CIVIL AVIATION AUTHORITY
OF NEW ZEALAND

AIRCRAFT ACCIDENT REPORT

OCCURRENCE NUMBER 05/3727

NZ AEROSPACE FU24-950/M601D

ZK-DZG

5 KM WEST OF WHANGAREI (PUKENUI FOREST)

22 NOVEMBER 2005

Glossary of abbreviations used in this report:

AGL	Above ground level
AMSL	Above mean sea level
C	Celsius
c.g.	Centre of gravity
CAA	Civil Aviation Authority
cm	centimetre
E	east
ELT	emergency location transmitter
ft	foot or feet
GPS	Global Positioning System
hPa	hectopascals
HP	Horsepower
IAS	Indicated airspeed
KIAS	Knots indicated airspeed
km	kilometre(s)
m	metre(s)
MHz	megahertz
NZDT	New Zealand Daylight Time
S	south
SHP	shaft horsepower
STC	Supplemental Type Certificate
UTC	Co-ordinated Universal Time

AIRCRAFT ACCIDENT REPORT

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Aircraft type, serial number and registration:	NZ Aerospace FU24-950 (Fletcher)/MD601D, 207, ZK-DZG
Number and type of engines:	1 Walter M601D-11NZ turboprop
Year of manufacture:	1975
Date and time:	22 November 2005, 1140 hours[1] (approx)
Location:	5 km west of Whangarei Latitude[2]: S 35° 42.9' Longitude: E 174° 16.0'
Type of flight:	Agricultural – Transit Flight
Persons on board:	Crew: 1 Passengers: 1
Injuries:	Crew: 1 fatal Passengers: 1 fatal
Nature of damage:	Aircraft destroyed
Pilot's licence:	Commercial Pilot Licence (Aeroplane)
Pilot's age:	49 years
Pilot's total flying experience:	Approximately 16,000 hours, 2,382 hours on type
Information sources:	Civil Aviation Authority field investigation
Investigator in Charge:	Mr P J Kirker

[1] Times are NZDT (UTC + 13 hours).

[2] WGS 84 co-ordinates.

Synopsis

The Civil Aviation Authority (CAA) was notified of the accident on 23 November 2005. The Transport Accident Investigation Commission was notified shortly thereafter, but declined to investigate. A site investigation by CAA Safety Investigators commenced the next day.

The aircraft was being flown on a transit flight from a farm airstrip near Kaikohe to Whangarei aerodrome where it was intended that the aircraft would undergo maintenance. The aircraft did not arrive as expected and a family member of the pilot reported it missing that evening. After an extensive aerial search the wreckage was located the following day in Pukenui Forest, about 5 km west of Whangarei. The pilot and loader driver on board the aircraft died in the accident.

1. Factual information

1.1 History of the flight

1.1.1 On the day prior to the accident, the pilot had returned in the aircraft to Whangarei aerodrome after a day's top-dressing work. That evening the pilot telephoned the aircraft operator's Chief Engineer and told him that the aircraft's airspeed indicator was stuck on a reading of 80 KIAS. The engineer advised the pilot to have an aircraft engineer based at Whangarei aerodrome 'clean out' the aircraft's pitot-static line.

1.1.2 Early in the morning on the day of the accident (22 November 2005), the pilot and loader-driver flew in the aircraft 50 km to the north-west of Whangarei to spread fertiliser on a farm property. During the morning the weather conditions became unfavourable for aerial top-dressing. The pilot rang an aircraft engineer at Whangarei aerodrome around 1100 hours on his cell phone to advise that he intended to fly the aircraft to Whangarei aerodrome to allow an engineer to look at the pitot-static line. The pilot expected to arrive around midday. The engineer agreed to look at clearing the suspected blockage in the pitot-static line.

1.1.3 Immediately before departing for Whangarei, the pilot spoke to a truck driver who had recently delivered fertiliser to the airstrip. During the conversation the pilot commented that an amber light on the cockpit instrument panel had started flickering. The pilot attributed this flickering to an electrical short-circuit somewhere in the aircraft wiring. The truck driver said that the pilot did not appear concerned about the light as the pilot commented there would only be a problem if a second cockpit light came on.

1.1.4 From the navigation data downloaded from the aircraft's GPS unit, it was established that after departing the farm airstrip the aircraft flew 39 km on a course which placed it slightly right of the direct track to Whangarei aerodrome. At around 1140 hours witnesses reported seeing the aircraft heading towards the Pukenui Forest area at around 500 ft AGL. The wind at ground level at that time was reported as being very strong. A witness stated that the aircraft had some sideways drift due to the wind direction, and at one point he saw the aircraft's wings rocking from side to side. Another witness reported seeing the aircraft make a sudden right hand descending turn as it was crossing the Pukenui Forest. The aircraft's angle of descent was increasing during the turn and then the aircraft disappeared behind a ridge line after the turn continued through more than 270 degrees.

1.1.5 The aircraft engineer at Whangarei aerodrome took no action when the aircraft did not arrive around midday as in his experience it is not unusual for agricultural pilots to change their plans at the last minute. A member of the pilot's family alerted the emergency services at 2200 hours when she became concerned that there had been no contact from the pilot. After an extensive aerial search the aircraft wreckage was located the following day about 50 metres below a ridge line in a heavily wooded area of the Pukenui forest. Searchers discovered the bodies of the pilot and loader-driver in the aircraft wreckage. Both had suffered fatal injuries. Neither the Rescue Coordination Centre New Zealand nor the searching aircraft detected an emergency beacon signal from the aircraft wreckage.

