Air Accidents Investigation Branch

AAIB Bulletin 3/2019

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This bulletin contains facts which have been determined up to the time of compilation.

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(ALL TIMES IN THIS BULLETIN ARE UTC)

AAIB Field Investigation Reports

A Field Investigation is an independent investigation in which AAIB investigators collect, record and analyse evidence.

The process may include, attending the scene of the accident or serious incident; interviewing witnesses; reviewing documents, procedures and practices; examining aircraft wreckage or components; and analysing recorded data.

The investigation, which can take a number of months to complete, will conclude with a published report.

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.

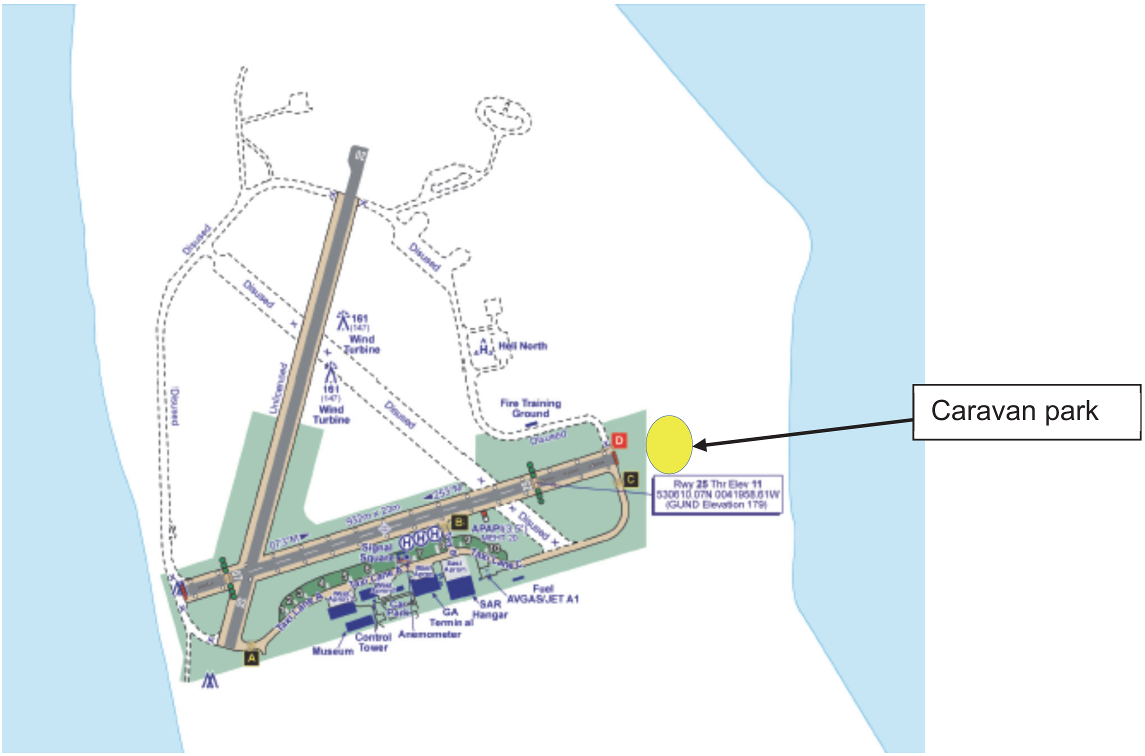


Figure 1

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.

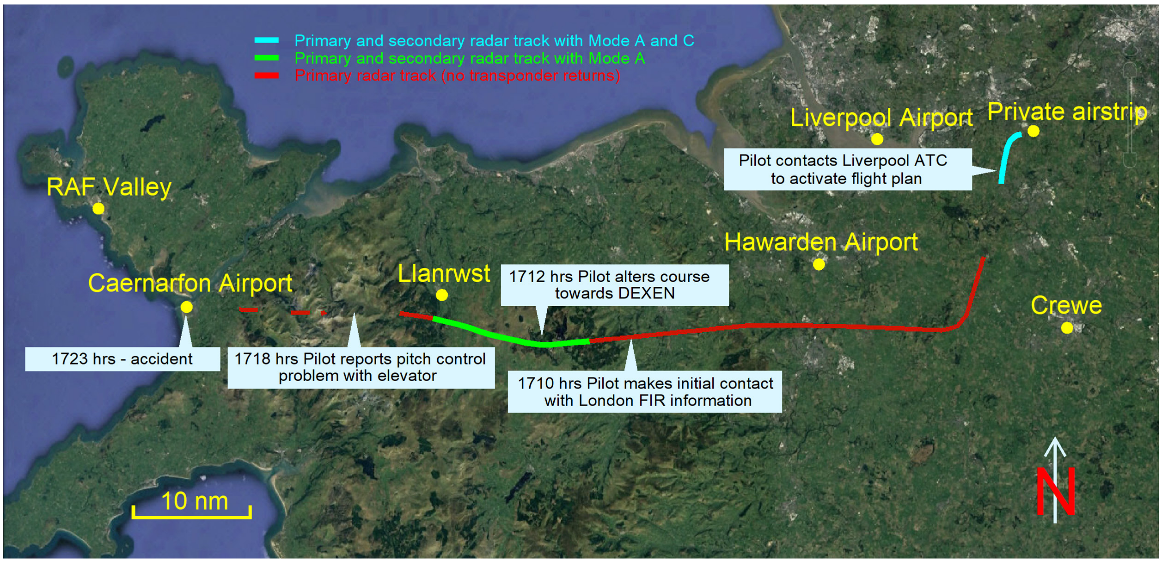


Figure 2

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.

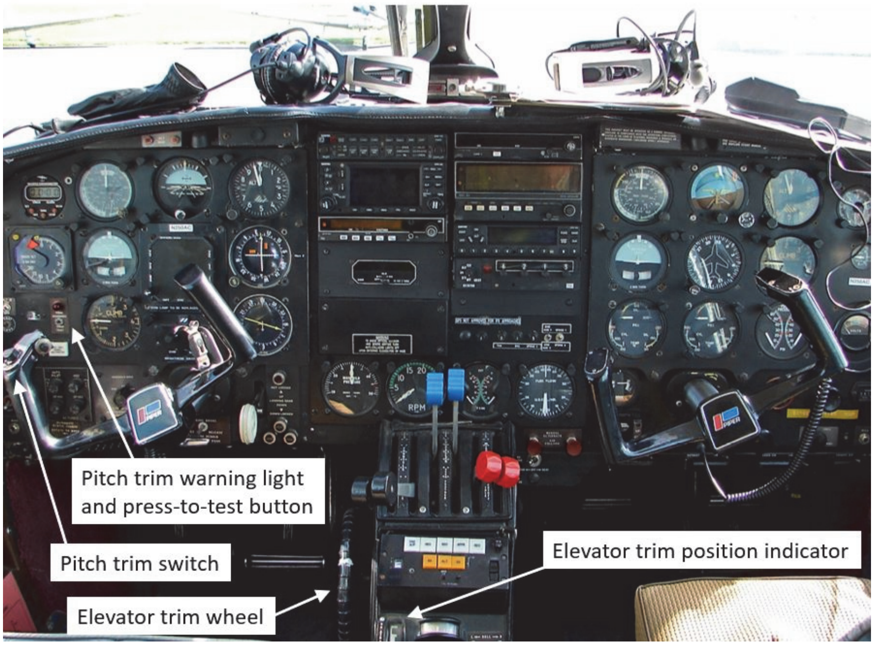


Figure 3

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.

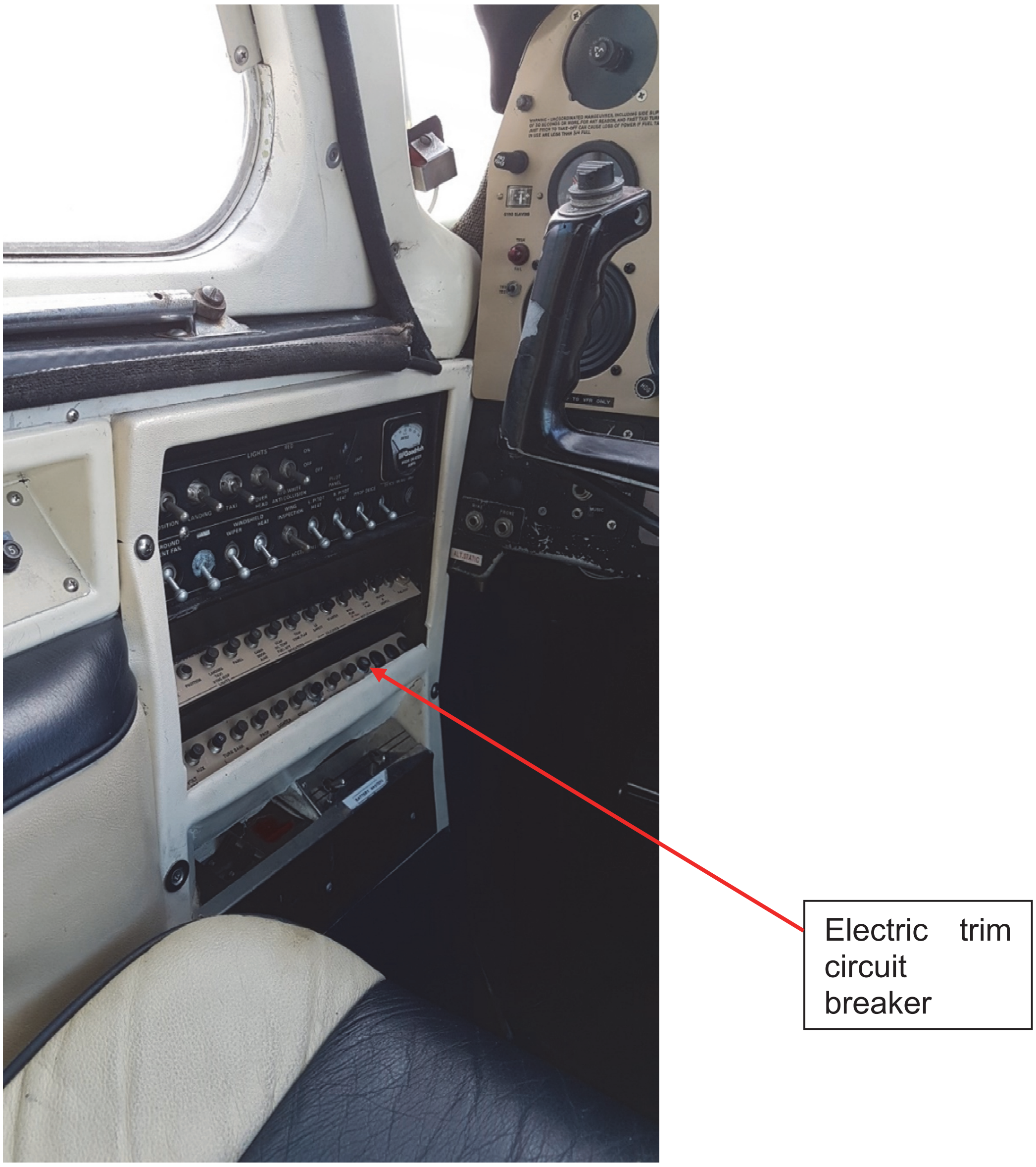


Figure 4

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.

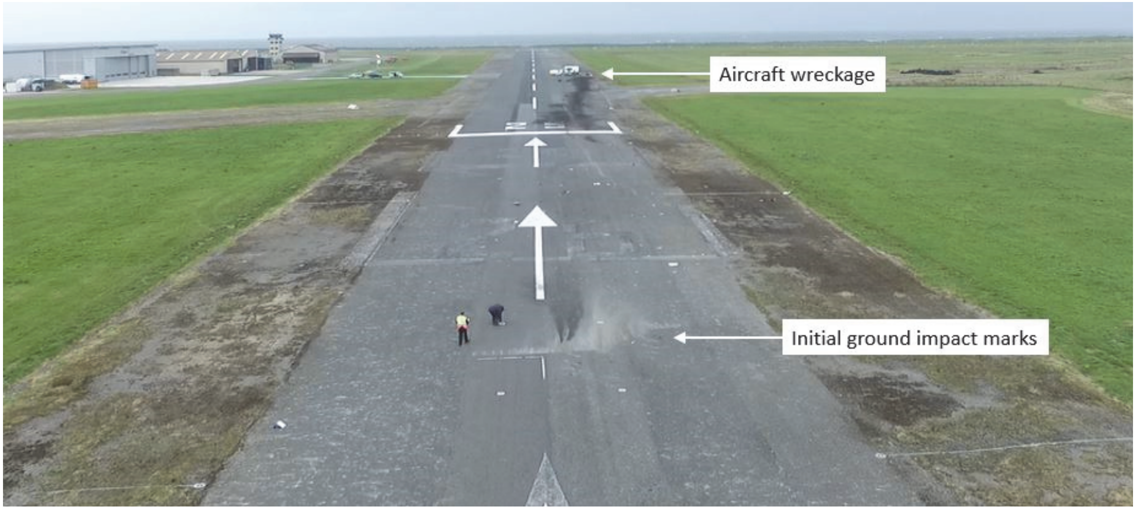


Figure 5
Accident site (image courtesy of North Wales Police)

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.

