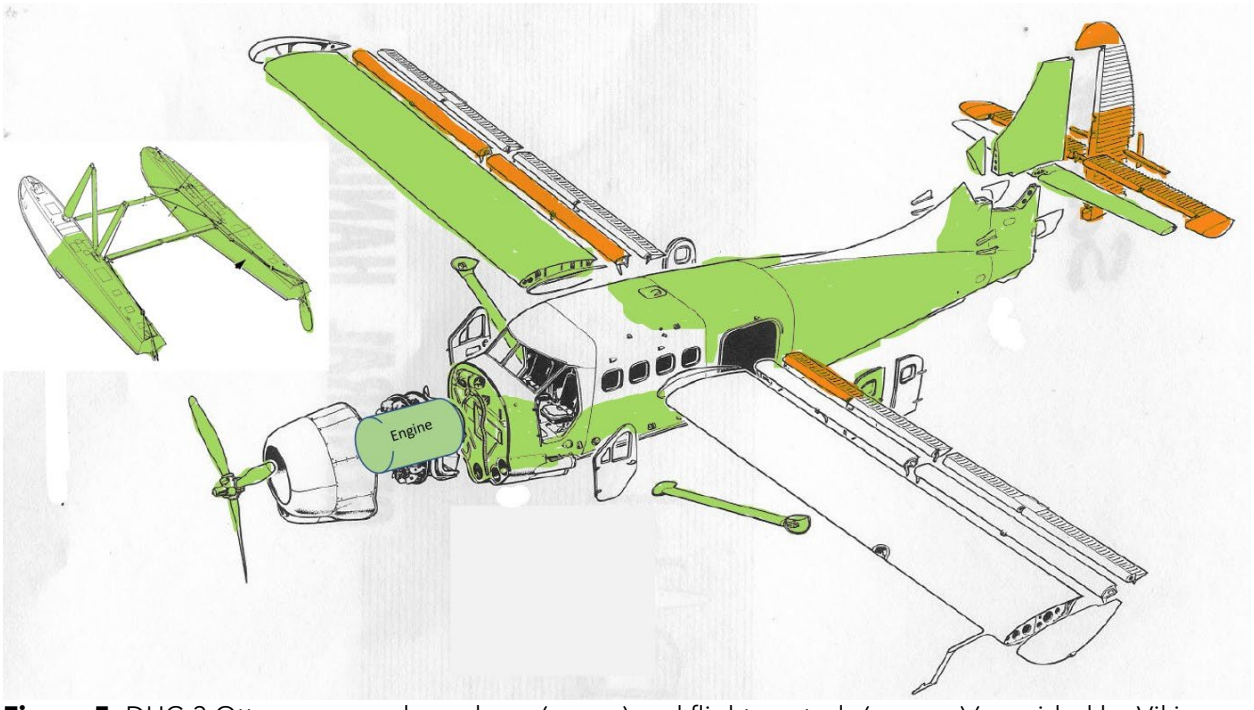

Figure 5. DHC-3 Otter recovered wreckage (green) and flight controls (orange) (provided by Viking, annotated by NTSB)

The airplane data plate had the following information:

Manufacturer: de Havilland Aircraft of Canada Limited
Type: DHC 3 Otter
Model No.: DHC 3
Serial No.: 466
Insp: (blank)
Date: 12·5·67
D.O.T. Type Approval No. 27

3.1 Fuselage

The forward fuselage section spanned from FS 0 to about FS 204. The forward fuselage and cockpit were crushed aft and portions of the instrument panel were contained in the wreckage. The windshields and upper fuselage crown structure was not identified in the recovered wreckage. This section of the fuselage contained the frames/bulkheads at FS 111, 139, 153, 171, and 194 all with portions of fuel bladders located in the bays below the floor. About 7.5 feet of the right- and left-wing lift struts were attached to the fuselage fittings at FS 153 on each side. The right aft float strut was attached to the fuselage fitting and was fractured at the float attach clevis. There were no cracks observed in the right lower and upper lug plates and lug fittings or the left lower lug plates and fittings. The corresponding bolts were present and secured. The entire wing strut tie bar was present but fractured in multiple locations. No corrosion was observed on the tie bar. The left forward cargo/passenger door was recovered but was separated from the fuselage. The left cargo/passenger door frame was fractured at the lower forward hinge and a majority of the door frame remained with the center fuselage section. The left aft cargo/passenger door was not identified in the recovered wreckage.

The main nose fuel tank and engine mount were installed as part of the Stolaris Aviation, Inc. turboprop conversion STC. The main fuel tank and firewall were separated from the fuselage structure. The upper portion of the firewall was deformed around the main fuel tank. The lower left and right fuel tank mounts on the aft side of the tank retained fragments of fuselage structure. The left door post remained attached to the upper left main tank structure. The oil cooler was recovered. The lower left and right engine mount arms were attached to the forward side of the main fuel tank. The ends of both arms did not have engine connecting hardware in place.