1.1.6 The accident occurred in daylight at approximately 1140 hours NZDT on 22 November 2005 in the Pukenui Forest about 5 km to the west of Whangarei, at an elevation of 920 ft AMSL. Latitude: S 35° 42.9', longitude: E 174° 16.0'. Grid reference 260-QO7-253087.

1.2 Injuries to persons

Injuries	*Crew*	*Passengers*	*Other*
Fatal	1	1	0
Serious	0	0	0
Minor/None	0	0	

1.3 Damage to aircraft

1.3.1 The aircraft was destroyed.

1.4 Other damage

1.4.1 No other property was reported damaged in the accident.

1.5 Personnel information

1.5.1 The pilot, aged 49, held a valid Commercial Pilot Licence (Aeroplane) first issued in 1993. Following an aviation medical assessment on 8 September 2005, the pilot was issued a Class 1 Medical Certificate. This certificate was valid until 8 March 2006, and included an extension valid until 7 September 2006. The pilot also held a Class 2 Medical Certificate valid until 7 September 2007. There were no active conditions or restrictions associated with his medical certificates at the time of the accident.

1.5.2 At the time of the accident the pilot had flown at least 16,000 hours. 15,000 of these hours had been carried out in the agricultural role. He had completed an aircraft type rating for the FU24 Walter M601D conversion on 13 September 2002 and obtained a pilot chemical rating refresher on 10 October 2002. The pilot completed his last biennial flight review and annual currency check for single seat agricultural operations on 14 March 2005.

1.6 Aircraft information

1.6.1 The aircraft was a New Zealand Aerospace Industries Limited FU24-950 (Fletcher), serial number 207, manufactured in 1975. The aircraft had accrued a total of 10597.25 flight hours as at 22 November 2005.

1.6.2 The turbine engine, a Walter M601D-11NZ, serial number 852018, manufactured by Walter Engines a.s. in the Czech Republic, had completed 753 hours time in service. Installation of the engine complied with the Turbine Conversions Ltd's Supplemental Type Certificate (STC) number 98/21E/15 and the aircraft was re-issued a restricted category airworthiness certificate on 19 February 2001.

1.6.3 The Avia Hamilton Standard V508D-AG propeller, serial number 31-066-1780, had completed 931 hours since overhaul. Installation of the propeller was also in compliance with STC number 98/21E/15.

1.6.4 The aircraft's annual review of airworthiness was current and had been carried out on 20 December 2004. The last 150 hour maintenance inspection was performed on 22 June 2005 when the aircraft had accumulated 10,494.58 flight hours.

1.7 Meteorological information

1.7.1 Witnesses in the area at the time of the accident reported the weather as being very windy with passing rain showers and cloudy conditions. A weather station located less than 10 km from the crash site recorded the following conditions on the day of the accident:

- Wind from a south-westerly direction with a sustained wind speed of 16 to 22 knots, and gusts of 25 to 30 knots.
- The peak wind reading was recorded at over 32 knots early in the afternoon.
- Temperature: 21 degrees C.
- Barometric pressure: 1008 hPa.
- Two passing rain showers between 0800 hours and 1000 hours.

1.8 Aids to navigation

1.8.1 The availability and effectiveness of navigational aids were not relevant to the accident.

1.9 Communications

1.9.1 There was no report of the pilot making an emergency radio call.

1.10 Aerodrome information

1.10.1 Aerodrome facilities were not relevant to the accident.

1.11 Flight recorders

1.11.1 The aircraft was fitted with a GPS unit (model AG-NAV®2) which is specifically designed to provide directional guidance and navigation information to permit precise aerial application in the agricultural and forestry industries. The unit was operating in the 'transit' mode during the flight and was therefore recording the aircraft's geographical position and altitude every two seconds. Investigators removed the unit from the wreckage and successfully downloaded the data using electronic topographical mapping software to display the data.

1.11.2 The track data from the GPS unit showed that the aircraft had flown slightly right of the direct track to Whangarei aerodrome for around 23 km after departing the farm airstrip. The aircraft then turned a further seven degrees to the right, which it maintained for another 9 km. The aircraft at this point was about 3 km to the right of the direct track between the airstrip and Whangarei aerodrome. The aircraft then turned 25 degrees to the left and followed this direction for 7 km. This track took the aircraft towards the highest point in the Pukenui Forest.

1.11.3 The last recorded GPS data plot was 694 metres to the south-west of the accident site at a height of about 800 ft AGL. Information from the GPS manufacturer indicates that the GPS unit most likely did not have sufficient time to save the last block of track data in to its hard memory from the buffer prior to the accident. It is therefore possible that the GPS unit did not record up to 40 seconds of the final track data.

1.12 Wreckage and impact information

1.12.1 The aircraft came to rest in a partially inverted nose down attitude, with the tail section folded around a tree trunk (refer to Photograph 1). The vertical fin had detached and was resting on the ground a few metres away from the main wreckage. A small part of the vertical fin's lower front structure containing the fin's forward attachment fitting was still attached to the aircraft's fuselage. The rudder control surface was still connected to the aft fuselage by its torque tube. The wings had remained connected to the fuselage by their respective wing root attachment fittings. The outboard section of the left wing had detached from the main portion of the wing and there was damage consistent with the left wing leading edge striking a large tree.

Photograph 1 - Aircraft wreckage at accident site.

1.12.2 The strike marks on the trees along the flight path indicates that the aircraft entered the forest canopy at a very high angle of bank (probably left wing low) and in a steep nose down attitude.