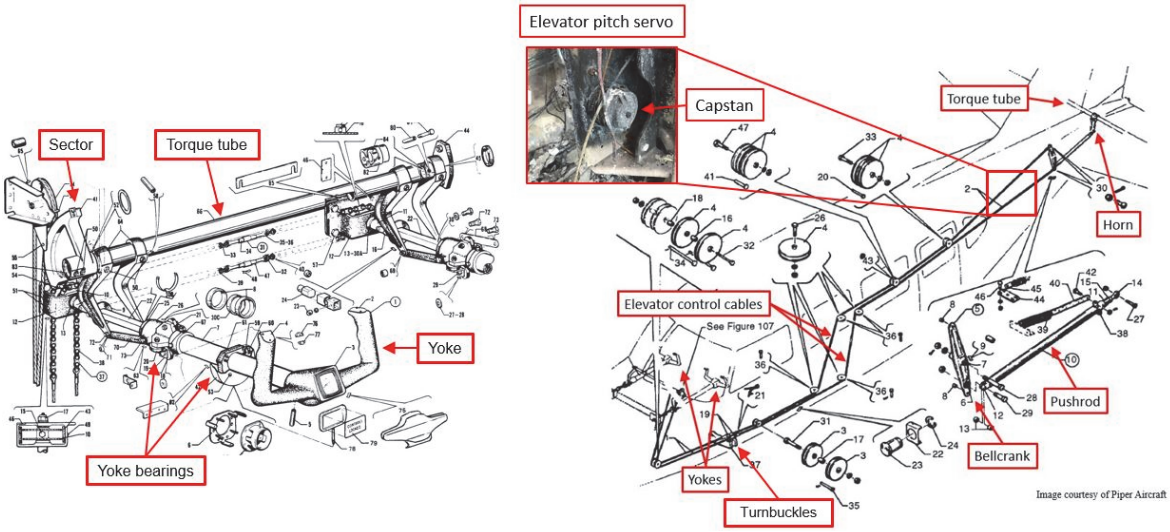


Figure 6

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).

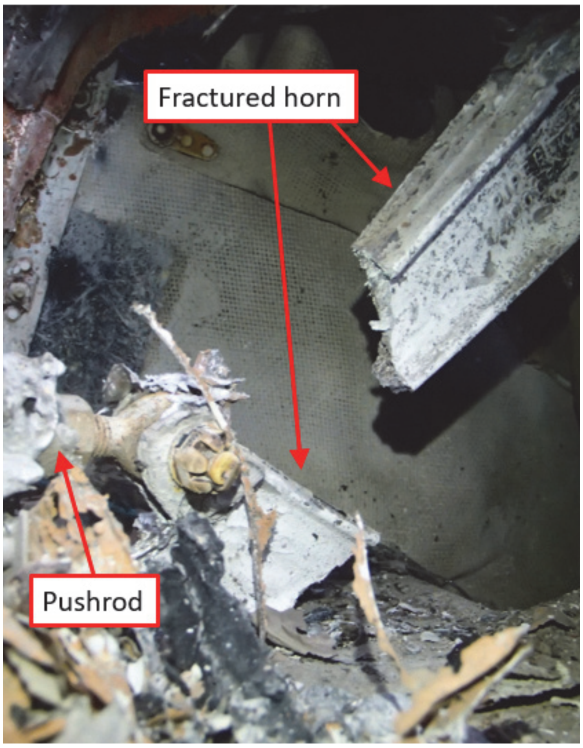


Figure 7

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.

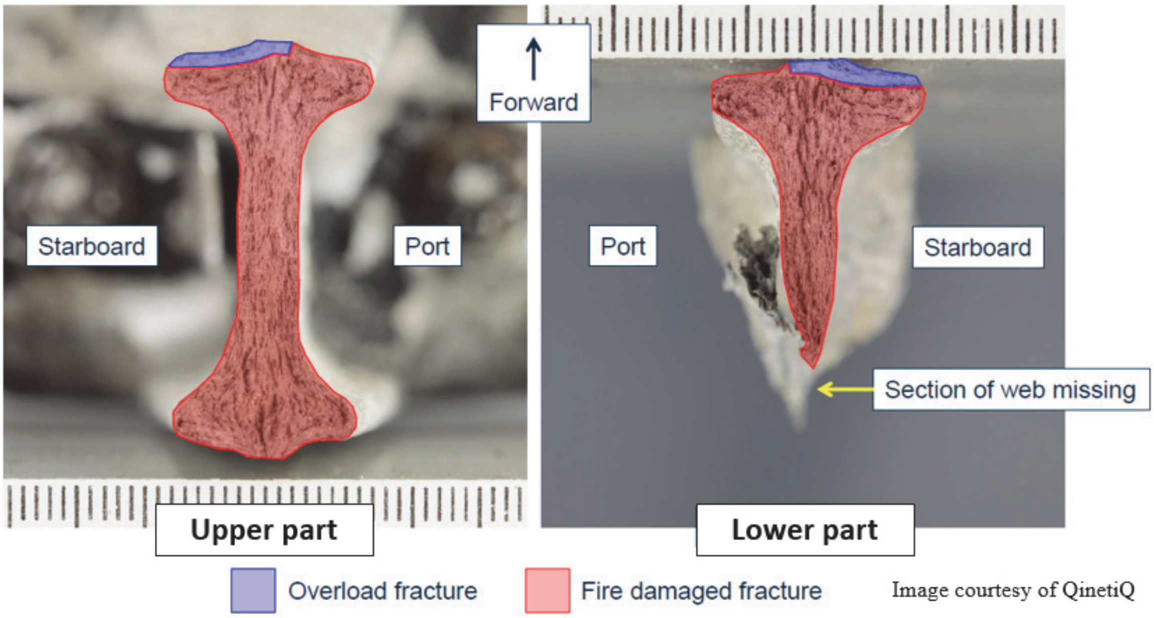


Figure 8

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.

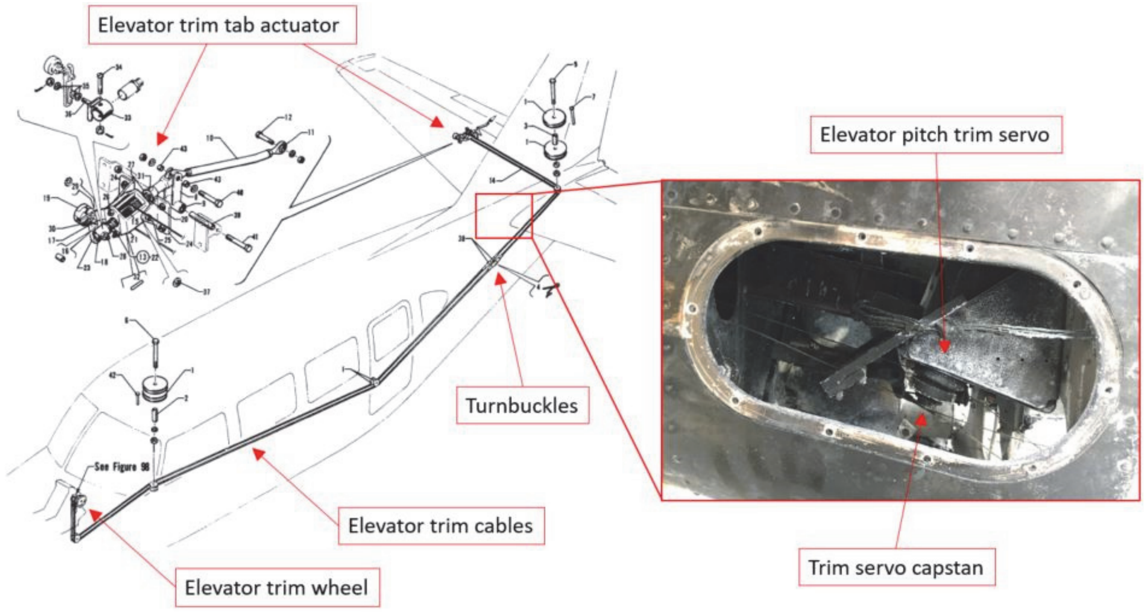


Figure 9

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.

ACCIDENT

Aircraft Type and Registration:	Auster AOP.9, G-BXON	
No & Type of Engines:	1 Bombardier Cirrus 20801 piston engine	
Year of Manufacture:	1955 (Serial no: AUS/10/60)	
Date & Time (UTC):	18 June 2017 at 1135 hrs	
Location:	Spanhoe Airfield, Northamptonshire	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - 1
Injuries:	Crew - 1 (Fatal)	Passengers - 1 (Serious)
Nature of Damage:	Aircraft destroyed	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	49 years	
Commander's Flying Experience:	409 hours (of which 0.5 hours were on type) Last 90 days - 2.0 hours Last 28 days - 0.5 hours	
Information Source:	AAIB Field Investigation	

Synopsis

The pilot was undertaking his second flight on the recently-restored vintage ex-military aircraft. Shortly after taking off from Spanhoe Airfield, the aircraft was observed to bank left into a steep descent and strike the ground to the left of the runway. The pilot was fatally injured, and the passenger sustained serious injuries. The investigation determined that the aircraft stalled at a low height, from which it did not recover before striking the ground. The investigation also identified several issues relating to the aircraft and engine performance, maintenance documentation, the Permit to Fly application process, and guidance for pilots preparing for their first flight on a new type. The Light Aircraft Association (LAA) has taken a number of safety actions. No Safety Recommendations are made.

History of the flight

G-BXON had recently been rebuilt and restored at Spanhoe Airfield. Its first Permit to Fly was issued by the Civil Aviation Authority (CAA) on 2 June 2017 and the LAA sent it to the pilot on 6 June 2017. The pilot, who was also the owner, flew the aircraft for the first time the day before the accident, accompanied by another pilot.

On the accident flight, the pilot took off from Spanhoe's Runway 27 at around 1130 hrs with a passenger. The pilot occupied the left seat, and the passenger was in the right.

A number of bystanders who were near the open entrance of a hangar watched the aircraft takeoff until it was obscured from view. Shortly after, on hearing a bang, and realising that the engine noise had ceased, they went outside to find a column of smoke rising from the field left of the departure end of the runway. One person phoned the emergency services and some of the group immediately went to the accident site, where the aircraft was found to be on fire. One of this group discharged a hand-held fire extinguisher however this had no effect due to the intensity of the fire. The pilot, who was still inside, was fatally injured. The passenger had sustained serious injuries and was found near the aircraft.

A horse rider had stopped at a position around 430 m from the end of the runway to watch the aircraft depart. She stated that the takeoff initially seemed normal but, soon after, the aircraft rocked slightly; first right then left. There was a short pause before the aircraft rolled left into a steep descent and struck the ground to the left of the runway. The engine noise sounded constant up until the impact. Figure 1 shows the location of the various witnesses.

Airfield information

Spanhoe is an unlicensed former World War II airfield in Northamptonshire, at an elevation of 340 ft amsl. It is situated 6 nm south-west of RAF Wittering, and within its Military Aerodrome Traffic Zone. It has a 700 m runway aligned 090° and 270° which is mainly concrete, and a 500 m grass runway aligned 140° and 320°.

