ACCIDENT

Aircraft Type and Registration:	Piper PA-31, N250AC
No & Type of Engines:	2 Lycoming TIO-540-A2C piston engines
Year of Manufacture:	1976 (Serial no: 31-7612040)
Date & Time (UTC):	6 September 2017 at 1723 hrs
Location:	Caernarfon Airport, Gwynedd
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Fatal) Passengers - N/A
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	62 years
Commander's Flying Experience[1]:	Over 4,000 hours (with experience on type) Last 90 days - unknown Last 28 days - unknown
Information Source:	AAIB Field Investigation

Synopsis

Approximately 20 minutes after takeoff from a private airstrip in Cheshire the pilot reported pitch control problems and stated his intention to divert to Caernarfon Airport. Approximately 5 minutes later, the aircraft struck Runway 25 at Caernarfon Airport, with landing gear and flaps retracted, at high speed, and with no noticeable flare manoeuvre. The aircraft was destroyed. The elevator trim was found in a significantly nose-down position, and whilst the reason for this could not be determined, it is likely it would have caused the pilot considerable difficulty in maintaining control of the aircraft.

The extensive fire damage to the wreckage and the limited recorded information made it difficult to determine the cause of this accident with a high level of confidence. A possible scenario is a trim runaway, and both the CAA and the EASA are taking safety action to promote awareness for trim runaways as a result of this accident.

History of the flight

The pilot operated N250AC from a private grass airstrip situated between Manchester and Liverpool. On the day of the accident he intended to fly to Dublin Weston Airport, which he visited regularly in this aircraft.

Footnote

[1] A number of the pilot's log books were not located but other evidence indicated his total flight time, and also that he flew N250AC regularly.

The pilot had shown an employee how to perform pre-flight preparations on his behalf and the latter did so regularly. This did not include instruction on how to perform any pre-flight checks on the autopilot or trim systems.

On the day of the accident, the employee stated that he spent 2 hours and 20 minutes preparing N250AC, during which he checked the elevator control surface and recalled it moving smoothly with no restrictions.

The employee reported that he submitted the relevant General Aviation Report[2] form two days before the accident. He produced a VFR flight plan which he filed after the pilot had checked it. The employee stated that this specified Dublin and Liverpool as destination alternate[3] aerodromes. The pilot was also familiar with Caernarfon Airport, located on the Welsh coast, and had flown there three days previously.

The employee recalled that the pilot arrived at approximately 1630 hrs. They walked around the aircraft together and the pilot departed in it shortly afterwards. The employee observed the elevator and ailerons being checked whilst the aircraft taxied, and they appeared to move normally.

N250AC took off at 1653 hrs and the employee observed the landing gear retract normally at approximately 20 ft agl. Shortly after, the aircraft was recorded on primary and secondary radar at an altitude of about 550 ft amsl and squawking 7000[4]. The aircraft turned onto a southerly course and progressively climbed to about 1,100 ft amsl. The pilot then contacted Liverpool Approach and requested activation of his flight plan; shortly after the aircraft stopped transmitting Mode A and C transponder information (Figure 2).

Anecdotal evidence from a relative of the pilot who was also a commercial pilot suggested that it is likely that the pilot would have flown the aircraft manually, as opposed to using the autopilot.

The aircraft continued on a southerly course until it was abeam the town of Crewe, Cheshire, where it changed course to the west. A few minutes later at 1702 hrs, Liverpool Approach confirmed that the flight plan had been activated, upon which the pilot advised that he was changing frequency to the London FIR information service (London Information).

The pilot contacted London Information at 1710 hrs. The aircraft was 35 nm east of Caernarfon Airport. The pilot reported the aircraft was at 4,200 ft amsl and requested assistance in coordinating his arrival at Dublin. This was acknowledged and the pilot was requested to set his transponder Mode A squawk code to 1177, and transmit Mode C

Footnote

2 General Aviation pilots, operators and owners of aircraft making international journeys are required to report their expected journey to UK authorities. The UK Government states that the General Aviation Report is used by Border Force and the Police to facilitate the passage of legitimate persons and goods across the border and prevent crime and terrorism.

3 'Destination alternate' – an aerodrome at which an aircraft would be able to land should it become impossible or inadvisable to land at the aerodrome of intended landing. Different to an 'en route alternate'.

4 The general conspicuity code was set on the transponder.

altitude information. Mode A was then transmitted from the aircraft, but no Mode C altitude data was received by radar. The aircraft's groundspeed at this time was about 160 kt, which equates to an estimated indicated airspeed of approximately 165 KIAS based on a wind[5] from 300° at 20 kt. During these transmissions, the pilot gave an estimated time of arrival at waypoint DEXEN[6] as 1745 and thereafter turned right approximately 10° towards DEXEN.

Shortly after, as the aircraft approached Snowdonia, the pilot confirmed with the ATCO that the regional QNH was 1013 hPa. Three minutes later at 1717 hrs, the pilot transmitted the aircraft's callsign, indicating that he wanted to transmit a message. The ATCO acknowledged, but asked the pilot to 'standby' as she was dealing with other aircraft. N250AC was about 16.5 nm from Caernarfon Airport.

At 1718:25 hrs the pilot radioed London Information again. The following is a transcript of communications between the pilot and the ATCO:

N250AC:	"LONDON INFORMATION NOVEMBER TWO FIVE ZERO ALPHA CHARLIE"
ATCO:	"NOVEMBER ZERO ALPHA CHARLIE PASS YOUR MESSAGE"
N250AC:	"WE ARE HAVING SOME PITCH CONTROL PROBLEMS EH WITH THE ELEVATOR AND SO AS A PRECAUTION I AM GOING TO DIVERT TO EH CAERNARFON"
ATCO:	"NOVEMBER ZERO ALPHA CHARLIE ROGER, ARE YOU DECLARING A PAN"
N250AC:	"UM SAY AGAIN"
ATCO:	"NOVEMBER ZERO ALPHA CHARLIE DO YOU WISH TO DECLARE A PAN"
N250AC:	"NOT AS YET I'LL SEE HOW IT GOES"
ATCO:	"ROGER DO YOU HAVE AN ETA FOR CAERNARFON AND WE WILL PASS YOUR DETAILS ALONG"
N250AC:	"EH TWO FIVE"
ATCO:	"ROGER SO TIME ONE SEVEN TWO FIVE FOR CAERNARFON"
N250AC:	"AFFIRM"
ATCO:	"ROGER WE WILL PASS YOUR DETAILS"

After reporting the control problem, the aircraft turned left slightly and tracked towards Caernarfon. As the aircraft flew over Snowdonia it was maintaining a westerly course towards Caernarfon Airport, and it was intermittently recorded by primary radar. At 1721:20 hrs, the aircraft was about 6.4 nm from Caernarfon Airport and 15 nm from RAF Valley, Anglesey. This coincided with the ATCO advising the pilot that Caernarfon appeared to be closed because there was no answer from the tower, and offering to liaise with RAF Valley as an alternate destination. The pilot did not respond to this transmission. Analysis of primary radar coverage indicates that the aircraft was above 4,000 ft amsl.

Footnote

5 5,000 ft amsl spot wind at a temperature of 7°C provided in an aftercast by the Met Office.
6 The pilot gave navigational waypoint DEXEN as his point of entry in to Irish airspace, which is approximately 35 nm west of RAF Valley.

The aircraft was recorded again on radar between 1721:44 hrs and 1722:12 hrs when it was 4 nm from Caernarfon. Its average groundspeed had increased to about 175 kt, which equates to an estimated indicated airspeed of approximately 180 KIAS[7]. Analysis of radar coverage indicated the aircraft was above 2,600 ft amsl.

At 1723:16[8] hrs, CCTV footage showed the aircraft during the final seconds of the flight as it approached Runway 25 at Caernarfon Airport.

Eyewitnesses reported that the aircraft appeared to approach faster and lower than usual, and was rocking from side to side. Its engines were making a high-pitched noise, as though they were operating at a high rpm setting.

The aircraft contacted the runway heavily with a high rate of descent. It then bounced into the air for just less than two seconds, during which it rolled right, through almost 360° around its longitudinal axis, before impact with the runway again. A significant fire broke out as the aircraft slid along the runway. The aircraft came to rest nine seconds after it had initially struck the runway. The RFFS arrived at the aircraft five minutes later at 1728 hrs, and shortly after started to apply fire suppressant. The pilot had been fatally injured.

Weight and balance

Information provided by the pilot's employee, who loaded and fuelled N250AC before the accident flight, indicated that the aircraft's weight and balance were within the limits specified for this aircraft type, and that there was sufficient fuel onboard for the planned route.

Meteorology

An aftercast for the planned route provided by the Met Office showed some cloud above 2,000 ft amsl, with good visibility beneath and no significant weather. The 5,000 ft wind and air temperature at 1800 hrs were 300° at 20 kt, and 7°C.

RAF Valley's METAR at 1750 hrs reported wind from 210° at 12 kt, visibility greater than 10 km, few clouds at 4,500 ft and broken cloud at 10,000 ft, temperature 15°C, and QNH 1019 hPa.

METARs for Hawarden, Liverpool and Manchester showed similar conditions. METAR information for Caernarfon was not available.