The following cockpit instruments were present:

Airspeed indicator (needle indicated 114kts)
Compass
Bank indicator (broken but indicating left)
Interstage Turbine Temperature (ITT) indicator (no needle)

Fuel quantity indicator for three center tanks (all at 0)
Fuel main tank indicator (unreadable)
Shadin fuel flow indicator (digital face only, body missing from back)
Engine torque indicator (0)
Fuel transfer selector handle (front tank position)
Flaps indicator (needle was beyond "down" and in the bottom of the slot)
Rudder trim indicator (damaged with needle about 1/3 travel right of center)
Hobbs meter – (broken)

The switch and circuit breaker panels were deformed and fractured. The following observations were recorded.

Boost Pump switch (toggle bent left and mechanism was broken)
Starter switch (toggle bent left and in neutral position – could move up and down)
Igniter 1 switch (toggle missing)
Igniter 2 switch (toggle missing)
Generator switch (toggle bent down and mechanism was broken)
Battery Master switch (toggle bent left and in off position)
Avionics Master switch (toggle bent left and mechanism broken)
Emergency Circuit guarded switch (toggle broken)
Igniter indicator (missing)
Land LT switch (toggle broken)
Pitot switch (toggle broken)
Strobe switch (toggle broken)
Nav switch (missing)

Flight Instrument Dimmer (knob was bent to the upper left)
Voltmeter (Press Volts button was broken)
Engine Instrument Dimmer (tab pointing to approximately 5:00 position)

Low Level Float, Fuel Flow, Start Sequence, Number 2 Fuel Boost Pump, Number 1 Fuel Transfer Pump, Number 2 Fuel Transfer Pump, COM2, FM1, AA34, and Hobbs circuit breakers were all open.

Warning Lights, Number 1 Fuel Boost Pump, Volt Amp Meter, Fuel Quantity, Pitot, USB, COM1, and NAT RH circuit breakers were all closed.

Generator, Engine Inst Lights, Flight Inst Lights, Engine Load Monitor, Emergency Circuit, Oil Temp and Pressure Indicator, Inverter, Engine Limiter, Mid Level Float Switch, High Level Float Switch, Igniter 1, Igniter 2, Cabin Heat, NAT LH, INT TIE, Music, TAWS, 24/12, Encoder, GPS, XPDR, AUD, Land L, Strobe, Gear, Pump, and Fuel PX circuit breakers were missing, broken, or the status couldn't be determined.

Other selectors found in the cockpit:

Cabin Heat (off position)
Bleed Air Cabin Heat handle (pushed in and turned vertically)
Fuel Cutoff lever (still in pinned position)
Particle Separator lever (damaged and in a middle position)

The control column was pinned in the pilot position (flipped to the pilot side). The welds where the vertical column tube meets the horizontal tube were intact. The aileron trim mechanism located on the column was severed just below the upper eye end but both ends remained connected at their respective attachment locations. The flaps lever was beyond the up stop (over traveled up). The Manual Stab Trim wheel was found deformed and damaged. The trim indicator needle was bent away from the indication plate and damaged but was in the full nose down position.

The center fuselage section extended from about FS 170 to FS 308. This section was severely damaged and distorted with some portions missing or unrecognizable. This section contained the flap actuator and overhead flight control cable runs.

3.2 Empennage

The aft fuselage and empennage were separated near FS 308. The left side of the horizontal stabilizer, vertical stabilizer, and the lower portion of the rudder remained attached to the empennage. The left and right elevators were separated from the horizontal stabilizer, and both were recovered. There was an indention on the left side fuselage skin in the shape of the horizontal stabilizer leading edge just forward of the stabilizer cutout. The horizontal stabilizer shelf was crushed downward near the location of the stabilizer rear spar. There were linear fore-aft scrapes on the horizontal stabilizer lower skin rivet lines coincident with the edges of the shelf.

Most of the right side of the horizontal stabilizer was fractured off and not recovered. About 2 feet of the spar and leading edge of the right horizonal stabilizer remained attached. The forward end of this section was pulled outboard away from the fuselage and had a downward bend located about 6 inches from the root. The remaining part of the stabilizer had fractured from this section on a 45° angle downward and aft. There was a downward indentation on the leading edge starting at the stab root that extended outboard about 2 feet.