1.12.3 The aircraft appears to have been 'slipping' sideways to the right along its lateral axis as it struck the shallow rising forest floor. Although the aircraft appeared to have had very little forward velocity at the time it struck the ground, the aircraft's nose section and cockpit area had been forced to the left and compressed into the ground, thereby significantly reducing the occupiable space in the cockpit area.

1.12.4 The propeller was found separated from the engine as a result of the reduction gearbox casing breaking apart during the impact with the ground. Examination of the propeller blades indicated that the engine was most likely operating at a low power setting at the time of impact.

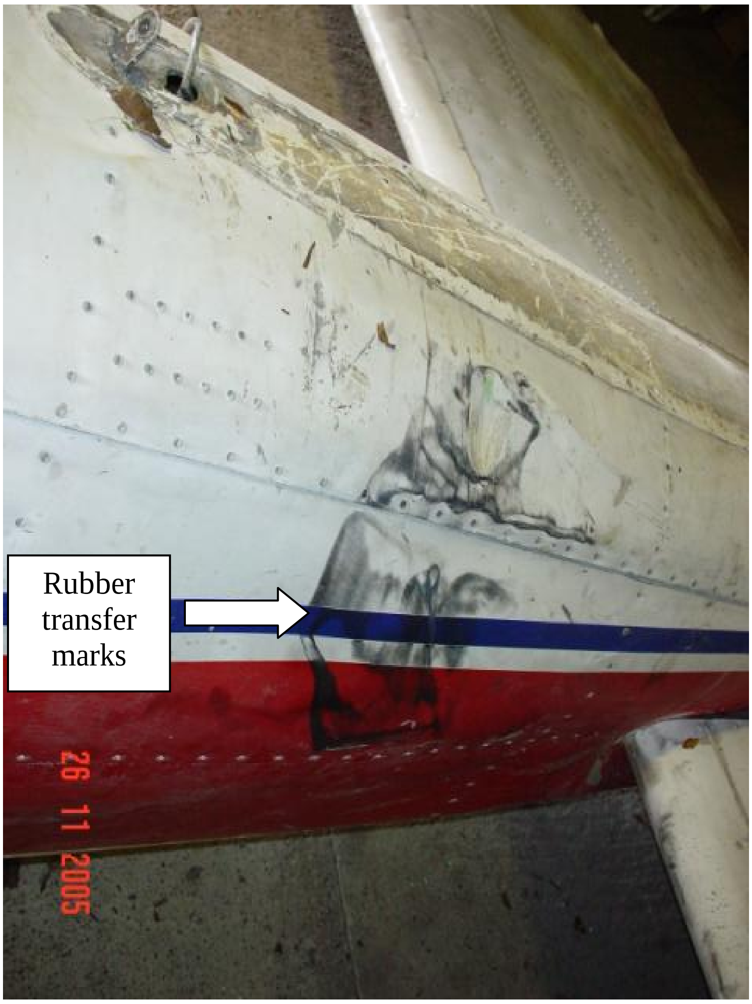
1.12.5 The primary flight control surfaces were all accounted for at the accident site and integrity of the flight control systems was established. The flaps were in the retracted position but reliable information about the position of the cockpit flight and engine controls could not be obtained because the accident caused substantial damage to the forward cockpit area.

1.12.6 Despite the fuel tanks being ruptured, some fuel was found in the low lying sections of the fuel tanks and the gasolator (collector tank). The airframe fuel filter element and bowl contained some water and a significant amount of fine particles and debris.

1.12.7 The engine intake screen contained a significant amount of fibreglass debris and paint shards from the engine cowling, indicating that the engine was probably operating at the time of impact.

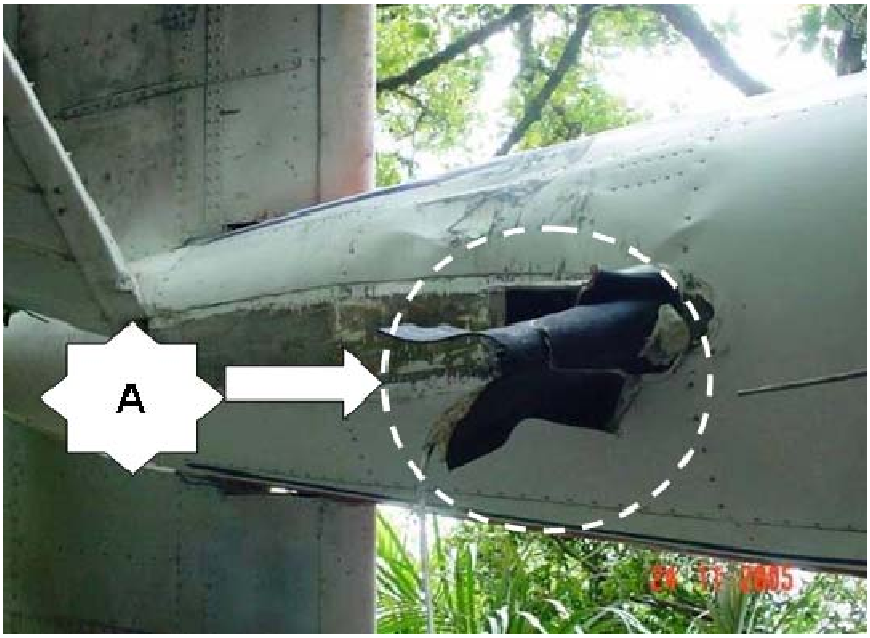
1.12.8 The two main landing gear oleos and wheels were separated from their attachments and were located near the wreckage.

1.12.9 There were paint and rubber transfer marks and impact damage on the left side of the aircraft's aft fuselage (shown in Photograph 2). These marks matched up with damage found on the vertical fin. Paint transfer marks and damage on the fin suggested that the fin had also folded around the left hand leading edge of the elevator.