Aerodrome information

Caernarfon's operational runway is 932 m long and orientated 070°/250° (Figure 1). The airport's published summer operating hours were from 0800 to 1700 hrs.

A number of the eyewitnesses were situated in a caravan site under the final approach to Runway 25. RAF Valley is approximately 11 nm north-west of Caernarfon Airport.

Footnote

7 Based on a spot wind at 5,000 ft amsl from 300° at 20 kt and a temperature of 7°C.
8 The CCTV time stamp was corrected for a 10 second offset from UTC.

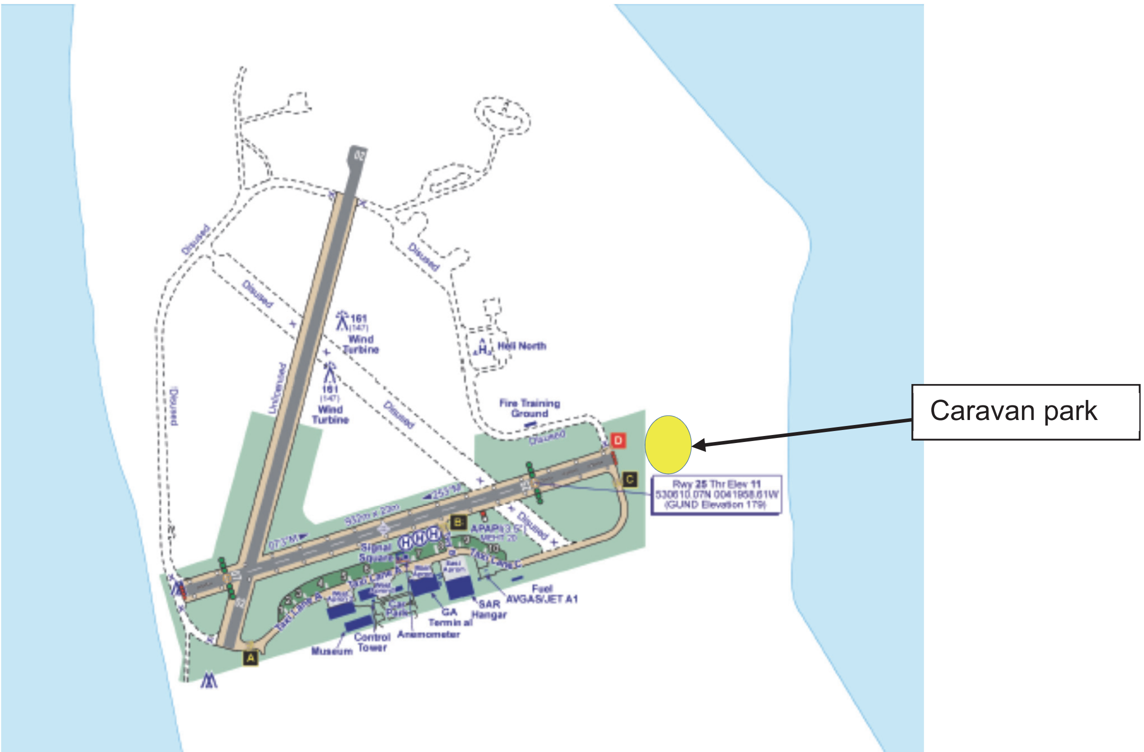

Figure 1

Caernarfon Airport and location of caravan park

Personnel

The pilot held an EASA Class 1 medical certificate, which had been revalidated on 13 April 2017. He had a valid EASA CPL(A) with multi-engine and instrument ratings, and UK PPLs for both fixed and rotary wing aircraft. He also had similar licensing certificates and ratings issued by the FAA.

The pilot's 42 years of flying experience included various piston and turbine engine aeroplanes and helicopters, and he had owned both fixed wing and rotary aircraft. Several of his log books were not located after the accident, including the most recent ones, so an accurate breakdown of his experience could not be determined. However, he declared a total of 4,000 flying hours at his last medical revalidation, and 50 hours in the previous 13 months. Flight planning paperwork provided by his employee indicated that he had planned around 25 flights to or from Ireland in the period since 11 April 2015. Any domestic flights which may have occurred would have been in addition to these.

Medical and pathological information

A post-mortem examination of the pilot revealed no evidence of underlying disease or toxicology which could have contributed to the event. It concluded that the cause of death was multiple injuries sustained when the aircraft struck the runway.

Recorded information

Sources of recorded information

Recorded radar information (primary and secondary Mode A and C[9]) was available from ground-based sites located at Manchester Airport and St Anne's (near Blackpool). The radar data provided an almost complete record of the accident flight, starting shortly after the aircraft had taken off and ending when the aircraft was about 4 nm east of Caernarfon Airport. Figure 2 provides a plot of the aircraft radar track.

RTF recordings were available of communications between the pilot and both Liverpool Approach and London Information. RTF communications were not recorded at Caernarfon Airport.

Closed Circuit Television (CCTV) footage of the accident was captured by two cameras located at Caernarfon Airport. One camera, installed on the control tower, provided a field of view that included the approach to Runway 25 and approximately the first 500 m of the runway. Images from this camera showed the aircraft from four seconds[10] before it struck the runway to it coming to a stop. The other camera, installed on an adjacent hangar, recorded the aircraft as it slid along the runway before disappearing out of camera view.

The aircraft was not fitted, nor was required to be, with a flight data recorder.

Interpretation

Assuming that N250AC flew a direct track from the last radar point at 4 nm from the runway, its average indicated airspeed would have been approximately 190 KIAS based on a wind from 210°at 12 kt[11].

Analysis of the CCTV footage indicated that, prior to impact, the aircraft was in an almost wings-level attitude and the landing gear was retracted. The approach track was calculated to be about 245°T, the flight path angle was about 9° nose-down, the descent rate was about 2,700 ft/min and the estimated groundspeed was approximately 175 kt; this equates to an indicated airspeed of about 185 KIAS based on a wind from 210° at 12 kt.

Footnote

9 Mode A refers to the four-digit 'squawk' code set on the transponder and Mode C refers to the aircraft's pressure altitude which is transmitted in 100 ft increments.
10 The resolution of the camera meant that the aircraft was not discernible until four seconds prior to impact.
11 Reported at RAF Valley (EGOV) around the time of the accident.

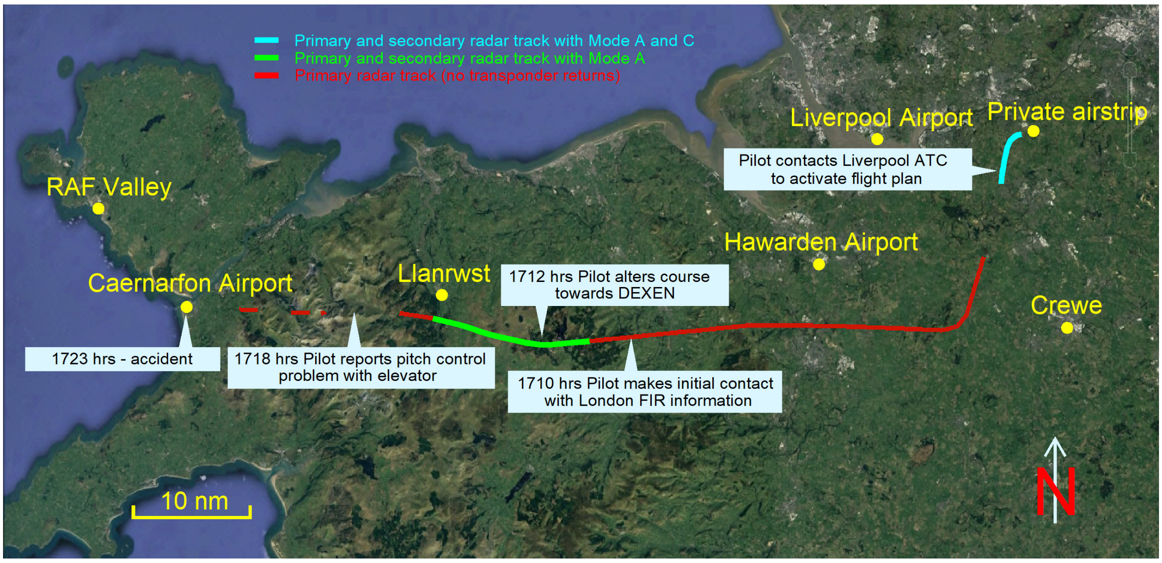

Figure 2

Radar track of N250AC

Map data: Google, Landsat/Copernicus

Aircraft information

The Piper PA-31 Navajo has two turbocharged piston engines with three-bladed variable pitch propellers, retractable landing gear and seating for two pilots and four passengers. The aircraft was manufactured in 1976 and had been operated by the owner since approximately 2002. The aircraft's logbooks were not located following the accident, however technical records provided by the aircraft's maintenance facility showed that an annual inspection had been carried out on 8 February 2017, at 9,243 flying hours. The last recorded maintenance activity was the replacement of the left engine's turbocharger, which occurred on 1 September 2017. There was no record of any ongoing or deferred aircraft defects.