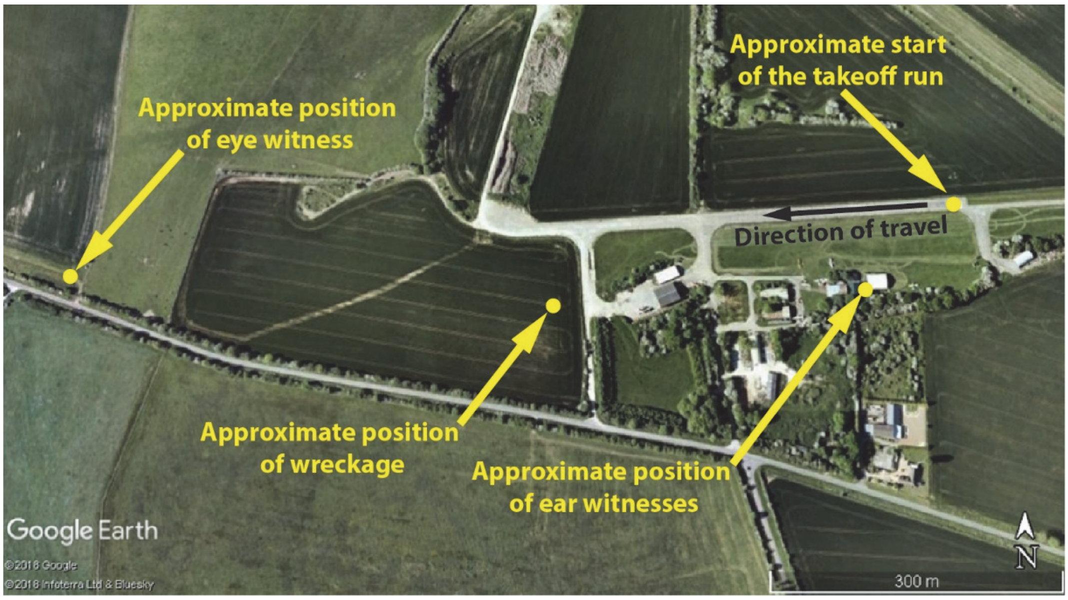


Figure 1

Spanhoe Airfield and location of witnesses

Flight on the previous day

The pilot's first flight on the aircraft departed from Spanhoe's Runway 27 at approximately 1600 hrs on 17 June 2017. He was accompanied by a pilot who had AOP.9 experience, hereinafter referred to as 'Pilot B'. The pilot acted as commander from the left seat. Pilot B occupied the right seat as a passenger, albeit acting in a supportive capacity.

Pilot B reported that takeoff flaps were used for the departure, and that the pilot accurately flew a climb speed of 60 KIAS. The pilot had asked him to monitor the takeoff engine rpm, which he recalled as being approximately 2,300 rpm. Pilot B recalled that the rate of climb (ROC) was relatively low although he was not concerned about it. The pilot raised the flaps at approximately 450 ft agl and turned left downwind. They left the circuit briefly to fly some steep turns and then landed back on Runway 27. The pilot's logbook recorded a 30 min chock-to-chock time.

Pilot B stated that he had been impressed by the pilot's professionalism during the flight. He recalled commending the pilot on his precise speed control and suggesting that he may also benefit from 'feeling' how the aircraft is performing.

Meteorology

Aftercast information provided by the Met Office indicated that, during the weekend of the accident, there was high pressure across the UK and conditions were very warm.

The weather at RAF Wittering around the time of G-BXON's first flight and the accident flight was reported as follows:

> 17 June 2017 at 1550 hrs: wind from 260° at 7 kt, visibility greater than 10 km, scattered cloud at 4200 ft, temperature 29°C and QNH 1024 hPa.
>
> 18 June 2017 at 1150 hrs: wind from 240° at 7 kt, visibility greater than 10 km, no cloud, temperature 28°C and QNH 1023 hPa.

These conditions resulted in density altitudes[1] (DA) at Spanhoe of approximately 1,930 ft and 1,840 ft[2] for the penultimate and accident flights respectively.

Recorded information

Accident flight

No recorded data was recovered from the aircraft and the aircraft was below radar coverage.

Flight on the previous day

The takeoff and landing at Spanhoe on the day before the accident were videoed by a bystander at the airfield; the recording indicated an airborne time of approximately 10 minutes. The audio and images from the takeoff video were analysed to calculate the aircraft's groundspeed and to review the climb performance, engine speed and flap settings.

The windsock was visible in the takeoff video and indicated a light, varying headwind. Based on RAF Wittering's weather report at that time, a 7 kt wind correction was added to the

Footnote

1 Density altitude: Pressure altitude corrected for variations from standard temperature. As density altitude increases, an aircraft's performance reduces, and vice versa.

2 DA values throughout this report have been corrected for humidity.

aircraft's calculated groundspeed to derive its approximate true airspeed (TAS)[3]. However, there are limitations to the accuracy of the calculated groundspeed, and the derived TAS, as the wind speed correction applied for the latter was based on the reported wind conditions at an airfield 6 nm away.

The takeoff occurred at 1557 hrs. Audio analysis indicates that, as the aircraft passed the camera position during the takeoff roll, the engine speed was 2,300 rpm ±50 rpm and there was no significant variation subsequently. The video images show approximately 17° ± 2.5° of flap, consistent with a takeoff flap setting; no flap asymmetry was evident.

As derived from the video images, the aircraft lifted off with a true airspeed of approximately 56 KTAS. It climbed away at approximately 57 to 60 KTAS, with a ROC of approximately 500 ft/min.

After the aircraft climbed through about 70 ft aal, it was no longer possible to extract useful data from the imagery. On the accident flight the following day the aircraft travelled approximately 80 m further along the runway from this point before departing from controlled flight.

Personnel information

Pilot

The pilot held an EASA Private Pilot's Licence (PPL(A)) and his logbook provided evidence that he had gained appropriate training[4] and experience in operating taildragger[5] aircraft. It showed a total of 409 flying hours, including 217 hours on taildragger aircraft. Prior to flying G-BXON on 17 June 2017, the pilot had logged two flights[6] in the preceding 90 days. He had no recorded hours on any Auster type, but a significant proportion was on other high-winged taildragger aircraft.

Spanhoe had a close-knit community and witnesses reported that the accident pilot was eager, though somewhat apprehensive, to fly his newly-restored aircraft. Anecdotal evidence indicated that he had been very focussed on G-BXON's rebuild. It was not determined to what extent he had prepared himself on the AOP.9's specific handling characteristics but another AOP.9 owner reported that the pilot had often accompanied him as a passenger in his aircraft and, on those occasions, they did talk about handling matters. That aircraft was not fitted with dual controls.

The pilot was described as being cautious and as someone who would 'fly by the numbers', tending not to deviate from target figures.

Footnote

3 TAS is the speed of the aircraft through the air, whilst indicated airspeed (IAS) (presented on the airspeed indicator (ASI)) is a measurement of dynamic pressure entering the aircraft's pitot tube. TAS is usually higher than IAS and at low altitudes the difference is insignificant.

4 Starting in 2003, the pilot had flown a number of hours in a Pitts S2A tailwheel aircraft with instructors, which he referred to as a '*conversion*'. There was no instructor's signature present in the pilot's logbook relating to completion of tailwheel differences training, but this may have been due to an administrative oversight.

5 Aircraft with a tailwheel or tailskid.

6 One of these was a Single Engine Piston (SEP) revalidation training flight involving more than one takeoff and landing.

Pilot B

Pilot B was an experienced naval and airline pilot who had owned a number of light aircraft including, previously, an AOP.9. He had 20 hours 35 minutes of flight time in the AOP.9, and his last flight in one was in G-BXON the day before the accident.

Passenger

The passenger on the accident flight was a friend of the pilot. He had automotive engine experience and had assisted with some aspects of the work on G-BXON's engine during its restoration. He was not a qualified pilot.

LAA inspector and testing pilot

The pilot had engaged the services of an LAA inspector to assist with and oversee the completion of G-BXON's rebuild, and the application for its Permit to Fly. The inspector held LAA approvals to sign off aircraft build projects, final inspections before first flight, aircraft maintenance and permit renewal recommendations. Although not required for the maintenance and inspection of LAA aircraft, he was also a Licensed Aircraft Maintenance Engineer (LAME) and owned an aircraft maintenance organisation based at Spanhoe. He also held valid EASA Part 66 and BCAR Section L licences and an ELA-1 authorisation, which allowed him to make recommendations to the CAA for issue/renewal of an aircraft Certificate of Airworthiness (CofA).

This individual was also a former flying instructor and had particular Auster expertise, having previously owned and overseen the rebuild of a number of AOP.9s. He had conducted all the test flying on G-BXON. Previously, he had performed flight testing on other aircraft under the CAA process.

First flights on type

Amongst the LAA community, a pilot's first flight on type was colloquially referred to as a 'check-out' as they would tend to be accompanied by another pilot experienced on type. However, there was no requirement for this flight to be instructional and, providing that a pilot and an aircraft were compliant with the necessary licencing and certification requirements, then a pilot new-to-type could act as commander and carry passengers.

There was an informal expectation at Spanhoe that the pilot would fly G-BXON for the first time alongside its LAA inspector and testing pilot, or another AOP.9 owner with recent experience on type. These individuals had limited availability over the accident weekend. Pilot B reported that the accident pilot approached him shortly before 1600 hrs on 17 June 2017 requesting he accompany him on his first flight.

Description of the aircraft

The Auster AOP.9 is a high-wing, strut-braced tailwheel aircraft with three seats, originally designed for military airborne reconnaissance. The fuselage is constructed of welded steel tubes covered with a doped fabric. The wings are fabric-covered, with the exception of the metallic leading edge and the tail unit is of all-metal construction.

The AOP.9 is powered by a Bombardier Cirrus 20801 inverted in-line engine, driving a two-blade, fixed-pitch metal propeller. Fuel is carried in flexible tanks located in the left and right wing roots and is gravity-fed to a collector tank. An electrically-driven fuel booster pump in the collector tank feeds fuel to two mechanical engine-driven pumps and then to a fuel injection pump, from which a metered quantity of fuel is delivered directly into the engine cylinders via fuel injection nozzles.

The flying controls[7] are conventional with control surfaces operated by push-pull rods, cables and chains. The aircraft is equipped with hydraulically-operated split flaps, actuated by a handpump and an UP/DOWN selector lever centrally mounted on the cabin roof structure. The flaps may be lowered to any intermediate position; the takeoff position is reached when the lower surface of the flap is in line with a yellow mark painted on the aileron hinge bracket.

The ailerons are linked to the flaps via a cam and cam follower, so that when the flaps are lowered, the ailerons droop up to a maximum of 10°, thereby increasing the effective flap area. At the takeoff flap position, the cam profile changes sharply, so the aileron droop does not increase with further lowering of the flaps.

The AOP.9 features a retractable pitot probe; it can be extended or retracted on the ground by withdrawing a spring-loaded locking pin on the lower wing surface. In order to lock it in either position, the locking pin must be engaged in one of the two locating holes on the underside of the probe.

The AOP.9 is not equipped with an artificial stall warning device.

Accident site and wreckage information

The accident site was located in an area of standing crop, to the left of the end of Runway 27. Examination of the ground marks and wreckage distribution indicates a dynamic impact sequence, in which the left wingtip and pitot probe made first contact with the ground, dislodging the left wingtip fairing. The aircraft then cartwheeled with the propeller and engine striking the ground, followed by the right landing gear and right wingtip. The initial impact trail was on an approximate heading of 196° and the aircraft came to rest upright on an approximate heading of 287° (Figure 2).

Several propeller strikes were evident in the crop and two distinct propeller strikes on the ground exhibited yellow paint transfer from the propeller tips (Figure 3).

An intense post-impact fire had consumed the contents of the aircraft, the cockpit controls, instrument panel and the fabric covering of the fuselage and wings.

Both wings had detached from the fuselage mounting points as a result of the impact and fire damage but remained close to the fuselage. The right elevator had separated and was found close to the main wreckage. All three aircraft doors had detached during the impact. The engine was no longer attached to its mounting points and was lying on its side.

Footnote

[7] G-BXON was fitted with dual controls, which was an optional fit on the AOP.9.