Photograph 2 – Rubber transfer marks.

1.12.10 A 30 cm high portion of the vertical fin's front lower leading edge around the forward attachment fitting remained connected to the aircraft by its attachment bolt (marked 'A' in Photograph 3). Further examination of this structure revealed that a rectangular section about the size of a matchbox was missing from the fin's leading edge skin (shown in Photograph 4). There were two horizontal marks about one centimetre long inside the protective rubber anti-abrasion strip which covers the fin's leading edge. These marks corresponded with the upper and lower fracture surfaces of the missing rectangular section from the leading edge. The skin either side of the fracture surfaces had also been bent back, indicating that the fin had at some point in the failure sequence moved in a rearward direction. The damage to the fin's main structural (rear attachment) support beam indicated that the fin had failed as a result of a lateral force being applied to the right side of the fin. The rudder was also bent towards the left side of the aircraft around its torque tube.



Photograph 3 – Vertical fin's lower front leading edge.

Photograph 4 – Missing section in vertical fin's leading edge.

1.13 Medical and pathological information

1.13.1 The post mortem report concluded that the pilot and passenger died from injuries consistent with a high-energy impact.

1.13.2 The post mortem found no indication of any pre-existing medical condition that could have resulted in incapacitation or affected the pilot's ability to fly the aircraft.

1.13.3 The post mortem found nothing remarkable during the toxicological tests.

1.14 Fire

1.14.1 Fire did not occur as a result of the accident.

1.15 Survival aspects

1.15.1 Despite the pilot wearing a helmet and being restrained in his seat by a combination lap and shoulder harness, the severity of the injuries caused by the sudden deceleration at the time of impact were most likely beyond human tolerance and instantly fatal. The passenger was not wearing a helmet, but was wearing the same type of seat harness arrangement.

1.15.2 The aircraft was fitted with a Pointer 3000-1 ELT. The ELT arming switch was found in the 'off' position and the ELT had some minor impact damage. The coaxial connection located on the ELT was damaged and the cable from the ELT to the aerial was severed in several places. The ELT was therefore not capable of transmitting an emergency signal even if it had activated.

1.16 Tests and research

1.16.1 The airframe fuel filter element was sent to a laboratory for analysis and this revealed that the bulk of the debris in the element (greater than 70%) was particulate in nature and of geological origin (dirt, dust, and small stones). The remainder was made up predominately of metallic particles; aluminium, iron, copper and zinc.

1.16.2 The engine manufacturer performed a strip down of the engine and fuel control unit. The manufacturer reported finding traces of water in the fuel system. There was no evidence that a mechanical fault with the engine or fuel control unit may have contributed to the accident.

1.16.3 The CAA was able to observe structural load tests being performed on another Fletcher FU24 vertical fin for a different STC (modification) project. The fin in this case was shown to meet all the calculated static strength requirements. During the largest application of static load on the fin, a diagonal crease line formed in the skin along the side of the fin. This extended out to the leading edge of the vertical fin and produced buckling deformation at a point proximal to where the vertical fin on ZK-DZG appeared to have suffered structural failure. The test programme demonstrated that structural loads and stresses experienced by the fin are carried to some degree by the fin's leading edge skin.

1.16.4 The certification standards for the Fletcher aircraft require it to meet particular structural requirements. These standards, amongst other things, dictate that the aircraft fin must be able to withstand the aerodynamic loads that will be encountered when the aircraft is sideslipping. The aerodynamic load due to sideslip creates a 'forward bias' load distribution on the fin, placing the majority of the load in the region of the leading edge skin. The relative wind direction and gusting conditions on the day of ZK-DZG's accident could easily have caused the aircraft to sideslip. It's conceivable therefore that the fin's leading edge skin was under significant structural loading during the flight.

1.16.5 Two marks on the inside of the vertical fin's protective rubber anti-abrasion strip indicated the likely existence of two fractures in the leading edge skin prior to the accident. The surface of each fracture showed signs of wear. This most likely would have been caused by the mating surfaces of the skin rubbing together. The wear marks prevented the age of the fractures from being determined. Microscopic examination of the fracture surfaces indicated that metal fatigue probably caused the fractures. One metallurgical report suggested the fractures could have been up to 11 cms long when the fin suffered a structural failure and may have come from a network of pre-existing cracks in that area.

1.16.6 Aircraft maintenance records show that the vertical fin was last visually inspected in the area of the fractures 2070.85 flying hours before the accident. It is very likely the fractures were not present at this time and the absence of any fretting corrosion suggests the fractures were most likely formed relatively recently. A metallurgist commented that the fractures could have been initiated by impact damage; some event or events causing structural overload on the fin; or a manufacturing induced defect. Examination of the protective rubber anti-abrasion strip showed that the tearing and stretching of the rubber had initiated at the same location as the leading edge fractures. Metallurgy tests confirmed that the skin of the vertical fin was made from the correct material and had the required hardness (Alclad 2024 aluminium alloy in the T3 temper condition).

1.16.7 The data from the Engine Load Monitor was examined. This data showed that the propeller was not feathered in flight, which supports the view that the engine had not failed. All other engine cycle and elapsed time readings were normal.

1.16.8 A comparison of the engine performance trend monitoring data previously recorded by the pilot was made with another aircraft of the same type. The readings were all determined to be normal.