The aircraft's flying controls are conventional, unpowered and operated directly by the control yokes and rudder pedals via mechanical linkages. The elevator control circuit includes an electrically-powered pitch servo, actuated by the autopilot. Aileron, elevator and rudder trim are manually operated by trim wheels connected to cable-wrapped drums located in the cockpit centre pedestal (Figure 3). With rotation of a drum, a screw is moved fore or aft to allow the positioning of the trim tab. An electric sender unit is attached to each trim tab screw assembly to transmit an electrical signal to the trim position indicator on the centre pedestal, to provide a visual indication of the trim tab positions to the pilot.

Electric pitch trim system

The electric pitch trim system (Figure 9) is powered when the aircraft master switch is ON and the electric trim circuit breaker is engaged. When the left part of the control yoke pitch trim switch is pressed down, and the right part of the switch is moved forward, a solenoid in the pitch trim servo causes the pitch trim motor to engage with the cable capstan and rotation of the pitch trim motor moves the elevator trim cable to change the position of the elevator trim tab, to provide nose-down trim. The pitch trim servo capstan has an internal clutch to allow the elevator trim cables to move, should the servo jam. Rearwards movement of the right pitch trim toggle switch, with the left part of the switch depressed, moves the elevator trim tab to provide nose-up trim. The two-part switch is designed such that should one part of the switch fail closed, the pitch trim system will not operate unless the other part of the pitch trim switch is operated by the pilot, to prevent a trim runaway condition due to a single switch failure.

The electric pitch trim system has two modes of operation; a manual mode and an automatic mode.

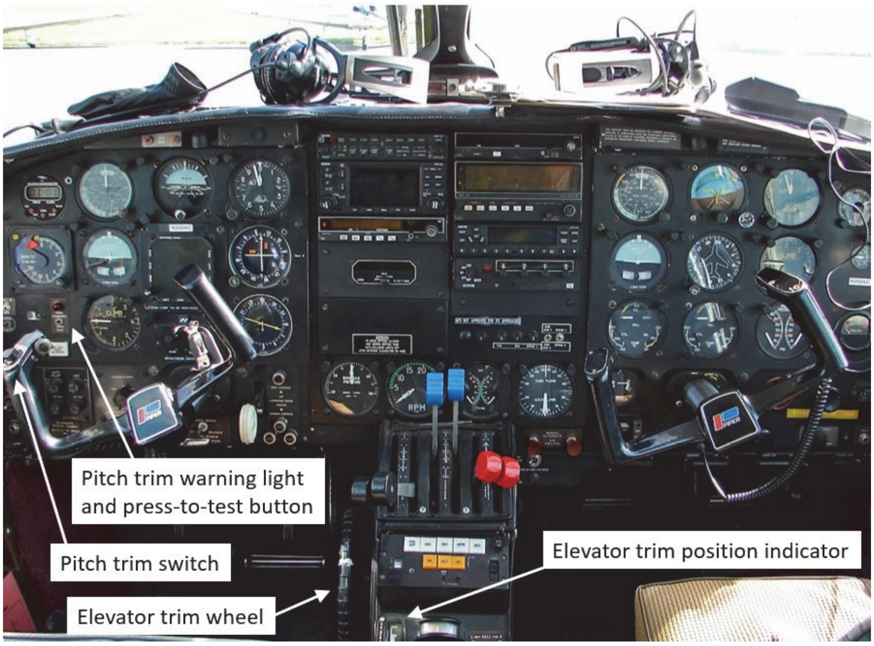

Figure 3

N250AC cockpit, showing trim controls (image used with permission)

Manual mode

The manual mode is operational only when the pitch axis of the autopilot is disengaged. The position of the elevator trim tab is directly controlled by pilot demand, either via movement of the elevator trim wheel on the cockpit pedestal or by selection of the electric pitch trim switch on the left control yoke.

Automatic mode

When the pitch axis of the autopilot is engaged, the pitch trim switch on the left control yoke becomes inoperative and any movement of the switch will cause the autopilot to disconnect. The autopilot pitch servo detects any differential elevator cable tension caused by an out-of-trim condition, and the automatic pitch trim system actuates the pitch trim servo to move the elevator trim tab to re-trim the elevator. Any attempt to overpower the autopilot pitch axis will cause the automatic pitch trim to oppose the applied force, resulting in an out-of-trim condition and high yoke forces.

Pitch trim warning system

In manual and automatic pitch trim modes, a pitch trim warning system is provided. The function of this system is to provide the pilot with a visual indication of an abnormally long or continuous pitch trim servo operation. The system consists of a logic circuit that is designed to be failsafe, an electronic timing device within the pitch trim servo and an indicator warning light on the left side of the instrument panel. The indicator warning light (Figure 3) will illuminate if the pitch trim servo operates for longer than 3-4 seconds, and extinguishes when the pitch trim servo ceases to operate. Illumination of the indicator warning light is coincident with the operation of a relay in the pitch trim servo that removes power from the pitch trim servo motor, to prevent a trim runaway.

The automatic pitch trim system normally maintains trim with pitch trim servo operations of less than one second duration and therefore a prolonged illumination of the indicator warning light may indicate a runaway pitch trim servo, or a slipping pitch trim servo clutch, or low elevator trim cable tension. A 'press-to-test' switch is provided next to the indicator warning light to permit the pilot to check for correct operation of the pitch trim warning system. When pressed, this switch introduces a failure within the pitch trim system removing power from the pitch trim servo and causing the warning light to illuminate.

Autopilot

N250AC was equipped with a Bendix Altimatic V-1 two-axis autopilot, which when engaged can manoeuvre the aircraft in response to following pre-selected flight control functions:

- Automatic pitch trim
- Altitude hold
- Pitch command (for climb or descend)
- Radio coupling (VOR/LOC), capture and tracking
- ILS localiser back course capture and tracking
- Automatic ILS glideslope capture
- Pre-selected heading hold
- All angle VOR/LOC capture
- Manual turn control

The system is composed of a mode control panel, a computer-amplifier, a power supply, an altitude controller, pitch and roll control servos, a directional gyro and optional flight director instrumentation. The autopilot is powered through the autopilot master switch and the power supply circuit is protected with a circuit breaker on the circuit breaker panel. The autopilot is engaged by selecting the desired mode on the mode control panel. The autopilot can be disengaged by either selecting the autopilot release switch on the left control yoke, or by pressing the electric trim switch during autopilot operation, or by switching the autopilot master switch to OFF, or by pulling the autopilot circuit breaker.

Circuit breaker panel

Electrical switches for the aircraft's systems, including the master switch, are located on the circuit breaker panel on the left cockpit sidewall (Figure 4). Circuit breakers are provided that automatically open each electric circuit should an overload occur. The pitch trim servo has a dedicated circuit breaker located on this circuit breaker panel. It is possible to manually open the circuit breakers by pulling their reset buttons outwards, which disconnects the selected circuit from electrical power.