The center and left side of the horizontal stabilizer remained attached and was twisted clockwise (as viewed looking down) approximately 15° around the center point. The horizontal stabilizer remained attached at the forward attach points. The horizontal stabilizer was part number (P/N) C3-TP-1-181, serial number (S/N) FW466, and date of manufacture (DOM) 10/6/63. The entire left side of the stabilizer was mostly intact but was damaged and bent. There was a downward indentation on the leading edge starting at the stab root that extended outboard about 2.5 feet. Just aft of this indentation the upper stabilizer skin was crushed downwards between the

forward and aft spars and the underside of the stabilizer was buckled in this area. The elevator control rod was intact in the empennage and remained connected to the elevator torque tube control arm. The torque tube was intact and installed on the hinge points on the aft spar of the horizontal stabilizer. The torque tube was free to move. The right side of the elevator torque tube remained attached to a separated section of the right elevator root rib that was pulled from the elevator. The left side of the elevator torque tube was intact with the elevator attach bolts still installed in the upper and lower elevator attach flanges. The upper left elevator attach flange was deformed outboard, and the lower left elevator attach flange was deformed inboard. The forward elevator trim tab control rod remained attached at the aft end to a fractured piece of the bellcrank normally located on the left elevator forward spar. The bellcrank was fractured through the bellcrank pivot point. The other section of bellcrank remained attached to the left elevator forward spar. The left outboard elevator hinge was pulled from its mount location on the stabilizer rear spar and remained attached to the left elevator. There was no evidence of fretting or cracking observed on the exterior surface of the horizontal stabilizer attachment fitting and associated ribs. No cracking was observed in the horizontal stabilizer forward attachment fittings in the empennage and no smoking rivets were observed at the horizontal stabilizer forward attachment lug doubler.

The left elevator was mostly intact but damaged and was separated from the stabilizer at the hinge points. The left elevator root rib was deformed inboard where it attached to the torque tube. The left elevator leading edge was crushed aft. The forward spar was deformed near the elevator root. The leading edge of the left elevator tip was bent upward with the counterweights still attached. The left elevator was buckled near left HSS 67 with the outboard section folded slightly upwards, and the forward and aft spars were broken at this location. The inboard 5 inches of the left elevator trim tab hinge was partially separated from the aft auxiliary spar. The hinge was fractured in this location and cracks were visible in the inboard elevator aft auxiliary spar (AD 2022-21-51). The remaining portion of the trim tab hinge remained attached to the auxiliary spar with a dark reside consistent with fretting observed on the inboard 12 inches. The left trim tab control surface was mostly intact and was deformed downward on the inboard end. The trim tab balance weights were intact, and the arm was bent about 90° outboard. The left elevator upper skin had two small areas of multiple shallow indentations about 6.25 inch and 7.5 inches forward of the auxiliary spar. The left elevator trim tab had an 8-inch chord and was not consistent with the Viking STC flutter prevention kit. The aft trim tab control rod remained attached to the trim tab and was fractured about 16 inches forward of the trim tab connection bolt.

The right elevator was mostly intact but damaged and was separated from the stabilizer at the hinge points. The right elevator leading edge was crushed aft. There was brown staining evident on the top, inboard half of the right elevator. The leading

edge of the right elevator tip was crushed aft at a 45° angle with a distinct impact impression. The impact impression was consistent with the shape of the strut cuff. A section of the right elevator root rib about 12 inches long was separated from the elevator and remained attached to the elevator torque tube. The elevator was buckled with the outboard section folded upwards near right HSS 72 and the forward and aft spars were broken at this location. The upper skin was separated from the spar in this location. The right elevator counterweights were intact and installed. The right elevator servo tab was intact and installed. Both actuating rods remained attached to the servo tab, but both were broken near the horizontal stabilizer aft spar location at the rod ends. The servo tab hinge was intact with little localized dark residue identified. The underside of the elevator had punctures near right HSS 23 and right HSS 91. There was a tear in the lower elevator skin near the outboard end of the servo tab that extended from the auxiliary spar to the aft spar.

The vertical stabilizer and rudder from the top down to about the rudder center hinge was crushed in a downward direction and/or missing. The rudder cap was present but was bent and damaged. The bottom 64 inches of the rudder was mostly intact with some deformation present. The rudder remained connected at the lower hinge and trim tab actuator. The rudder section that would connect to the center hinge was not identified. The rudder control rod remained connected to the rudder. The rudder trim tab was intact and installed and remained connected at the hinge. The upper 8 inches of the rudder trim tab hinge was pulled away from the auxiliary spar. No dark residue was observed on the hinge. There was no evidence of rudder overtravel on the rudder stops. The ventral fin was intact and installed but later removed to facilitate the wreckage layout.

The extension of the rudder trim actuator was measured from the center of the aft connection bolt to the base of the actuator to be about 2-1/16 inch. According to Viking, this measurement equates to a trim setting about 7° left of center. The control rod from the trim actuator to the rudder trim tab was connected at both ends. The trailing edge of the rudder trim tab was deflected about 1-5/8 inch to the right of center.