1.17 Organisational and management information

1.17.1 Organisational and management issues were not relevant to the accident.

1.18 Additional information

1.18.1 The Fletcher vertical fin has remained substantially unchanged since its initial design in the 1950s. The fin is essentially a rear supported cantilever structure. Its construction employs a single channel section post (vertical) beam assembly at the rear of the fin and a single pivoting attachment point at the front (refer to Figure 1). The forward attachment point has minimal design redundancy and allows any side loads on the fin to be transferred to the fin's leading edge skin, particularly in the region of the lower leading edge. Any failure of the fin's forward attachment during flight will allow aerodynamic forces to overload and fracture the fin's rear vertical beam, invariably causing the fin to separate from the fuselage. The vertical fins on other common agricultural aircraft such as the Air Tractor and Cessna A188 Ag-Wagon have a forward and rear spar with at least two forward fixed attachment points. This provides improved structural strength and inherent design redundancy when compared with the Fletcher fin.

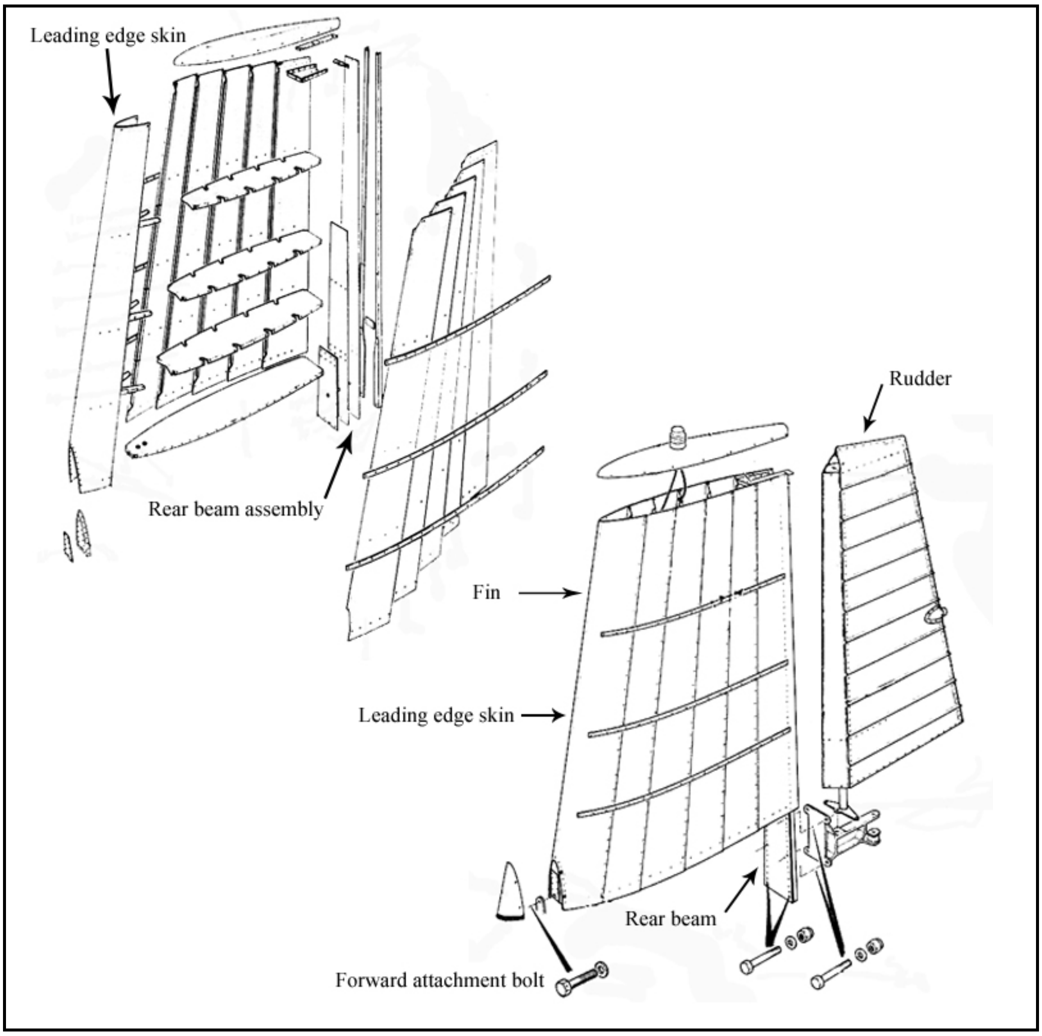


Figure 1 - Fletcher FU24-950 Vertical Fin Construction.

1.18.2 According to CAA records, there have been eight in-flight vertical fin failures on Fletcher aircraft since 1973. Two of these fin failures (ZK-EGO in 2002, and ZK-DZG in 2005) have resulted in three fatalities. Since the first fatal accident[3] in 2002, seven reports have been filed with the CAA regarding cracks detected in Fletcher fins. Four of these reports related to cracks discovered in the fin's leading edge skin. Cracks have also recently been discovered in the vertical fin leading edge skin of Cresco 08-600 agricultural aircraft. The Cresco is a turboprop-powered derivative of the Fletcher FU-24 and has a similarly constructed vertical fin. The discovery of these cracks has prompted the CAA to issue an airworthiness directive[4] requiring Cresco aircraft operators to perform regular inspections of the vertical fin's leading edge skin to detect any defects.

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[3] ZK-EGO, a Fletcher FU24-950 - CAA occurrence number 02/1167.

[4] Airworthiness Directive DCA/CRESCO/13 - Fin Leading Edge Inspection.