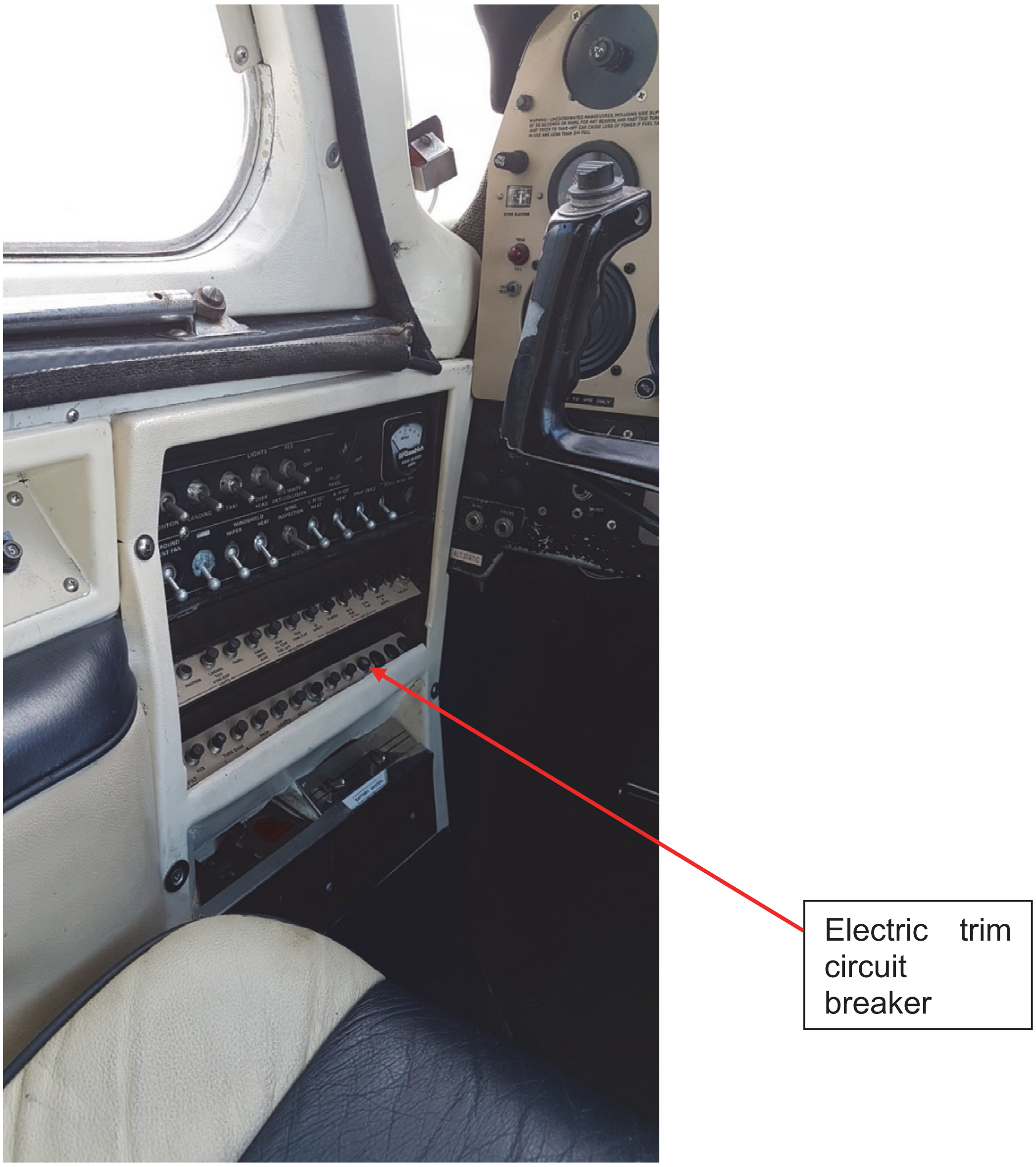

Figure 4

Circuit breaker panel in a representative PA-31

Airworthiness requirements for controllability

Previous amendments of the relevant certification specification documents under the FAA and the EASA[12], expressed controllability and manoeuvrability requirements as FAR 23.143 and CS 23.143. These specified force limits for pitch control as 34 kgf[13] for temporary application with two hands on the control wheel rim, 23 kgf for temporary application with one hand on the control wheel rim, and 5 kgf for prolonged application. Prolonged application was defined[14] as 'some condition that could not be trimmed out, such as a forward c.g. landing. The time of application would be for the final approach only, if the aeroplane could be flown in trim to that point.'

The current amendments to FAR 23 and CS 23[15] represent a transition to performance-based airworthiness standards. As such, control force limits are no longer specified. 'Controllability' is now defined in both documents as follows:

> *'23.2135 Controllability.*
>
> *(a) The airplane must be controllable and maneuverable, without requiring exceptional piloting skill, alertness, or strength, within the operating envelope—*
>
> *(1) At all loading conditions for which certification is requested;*
>
> *(2) During all phases of flight;*
>
> *(3) With likely reversible flight control or propulsion system failure; and*
>
> *(4) During configuration changes.'*

Aircraft operation

PA-31 Navajo checklists

The pre-flight checklists for N250AC were outlined in section 3 of its Flight Manual under *'normal operating procedures'*. These procedures did not include reference to the autopilot and trim systems, other than to ensure that the elevator trim is set to the neutral position for the walk around inspection and then, later, to ensure that it is in the correct position for takeoff.

Section 5 of the Flight Manual contained various supplements. A number of these related to various autopilot types which could be installed in relevant PA-31s. The Bendix Altimatic V-1 autopilot supplement, relevant for N250AC, contained pre-flight procedures, and normal and emergency in-flight procedures, for both the autopilot and the manual electric trim systems.

Footnote

[12] For example, *'Certification Specifications for Normal Category Aeroplanes CS-23'* Amendment 4, https://www.easa.europa.eu/sites/default/files/dfu/CS-23%20Amendment%204.pdf (accessed 21 September 2018), and equivalent FAA document.

[13] The force values contained within the documents were specified in Newtons and pounds of force and have been converted to kgf in this report for the purpose of consistency.

[14] CS-23 Amendment 4 Book 2 Flight Test Guide Book, section 4 Controllability and Manoeuvrability.

[15] CS-23 Amendment 5 and equivalent FAA document.

The autopilot *'Pre-flight check-out procedures'* were:

> '2. *PREFLIGHT CHECKOUT PROCEDURES*
>
> *(a) AUTOPILOT MASTER SWITCH – Turn autopilot master switch to ON.*
>
> *(b) BEFORE TAKEOFF – Engage the autopilot, apply a force to the controls (on one axis at a time) to determine if the autopilot may be overpowered.*
>
> *(1) Press Hdg, Nav, Appr, Rev buttons one at a time, place pitch command disc in center detent position and check respective lights on the Flight Controller for operation.*
>
> *(c) RELEASE SWITCH – Disengage the autopilot by pressing the Autopoilot Release Switch, located on the left side of the pilot's control wheel, and recheck aircraft pitch trim before takeoff.*
>
> *(d) GYRO CHECK – Check attitude gyro for proper erection. Set the directional gyro, if manual slaving type.*
>
> *(e) PITCH TRIM INDICATOR – Centering the Pitch Trim Indicator (by rotating the pitch command) prior to engagement will insure that the aircraft will continue in its present attitude. However, if the Trim Indicator is not centered, aircraft will smoothly take up the attitude dictated by the pitch command.'*

The autopilot *'In-flight procedures'* section included:

> *'…AUTOMATIC PITCH TRIM is provided whenever the autopilot is engaged. Any attempt to overpower the autopilot pitch axis will cause the pitch trim to oppose the applied force, resulting in an out-of-trim condition and high stick forces.*
>
> *To manually operate the elevator trim tab, the autopilot must be disengaged. Pushing the release switch will disengage the autopilot.'*

The *'Manual electric trim'* procedures stated:

> *'…TRIM EMERGENCY PROCEDURES*
>
> *In* [the] *event of an in-flight malfunction of the electric trim system, disconnect by pulling electric trim circuit protector* [breaker].
>
> *TRIM PRE-FLIGHT PROCEDURES*
>
> *The following pre-flight shall be conducted prior to each flight and during flight as considered appropriate.'*

> (1) *A/P Master Switch – ON*
>
> (2) *Trim Warning Light – OUT*
>
> (3) *Manual Trim Wheel Freedom of Movement – Check*
>
> (4) *Actuate Electric Trim Switch and observe proper direction of movement of manual trim wheel – Check*
>
> (5) *Press the press-to-test button next to the trim warning light. Light should light while being pressed and should not run – Check.'*

Under '*Emergency Operating Procedures'* the Flight Manual stated:

> '(a) *In* [the] *event a malfunction in the autopilot performance is detected, the pilot must immediately disengage the autopilot by momentarily pressing the Autopilot Release Switch on the control wheel.*
>
> (b) *In* [the] *event of a runaway pitch trim during autopilot operation, an overpower force of up to 20 lbs.*[16] *at the control wheel will be experienced at the time of disengagement (3 second delay for recognition time). Pull A/P circuit breaker and have the system checked prior to re-engagement…'*

PA-31 Navajo normal operation

The PA-31 Navajo Flight Manual used by the pilot defined the maximum structural cruise speed (V_{NO}) as 187 KIAS. It stated that for landing, when the airspeed is below 152 KIAS, flap 15° may be selected. Landing gear and full flap may be selected when below their limiting speed of 130 KIAS. Whilst the pilot's copy of the Flight Manual[17] did not specify a final approach speed, another version of the manual quoted that speed as 95 KIAS.

Stabilised approaches

The Flight Safety Foundation's document[18] entitled *'Approach-and-Landing Accident Reduction Tool Kit – Briefing Note 7.1 Stabilised Approach'* lists the criteria for a stabilised approach under VFR. An approach is stabilised when all criteria are met. Table 1 below relates these to the accident approach.

Footnote

[16] 20 lbf equates to approximately 9 kgf.
[17] The pilot's copy of the Flight Manual states that it applies to aircraft with serial numbers 31-752 and up
[18] https://www.skybrary.aero/bookshelf/books/864.pdf (accessed on 21 September 2018).

Stabilised criteria	Correct	Accident approach
The aircraft is on the correct flight path	2,100 ft amsl at 6.4 nm[1] 1,400 ft amsl at 4.0 nm[1]	Above 4,000 ft amsl at 6.4 nm Above 2,600 ft amsl at 4.0 nm
Only small changes in heading/ pitch are required to maintain the correct flight path		Not achieved, 9° nose-down pitch in final seconds
The aircraft speed is not more than V_{REF}+20 knots indicated airspeed and not less than V_{REF}[2]	95 kt +20, -0	185-190 KIAS – 70-75 KIAS above V_{REF}+20
The aircraft is in the correct landing configuration	Flap full, landing gear down	Flap and landing gear remained up – airspeed 55-60 KIAS above limiting speed
Sink rate is no greater than 1,000 feet per minute		Average of 2,000 fpm or more from 6.4 nm, and 2,700 fpm in last few seconds.
Power setting is appropriate for the aircraft configuration and is not below the minimum power for approach as defined by the aircraft's operating manual		Power setting unknown. Some but not full power applied and propellers close to fully fine.