The top eye end and bearing assembly clamp nut was found unscrewed from the horizontal stabilizer trim actuator upper housing with no obvious damage to the threads. The top eye end and bearing assembly remained connected to the horizontal stabilizer mounting bracket by the upper actuator attachment bolt and could pivot freely about this bolt (Figure 6). The clamp nut could spin freely about the top eye end and bearing assembly eye bolt. The bolt attaching the lower end of the horizontal stabilizer trim actuator to the airplane was intact and installed. The lower horizontal stabilizer actuator mounting block did not exhibit looseness. The lower actuator housing could rotate freely fore-aft about the lower attachment bolt. When

the assembly was rotated full forward about the lower attachment bolt, the actuator upper assembly contacted structure. The structure was bent inwards and downwards in this location. Directly above the actuator when it was in this full forward position, the lower center skin of the horizontal stabilizer was punched through at a 90° angle. The punch through was in a rounded shape and left a circular grease imprint on the contact surface that was consistent with the top of the actuator upper housing assembly without the top eye end and bearing assembly present (Figure 7). The lock ring was not present in the lock ring groove of the upper housing assembly. The through hole in the lock ring groove was mostly clean and light could be seen through it. The area below the actuator, as well as inside the horizontal stabilizer in the area of the punch through, was searched visually and with a magnet for the lock ring but the lock ring was not found. The control cables were no longer uniformly wrapped around the drum. The actuator extension measured about 2.75 inches from the lower eye attachment bolt to the base of the actuator housing which equates to an incidence of about -2° (takeoff/neutral position) according to Viking if the clamp nut was fully seated in the top of the actuator. During removal of the actuator, the lower attachment bolt fell into the fuselage and was not recovered.

Figure 6. Horizontal stabilizer trim actuator top eye end and bearing assembly as found attached to the horizontal stabilizer mounting bracket (NTSB photo)

Figure 7. Lower stabilizer skin punch through and grease imprint (NTSB photo)

3.3 Wings

Although the left wing was identified intact by video imagery, the recovery crew was not able to locate the wing for final wreckage recovery efforts. The inboard section of the left inboard aft flap about 6 feet long was recovered and identified. The left inboard flap hinge lever was attached to the fuselage.

The right wing measured 25.6 feet long from wing root rib to wing tip rib. The wing tip was separated and not identified in the recovered wreckage. There was a complete chordwise separation of the right wing about 6 feet outboard of the wing root. The outboard end was displaced upward about 20°. The leading edge and wing

skins were crushed and buckled chordwise accordion style along the wingspan. The leading edge rubber boot was separated along the entire wingspan. The upper wing skin was displaced aft and separated from the wing main spar upper cap. The right wing had a pronounced downward twist at the wing tip. The outboard half of the inboard fore-flap and the inboard half of the outboard fore-flap remained attached to the wing. The inboard half of the inboard fore-flap and the outboard half of the outboard fore-flap were separated from the wing. The forward wing attach clevis was fractured through the eye. The aft wing attach clevis was attached with a bolt to the aft carry-through spar. The lower wing skin was split open along the forward side of the wing forward spar from the root to about WS 285. A section of the lower right wing and leading edge skin, about 3 feet by 1.5 feet, was missing about 4 feet inboard of the wing tip. About 2 feet of the right lift strut remained attached to the underside of the wing. The underside of the flap shroud skins had pulled thru their wing rivets from the wing root out to the outboard flap center hinge. There were no smoking rivets (fretting) identified visually and the access panels and borescope holes necessary to comply with AD 2015-24-02 were present.

3.4 Floats

The right float was recovered and was fractured in half. The aft half of the left float was recovered. The right forward float strut separated from the airframe but remained attached to the float. The left forward float strut was separated from the airframe and float. A section of fuselage bulkhead remained attached at the upper end and a section of float bulkhead remained attached at the lower end of the left forward float strut. The intact forward spreader bar remained attached at the lower end of the left forward float strut with the end of the flying wire. The left aft float strut and attached diagonal strut were separated and recovered. The right aft float strut was separated and recovered. The aft spreader bar was fractured in half and each side remained attached to the left and right floats. There were no float baggage compartments or baggage identified in the float wreckage.

3.5 Engine and Propeller

The accident airplane was powered by a GE Aviation Czech s.r.o (formerly Walters Engines a.s., Walter a.s., and Motorlet a.s.), model H80-200 turboshaft engine. The H80-200 is comprised of a 2-stage axial compressor followed by a single-stage centrifugal compressor powered by single-stage gas generator turbine, a reverse flow annular combustor, and a single-stage free power turbine.