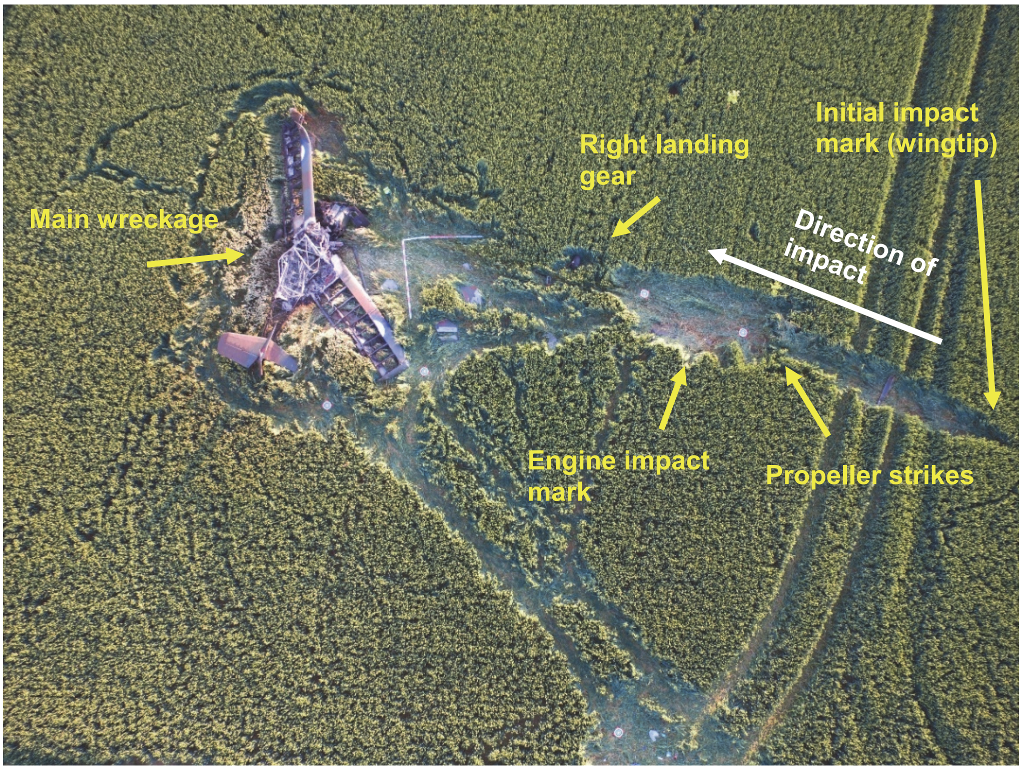


Figure 2

Aircraft wreckage and impact trail

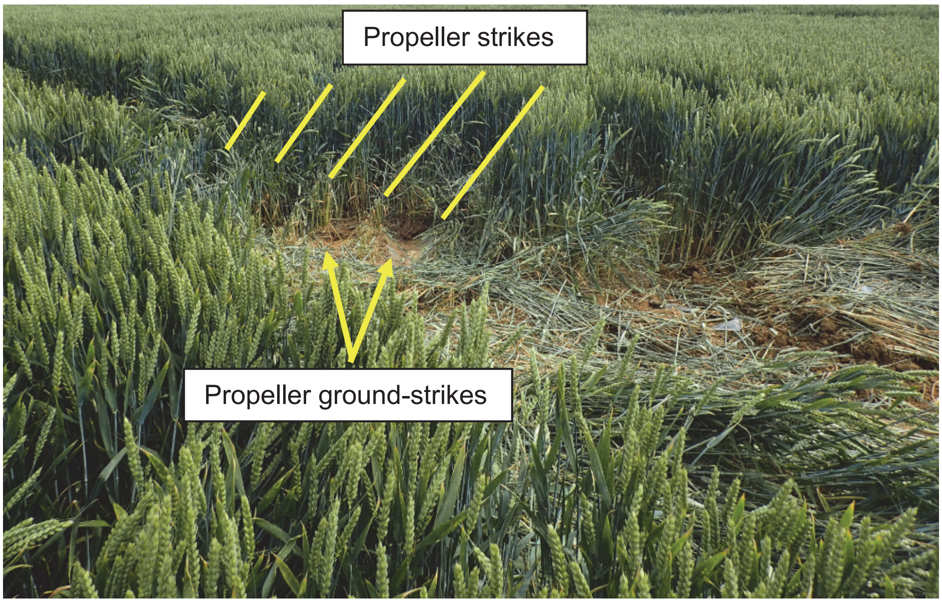


Figure 3

Propeller strikes

Detailed aircraft examination

General

The outer right wing leading edge exhibited damage consistent with striking the ground. With the exception of the metallic leading edge skin panels, all of the right wing structure inboard of the fuel tank boundary rib, including part of the flap, flap operating torque tube and aileron control run, was absent, having been consumed by the post-impact fire.

The outer left wing and wingtip displayed damage consistent with striking the ground and the wingtip rib was bent inwards by about 90°. All the wing structure in the inboard-most rib bay, including the part of the left flap surface and the inner portion of the flap operating torque tube had been consumed by the fire.

The pitot probe was filled with soil and bent upwards and outboard. It was found in a partially extended position and the locking pin was not engaged in either of the locating holes. Examination revealed that it was likely the pitot probe had been fully extended and impact forces displaced it towards the retracted position, overcoming the spring force of the locking pin. It was not possible to examine or test the remainder of the pitot/static system due to impact and fire damage.

Flying controls

The right elevator separated from the tailplane during the impact, however, all the cables and connections in the control runs for the elevator and rudder control systems remained intact. The elevator trim tab on the left elevator was found to be in the neutral position, however, the pre-impact trim setting could not be determined due to the extent of the disruption to the cockpit.

The right aileron outer attachment bolt mounted to the wingtip rib had pulled through its mounting due to impact forces, but the right aileron control circuit was otherwise intact. The left aileron outer attachment bolt had also pulled through its mounting and the cam follower for the aileron droop mechanism had dislodged from the cam due to impact forces. The left aileron control rod had separated at the joint between the rod and the forward end-fitting; the four rivets which held it in place had sheared.

The inboard end of the left flap torque tube was unrestrained, so it was not possible to make any determination of the flap position. The lower surface of the right flap was broadly aligned with the yellow indicator line on the aileron hinge bracket and witness marks indicated that it had been in the takeoff position at the time of impact.

Cockpit

The steel tubular structure of the cockpit remained largely intact, however the extensive fire damage meant that no meaningful information could be obtained from the instrument panel, instruments, flight controls or engine controls.

Each of the three aircraft seats was equipped with a four-point ‘ZA-type’ harness with a quick release fitting (QRF). It was not possible to assess the effectiveness of the restraint system on the occupied seats, as the harnesses had been entirely consumed by the post-impact fire, but three QRFs were found within the aircraft wreckage. One QRF, assumed to be that from the left seat, was fire-damaged and still had all four buckles engaged. The release mechanism appeared to function freely, however the buckles did not release, most likely due to deformation sustained in the accident. A second QRF was discoloured due to heat but appeared otherwise undamaged; one shoulder buckle remained engaged and the others were released. A third QRF was found close to the observer's seat in the back of the aircraft; the two lap buckles were engaged but, due to the extent of the fire damage, the mechanism could not be operated.

Engine examination

General

The engine and its ancillary components were examined under the supervision of the AAIB, at a specialist engine maintenance facility experienced in working on vintage piston engines.

The propeller, spinner and No.1 cylinder baffles exhibited damage consistent with striking the ground and a number of the engine accessories were broken or had been damaged in the post-impact fire. However, the engine otherwise appeared largely intact. The engine would not rotate freely until the camshaft was removed and, although not visually apparent, it was determined that impact-related distortion in the cam assembly had prevented both the camshaft and engine from turning.

No. 1, 3 and 4 cylinders exhibited poor compression, with leakage past the exhaust valves being evident. The inlet and exhaust valves were poorly seated to varying degrees on all cylinders and there were signs of blow-by and/or carbon build-up on the exhaust valves. They did not have the appearance of valves which had been recently lapped. All cylinders showed signs of glazing along with some corrosion pitting and evidence of only minimal honing. In addition, the No.1 and 2 cylinders were very oily.

The spark plugs were of varying aerospace types and the firing gaps ranged from 0.015 to 0.025 inches compared to the recommended gap of 0.012 to 0.015 inches. When tested, only three of the spark plugs exhibited a strong spark with the others exhibiting weak and/or intermittent sparks and, in one case, a spark that tracked down the insulation rather than jumping across the gap. The ignition leads had been manufactured from copper-cored automotive wire and had the appearance of having been recently replaced.

Magneto[8] timing checks revealed that the timing on the left side was slightly out, such that the voltage pulse occurred early at 48°, rather than the specified 41° ± 1°, before Top Dead Centre (TDC). The left and right contact breakers' point gaps were 0.026 inches and 0.014 inches respectively; the recommend gap is 0.009 ± 0.001 inches. The magneto was run on a test rig and sparking was evident at the contact breaker points due to the large gaps. It operated for approximately 2 hours before failing 'hot' at a temperature of 59°C. A burning smell was

Footnote

8 The Bombardier Cirrus 20801 is fitted with a duplex magneto which contains two separate ignition circuits within a single unit.

evident throughout the test and visual inspection showed heat degradation of the lacquer coating on the lower coils. It was not possible to determine whether this was related to the post-impact fire or whether the magneto had previously exceeded its operating temperature.

Two pieces of re-solidified molten white metal and two flakes of paint-like material, were found in the main oil filter housing. There was no evidence that this debris had come from within the engine and its origin was not determined, however, the filter had prevented it from entering the engine oil supply. It was noted that the cap nut of the oil pressure relief valve (OPRV) was unlocked with three threads visible and had not been wire-locked and there were indications of relatively recent maintenance on the valve guide and ball. The engine oil was blacker than expected, possibly as a result of the blow-by noted on the cylinders.

Mechanical fuel pumps

There was no fuel present in either of the mechanical fuel pumps, the interconnecting pipe, nor the fuel line to the fuel injection pump. Although externally heat damaged, the fuel pumps and pipes were intact so there was no evidence that fuel could have leaked out since the accident but the possibility that the fuel evaporated in the post-impact fire could not be ruled out. The securing wing nuts on the fuel pump bowls were not wire-locked.

When run on a fuel test rig neither pump was able to develop or maintain suction pressure to deliver fuel, even when manually primed. It was therefore not possible to conduct a delivery flow rate test on the pumps. Additionally, in certain conditions, fuel was observed to leak from the pump body and the fuel drain, which indicated that fuel was leaking past the internal diaphragm. In an attempt to determine how the pumps would perform on-aircraft, the installed aircraft condition was simulated by providing gravity-fed fuel to the pumps from an external source mounted above the test rig. In this condition, the head of fuel created sufficient pressure to allow fuel to pass through the pumps. A rudimentary flow rate check was conducted at a test rig operating speed of 800 rpm[9]. After taking into account the contribution from the gravity-fed fuel, the delivery rate for each pump solely due to pump action was determined to be approximately 21% of the expected delivery rate at this operating speed.

Disassembly revealed that on both pumps the clamping nut at the base of the central spindle was loose, resulting in the internal diaphragm not being adequately clamped. Additionally, the diaphragms did not have the appearance of having been professionally fitted and cut to size, exhibiting stretching and creasing, elongated bolt holes and a crudely-cut central hole (Figure 4). Oil had leaked to the fuel side of the diaphragm, indicating that the diaphragm did not form an effective seal between the fuel and oil (atmospheric) side of the pump. One effect of this is that fuel could escape through the centre of the diaphragm into the oil side of the pump and exit a fuel drain in the upper part of the pump body; this would result in reduced suction.

Footnote

[9] The fuel flow test described in the *'Amal Operation, maintenance and overhaul instructions for Fuel Pump type 240/8'* has four test points at various test rig operating speeds; 800 rpm is the third test point.

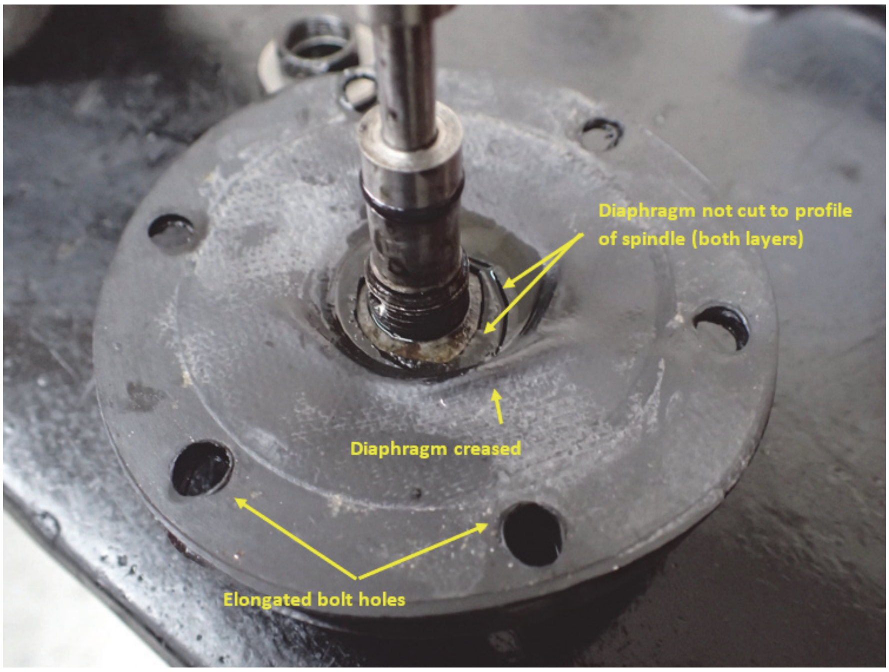


Figure 4

View showing oil side of diaphragm from right mechanical fuel pump

Fuel injection pump

The fuel injection pump was intact and did not display any obvious impact damage. No fuel was present in the pump, but a small amount of residual fuel was found in the No. 4 fuel injection line and was retained for further analysis.