Table footnotes:

1 Approximate altitudes based on a 3° glideslope.
2 Target approach speed.

Table 1

Comparison of accident approach conditions with stabilised approach criteria[19]

Accident site

The aircraft had struck the paved surface of Runway 25, 3 m to the right of the runway centreline and 101 m before the displaced threshold (Figure 5). The main wreckage of the aircraft, consisting of the fuselage, empennage, right wing and engine and most of the left wing apart from the left engine had come to rest on the runway surface 293 m beyond the initial impact point. A severe post-impact fire had consumed the majority of the aircraft with only the nose section ahead of the cockpit remaining free from fire damage. Examination of the wreckage confirmed that the aircraft had been structurally complete at the point of impact. The landing gear was retracted and the flaps were fully up, confirmed by the position of the flap jackscrew actuators.

Footnote

19 The Flight Safety Foundation states that ALAR briefing notes were prepared primarily for operators and pilots of turbine-powered aeroplanes with underwing-mounted engines but can be adapted for those who operate fuselage-mounted turbine engines, turboprop-powered aeroplanes and piston-powered aeroplanes.

Assessment of the initial ground impact marks indicated that the aircraft had struck the ground in a nose-down attitude with a slight left bank. The distance between the first and second propeller ground impact marks was 72 cm for both the left and right engines, indicating that both engines were operating at the same speed at impact and the aircraft's groundspeed at impact was approximately 180 kt. The absence of ground marks from the aircraft's flaps and landing gear further confirmed that both were retracted at impact.

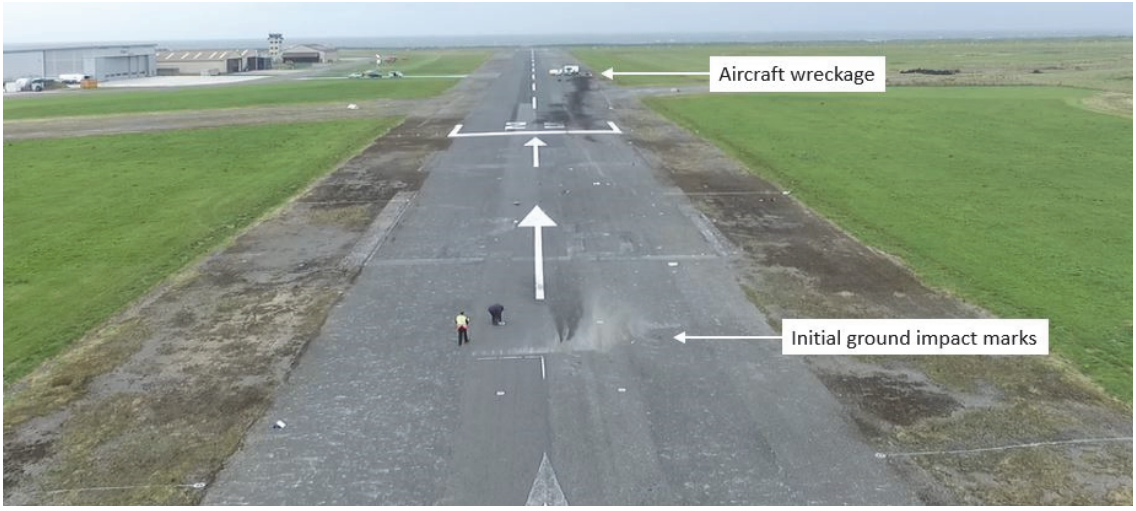

Figure 5

Accident site (image courtesy of North Wales Police)

Wreckage examination

The aircraft wreckage was recovered to the AAIB's facility at Farnborough for detailed examination.

The damage from the post-impact fire had destroyed the upper fuselage structure and much of the cockpit area. Hence most of the wiring and electrical components in the cockpit, including the circuit breaker panel and the pitch trim switch were not available for inspection.

Flying controls

It was not possible to functionally test the left and right control yoke slide assemblies (Figure 6), which translate pilot pitch demand into elevator control cable motion, due to fire damage. Visual examination however confirmed the presence of all the required yoke slide bearings and the correct connection of the yoke slide assemblies to the elevator control torque tube and elevator cable control sector. The elevator control cables were correctly routed and terminated at the elevator control sector.

Examination of the elevator control cables between the control yokes and the elevator pushrod did not reveal any evidence of a pre-impact defect, misrouting or disconnection. It was not possible to determine the pre-impact cable tension of the elevator control cables due to accident damage to the fuselage. The elevator cables were connected to the elevator bellcrank and the bellcrank itself was free to rotate normally. The elevator pushrod was intact and attached at both ends, and the pushrod's rod-ends were correctly installed and structurally intact.

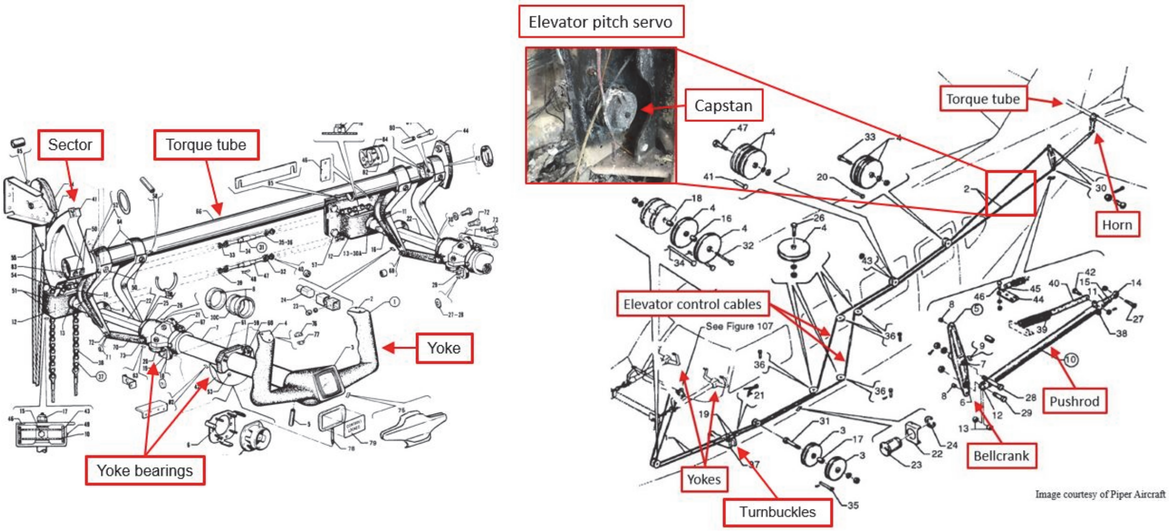

Figure 6

PA-31 elevator controls

The elevator horn, which connects the pushrod to the elevator torque tube, was found to be fractured on initial examination of the wreckage at the accident site (Figure 7).

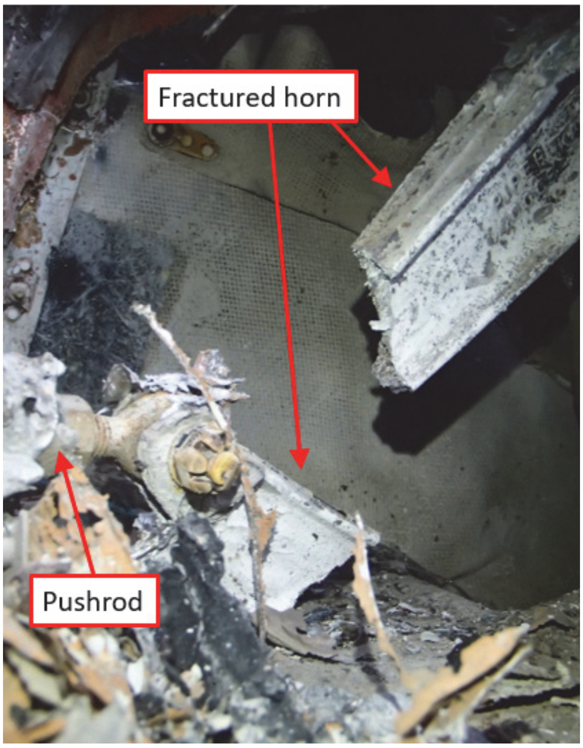

Figure 7

Fractured elevator horn as found at accident site

Both parts of the elevator horn had partially melted in the post-accident fire. The lower section of the horn was attached to the pushrod's aft rod-end and the upper section of the horn remained attached to the elevator torque tube. Both parts of the fractured horn were subjected to specialist metallurgical examination.