According to the Federal Aviation Administration (FAA) Type Certificate Data Sheet (TCDS), E00048EN, Revision 16, dated March 9, 2020, the H80-200 was certificated on March 13, 2012, and has a maximum continuous at sea level and takeoff at sea level (5 minutes) of 800 shaft horsepower (SHP)/597 Kilowatts (kW), both are flat

rated to 105.8°F (41°C)[1]. The engine has a maximum continuous and takeoff (5 minute) propeller speed of 2080 revolutions per minute (rpm) which equates to 101.5% maximum gas generator speed.

The engine date plate had the following information (Figure 8):

General Electric (GE) BGA Turboprops
Model: H80-200
S/N: 132001
Date of Manufacture: May 21, 2013
Type Cert: EASA E 070 IE-40
Takeoff Power: 597 KW

Figure 8. Engine data plate (NTSB photo)

The engine was mostly intact, and the propeller assembly was separated from the front of the engine (Figure 9). The engine exhaust duct liner exhibited a counterclockwise twist as viewed from the rear. The upper engine mount connections were connected to the engine mount ring structure. The upper engine mount left and right arms were separated intact from the main fuel tank and fire wall. The engine mount "feet" had fragments of fire wall material still attached. The three engine mount points on the engine were connected to the engine mount ring.

[1] Engine ratings are based on ICAO International Standard Atmosphere sea level, static conditions with no installation losses, compressor intake screen installed, no external accessory loads and no air bleed.

Figure 9. Recovered engine with engine mount attached (NTSB photo)

The engine accessory section had moderate saltwater/magnesium corrosion damage. The generator/starter had separated and was recovered. The fuel control unit and fuel pump were attached. The fuel control arms and levers that were present all had connecting hardware attached. The fuel control power level needle was pointing between the upper 30° | 40° markings. The intake screen was attached and safety wired. The compressor could not be rotated by hand. The inlet screen was removed, and the compressor was inspected using a mirror. The 1st stage compressor blades did not exhibit any foreign object damage or broken blades that could be observed. A hole in the forward part of the compressor case allowed a view of the 1 o'clock area of the combustion liner which was unremarkable.

An inspection mirror was placed up the exhaust duct and the power turbine blades were examined visually. The turbine blades exhibited blade tip damage, broken blades, and blades deformed opposite the direction of rotation. The turbine could not be rotated by hand. The external thermocouple connections were all present and intact.

The propeller reduction gearbox was separated from the engine and had severe saltwater/magnesium corrosion. The front of the engine consisted of a plate with three 2.25-inch gears configured in a triangle (reduction gearbox 1st stage). The gears had white corrosive product on them. Visual examination did not identify any gear tooth damage.

The 2nd stage reduction gear was present, and no damage was observed on the gear teeth. The propeller governor was attached (LUN 7816-8, S/N 174002). All connecting rods were attached with their connecting hardware. The 8 bolts connecting the propeller hub were present and safety wired.

The propeller installed on the accident engine was an Avia V508H 3-bladed aluminum, single acting, feathering, and reversable constant speed propeller with a maximum allowed rotational speed of 2200 rpm; a feathering pump was not required. The propeller hub was recovered with two blades attached (Figure 10). The separated propeller blade was also recovered.