1.18.3 The original type certificate for the Fletcher aircraft was issued in the 1950s. Since that time the engine has been progressively up-rated over the years from 250 to over 600 HP. A Walter M601D-11NZ turbine engine had been installed in ZK-DZG in place of the standard 400 HP Lycoming IO-720 piston engine. The CAA approved this conversion under STC 98/21E/15 on 9 August 2000. The Walter engine is capable of producing 55% more horsepower than the Lycoming engine[5]. The increased horsepower of the Walter turbine engine provides the Fletcher with the capability of carrying heavier loads more often. This in-turn has meant that the airframe is being subjected to increased stresses.

1.18.4 The throttle lever on ZK-DZG had wear marks in its paint work which showed that the throttle had been taken past the de-rating stop. The de-rating stop acts principally as an end-stop for the throttle lever and ordinarily determines the maximum power setting for the engine. A check of other turbine powered Fletcher aircraft showed that they also had similar wear marks in the paint on the throttle lever. From discussions had with industry pilots it would appear that a common practice is to advance the throttle past the de-rating stop. It was noted that other pilots had flown ZK-DZG following its turbine engine conversion. The current throttle quadrant configuration allows the pilot to easily do this by moving the throttle sideways and then forward past the stop. During this process the paint on the throttle lever is scuffed or worn away. Advancing the throttle past the de-rate stop is normally only intended for emergency situations when extra engine power may be required. However there is little to discourage the pilots from doing this during normal operations as there is no requirement to record any engine power exceedance and there is no penalty maintenance inspections called for in the aircraft's maintenance publications. This means that the engines most likely have been operating above the maximum horsepower level (by as much as 13%) for which the aircraft had been certified under the STC 98/21E/15. The implication that this may have on the aircraft's airworthiness and safety is currently under review by the CAA.

1.18.5 The turbine engine conversion under the STC 98/21E/15 required the vertical fin to be visually inspected for any defects after the last flight of the day, and during every scheduled maintenance (50 and 100 hour) inspection. These inspections are also a standard manufacturer's requirement for all variants of the Fletcher aircraft. The fin is dependent on these inspections for its continuing airworthiness, a process known as 'safety by inspection'. Unfortunately in the case of ZK-DZG, the condition of the leading edge skin could not be inspected because it was covered by a black rubber anti-abrasion strip. It was therefore possible for defects to go undetected in the fin's leading edge skin.

1.18.6 At the time of the accident it was common practice to fit a black rubber anti-abrasion strip to the leading edge of the vertical fin on most Fletcher aircraft[6]. The purpose of the rubber was to reduce possible damage to the fin's leading edge skin

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[5] The Walter M601D-11NZ turbine engine is capable of providing 430 HP continuously and a takeoff power of 550 HP for up to 5 minutes, and maximum available power of 620 HP.

[6] Modification number JA/FU24/M258 approved by the CAA on 19 December 1975.

from slipstream debris. It appears that the significance this modification had on preventing the completion of the required inspections on the fin's leading edge was not fully appreciated or considered. The fitting of the black rubber strip on the fin's leading edge was therefore effectively curing one problem while causing potentially another more serious airworthiness safety issue. This safety issue has now been addressed by the CAA issuing an airworthiness directive[7] in May 2007. This airworthiness directive reaffirms the manufacturer's requirement more clearly with respect to the need to conduct regular inspections[8] of the fin's leading edge skin. These inspections require the removal of any non-transparent protective coatings installed on the fin's leading edge. This airworthiness directive also provides Fletcher aircraft operators with the option of installing transparent polyurethane protective tape on the fin's leading edge, thereby allowing the inspections to be performed without removing the protective strip.

1.18.7 A CAA investigation[9] in to a fatal accident involving a Fletcher aircraft in 2002 attributed the accident to a structural failure of the vertical fin. The investigation determined that the fin failure was the result of a fatigue crack in the fin's leading edge skin. It was reported that the crack was initiated by cuts accidently made in the fin's leading edge skin during maintenance. The cuts came from a sharp knife which was used to trim the fin's protective rubber strip. These cuts were about five thousandths of an inch deep (around 25% of the skin thickness) and effectively weakened the fin's forward attachment. The CAA subsequently issued an emergency airworthiness directive[10] requiring a one-time inspection for cracks near the base of the fin's leading edge skin. This accident demonstrated that the structural integrity of the fin is very dependent on there being no defects in the fin's leading edge skin.

1.18.8 The CAA amended the STC 98/21E/15 on 8 May 2002 (STC Report 98/21E/17 refers) to allow the aircraft to be fitted with a different propeller capable of developing greater thrust at lower speeds. This propeller type was fitted to ZK-DZG. The STC Report 98/21E/17 commented that –

> 'The (*increased*) performance of the turbine engine conversion would provide (*the aircraft with*) greater load carrying capacity on a more frequent basis and therefore any weaknesses in the airframe, particularly in areas like the tailplane and undercarriage would show up earlier'.

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[7] Airworthiness Directive DCA/FU24/176C - Fin & Leading Edge – Inspection and Repair.

[8] A visual inspection by the pilot after every last flight of the day; a visual inspection by an engineer every 50 hours (time in service); and a detailed inspection every 100 hours (time in service).

[9] ZK-EGO, a Fletcher FU24-950 fitted with a Lycoming IO-720-A1B engine - CAA investigation occurrence number 02/1167.

[10] Airworthiness Directive DCA/FU24/173 - Forward Fin Structure – Inspection.

No further investigation was done at that time to determine the effect of the greater thrust from the propeller and engine, or the increased load carrying capacity of the aircraft.

1.18.9 The CAA approved a Maintenance Programme for the operator of ZK-DZG which allows scheduled maintenance inspections to be performed every 150 hours instead of the aircraft manufacturer's standard 50 hour inspection interval. It appears that the approval process for these extensions did not take account of the aircraft manufacturer's airworthiness inspection requirements for the vertical fin.