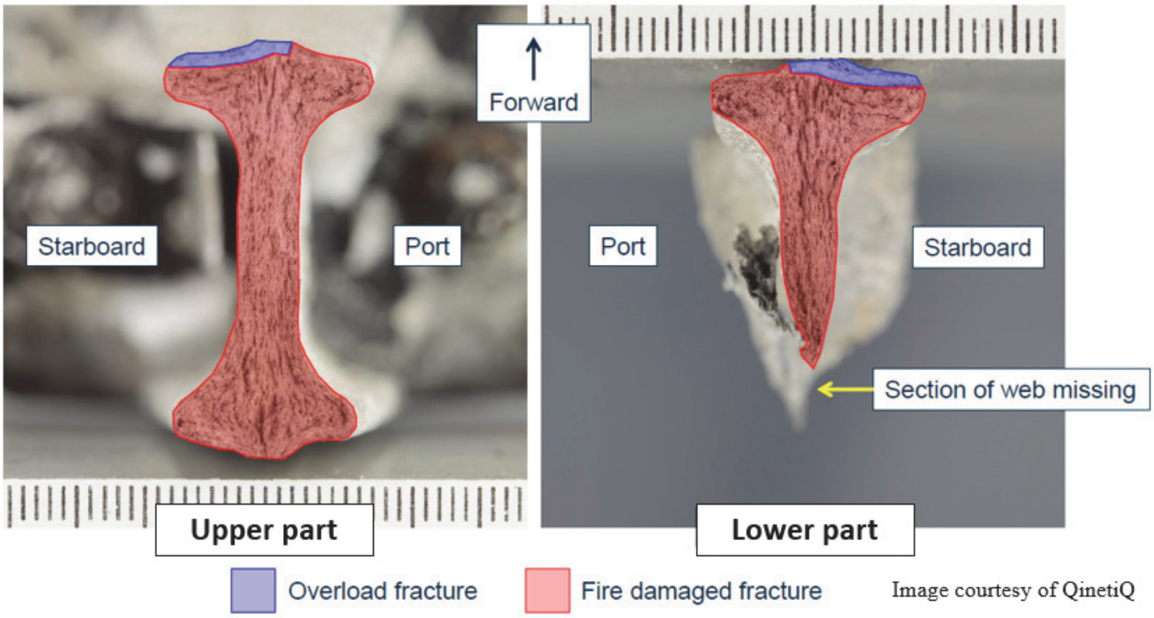

Figure 8

Fractographic assessment of elevator horn fracture surfaces

This examination revealed that most of the horn fracture surface exhibited features consistent with localised melting and fire damage (Figure 8). The fracture surface had a rough macro appearance, with the topography following the underlying grain microstructure of the material. No evidence of progressive crack growth, such as fatigue, was observed and no flat areas of fracture surface were evident that would be consistent with this type of crack growth.

A small area of non-fire damaged ductile overload, equating to 4% of the fracture surface, was visible at the forward section of the horn indicating that this area had separated after the post-accident fire had been extinguished. This may have occurred during disturbance of the wreckage during fire-fighting operations or due to wind blowing on the elevator after the accident.

The left and right elevator halves were correctly bolted to the elevator torque tube. The elevator assembly was free to rotate about its hinge line and had the required range of motion between the up and down control stops. There are six elevator hinges on the PA-31 elevator, three per elevator half; each hinge had the correct hardware installed.

Examination of the aircraft's other flying controls did not reveal any evidence of a pre-accident defect.

Elevator trim system

The elevator trim system cables were identified in the aircraft wreckage and found to be continuous from the elevator trim wheel in the cockpit to the elevator trim tab actuator in the right tailplane (Figure 9). Both adjustment turnbuckles within the elevator trim cable system were correctly assembled and wire-locked. The elevator trim cable was correctly wrapped around the pitch trim servo capstan and idler pulley assembly, and the pitch trim servo was securely attached to the airframe within its mounting bracket. Fire damage prevented any electrical wiring or functional checks of the pitch trim servo.

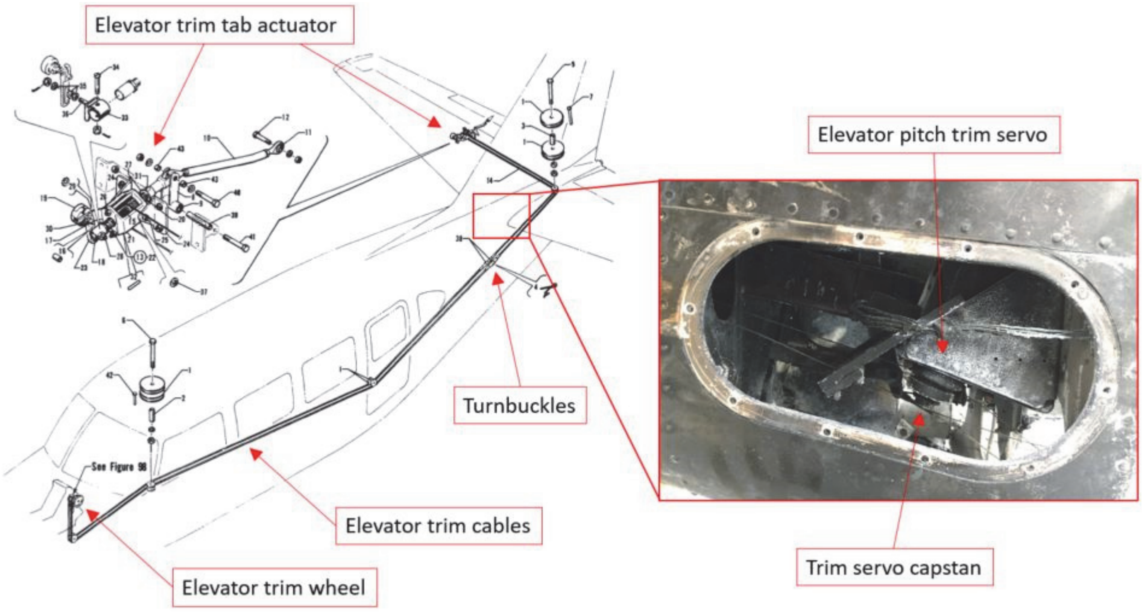

Figure 9
Elevator trim system

The elevator trim tab was functionally tested and was free to move between the extreme trailing edge up and down positions. The elevator trim tab position as observed at the accident site was 12.4° trailing edge up, with the elevator held in the neutral position[20]. The range of elevator trim tab deflection is 16° ±1° trailing edge up (providing nose-down pitch trim), and 29° ±1° trailing edge down (nose-up pitch trim), with the elevator in a neutral position (Figure 10). The elevator trim tab position as observed at the accident site was therefore close to, but not at, the full nose-down trim position.

Footnote

20 The elevator trim tab is geared to the elevator such that as the elevator rotates about its hinge line, the elevator trim tab rotates relative to the elevator. This gearing causes the elevator trim tab to also act as an anti-balance tab.

Maximum nose down trim, tab 16° up

Tab position as found, 12.4° up

Maximum nose up trim, tab 29° down

Figure 10

Elevator trim tab position as found at accident site, and range of movement

Autopilot

Damage sustained in the accident prevented functional testing of the aircraft's Bendix Altimatic V-1 autopilot system. The autopilot pitch servo was mechanically connected to the elevator bellcrank via a bridle cable assembly that was correctly wrapped and secured around the servo's capstan pulley. The pitch servo was internally examined using X-ray CT[21] imaging, which showed that the solenoid that engages the servo motor driving gear with the capstan pulley was in the de-energised position, with the driving gear disengaged from the capstan pulley. This is the normal configuration for the servo when electrical power is removed from the servo engage solenoid, and allows the servo capstan to rotate freely in response to pilot-commanded movement of the elevator when the autopilot is not engaged. The CT scans did not reveal any pre-accident related mechanical defect within the servo assembly.

The servo capstan features a friction plate clutch that allows the pilot to overpower the servo by application of force to the aircraft's control yoke. The capstan's internal friction clutch breakout torque level was tested with the assistance of the equipment's manufacturer. This test revealed that the clutch breakout torque level was 20 in.lbs, compared to the specified limit of 15 in.lbs ±1 in.lb. It is possible that heat damage to the capstan clutch sustained during the post-impact fire may have affected the breakout torque level. However, even if the breakout torque during the accident flight had been 20 in.lbs, this is unlikely to have affected the ability of the pilot to overpower the autopilot pitch servo, if the pitch servo had been engaged.

Engines

Due to accident damage, neither engine was in a condition to be functionally tested. Visual examination of both engines did not reveal any evidence of a pre-accident defect or mechanical failure that would have prevented normal engine operation.

Footnote

21 Computed Tomography is an X-ray scanning technique in which X-ray images are computer-processed to produce individual 'slice' images through an object.

Propellers

The right propeller had remained attached to the right engine and all three propeller blades were attached to the propeller hub. The left propeller had separated from the left engine during the accident and came to rest in the debris trail on the runway. All three left propeller blades remained attached to the hub. Both propellers exhibited significant blade bending, consistent with rotation under low power at impact.

The propellers were disassembled at an overhaul facility to permit internal examination of the blade pitch-change mechanisms. Internal witness marking on both propellers' pitch-change pre-load plates indicated that the propeller blade angle[22] of both propellers at impact was approximately 19°. The operational range of propeller blade angle varies between 82° in the feathered position through to 13° at the fully fine position. The propeller blade angle at impact was therefore within the operational range, and close to the fully fine position.

Other observations

The nose baggage compartment door was found within the debris trail with its latch securely fixed in the closed position, indicating that the baggage door was closed at impact. Due to the severity of the post-accident fire and its effect on the aircraft's flight instruments it was not possible to determine their pre-impact readings or condition. The fire damage also precluded identification of the cockpit-selected positions of the flaps and landing gear controls.