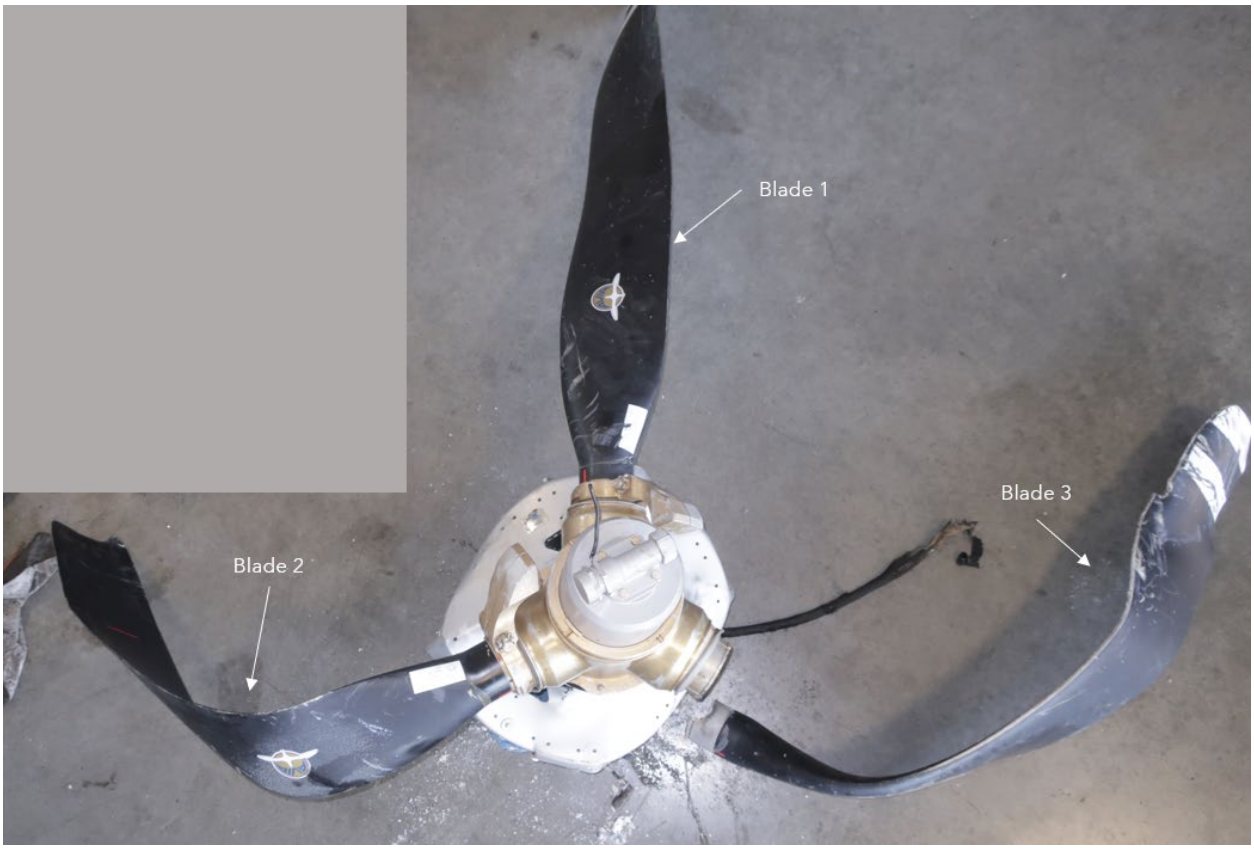

Figure 10. Recovered propeller hub and all three blades (NTSB photo)

Propeller blade numbers had been identified by the manufacturer and specified on each blade data tag. Propeller blades Nos. 1 and 2 remained in the hub with the counterweights attached. Both blades had turned within the hub and the alignment marks were misaligned. Propeller blade No. 3 was separated from the hub and the counterweights were not present. The propeller servo piston assembly was secure in place on the hub.

Blade 1:
Avia Propeller
Model: V508E/106/A
S/N: 92065502
The blade was in place in the hub and exhibited a slight torsional twist with slight trailing edge s-bending

Blade 2:
Avia Propeller
Model: V508E/106/A
S/N: 92065502
The blade was in place in the hub and was bent aft about 80° with the leading edge facing aft. Hard body leading edge damage was evident on the blade tip.

Blade 3
Avia Propeller
Model: V508E/106/A
S/N: 92065502
The blade was broken out of the hub and the blade butt exhibited heavy saltwater corrosion. The blade was twisted along its length, bent aft about 50°, and the leading edge had s-bending at the tip. There was leading edge damage with ½ inch semicircular gouge located about 8 inches from the tip.

3.6 Flight Control Continuity

The aileron chain in the control column was broken. The aileron cables remained connected to the quadrant that remained connected to the base of the column. The left side cable was intact and connected to the aileron quadrant in the ceiling. The right side cable was severed about 60 inches from the quadrant at the base of the column and had a splayed, broomstraw appearance consistent with tension overload. From the break, the cable was intact and remained connected to the aileron quadrant in the ceiling. About 20 inches of one aileron cable was attached to the aileron quadrant in the ceiling and terminated at a turnbuckle. The turnbuckle demonstrated bending signatures and was separated. The other cable was separated from the quadrant and not identified. In the right wing, a cable beginning with a turnbuckle ran from the wing root down the aft side of the main spar. The cable was cut during recovery and marked with tape at the cut location. At WS 247 the cable changed direction to traverse aft and was connected to the right wing aileron quadrant. A second cable, about 16 inches long, was attached to the quadrant and the end had a splayed, broomstraw appearance. No additional aileron cables were identified in the recovered wreckage.

The pilot rudder pedals were identified in the cockpit. The links from the right and left pedals to the torque tube were connected at both ends. The right link was partially fractured at a pinch in the tube but continuity remained. The rudder control quadrant normally connected to the torque tube was separated and not identified. About 17 inches of the left rudder cable with the quadrant bolt attached to one end and cut at the other end was caught in the rudder cable pulley located just forward of where the quadrant should have been. The other cut end of this cable was located in the area of the cockpit/cabin divider, and the cable continued aft to about FS 204.

The right rudder cable end with the quadrant connection bolt attached was found near FS 139 and the cable continued aft (with the left rudder cable) to about FS 204. Both cables were cut by the recovery crew near FS 204. The left and right rudder cables were intact from the cut near FS 204 aft to about FS 398. At FS 398, one rudder cable was severed with a splayed, broomstraw appearance and the other was cut. The remaining short sections of the cables continued to the aft rudder quadrant and both cables remained attached to the quadrant. The cable that was cut at FS 398 was attached to the right side of the quadrant. The rudder control rod remained attached to the quadrant and the rudder. Movement of the quadrant produced movement of the rudder.