1.18.10 Based on information from in-service experience and advice from the engine manufacturer, the operator's Maintenance Programme for ZK-DZG scheduled the (turbine engine) airframe fuel filter[11] to be serviced every 300 hours. The standard interval for servicing the airframe fuel filter fitted to Fletcher aircraft is 50 hours[12]. The longer interval between servicings of the turbine engine airframe fuel filter may explain why a lot of debris and water was discovered in ZK-DZG's airframe fuel filter.

1.19 Useful or effective investigation techniques

1.19.1 The last 60 seconds of track data from the aircraft's GPS unit was converted in to a three dimensional fly-through video using high resolution digital ortho-photography of the Pukenui Forest. The video indicated that the aircraft was flying towards the highest point in the forest and identified a slight track deviation and course correction made by the aircraft at the point 20 seconds before the end of the recorded GPS track data. It is possible that this occurred due to a high wind gust acting on the aircraft.

2. Analysis

2.1 An amber cockpit light known as the 'Beta[13] switch indicator light' is mounted on the bulkhead above the aircraft's instrument panel. When the Beta switch on the engine control quadrant power lever is selected, the amber Beta light will illuminate along with a second green Beta caution light on the instrument panel. It appears that the pilot determined that the flickering amber light, assumed to be the Beta light, was a spurious activation as the second (green) light had apparently not illuminated and there was no evidence that the propeller had moved into the beta range at any time.

2.2 Using the data retrieved from the GPS unit installed in the aircraft, and information obtained from agricultural pilots who fly Walter powered Fletcher aircraft, it was

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[11] The airframe fuel filter used for the Walter turbine engine is a specific type matched to the engine. It differs from the standard airframe filter used in piston engine Fletcher aircraft.

[12] As prescribed in the Maintenance Manual for Fletcher FU24-950 Series, Chapter 5- Maintenance Schedule.

[13] Engine operational mode in which the propeller blade pitch is controlled by the cockpit power lever, including the range from zero to negative thrust.

likely that the aircraft had a true airspeed of approximately 120 knots as it flew across the Pukenui Forest. The aircraft's flight manual[14] states the maximum structural cruise speed (V_{NO}) during conditions of atmospheric turbulence is 116 KIAS. This speed limit is imposed to reduce the possibility of unexpected gusts exerting excessive loads on the airframe. While the aircraft was estimated to be only exceeding the maximum permitted airspeed for those conditions by about 4 knots IAS (3 to 4 percent above the limit), aerodynamic forces experienced by the airframe increase considerably with increases in the aircraft's velocity[15]. As a result, there was a small added risk of the aircraft possibly suffering some form of structural damage under these conditions. When it was established that the aircraft had most likely exceeded the V_{NO} limit, the CAA sent a letter[16] on 13 April 2006 to all certificated agricultural operators reminding them, amongst other things, to ensure that pilots observe all flight manual airspeed limitations.

2.3 Civil Aviation Rule 91.537 prescribes that an aircraft may not fly if instruments and equipment specified as part of the aircraft's type certificate airworthiness requirements are inoperative. The aircraft was flying with an inoperative airspeed indicator at the time of the accident and therefore was not compliant with aviation rules. Because the airspeed indicator was inoperative, the pilot would not have been able to precisely determine the aircraft's airspeed. The pilot could have used the ground speed information from the aircraft's GPS to determine the aircraft's airspeed, but this method is impractical as the pilot would be required to take account of local wind speed and direction. It is more likely that the pilot was relying on known engine power lever settings to establish the aircraft's airspeed.

2.4 The engine manufacturer did not find any mechanical faults with the engine during the engine strip and it appears that the engine and propeller were operating normally at the time of impact. The debris and water found in the airframe fuel filter was therefore not considered to have contributed to the accident.

2.5 Overall the evidence suggests that the vertical fin probably failed in flight as a result of a pre-existing structural weakness in the fin's leading edge skin and a high aerodynamic flight load. The high aerodynamic flight load most likely occurred from a combination of a wind gust and the aircraft's speed. The certification design standards require the fin to be designed to withstand all expected turbulence gust loads with an added margin of safety. The wind gusts at the time of the accident would alone not have been strong enough to cause this type of structural failure.

2.6 There is evidence that the vertical fin folded down onto the left side of the aft fuselage and then became wrapped around the leading edge of the horizontal stabiliser. It is possible that the fin was held in this position for a short period of time by the rudder remaining attached to the fin by its top hinge. At this point the

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[14] Walter Fletcher Flight Manual and Pilot's Operating Handbook (AIR 2672).

[15] Aerodynamic forces increase by the square of the aircraft's velocity (i.e. dynamic pressure = $\frac{1}{2}\rho V^2$).

[16] CAA Reference DW1114484-0.

pilot would have had limited or no control over the aircraft. Such loss of control is consistent with a witness report describing the aircraft entering a steep downward right hand spiralling turn.

2.7 The investigation of this accident has identified airworthiness issues regarding the structural design of the Fletcher fin, its low tolerance to damage, and susceptibility to fatigue failures. This has required certain design features of the Fletcher fin to be reviewed by the CAA. In particular attention has been focused on the fin's forward attachment and associated structure -namely single load paths (one attachment bolt and lug providing no redundancy); minimal design strength; and susceptibility to significant structural failure from any damage incurred to the leading edge skin.