PA-31 flight trial

Results

The AAIB commissioned a flight trial using a representative PA-31, ballasted and fuelled to match as closely as practical the weight and balance of the accident aircraft. Trials were flown to explore its handling characteristics in the event of an elevator control jam. Measurements were made with a simple spring balance for the forces required to overcome autopilot operation or a trim runaway to provide some indicative control force information; it was not the purpose of the flight trial to assess the aircraft against airworthiness requirements.

The aircraft was shown to be controllable in all of the speed and configuration combinations used to simulate an elevator control jam. The test pilot reported that a strategy could be devised to manoeuvre the aircraft in pitch using the elevator trim tab. He considered this would be difficult and that it would "take some time to learn and practise this unusual control technique". He reported that the technique became more difficult with increasing airspeed. In one example, where the aircraft's landing gear and flap were retracted, the test pilot noted that "aggressive high gain use of the manual trim wheel" was required at 170 KIAS, but not at 130 KIAS.

Footnote

22 Propeller blade angles are measured at a station 30 inches from the root of the propeller blade.

The test aircraft's autopilot was representative of that fitted to the accident aircraft. It was "very difficult" to override the autopilot and the test pilot considered this might cause a problem if it could not be electrically disconnected following some form of runaway.

The simulated trim runaways resulted in high control forces, with the nose-up runaway resulting in such a high two-handed push force that the handling pilot could not maintain level flight without assistance. In the nose-down runaway case, the test pilot found he could control it on his own but considered that it would be very tiring. Reducing power, slowing down or applying flap would all result in an increased nose-down tendency. He considered it possible that this condition would allow a pilot to control the aircraft in a clean[23] high-speed transit for a few minutes, but not have sufficient strength to reduce power and flare the aircraft for landing.

Table 2 shows the measured yoke control forces for maintaining level flight at various indicated airspeeds in several configurations with full nose-down trim applied.

KIAS	Flaps	Gear	Trim Position	Force kgf
190	UP	UP	Full ND	18
170	UP	UP	Full ND	16
130	UP	UP	Full ND	20
125-130	UP	DOWN	Full ND	20+
125-130	DOWN	DOWN	Full ND	20+

Table 2

Yoke control force to maintain level flight with nose-down trim

Table 2 shows that control forces increased with reducing airspeed, and also with the deployment of landing gear and flaps.

Additional information

After the flight trial, the forces required to override the electrical trim actuation using the manual trim wheel were measured on the same aircraft. It took 2.1 kgf to resist the electrical trim, and 2.4 kgf to counter it.

Footnote

[23] Landing gear and flaps retracted.

Occurrences involving abnormal nose-down trim

AAIB report, VP-BJM: Serious Incident at West Sussex, 2005

The AAIB reported on a serious incident involving a Bombardier Challenger 604, VP-BJM, in which a failure of the stabiliser trim system resulted in almost fully nose-down trim[24]. Control of the aircraft required both pilots to apply prolonged aft pressure on the control column. The commander stated that great physical effort was required to fly the aircraft and commented that any increase in this effort, occasioned for example by the addition of flap, might have rendered control of the aircraft beyond the combined capability of the crew. Therefore, the commander elected to land with flap retracted, despite the aircraft's QRH specifying the use of 20° flap in such a condition. The destination runway at Farnborough was not long enough for this so the commander declared a PAN and requested a diversion to Stansted. However, around 6 min later, concerned about the physical effort required to fly the aircraft manually, the commander decided to divert to Heathrow, which was closer, and declared a MAYDAY.

The crew attempted to fly a stabilised flapless approach at a target airspeed of approximately 160 KIAS, considerably faster than required for a normal approach with flap. A successful landing was achieved by the coordinated efforts of the commander and co-pilot operating the primary flight controls, and a third off-duty employee closing the thrust levers on touch down. There were no injuries sustained during the event.

NTSB report, N996JR: Accident at Penn Cove, Washington, 2003

A single-pilot operated Cessna Citation 525, N996JR[25], experienced a loss of elevator trim control that resulted in an uncommanded nose-down pitch attitude. Although the pilot and a passenger seated in the co-pilot's seat both applied maximum back pressure on the control column, the attitude increased beyond 10° nose-down, the airspeed approached 263 KIAS, and the rate of descent reached approximately 2,000 fpm. The pilot stated that he could not safely remove either hand from the control column for more than several seconds at a time. He determined that he could not safely land the aircraft on a runway, so elected to land on the nearby water of Penn Cove, using landing flap, and with landing gear retracted. There were no fatalities.

This NTSB investigation concluded that it was likely that the force limits which had been defined in FAR 23.143 at the time of the accident were exceeded during the occurrence.

The subject aircraft type had no clear indications or warning for an electric elevator trim runaway (such as an aural or visual trim-in-motion warning), the accident pilot had only indirect indications[26] to assist in identifying the condition. These indications were insufficient to allow timely recognition of the problem. The report stated:

Footnote

24 AAIB Aircraft Accident report 1/2008 https://assets.publishing.service.gov.uk/media/5422f7b240f0b613460006eb/VP-BJM_2-2008.pdf (accessed on 18 September 2018).

25 NTSB Safety Recommendation A-07-52 through 54 https://www.ntsb.gov/safety/safety-recs/recletters/A07_52_54.pdf (accessed 9 October 2018)

26 For example, tactile indications of increasing pitch control force, and the continuous nose-down motion of the trim wheel or the elevator trim position indicator.

> *'Because the airplane is certified for single-pilot operation, it is critical to alert a pilot to a trim runaway condition before the associated control forces exceed what a single pilot can manage.'*

In this event, the only way the accident pilot could have arrested the pitch trim runaway would have been to pull the pitch trim circuit breaker – which was one of an array of identically sized, shaped and coloured circuit breakers. The report stated:

> *'…given the pilot's report of the control forces involved, it is unlikely that he would have been able to quickly locate and pull the appropriate circuit breaker while maintaining control of the airplane. In addition, during airplane simulator trials, Cessna's test pilot, flying as a single pilot, was unable to counteract the control forces from similar elevator trim runaway conditions while attempting to pull the pitch trim circuit breaker.*

[A footnote to the previous sentence states: *When a second pilot assisted with backpressure on the control column, the test pilot was able to locate and pull the pitch trim circuit breaker*.]

> *A pilot's rapid identification and disabling of the pitch trim circuit breaker is essential to effectively respond to the rapid increase and excessive magnitude of control forces during an elevator trim runaway in a Cessna Citation 525.'*

Research

The FAA performed studies of general aviation pilot responses to a number of autopilot malfunctions[27] in a fixed-base simulator configured as a Piper Malibu, with a Bendix/King KFC-150 autopilot.

In considering factors which might lead to an autopilot-related accident, the paper stated:

> *'The tempering factors, one would expect, would be that a prudent pilot generally would learn everything possible about the airplane to be flown, particularly if it were owned or regularly flown by the pilot… This is often not the case, however…*
>
> *…In the case of general aviation, it is likely that many pilots will not have experienced autopilot failures prior to their first need to respond to one as pilot in command.'*

The paper cited two accidents where the elevator trim was found in the full nose-down position. In one of those, it was determined that 45 lb (20.4 kg) force would have been required to maintain level flight.

Footnote

27 http://www.dtic.mil/dtic/tr/fulltext/u2/a340243.pdf (accessed 9 Oct 2018).

When describing the design of the studies, the author(s) stated:

> *'It was recognised that the most hazardous malfunction, in terms of its ability to place the aircraft in a configuration from which it might be difficult to recover, was the runaway pitch-trim-down failure…'*

The study showed that in the case of nose-down pitch trim runaway, the average time for initial action was 12.2 seconds, and the average lag thereafter to pulling the pitch trim circuit breaker was 36.4 seconds (and ranged from 3.6 to 160.0 seconds). Therefore, the average time to recognise and correct the malfunction was 48.6 seconds. Thirteen of the twenty four participants encountered 'flight-terminating circumstances'[28].

In the *'Post-test Questionnaire/Interview'* section, the paper stated:

> *'When asked to report on the difficulty or ease of diagnosing and recovering from autopilot failures experienced during their experimental session, our subjects unanimously agreed that runaway pitch trim was the most difficult from which to recover.'*

Analysis

Introduction

The pilot reported "WE ARE HAVING SOME PITCH CONTROL PROBLEMS EH WITH THE ELEVATOR" and "I AM GOING TO DIVERT TO CAERNARFON". Evidently, he was having a problem controlling the aircraft in pitch. No further information was received by air traffic control about the symptoms of the problem or his attempts to diagnose it. This could indicate that he was having to prioritise dealing with a possible malfunction, rather than communicating the nature of it.

He had already flown over much of the mountainous terrain on his intended route, and Runway 25 at Caernarfon was almost directly ahead. Given that he was familiar with the aerodrome, it may have seemed an attractive option for a diversion.

Estimates using radar and CCTV information suggests that the aircraft's airspeed had increased from around 165 KIAS when the pitch control problem was reported to around 190 KIAS when the aircraft struck the ground. It is possible that a technical condition was necessitating a high airspeed.

The radar data indicates that, after reporting pitch control problems to London Information, the pilot turned the aircraft directly towards Runway 25 at Caernarfon and flew there without delay. The airport was closed. The aircraft's airspeed was about 95 kt above the normal approach speed, and considerably above the limiting speed for landing gear and flaps, both of which remained retracted. This indicates either that the pilot did not intend to land or that he was having difficulty controlling the aircraft.