The elevator connecting rod between the bottom of the control column and the control lever assembly was intact and attached at both ends. The control lever assembly remained connected at its pivot point and both elevator cables remained attached to the control lever assembly. The elevator up cable was cut about 7 inches from its attach point on the control lever assembly, and the elevator down cable was cut about 18 inches from its attach point on the control lever assembly. The opposing cut ends of the elevator cables were located in the area of the cockpit/cabin divider near FS 111, and the cables continued aft to about FS 204 where they were again cut. Both elevator cables continued aft from FS 204 to near FS 380 where they were separated with ends that had a splayed, broomstraw appearance. The cables continued aft from FS 380 and remained connected to the elevator quadrant. The elevator connecting rod between the elevator quadrant and the elevator torque tube remained intact and attached at both ends.

The trim tab-flap interconnect bellcrank in the ceiling between the wings near FS 160 was found connected to structure but was damaged and bent. The connecting link to the flap pushrod was severed with only the clevis remaining attached to the bellcrank. The remainder of the connecting link was not identified in the recovered wreckage. The elevator trim tab control cables remained attached to the flap interconnect bellcrank. The trim cables were intact aft to about FS 380 where one cable was cut and the other had a splayed, broomstraw appearance. The two trim cables extended aft about 2 feet where they remained connected to the actuating lever. The actuating lever was intact and installed and remained connected to the trim tab forward connecting rod. The trim tab forward connecting rod was intact and remined connected to the aft bellcrank arm. The bellcrank arm was fractured from the bellcrank. The other portion of the bellcrank was attached to the left elevator and the aft trim tab connecting rod was attached. The aft trim tab connecting rod was fractured about 6 inches aft of the bellcrank. The aft end of the aft trim tab connecting rod remained attached to the left elevator trim tab.

The rudder trim and horizontal stabilizer trim cables were not identified in the wreckage from their respective controls in the cockpit to FS 171. Near FS 171 all the trim cables had ends with a splayed, broomstraw appearance. The rudder trim and stabilizer trim cables were intact from near FS 171 aft to about FS 383 where they were all cut. The rudder trim and stabilizer trim cables were intact from the cut near FS 383 aft to the individual trim actuators.

The flap selector lever was positioned beyond the upper stop. The hydraulic lines were severed in multiple places between the cockpit and about FS 111. The hydraulic lines were not identified between FS 111 and the flap actuator. The flap actuator was in the full retracted position, and when pulled out would return to the full retracted position. The left flap connecting link was intact and attached to the flap actuator. The aft end of the left flap connecting link was separated from the bellcrank, but the bolt remained in the end of the link. The right flap connecting link was attached to the flap actuator and fractured between the actuator and bellcrank. The flap control links in the right wing were separated in multiple locations. All observed breaks in the remaining right wing flap control links had signatures of crushing and/or bending and/or pinching and jagged edges consistent with overload separation.

3.7 Wreckage Retained

The horizontal stabilizer trim actuator clamp nut was unbolted from the horizontal stabilizer and the main actuator housing was unbolted from the fuselage structure. The parts of the stabilizer trim actuator were shipped to the NTSB Materials Laboratory for further examination. The left and right elevators were also shipped to the NTSB Materials Laboratory for further examination. The results of the examinations can be found in the Materials Laboratory Factual Reports in the public docket.

4.0 FAA Information

On September 15, 2022, the FAA published an Airworthiness Concern Sheet (ACS) to solicit information from all operators of DHC-3 Otter airplanes. The FAA had received reports from an operator (not the accident operator) that had detected cracks during inspection in the left elevator auxiliary spar at the inboard end adjacent to the attach point for the trim tab balance weight on two airplanes. The ACS asked operators to provide information on results of further inspections of the auxiliary spar. On October 4, 2022, the FAA issued Emergency AD 2022-21-51 applicable to all DHC-3 Otter airplanes requiring repetitive detailed visual inspections of the entire left elevator auxiliary spar for cracks, corrosion, and previous repairs. The inspection was required to be completed within 10 hours or 3 days after receipt and repetitively at intervals not to exceed 110 hours. If any cracks, corrosion beyond level 1, or previous repairs were found, the AD required the replacement of the left elevator auxiliary spar. The AD also required operators to report the results after each inspection.