The timing of the fuel injection system is normally set to coincide approximately with the induction period of the engine. A fuel injection pump timing check was performed and fuel delivery to the No.1 cylinder commenced at 130° before TDC and stopped at 27° before TDC; the engine manual indicated that fuel delivery should commence at 27° before TDC.

The fuel injection pump and nozzles were removed from the engine and tested on a fuel test rig using shop fuel lines. Leaks were observed on the No. 2 and 4 fuel injection nozzles. The part of both nozzles which mates with the fitting on the fuel injection line exhibited an uneven surface, with burrs, such as if they had been damaged by a spanner. This may have made it difficult to achieve an effective seal between the nozzles and fuel fittings on the aircraft. Additionally, two of the six clamping screws on the No. 2 nozzle were loose, causing fuel to leak from the injector body. These anomalies were rectified to allow testing of the injection pump.

The pump operated normally when tested but the fuel flow was out of calibration because the mixture strength was running lean. The adjuster nut on the pump, which allows mixture strength to be altered, did not have an index mark, so it was not possible to determine if/how it had been previously adjusted. However, the end cap on the adjuster nut had modern wire locking, which indicated that it may have been disturbed at some point.

Aileron control rods

Left aileron control rod

The heads of the failed rivets in the left aileron control rod forward end-fitting were not found. However, the rivet tails remained within the end-fitting and were subjected to metallurgical examination. The top rivet tail came loose during removal of the control rod from the aircraft and is shown separately in Figure 5.

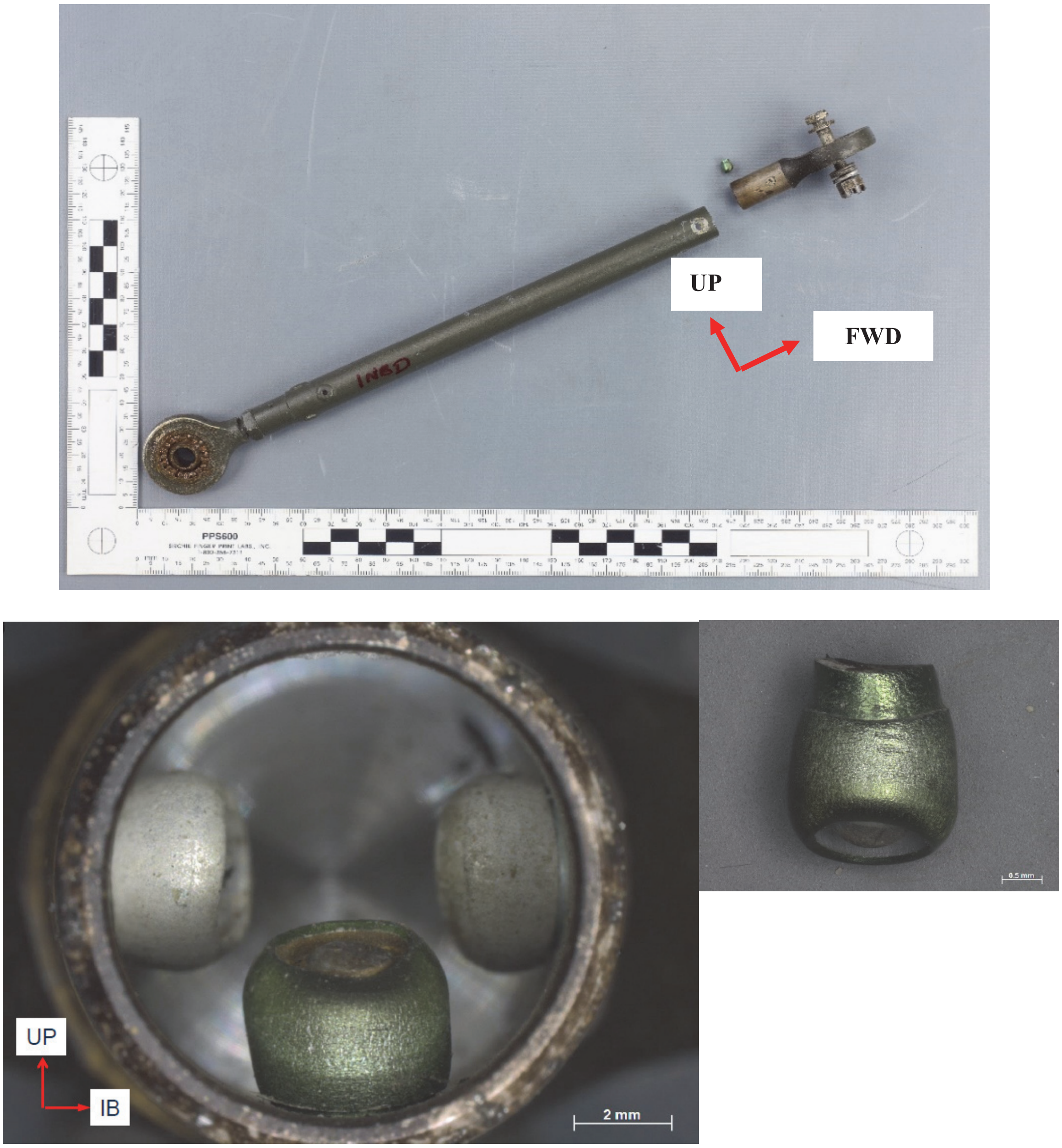


Figure 5

Left aileron control rod (top) and end-fitting attachment rivets (bottom)

The rivets were identified as ⅛ inch diameter break-stem, pop-type blind rivets[10]. The inboard and outboard rivet tails were grey and were filled with corrosion product and paint. Conversely, the top and bottom rivet tails were green, and only the head of the mandrel was observed in the hollow centre.

Metallurgical examination showed that the fracture surfaces of all four rivets exhibited differing amounts of mechanical damage, caused by contact between the opposing fracture surfaces during detachment of the end-fitting. The remaining surface detail showed that all four rivets had failed as a result of ductile overload in shear, indicating that they were carrying load at the time of failure. The outboard rivet also exhibited three distinct patches of intergranular fracture (shown in purple in Figure 6), which indicated the presence of pre-existing intergranular cracking prior to the shear overload failure. The precise extent of the intergranular fracture could not be determined due to the mechanical damage, but the areas in which it was observed indicated that it may have extended across one third of the surface area.

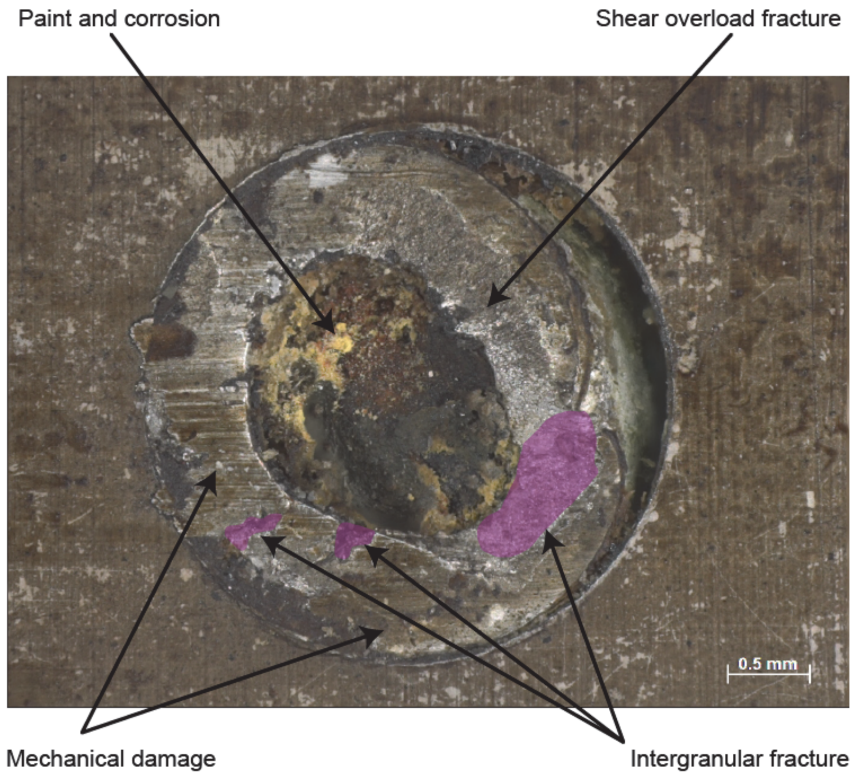


Figure 6

Fracture surface of outboard rivet showing areas of intergranular corrosion

Footnote

[10] Blind pop rivets are installed by pulling a mandrel through from the head side. When a tight joint has formed, the mandrel breaks at a pre-determined position on the stem, hence they are referred to as break-stem rivets. The head of the mandrel remains in the centre of the hollow rivet but does not provide any support to the joint in shear.

Intergranular corrosion and stress corrosion cracking[11] was also observed on the internal surfaces of the inboard and outboard rivets. Although no intergranular fracture was evident on the fracture surface of the inboard rivet, the mechanical damage may have destroyed any pre-existing cracking that was present.

Energy Dispersive X-ray (EDX) analysis determined that all four rivets were manufactured from an aluminium-magnesium alloy consistent with 5056 Grade, which is commonly used for rivets. Micro-hardness tests indicated that the hardness range of the rivets was closer to the annealed condition than the fully hard condition[12].

All four rivets on the aft fitting of the control rod were green and manufactured from the same material as those on the forward fitting.

Right aileron control rod

A comparative examination of the right aileron control rod identified that all eight end-fitting attachment rivets were grey in colour. It was noted that the inboard rivet on the aft end-fitting had failed. The rivet tail was filled with corrosion product and the rivet head was absent. The remaining rivets were intact, and there was no evidence that the joint had distorted under shear loading. Detailed examination showed that the fracture surface of the failed rivet was entirely comprised of intergranular failure. The absence of any ductile shear overload features indicated that this rivet was not carrying any load at the time of failure. The remaining rivets in the right aileron control rod were not examined.

Aileron control rod drawings and material properties

The AOP.9 spares manual[13] indicates that, following a modification, there are two standards of aileron control rod, for which there are separate drawing numbers. No part number was marked on the failed aileron control rod from G-BXON, so it was not possible to identify whether it was of a pre or post-modification design. The original pre-modification drawing was not located, however, the AOP.9 Type Record document made reference to the pre-modification drawing and indicated that the original rivets were AGS 2048-420 ⅛ inch pop rivets. The data sheet for AGS 2048-420 rivets indicated that they are green in colour and made from BS L.58[14] aluminium alloy which is equivalent to 5056 Grade.

Footnote

[11] Stress corrosion cracking can occur when susceptible metals or alloys are subject to a continuing tensile stress above a threshold level in a corrosive environment. Initiation normally occurs when the protective surface finish has been compromised allowing corrosion to start. In the case of the rivets, the residual stresses from the rivet forming process may be sufficient, in combination with a corrosive environment, to provide the conditions for stress corrosion cracking.

[12] Typical hardness values for 5056 Grade aluminium are 74 HV in the annealed condition and 123 HV in the fully hard condition. The hardness results obtained indicated that there had probably been some strain hardening of the rivets close to the fracture surface, due to deformation caused by the installation process. In each case the lowest hardness value for each rivet was measured close to the fracture surface and ranged from 85 HV to 93 HV. The rivets were therefore closer to the annealed condition.

[13] Air Publication 2440 H Volume 3, Part 1 *'Auster Mk.9 (AOP) Aircraft Schedule of Spare Parts',* first issued December 1954, amended June 1962.

[14] The BS L.58 specification *'Wire for solid, cold-forged rivets of aluminium – 5% magnesium alloy'* has since been superseded by BS 3L.58, but the material properties remain the same.

A copy of the post-modification drawing[15] was provided to the investigation and specified the use of ⅛ inch diameter Chobert snap-head rivets[16] and sealing pins[17]. The change to Chobert rivets did not appear to be directly related to the modification but had been added to the drawing at a subsequent revision.

The Chobert rivets have an ultimate shear strength of 240 – 260 MPa, dependent upon the sealing pin material. By comparison, 5056 Grade aluminium alloy in the annealed condition, from which G-BXON's rivets were manufactured, typically has an ultimate shear strength of 179 MPa, with a minimum shear strength of approximately 159 MPa.

Aerodynamic flight loads for the AOP.9 aileron were calculated[18] by the AAIB. Based on the rivets used in G-BXON and using the minimum allowable shear strength for 5056 Grade, the ultimate shear strength of the rivets was calculated to be sufficient to sustain the maximum flight loads which could be expected in the aileron control rod, even if two of the rivets had completely failed.