Footnote

[28] The simulator was frozen when high descent rates persisted within 100 ft of the ground or overspeed conditions were attained.

The extensive fire damage to the wreckage and the limited recorded information made it difficult to determine the cause of this accident with a high level of confidence.

The elevator trim tab was found close to, but not at, the full nose-down trim position. This is not a normal position for an approach and landing, and it would have caused the pilot considerable difficulty in controlling the aircraft due to the large control forces. The nose-down forces would have tended to increase as the aircraft slowed down, and with the application of flaps and landing gear.

Eyewitness accounts were consistent with the aircraft approaching the runway at high speed, and making a high-pitched noise, as though the propellers were operating at a high rpm as the aircraft passed them. Whilst they also described the aircraft as being lower than usual, the recorded data showed that the average descent profile was significantly steeper than would normally be expected. The impact damage to the propeller blades indicated that at the point the aircraft struck the runway it had some, but not full, power applied. This could indicate that the pilot reduced power prior to landing.

Engineering

A detailed examination of the aircraft's elevator controls did not identify any technical problem that could have accounted for a loss of elevator control during the accident flight.

The fracture damage observed on the broken elevator horn was most probably sustained when the aircraft initially struck the runway as, had the horn fractured during flight, the small area of unburned ductile overload would not have sufficient strength alone to remain intact during the accident sequence.

The autopilot pitch servo was recovered from the wreckage. The clutch functioned when tested, and the breakout torque was sufficiently low that it would not have impeded the pilot overcoming the autopilot pitch servo in the event that the pilot was not able to disconnect the autopilot. It was concluded that the autopilot pitch servo was not a factor in this accident.

The elevator trim tab was found close to, but not at, the full nose-down trim position. Impact and fire damage prevented any electrical and functional checks on the aircraft's pitch trim system and therefore it was not possible to identify a cause for a possible pitch trim runaway.

No other defects were noted with the aircraft's flying controls, engines or propellers, and both engines were running at the same speed and producing power when the accident occurred. The flaps and landing gear were both in their retracted positions. Due to the severity of the post-accident fire, it was not possible to determine whether either had been selected DOWN by the pilot and they had not responded, or whether the retracted positions were those intended by the pilot in response to the pitch control problems he reported.

Control jam discussion

It was not possible to exclude the possibility of a control jam, the evidence for which could have been lost during the impact sequence or post-accident fire. If an elevator control jam was to occur whilst flying approximately level, it would not initially alter the attitude and behaviour of the aircraft to a significant extent. Furthermore, flight trials showed that in the event of a jam that did not change[29] the test aircraft was controllable. The test pilot described the strategy for manoeuvring the aircraft in pitch as being difficult and unusual, and requiring time to learn and practice. There was no evidence of the accident pilot taking time to do that and, since that technique was shown to be more difficult at higher airspeeds, it would not have prevented him from slowing the aircraft down. Therefore, in the event of an elevator control jam that did not change, and considering that the aircraft should have been controllable, then there was no obvious reason for the pilot not to slow the aircraft down, and to divert with such urgency. It was therefore concluded that an elevator control jam was unlikely.

Autopilot override

The force required to override an autopilot once a large out-of-trim condition in pitch has developed was measured during the flight trial. The test pilot reported that he had found it very difficult to override the autopilot and considered that this might cause a problem if it could not be electrically disconnected following some form of runaway. Anecdotal information suggested that the pilot was likely to have flown the aircraft manually. Therefore, a problem with overriding or disengaging the autopilot did not appear to account for the flight profile of the accident aircraft.

Trim runaway

The elevator trim tab was found in an almost fully nose-down trim position. The flight path of the aircraft was consistent with an aircraft experiencing a significant nose-down trim.

In the flight trial, 16 to 20+ kgf was required to fly the aircraft straight and level with full nose-down trim, which is a significant control force to apply for a period of around five minutes. The test pilot during the flight trial reported that at high speed and with landing gear and flap retracted he found it possible, though tiring, to control the aircraft with the elevator trim tab in the full nose-down position. He reported that reducing power, slowing down or applying flap would all have increased the nose-down tendency, and a pilot might not have sufficient strength to reduce power and flare the aircraft for landing. Moreover, the forces required to flare the aircraft from such an unstable approach would most likely have exceeded those measured in the flight trial for straight and level flight. If the pilot had used one hand to reduce power, then controlling the aircraft, particularly during the flare, would have been more difficult. Additionally, judging the height at which to flare, and the strength required to do so, would most likely have been outside the pilot's training and experience.

Footnote

[29] The flight test aircraft was tested with a jam in a fixed position, and not a jam that became progressively more nose down.

The flight trial demonstrated that it was possible to override the electric trim actuation using the manual trim wheel. The almost fully nose-down position of the trim tab could suggest that the pilot had been doing this prior to the landing manoeuvre. If he had removed his hand from the manual trim wheel in order to reduce power and flare the aircraft for landing, an electric trim runaway condition would have driven the trim back towards the nose-down position.

Trim runaway safety discussion

It was not possible to determine the reason for the nose-down position of the elevator trim tab. However, the final flight path of N250AC was consistent with other occurrences in which a malfunction resulted in significant nose-down trim, and with the findings of the flight trial.

Overview

The FAA research paper indicated that general aviation pilots are often not fully aware of the systems onboard the aircraft they fly, and that they may not experience autopilot failures prior to their first need to respond to one as pilot in command. The FAA studies, previous events and the findings from this investigation have shown that, due to possible high control forces, trim runaway can be a difficult condition from which to recover.

Prompt recognition and response

The FAA study showed that, in a simulator, it took pilots 48.6 seconds to recover from the trim runaway nose-down case. The flight trial and the serious incident involving VP-BJM indicated that the longer time spent in this failure condition, the more tiring it becomes for the crew. Therefore, prompt and effective recognition and response during a trim runaway is likely to reduce the potential handling difficulties.

N250AC was fitted with a trim warning light to assist with recognition of a runaway pitch trim. However, this was located on the lower half of the instrument panel and was probably not tested regularly as part of the pre-flight procedures. There was no accompanying aural alert and, in the event of a trim runaway, other indications would have been indirect. In that case, it is possible that the condition could take time to diagnose.

Similar to that described in the N996JR accident report, the procedure for responding to a malfunction of the electric trim system was to pull the electric trim circuit breaker. In N250AC this was located in the lower portion of the circuit breaker panel, which was beside the pilot's left knee. Fire damage to the panel meant that it could not be determined whether any circuit breakers had been opened. The flight trial and other previous events have indicated that the forces associated with a trim runaway can be such that a single-pilot, in particular, could have difficulty flying the aircraft whilst attempting to locate and pull a circuit breaker.

The flight trial indicated that electric trim operation could be overridden by use of the manual trim control wheel on the PA-31.

Pre-flight procedures

The pre-flight procedures for the autopilot and trim systems were contained in a supplement within N250AC's Flight Manual, and these were not referenced in the 'normal operating procedure' pre-flight checklists. Anecdotal evidence indicated that the pre-flight procedures for those systems had not been carried out regularly on N250AC.

Pilot knowledge and awareness of trim runaway – safety message

The FAA research, other previous events, and findings from this investigation, indicate that a pilot's familiarity with the autopilot and trim system could reduce the time to recognise and effectively respond to a potentially hazardous trim runaway condition. This could include, for each aircraft type to be flown:

- System knowledge of the electric trim and autopilot, and the associated normal and abnormal operating procedures
- Carrying out the relevant pre-flight checklists for the autopilot and trim systems – being aware that they may be separate to the main pre-flight procedures
- Awareness of the indications of a trim runaway – remembering that the indications may not be 'direct'
- Appreciation of the significance of the control forces which may be required to control the aircraft in the event of a trim runaway, particularly for a single pilot
- Awareness of the corrective actions for a trim runaway – for example, how to locate and open the appropriate circuit breaker, and other possible ways to override or disable the system.

Conclusion

After reporting pitch control problems, N250AC made a direct diversion with a significantly unstable approach, in a clean configuration, to Runway 25 at Caernarfon Airport.

The elevator trim was found in a nose-down position and, whilst the reason for this could not be determined, it is likely that it caused the pilot considerable difficulty in controlling the aircraft. The aircraft struck Runway 25 at Caernarfon Airport, with landing gear and flaps retracted, at high speed, and with no noticeable flare manoeuvre.

The extensive fire damage to the wreckage and the limited recorded information made it difficult to determine the cause of this accident with a high level of confidence. It is possible there was a nose-down trim runaway that the pilot was unable to stop.

Safety actions

As a result of this investigation the EASA have undertaken action to promote awareness of trim runaways as part of its General Aviation safety promotion plan. It also intends to include trim runaway as part of a wider technical safety project, studying various technical failure scenarios. Also, as a result of this investigation the CAA plans to produce a coordinated package of educational information on trim runaway, including a video, Clued Up article and online information which will be targeted at GA pilots.

Both authorities have indicated that they intend to work together on the subject for a coordinated approach and to ensure a broad reach.