2.8 The industry practice of operating turbine engines past the maximum certified power setting is also being reviewed by the CAA in terms of its effect on safety and airworthiness. The additional engine power provided by turbine engines allows Fletcher aircraft to be to be operated with higher overload weights more frequently, and therefore further engineering studies are required in order to try and understand the effect this may have on the structural integrity of the aircraft.

2.9 The CAA has embarked on a program to review the Maintenance Programmes issued to all active agricultural operators. To assist this process the CAA is developing procedures to guide CAA staff when approving or amending Maintenance Programmes. These procedures will complement the guidance material provided in Advisory Circular AC 90-1 '*Aircraft maintenance programmes*'. This should ensure that all aircraft maintenance requirements are considered, such as those established as part of a STC, when any future operator's Maintenance Programme is being approved or amended.

2.10 The failure of the aircraft's ELT to operate following the accident increased the time taken to locate the wreckage by approximately 12 hours. While it appears this wasn't a survival issue in this accident, in other circumstances it could quite easily have been. Closer examination of the ELT showed that some internal components had suffered some minor physical displacement inside the ELT case as a result of the accident. The ELT itself however was still capable of transmitting a signal when it was bench tested. In this case no emergency transmission was possible due to the ELT arming switch being in the 'off' position and the coaxial cable between the ELT and its antenna being severed in several places caused by deformation of the airframe.

2.11 There is anecdotal evidence that agricultural pilots sometimes deactivate the ELT by switching the arming switch 'off'. This is to prevent the 'g' switch inadvertently activating the ELT when the aircraft is operating from rough airstrips. It is possible that the pilot may have done this and then forgotten to re-arm the ELT prior to the transit flight back to Whangarei. Alternatively the switch could have been disrupted and knocked into the 'off' position during the accident by the aircraft wreckage.

2.12 CAA Rules have recently required modernised 406 MHz ELTs to be fitted to aircraft[17]. The new ELTs are designed so that they cannot be easily switched off. They also allow a faster satellite fix on the ELT's position when it is activated. The latest version of the Advisory Circular AC43-11 (Revision 2, 12 June 2008) published by the CAA provides for improvements to the aircraft's ELT installation which should ensure a better chance of the ELT successfully transmitting an emergency signal following a survivable aircraft accident.

3. Conclusions

3.1 The pilot was appropriately licensed, experienced and fit to carry out the flight.

3.2 The pilot was flying the aircraft with an unserviceable airspeed indicator and he was most likely relying on known power lever settings to approximately determine the aircraft's speed.

3.3 The aircraft's airspeed at the time of the accident was close to the operating limit allowed for flying in the reported turbulent weather conditions.

3.4 Metallurgical examination confirmed that the vertical fin on the aircraft was weakened by pre-existing fractures in the leading edge section of the fin. These fractures could not be easily detected due to a rubber anti-abrasion strip applied over the fin's leading edge. The fractures were most likely caused by fatigue.

3.5 The vertical fin separated from the fuselage as a result of structural weakness in the leading edge skin and a significant aerodynamic flight load. The structural weakness has been attributed to pre-existing fatigue cracks in the fin's leading edge skin. The significant aerodynamic load has been attributed to a combination of a wind gust and the aircraft's airspeed.

3.6 The vertical fin appears to have struck the horizontal stabiliser, which would have caused the aircraft to depart from controlled flight. The pilot would have had very limited or no control over the aircraft.

3.7 The accident was not survivable.

4. Safety actions

4.1 The CAA sent a letter on 13 April 2006 to all certificated agricultural operators reminding them, amongst other things, to ensure that pilots observe the aircraft's airspeed limitations.

4.2 The CAA raised Action Item (No. 6A2359) on 5 May 2006 requiring its Aircraft Certification Unit (ACU) to carry out an engineering review to investigate the structural integrity of the Fletcher vertical fin. This review is in progress and the ACU will also review the STC 98/21E/15 (CAA Action Item No. 8A865 refers) for

[17] Automatic activated ELTs are required to meet the design standard TSO C126 and fitted to aircraft by 1 July 2008.

this aircraft type and any other turbine modified Fletcher aircraft to verify that they satisfy all appropriate airworthiness certification standards.

4.3 The CAA issued an airworthiness directive DCA/FU24/176 with effect from 1 June 2006, requiring all operators of Fletcher FU24 aircraft to inspect regularly for defects in the vertical fin leading edge skin. The airworthiness directive was later reissued to reduce the inspection interval to 50 hours (time in service) to align with the aircraft manufacturer's maintenance inspection intervals.

4.4 The CAA raised Aviation Related Concern (CAA ARC No. 7/ARCG/1) on 29 June 2006 to review all previously approved active Maintenance Programmes for agricultural operators which extend scheduled maintenance inspections beyond the aircraft manufacturer's recommended inspection intervals.

4.5 The CAA raised Action Item (No. 7A1000) on 10 November 2006 requiring an internal policy and procedure to be issued for the approving and amending of Maintenance Programmes.

4.6 The CAA raised an Action Item (No. 7A1869) on 18 April 2007 requiring the removal of all non-transparent protective strips from the leading edge of the Fletcher vertical fin.

4.7 The CAA raised an Action Item (No. 9A598) on 17 September 2008 to investigate and establish the potential airworthiness safety issues created by turbine powered Fletcher aircraft being operated above the certified engine power rating.

4.8 While not as a direct result of this accident, a review titled the 'Agricultural Aircraft Safety Review' has been initiated by the CAA General Aviation Group and its purpose it to: *"Gather information, authenticate anecdotal stories as far as is possible and make recommendations regarding currently operated agricultural aircraft design, continuing airworthiness, maintenance and operational practices and techniques that would improve the safety performance of this industry sector."*

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