The AOP.9 Type Record document included a '*Strength summary of aileron control circuit*' which indicated that the critical design load case for the rivets was the 'pilot effort' case; this refers to the maximum control stick loads that could be applied by a pilot on the aileron control circuit, for example, if trying to overcome a jammed aileron. For this load case, the load in each rivet was quoted as 194.25 lbs and the allowable load as 195 lbs, giving a reserve factor of 1.004.

Fuel sample analysis

The fuel sample retained from the fuel injection line and another sample taken from the jerry cans used to fuel G-BXON, were tested to determine whether they conformed to the industry standard fuel specification for Avgas 100LL[19].

The jerry can sample did not meet the specification for vapour pressure, indicating that it was contaminated with a more volatile fuel, most likely automotive gasoline. Further testing indicated that the sample was broadly consistent with Avgas 100LL and that the level of contamination was small.

The fuel injection line sample contained some particulate contamination and was green in appearance. Avgas 100LL typically has a blue tint. There was insufficient fuel to complete the full specification test, but analysis by other techniques indicated that, although similar to the jerry can sample, the fuel from the injection line had some volatile components

Footnote

15 Originally issued in July 1957, and subsequently revised in August 1957 and September 1962.
16 Chobert rivets are installed using a reusable steel mandrel which is pulled through the rivet towards the head. The installed rivet is hollow, although the use of a sealing pin effectively makes the rivet solid, increasing its shear strength and sealing the internal structure of the assembly from the environment.
17 The sealing pins can be manufactured from either L64 or DTD 423 grade aluminium alloy, which is equivalent to a modern 2014 T4 or 2014 T6 respectively.
18 Using the criteria described in 14 CFR FAR 23 Appendix A *'Simplified design load criteria of for conventional single-engine airplane of 6,000 pounds or less maximum weight'*.
19 Defence Standard 91-90/4 for Aviation Gasoline, produced by the UK MOD Aviation Fuels Committee and endorsed by the CAA.

missing. This sample also contained some phthalate esters[20] and other unidentified components.

Medical and pathological information

The pilot held a Class 2 medical certificate, valid until 22 July 2018, and records from his doctor indicated that he was in good health. A post-mortem of the pilot found no evidence of disease or toxicology that could have contributed to the event and concluded that the cause of death was burns sustained in the post-impact fire. The only injury not related to the effects of fire was a pelvic fracture and associated hip dislocation. The post-mortem report suggested that this could provide an explanation as to why the pilot was unable to extricate himself from the aircraft following the collision. However, the report also indicated that there was '*no macroscopically apparent soot staining*' in the pilot's airways and that the only '*slightly raised level*' of Carboxyhaemoglobin[21] in the pilot's blood '*supports that he died relatively quickly*' after the fire started.

The passenger suffered multiple impact injuries and burns to his left arm and leg. Following the accident, he was found about 21 m away from the aircraft wreckage. He later commented that, despite some vague flashbacks, he could not reliably recall anything between taxiing out to the runway and being found in the field afterwards.

Both occupants were wearing normal clothing which would not have offered protection against the post-impact fire.

LAA published guidance

Permit to Fly

Aircraft that do not meet the certification standards required to hold a CofA may operate in the UK under a national Permit to Fly[22,23] issued by the CAA. For aircraft operated under the LAA system, the CAA delegates responsibility to the LAA to oversee the airworthiness requirements and make recommendations for the issue of a Permit to Fly. The LAA, as the responsible sporting body, supports amateur build and restoration projects and maintenance of aircraft by its members, under the supervision of a suitably-approved LAA inspector. The LAA system places the responsibility for the airworthiness of the aircraft on the owner of the aircraft. On the Permit to Fly application form, an owner is required to sign the following declaration:

> *'I undertake to keep the aircraft in an airworthy condition and to operate it within the limitations of the Permit to Fly.'*

Footnote

[20] Phthalate esters, typically plasticisers, are substances added to plastics to increase their flexibility, transparency, durability and longevity. These are common contaminants found in Avgas, as they can be extracted from polymeric materials that are in contact with fuel, such as fuel hoses or plastic storage containers.

[21] Carboxyhaemoglobin is formed when carbon monoxide, a common product of combustion, is inhaled.

[22] Aircraft in this category are typically amateur-built, vintage, ex-military, microlights or gyroplanes without a valid Type Certificate.

[23] The Permit to Fly airworthiness regime allows aircraft to be built and/or maintained by an owner rather than a certified manufacturer or an approved maintenance organisation.

LAA Technical Leaflet TL 2.01 *'A guide to LAA aircraft ownership'*, dated 31 March 2014, provides a general summary of the responsibilities of owning, operating and maintaining a Permit to Fly aircraft. In the section titled *'Maintain the aircraft in an airworthy condition'* it states:

> *'The Permit to Fly requires that an aircraft be maintained in an airworthy condition…. LAA encourages owners to engage themselves fully with the maintenance of the aircraft, but alternatively this can be carried out on a commercial basis either using paid individuals or a maintenance organisation. Either way, by their very nature, Permit to Fly aircraft are somewhat unique and less well supported in airworthiness terms than their CofA cousins and need a greater degree of owner engagement, technical appreciation and vigilance to achieve an equivalent level of safety.'*

And*:*

> *'Note that if an LAA inspector carries out maintenance on behalf of an owner, he or she can do so but whether they are remunerated or not, this is not carried out under the LAA inspector's remit. The LAA inspector's remit only covers the inspection and certification role.'*

Rebuild and restoration of LAA aircraft

LAA Technical Leaflet TL 2.21 *'Rebuilding an aircraft under the LAA system'*, dated 3 January 2013, provides guidance for those undertaking an aircraft rebuild or restoration. It states:

> *'Between you and your inspector, you will need to write up worksheets describing the rebuild, to be signed up by your inspector as you go along. A copy of the worksheets are* [sic] *to be submitted on completion of the rebuild.'*

TL 2.21 describes the final inspection required upon completion of the rebuild and the process of applying to LAA Engineering for approval for flight testing. It states:

> *'When the rebuild of the aircraft is complete, a final inspection must be carried out. Normally this takes the form of an annual check as listed in the LAMS* [Light Aircraft Maintenance Schedule] *schedule or the LAA generic maintenance schedule (see TL 2.19). In addition, a symmetry check and in-depth rigging check is carried out and all systems calibrated and tested fuel flows checked and engine ground run.'*

And:

> *'A minimum period of five hours flying followed by a formal flight test is required before a full Permit to Fly can be issued.'*

LAA test flying

Testing pilots

LAA aircraft require test flying to qualify for initial issue of a Permit to Fly, and thereafter for renewal of a Permit to Fly. LAA Technical Leaflet TL 1.19, *'Initial test flying of LAA aircraft'*, dated 1 January 2008, is aimed at both owners and testing pilots, and outlines some of the safety and logistical considerations for the test flying process. It states:

> *'The choice of pilots for carrying out test flying is another issue where owners put forward their suggestion and LAA Engineering have to vet the proposal, based on the previous flying experience of the person put forward, currency on aeroplanes of the type concerned, or at least, similar or related types… The whole point of the test period is to get the aeroplane fine-tuned so it will handle properly in normal use later on.'*

The LAA produced a checklist[24] for testing pilots entitled *'LAA self-briefing tool for use pre first flight of newly completed aircraft'*. It includes items such as reading the relevant operating manual; awareness of the operating limitations; and awareness of special issues for the type, for example, handling issues. The tool also contains a prompt to consider applying '…*operating limitations over the standard ones eg reduced envelopes.*' At the time of this accident, no equivalent self-briefing tool existed for owners preparing for their first flight on type.

Testing pilots are not necessarily affiliated with the LAA, nor are there specific qualifications required.

Flight test schedule (FTS)

TL 1.19 also describes the LAA FTS, stating:

> *'The test form… looks for much more detailed evidence of satisfactory engine cooling and mixture settings than previously, calling for a five minute climb with readings taken every minute, and a more thorough investigation of the stall characteristics and speeds in each configuration.'*

The FTS form provides fields for testing pilots to record their observed values from a flight but, for a number of test items, there are no fields to record the expected values. These are further discussed in subsequent sections of this report.

The LAA's Technical Leaflet TL3.22 *'Flight Test Reports',* dated January 2014, asks testing pilots to supply the completed FTS to the aircraft owner, who should then send a copy to LAA Engineering together with any other requested information. Due to the informal nature of their role, testing pilots are not expected to brief owners on their aircraft's FTS. However, the LAA subsequently commented that because a testing pilot is normally an

Footnote

[24] http://www.lightaircraftassociation.co.uk/engineering/flight%20test%20self-brief.pdf [accessed 20 August 2018].

experienced enthusiast, nominated by an owner, then the two would normally take a keen interest in discussing the FTS, albeit informally.

Flying guidance for aircraft owners

There is no published LAA guidance for owners regarding the content or duration of their first flight on type, or on choosing an accompanying pilot. While the LAA is not responsible for pilot licensing or training, it does offer an optional Pilot Coaching Scheme which is designed to train LAA members in their aircraft and promote good standards of flying and airmanship. Following completion of an aircraft's test flying, TL 1.19 advises:

> *'…before flying the aircraft yourself, please remember that the LAA Pilot Coaching Scheme is there to get you up to speed with flying the aircraft and get the most out of it.'*

Furthermore, the LAA leaflet *'Ready to fly? - Pilot Coaching Scheme'* which was available at the time of the accident stated[25]:

> *'Statistics show that 20% of all homebuilt accidents happen during the first two flights and are usually caused by pilot error. The same is true of the first flight of any unfamiliar aircraft, whether it is homebuilt, vintage or microlight.*
>
> *The Pilot Coaching Scheme is here to provide tuition in the skills of learning to fly a new type of aircraft…*
>
> *Do not under-estimate the challenge which some of the types on the LAA register may represent…*
>
> *Look closely in the mirror, and ask yourself if you have sufficient experience to ensure that you can safely operate your new aircraft without any coaching…*
>
> *All coaches are current CAA and JAR-FCL certified Class Rating Instructors or Flight Instructors. They're also your trainer, confidante and mentor throughout the process of you learning to fly your aircraft.*
>
> *There is no reason to go through the process of learning to fly a new type alone or with a bunch of friends helping you guess how to do it.'*

It was not determined if G-BXON's pilot was aware of the LAA's Pilot Coaching Scheme. However, the LAA subsequently reported that the pilot had been sent a copy of TL 1.19. The LAA also commented that a survey in 2016 indicated that 95.8% of its members were aware of the pilot coaching scheme.

Footnote

[25] The LAA subsequently updated this leaflet and removed reference to the accident statistics, having advised that these were based on data from the USA rather than the UK.

G-BXON rebuild and restoration

Background information

G-BXON was constructed in 1955 by Auster Aircraft Ltd and was operated by the Army Air Corps until 1965, after which it fell into disuse. In 1997, the aircraft was purchased and placed on the UK civil register, with the intention of rebuilding it. However, before completion, one of the owners and a previous LAA inspector overseeing the rebuild, passed away and the aircraft was sold.

The accident pilot purchased G-BXON in March 2016 as a part-complete restoration project. The work already undertaken by the previous owners included structural work and complete fabric recovering and painting of the airframe and wings, and overhaul of the propeller. The engine was installed but had been inhibited. No worksheets were provided with the aircraft, so there was no record of the maintenance tasks which had been completed by the previous owners, and only limited historic technical records were provided.

Rebuild and Permit to Fly application process

The pilot decided to base G-BXON at Spanhoe Airfield, where he engaged an LAA inspector to assist with and oversee the completion of the rebuild. In May 2016 he notified LAA Engineering of his restoration project and the LAA confirmed that G-BXON was eligible to be restored and flown on an LAA Permit to Fly. The accompanying documentation indicated that the aircraft had last flown in August 1965, had accumulated 2,524 flight hours and its engine had accrued 252 operating hours since last overhaul.[26] The LAA requested that, upon completion of the rebuild, the pilot submit, among other items, worksheets detailing each stage of the strip down, inspection and rebuild, as well as final inspection checks, range of movements, duplicate inspections, engine ground runs etc. Also requested were details of any modifications, substitute materials and replacement parts, and copies of logbook certificates relating to engine rebuild, propeller overhaul, instrument calibration etc.

Over the following months the pilot undertook maintenance restoration tasks on the aircraft with the assistance of the LAA inspector, friends, and other aircraft owners based at Spanhoe. This included fitting the wings, conducting a 'top-end' overhaul of the engine and replacement of various engine and fuel system components.