On November 2, 2022, the FAA issued AD 2022-23-08 applicable to all DHC-3 Otter airplanes requiring a one-time visual inspection of the stabilizer trim actuator lock ring to ensure it was present and correctly installed based on preliminary findings from the investigation. The inspection was required to be completed within 10 hours and the results were to be reported to the FAA. As of March 23, 2023, the FAA reported that 16 US registered airplanes and 3 Canadian registered airplanes had been inspected, and there were no reports of missing or incorrectly installed lock rings. In addition, a foreign operator voluntarily reported that in 2019 they discovered an actuator with a broken lock ring. The lock ring was completely broken in half, with half of the lock ring found in the lower fuselage and the other portion remaining on the actuator with the tang barely engaged in the barrel hole. A crack was also visually observed in the tang bend of the lock ring. The clamp nut had a double drilled hole in the threads and was backed out about ½ turn from its secured position. The same operator further reported that in 2019 they found a lock ring installation where the tang was through the barrel hole but was not fully engaged in the clamp nut hole. In this instance the nut had not rotated from its secured position.

On March 28, 2023, the FAA issued Special Airworthiness Information Bulletin (SAIB) 2023-05 to all operators of DHC-3 Otter airplanes to inform them of the preliminary investigation findings, recommend additional maintenance actions, and to seek additional information regarding the horizontal stabilizer actuator.

5.0 Tests and Research

Kenmore Air operates and maintains a fleet of 10 DHC-3 airplanes. In response to AD 2022-21-51 and the lack of available replacement parts at the time, Kenmore began manufacturing a replacement elevator auxiliary spar under their Parts Manufacturer Approval (PMA) authority. The replacement auxiliary spar is manufactured from 0.040-inch thick 2024-T3 aluminum that is anodized and painted with epoxy primer. The part dimensions are consistent with the original, but the upper, lower, left, and right flanges are extended to allow for more flexibility during installation and the material thickness is increased.

About 25 years ago Kenmore developed an umbrella for the top of the horizontal stabilizer actuator to prevent moisture from entering the internal mechanism of the actuator. The rubber umbrella is installed on the horizontal stabilizer between the lower skin and the actuator mount on all their airplanes as a minor alteration. After the accident and based on the preliminary information published, Kenmore began development of a secondary lock feature for the horizontal stabilizer actuator clamp nut. STC SA02761SE was issued by the FAA on January 31, 2023. The STC modification provides a new clamp nut with a raised flange on the upper edge where safety wire can be attached. A new drilled head screw block bolt, washers, and castellated nut are provided to allow for the installation of safety wire between the clamp nut and bolt and a new lock ring is

provided for the clamp nut (Figure 11). The STC instructions state that only one hole is allowed in the clamp nut.

Figure 11. STC modification to horizontal stabilizer actuator clamp nut (NTSB photo)

The operation of the right elevator servo tab and the left elevator flap interconnect trim tab were examined on an intact Kenmore DHC-3 airplane in relation to the movement of the horizontal stabilizer through the actuator, the elevator, and the flaps. The right elevator servo tab only moves in response to the movement of the elevator. As the elevator moves trailing edge up the servo tab moves trailing edge down and vice-versa. The left elevator flap interconnect trim tab moves in response to movement of the horizontal stabilizer and to deployment of the flaps but does not move in response to movement of the elevator. As the horizontal stabilizer moves trailing edge down the left trim tab moves trailing edge up. As the flaps are deployed the left trim tab moves trailing edge up. When the trim actuator is set to its fully retracted position (full nose down airplane trim) the left trim tab balance weights are about 1.5 inches above the upper elevator upper skin at their closest point. The

balance weights cannot impact the elevator upper skin with an intact control mechanism.

6.0 Previous Accidents

On June 20, 1989, a de Havilland DHC-3 airplane, N41755, sustained an inflight failure of the stabilizer trim actuator.[2] The report states the following failure mode: "the aluminum sleeve which the steel shaft threads into was totally without threads. The steel shaft could be moved in and out of the sleeve without resistance." It is suspected that this failure mode would have resulted in an uncontrollable horizontal stabilizer, with the likely allowable movement of the stabilizer in the trailing edge down direction limited by at least the length of the actuator in its most retracted position. The accident report further stated that when the failure occurred, the nose of the aircraft quickly pitched down.

The NTSB was notified by the FAA of a Service Difficulty Report (SDR) from a Canadian operator with a difficulty date of November 1, 2001. The SDR stated "…following take off of a float equipped DHC 3T, the control column pitched violently forward and back before returning to a neutral position. The aircraft then pitched down and contacted the water in a nose down, wings level attitude." The report further stated "Investigation revealed the cable-operated jackscrew jammed due to internal corrosion of the jackscrew. Once jammed, the rivet securing the fork end to the actuator sheared resulting in a free-floating horizontal stabilizer."

Submitted by:

Adam Huray
Lead Aerospace Engineer (Systems)

Clinton R. Crookshanks
Aerospace Engineer (Structures)

Van S. McKenny IV
Aerospace Engineer (Helicopters)

[2] The NTSB case number for this accident is ANC89IA099.