In September 2016, the LAA inspector submitted, on behalf of the pilot, an application to the LAA for a Permit to Fly. It was accompanied by supporting worksheets listing 45 separate maintenance tasks, a list of modifications embodied on G-BXON and a '*Rebuild Final Inspection & Declaration of Design'*. All these documents were signed by the LAA inspector and dated 16 September 2016.

Between October 2016 and March 2017, in a series of email exchanges, the LAA requested the LAA inspector to clarify which of the maintenance tasks had been undertaken by the

Footnote

[26] No historic airframe or engine logbooks were found for G-BXON and therefore the original source for this information was not established.

previous owners/inspector and to state clearly that he had re-inspected and certified those tasks. It also requested that he provide the results of fuel flow tests and engine ground runs, and properly documented duplicate inspections, which had not been noted on the original worksheets.

On 10 April 2017, the LAA inspector submitted a single supplementary worksheet to the LAA to address this request. This worksheet identified which of the tasks on the initial worksheets had been undertaken by the previous owners/inspector and were subsequently re-certified by him. It also included a statement that all remaining tasks had been carried out under his supervision.

Flight testing and permit issue

On 26 April 2017, following receipt of this information, the LAA issued a *'Certificate of clearance'* for flight testing to the pilot and LAA inspector/testing pilot. The accompanying correspondence stated:

> *'No particular number of hours or landings is required, just as long as it takes to re-establish reliable use, fix any defects, trim to fly in balance and wings level, and then complete the flight test schedule.'*

Between 28 April 2017 and 10 May 2017, the testing pilot undertook three flights in G-BXON totalling 1 hour 10 minutes flight time. He reported that the aircraft had performed well on the first flight and required no defect rectification, so he flew again the next day. On 11 May 2017, he conducted a 40-minute formal flight test (the section *'G-BXON flight test'* later in this report covers this aspect in more detail), after which the completed FTS was sent to the LAA along with a copy of G-BXON's logbook page showing a total of 1 hour 50 minutes flight time. The testing pilot conducted a further flight lasting 20 minutes on 14 May 2017 with the accident pilot as a passenger.

G-BXON's Permit to Fly was issued by the CAA on 2 June 2017 and this was sent to the pilot by the LAA, together with the Certificate of Validity and Operating Limitations on 6 June 2017.

Engine maintenance

Some of the other Spanhoe-based aircraft owners who had assisted the pilot in restoring G-BXON reported that it had been a challenging and lengthy process to return the engine to proper working order. A friend with automotive engine experience had assisted the pilot in stripping the engine and cleaning engine inhibiting oil from 'top-end' components, which included honing the cylinders and cleaning and lapping the valves. Separately, it was reported that the magneto was also replaced.

It was reported that by August 2016 the engine was running but misfiring, did not operate consistently across the full rpm range and the oil pressure readings were fluctuating. Between August 2016 and January 2017, a number of problems were experienced with the fuel injection pump. The quill drive within the pump snapped a number of times, necessitating replacement of the quill drive and, on at least one occasion, the fuel injection pump itself. The oil hoses to the fuel injection pump and the fuel injection nozzles were also replaced. The problem was subsequently determined to be related to a high oil pressure feed to the injection pump, caused by a seized OPRV. This was subsequently adjusted.

Further engine issues experienced were reported to have included ignition problems and a persistent misfire on the No.4 cylinder. Work to address these included replacement of the right ignition lead in March 2017 and cleaning/replacement of the spark plugs. By the end of March 2017, the engine was reported to have been running well and the aircraft was successfully taxied for the first time on 9 April 2017.

Anecdotal information from witnesses suggested that G-BXON's engine had been developing approximately 2,200 to 2,300 rpm at takeoff setting. The pilot was reportedly not satisfied with this and had discussed the engine performance with another AOP.9 owner, by way of comparison.

It was reported that the pilot had fitted new longer ignition leads on the day before the accident, in preparation for installing automotive spark plugs[27].

In a text message exchange following the pilot's first flight on the day preceding the accident, the other AOP.9 owner asked if the loom [ignition lead] had worked. The pilot's response indicated that the engine had operated much better with more power, that there had been no misfiring in flight and that the magneto drop check after landing was okay.

Documentation

Maintenance tasks undertaken during G-BXON's restoration were documented on a standard LAA worksheet template, which contained fields for recording up to seven maintenance tasks. Against each task there were columns for the engineer/pilot and LAA inspector signatures. The worksheet template also contained a Permit Maintenance Release to be signed by the inspector which stated:

> *'The work recorded above has been completed to my satisfaction and in that respect the aircraft is considered fit for flight.'*

The worksheets submitted to the LAA in support of G-BXON's Permit to Fly application contained a brief outline of the maintenance tasks performed during rebuild. The tasks were not individually dated but had been collectively grouped together and retrospectively documented and dated 16 September 2016.

The original worksheets submitted in September 2016 described a number of engine-related maintenance tasks including overhaul and reinstallation of the mechanical and fuel injection pumps, engine top overhaul and reassembly, check of fuel flow to the injector pump and

Footnote

27 The pilot had contacted the LAA to enquire about the possibility of applying for a modification to convert to automotive spark plugs, due to the difficulty in obtaining the correct aerospace spark plugs for G-BXON's engine. However, he had not made the application before the accident occurred.

engine ground runs. The results of the fuel flow checks[28] and engine ground runs[29] were not originally recorded but were subsequently included on the single supplementary worksheet dated 10 April 2017.

Other tasks documented on the original worksheets included connection and testing of the pitot/static system, calibration and fitment of the altimeter and ASI, and propeller overhaul by a specialist overhaul company. The results of the ASI and altimeter calibration were not recorded.

All of the worksheets had been completed by the LAA inspector. He signed his initials against each task in the *'Inspector'* column and signed the Permit Maintenance Release statement at the bottom of each worksheet. The pilot's signature only appeared in the *'Engineer'* column against one task on the 10 April 2017 worksheet; this related to the duplicate inspection of the flight and engine controls, which required two signatures.

The *'Rebuild final Inspection and declaration of design'* form submitted with the worksheets described the extent of the work performed on the engine as *'Top overhaul. Fuel pumps overhauled. Injectors tested. Injector pump overhauled.'* The LAA inspector had signed both the fields for the *'builder'* and the *'inspector'*.

The engine-related work undertaken between September 2016 and April 2017 did not appear to have been recorded on worksheets.

The LAA inspector was vague in his recollections of exactly what work had been undertaken on G-BXON and when. He commented that he looked after many aircraft and could not recall the details of work done on each of them and that he did not keep copies of worksheets or separate records. He also advised that, while he might inspect individual maintenance tasks on different days, his preferred approach was to sign them off all together. Furthermore, he stated that he is only able to verify the condition of an aircraft at the time of his inspection, and that owners may change something subsequently.

Other than the worksheets submitted to the LAA in support of the Permit to Fly application, no other technical records were found which related to G-BXON's rebuild.

No receipts were found among the pilot's documentation, so it was not possible to determine the provenance of replacement parts used during the rebuild. An invoice from the maintenance organisation dated 22 February 2017 referenced installation of a new radio and wiring, investigating an engine problem, timing and installing a new fuel pump.

Footnote

[28] Noted on the worksheet as 32 gallons per hour under gravity and 58 gallons per hour with both mechanical fuel pumps operating, but it was not determined how these flow rates were measured. The AOP.9 maintenance manual calls for minimum flow rates to the mechanical fuel pumps under gravity, with the booster pump off and on, of 23 and 50 gallons per hour respectively. It also specifies a minimum flow rate between the mechanical fuel pumps and the fuel injector pump of 2.5 pints per minute (18.75 gallons per hour), This corresponds to the maximum expected fuel delivery rate described in the *'Amal Operation, maintenance and overhaul instructions for Fuel Pump type 240/8'*.

[29] The [maximum] static rpm was noted as 2,200 rpm.

G-BXON's logbook[30] did not contain any summary of the maintenance work carried out during the rebuild or cross-reference to the worksheets. The flights conducted between 28 April and 11 May 2017 were recorded, together with the flight conducted by the pilot on the day prior to the accident. The flight on 14 May 2017 was not recorded in the logbook.

Weight and balance

The AOP.9 Pilot's Notes[31] specifies two maximum weights. The normal maximum weight of 2,350 lb applies to all forms of flying. The overload maximum weight of 2,550 lb limits the aircraft to gentle manoeuvres only.

From information provided by witnesses, G-BXON's weight for the accident flight was calculated to be around 2,258 lbs and the CG was within specified limits.

Aircraft operating information

Pilot's Notes guidance

The Auster AOP.9 Pilot's Notes explains how to depart using takeoff flap as follows:

> *'…lower the flaps to take-off and open up to full throttle against the brakes… At full load the aircraft can be pulled off at approximately 45 knots. To clear obstacles climb at 50 knots, which will give the steepest angle of climb though not necessarily the greatest rate of climb. When clear of obstacles increase speed to 55 knots and raise the flap in stages by manipulating the selector lever… The speed should be allowed to increase slowly to 65 knots (normal climbing speed) and the last few degrees of flap pumped up with the hand pump.'*

It details the AOP.9's zero flap climb performance as follows:

> *'Climb at full throttle and 65 knots… The initial rate of climb is about 800 feet per minute…*

The '*Stalling'* section states:

> *'There is no warning of the stall in any configuration. Pilots should bear this in mind when manoeuvring near the ground at low airspeed… Shortly before the stall is reached the aircraft wallows slightly and then, at the stall, the nose will drop probably accompanied by either wing… Recovery is immediate on releasing the backward pressure on the control column, the height loss being about 200 feet. If the control column is held back after the aircraft has stalled, a spiral or spin may develop.'*

Footnote

30 The initial entry in G-BXON's logbook of total flight time carried forward had been mistakenly entered as 252 hours. This figure was in fact the operating hours of the engine since overhaul. The total flight time carried forward was 2,524 hours.

31 The Pilot's Notes document was produced under direction of the Air Ministry as the operating manual for the AOP.9.

Pilot interviews – AOP.9 handling characteristics

The AAIB interviewed a number of AOP.9 instructors and display pilots (military and non-military), and civilian AOP.9 owners.

The AOP.9 was widely described as an operationally challenging aircraft which should especially be flown by 'feel'. One pilot commented that many of its handling peculiarities are not included in the original Pilot's Notes, and that there had been no formal mechanism in the military for subsequently documenting them. Consequently, pilots have tended to share them anecdotally.

It was also mentioned that achieving the correct angle of attack[32] (AOA) during takeoff is important in the AOP.9. If a pilot under-rotates[33] the aircraft, its mainwheels might dig in to soft ground, thus inhibiting acceleration. Conversely, with over-rotation[34], the aircraft can 'stagnate', and the airspeed may not increase until the AOA is reduced.

The AOP.9 was viewed in general as a low-performing aircraft type. Some pilots explained that, if the aircraft does not initially climb well during takeoff on a hot day, they might choose to lower the nose so that the airspeed can increase whilst still in ground effect[35].

Most pilots expressed a preference for flying faster than the published speeds and one highlighted the potential for stalling the AOP.9 during takeoff, particularly due to the absence of any stall warning. One pilot stated that he would climb at an airspeed well above 60 KIAS when departing using takeoff flaps on a hot day.

The AOP.9's stalling characteristics were widely discussed. One pilot stated that, when flight testing an AOP.9, he accepts a maximum deviation of 3 or 4 KIAS from the published stall speeds. A main concern was the aircraft's tendency to drop a wing during the stall. If a pilot reacts to this using opposite aileron, a spin may develop. Aileron droop and high engine power settings exacerbate the wing drop.

CAA advice on stall and spin awareness

The CAA's '*Handling Sense Leaflet 2: Stall/Spin Awareness*' states:

> *'At least one of the symptoms of the fully developed stall MUST happen before the aeroplane can spin… these are: wing drop (undemanded roll), nose drop, inability to maintain level flight, and buffet. It is clearly inappropriate to wait for this confirmation before recovery.*
>
> *What signs will be evident to help us avoid a full stall and possible spin? …We can draw on the classic list of signs of the approaching stall: increasingly high*

Footnote

32 AOA is the angle between the oncoming air and a reference line on the aeroplane or wing.
33 Under-rotate: Too little back pressure applied to the control column during lift off.
34 Over-rotate: Too much back pressure applied to the control column during lift off.
35 Ground effect: the increased lift and decreased drag generated by an aeroplane's wings when it is close to the ground.

nose attitude (in level flight), reducing control effectiveness, low and decreasing airspeed, and the onset of buffet. These may be augmented by a mechanical stall warning device…

One of the most critical phases of flight is just after take-off or when going around from an approach to land. At low level, at relatively low speed and with a high nose attitude, an engine failure will lead to a rapid deceleration and increasing angle of attack…

To safely avoid the stall and spin: be alert and be prepared; practice regularly at safe altitude and keep your handling skills current; read and understand the contents of the Flight Manual/POH for your aeroplane; seek advice from a Flight Instructor if you are unsure of any techniques; be ready to apply immediate recovery action whenever you feel the aeroplane is not responding correctly. Now you have time to regain a safe flight path and analyse what happened. If prompt action is taken during the approaching stall, the attitude change required is small and height loss (if any) should be minimal.'

G-BXON flight test

Performance results and comparison

Table 1 details some of the results from G-BXON's formal flight test on 11 May 2017. Also presented are the published performance figures from the Pilot's Notes and the AOP.9 Flight Reference Cards[36] together with seven flight test results from other AOP.9s, all of which had the same engine/propeller combination as G-BXON. One aircraft was included twice because it was tested at different times under both the LAA and CAA regimes.

The other AOP.9s mainly involved aircraft tested by testing pilots for an initial LAA Permit to Fly. This flight test information was collated by the LAA after the accident in order for them to compare G-BXON with other examples of the type.

Loading

The LAA FTS requires an aircraft to depart at its maximum takeoff weight or maximum landing weight if it is lower. The testing pilot loaded G-BXON to 2,500 lb, which was 150 lb higher than its normal maximum weight and 50 lb less than the overload maximum weight. He stated that using the higher weight was a good practice he had learned during previous CofA aircraft testing.

Most of the other AOP.9s which were analysed had takeoff weights which were within 100 lb of the normal maximum weight. Two of the other AOP.9s had takeoff weights above the normal maximum weight. The highest of these was 2,507 lb, and that aircraft achieved a test ROC of 710 fpm.

Footnote

36 The AOP.9 Flight Reference Cards are a set of procedures prepared by the MOD Handling Squadron.

	Published figures*	Other AOP.9 flight tests - Average (Range)	G-BXON flight test
Climb performance – ROC at 65 KIAS	800 fpm**	667 (633-720) fpm	450 fpm
Climb performance – rpm at 65 KIAS	Not specified	2,320 (2,240-2,350) rpm	2,350 rpm
Stall speed, zero flap (V_{S1}(f0))	48 KIAS***	48 (46-48) KIAS	54 KIAS
Stall speed, takeoff flap (V_{s1}(t/o))	42 KIAS***	42 (42-45) KIAS	50 KIAS
Stall speed, landing flap (V_S0)	40 KIAS***	42 (40-42) KIAS	46 KIAS
Max static rpm	2,200-2,270 rpm	2,260 (2,200-2,350) rpm	2,200 rpm

* Figures from the AOP.9 Pilot's Notes, except max static rpm, which is quoted from the AOP.9 Flight Reference Cards.
** The Pilot's Notes state that the initial rate of climb is '*about 800 fpm*'.
*** The Pilot's Notes state that these are *'approximate stalling speeds in knots, engine off'*.

Table 1

G-BXON's flight test performance results compared with other AOP.9s and the Pilot's Notes values

Climb performance

The climb performance test assesses the relationship between achieved ROC and engine rpm. There are fields on the FTS for the testing pilot to record the observed ROC, but not the expected value.

The guidance in the *'Climb'* section of the FTS states:

> *'Important notes: Sustained 5 minute climb is normally required to be carried out to establish adequacy of cooling, proper functioning at altitude and to provide sufficient data points to calculate a reliable rate of climb figure. However, where the rate of climb exceeds 1500 ft/min, or an aircraft with a Cirrus Minor or a Gipsy Major engine[37] is fitted, then a 3 minute climb will be accepted. Incomplete climbs due to airspace cloud or other similar reasons will not be accepted.'*

G-BXON underwent a three-minute climb. The LAA stated that had it been unhappy with the shorter duration of climb on G-BXON's FTS, it would have requested a retest.

Table 1 shows that G-BXON's achieved climb rpm was similar to the other AOP.9s, but its average ROC (450 fpm) was substantially lower.

Footnote

[37] While G-BXON's Cirrus Bombardier engine was not listed on the FTS as an engine to which this alleviation applies, the LAA subsequently stated that it would have granted the alleviation if the applicant had requested it.

The DA at aerodrome level for G-BXON's flight test was approximately 1,240 ft. The corresponding DAs for the other AOP.9s[38] ranged from around 170 to 1,000 ft. The aircraft which was tested with an aerodrome DA of 880 ft produced a test ROC of 720 fpm.

After the accident, the testing pilot commented that, based on his experience at the time of the flight test, G-BXON's ROC had seemed acceptable to him. The LAA stated that its post-accident comparison of AOP.9 performance highlighted G-BXON's ROC as being '*somewhat down*' even considering the higher maximum weight that was used.

Stalling

The LAA stated that the stall speeds recorded on an aircraft's FTS are obtained with the engine power at idle. This test is normally performed in level flight. The Pilot's Notes provides an example of the effect of engine power on the stall speed, as related to typical approach conditions. The example indicates that, with full flap and 1,700 rpm, the stall speed is approximately 38 KIAS; 2 KIAS lower than the power off stall speed.

FTS guidance for stalling states:

> *'Required limits: Stall warning 4 KIAS to 12 KIAS… above measured stall speed.'*

On the FTS form against *'Stall warning (knots/mph IAS)'*, the testing pilot entered '*N/A*' [not applicable] and, against *'Type of stall warning (e.g. horn, lamp, natural buffet etc.)'* he noted '*NONE'*. Against '*Other characteristics (e.g. buffet prior to stall)'*, the testing pilot noted '*NONE'*. Against '*sequence of nose and wing drop (if any)* [at the stall]' the testing pilot entered '*NOSE ONLY*' for all three configurations.

There is no place on the FTS form to record the expected stall speeds and the testing pilot stated that he did not study them as part of the flight testing process. Furthermore, as apparent from a photo taken during restoration, G-BXON's ASI was of a type that did not have extra markings depicting airspeed limitations, for example, stall speeds.

From the LAA's post-accident comparison of AOP.9 performance, both the LAA and testing pilot separately commented that, notwithstanding the higher weight, the stall speeds recorded during G-BXON's flight test (Table 1) were relatively high. The LAA questioned whether an improperly calibrated ASI could have contributed to this. The testing pilot suggested that there could have been a blockage in the static system. These items could not be tested after the accident due to the extensive damage.

Maximum static rpm

The FTS requires that, with a wide-open throttle, the engine must not overspeed when the aircraft is static on the ground. The FTS form provides fields to copy the maximum allowable rpm limitation from an aircraft's flight manual, and the maximum achieved static rpm as measured during the flight test.

Footnote

38 DA information was available for all but two of the other FTSs.

In the maximum allowable rpm field, the testing pilot noted *'2,600 / 2,400'*. In the Pilot's Notes, 2,600 rpm corresponds with the '*takeoff and operational necessity*' figure, 2,400 rpm corresponds with the '*intermediate (1 hour limit)*' value and '*maximum continuous*' is stated as 2,300 rpm.

As can be seen from Table 1, G-BXON's achieved maximum static rpm of 2,200 rpm was within the range specified by the AOP.9 Flight Reference Cards. G-BXON's was the joint lowest maximum static rpm value achieved by those aircraft analysed. One other aircraft achieved the same value but, unlike G-BXON, that specific aircraft had flight test performance figures (Table 1) which were otherwise closely aligned with the Pilot's Notes figures.

The testing pilot explained that he normally used 2,000 rpm as the lowest acceptable limit for an AOP.9 in this test. The LAA stated that it would have queried a value of below 2,150 rpm.

Fast cruise condition in level flight

The fast cruise condition test determines the maximum achieved engine rpm[39] in level flight and the corresponding airspeed (V_h). The Pilot's Notes states values of 2,300 rpm and 90 KIAS, and G-BXON demonstrated values of 2,500 rpm and 89 KIAS.

Performance - general discussion

When advised of G-BXON's relative performance after the accident, the testing pilot suggested that its reasonable fast cruise performance and low climb performance with what he described as being reasonable engine rpm values, may indicate that its propeller was coarse pitched[40,41].

It is not known if the accident pilot had looked in detail at G-BXON's FTS or was aware of the aircraft's deviations from the published performance figures.

Comparison with a CAA flight test report

Although most of the AOP.9s in Table 1 had been test-flown under the LAA regime, one of those aircraft had also been previously subject to CAA flight testing for the purposes of granting a CAA Permit to Fly. The CAA's flight test department has since been dissolved and flight testing has been delegated to suitably approved organisations including the LAA. Nevertheless, the CAA test process for that other AOP.9 served as a comparison to that undergone by G-BXON.

Footnote

39 With the power lever fully forward in level flight, at an altitude below 2,000 ft.

40 Coarse pitch: Large angle between the propeller blade chord and the plane of the propeller disc, producing high forward speed for a given rotational speed.

41 In common with most other AOP.9s on the UK civil register, G-BXON was equipped with a Bombardier Cirrus 20801 engine and a Fairey Reed A66960/X8 fixed-pitch propeller. Two UK AOP.9s are fitted with a similar Fairey Reed A66960/X1 fixed-pitch propeller. On Fairey Reed propellers a different 'X' number on the model number generally denotes a change in pitch, but a higher 'X' number may refer to a higher (coarser) or a lower (finer) pitch value. The pitch of the X1 variant is 4.43 ft but the pitch for the X8 variant was not determined and could not be measured on G-BXON's propeller due to accident damage.

The CAA flight test was carried out by a qualified Test Pilot[42] who used the same check flight schedule (CFS[43]) as was used for flight testing prior to the issue of a CofA. The Test Pilot compared the aircraft's measured results with expected values from the Pilot's Notes in order to be able to recommend to the CAA that the aircraft be granted a Permit to Fly.

The aircraft in that case was loaded to its normal maximum weight. Its climb performance was tested over a 5-minute duration.

This CFS included space for the Test Pilot to record an aircraft's expected ROC and stall speed values from the relevant operating manual. The CFS also specified permitted deviations from these, stating that:

> *'aircraft with climb shortfalls of more than 70 fpm should not be accepted.'*

And:

> *'Required limits: …Stall speed +3 to -5 kts/mph relative to scheduled stall speed…'*

The Test Pilot recorded that that aircraft demonstrated a noticeable wing drop in all three configurations and noted:

> *'The wing drop would not allow the aircraft to be certified[44] and is a known potential deficiency of this type… The characteristic was repeatedly demonstrated to one of the owners and the other owner was fully briefed on completion of the flight test.'*

Information provided by the LAA

G-BXON worksheets

With respect to worksheets submitted in support of Permit to Fly applications, LAA Engineering commented that worksheets can differ significantly between applicants in terms of content, style and detail. Of the range it receives, it considered that the worksheets for G-BXON contained less than the average level of detail and further worksheets had to be requested before they were accepted. The LAA considered that the brevity of the worksheets may have been due in part to the fact that G-BXON had changed hands part way through the rebuild project, and the absence of worksheets from the previous owners/inspector.

G-BXON test flying

When asked why it did not stipulate a minimum amount of test flying for G-BXON, LAA Engineering commented that homebuilt aircraft normally require a minimum of five hours

Footnote

[42] CAA Check (Test) Flights were conducted either by the CAA's own experimental test pilots or by pilots specifically briefed and approved by the department following a check flight.
[43] The LAA reported that it developed its FTS from the CAA's CFS, by adapting it to the LAA environment.
[44] The certification referred to is the granting of a CofA.

test flying because they have not flown before, and because there is more variability between examples. However, for factory-built aircraft with published technical documentation, like the AOP.9, a reduced number of hours test flying is often deemed acceptable. The LAA stated that, because G-BXON was unmodified from its original design and the testing pilot was experienced on type, no minimum testing time was stipulated in this case. LAA Engineering indicated that, if it had been aware that defects requiring ongoing rectification and component replacement had been experienced on G-BXON's engine until shortly before the test flying commenced, it would have specified a minimum number of hours to be flown.

LAA test flying – performance

The LAA advised that there is an absence of performance data for some aircraft types and that there can be variation in modification state between individual aircraft of the same type in their fleet (eg different propeller types). As a consequence, assessment of an aircraft's performance at initial Permit to Fly application tends to be based on experience with similar examples and adequacy for the intended role, rather than on closely matching available data for the type.

For each subsequent flight test for a Permit to Fly renewal, the aircraft's climb performance is compared against its values from previous years to identify any trends or anomalies.

Analysis

Introduction

G-BXON departed controlled flight during its takeoff climb from Spanhoe. The investigation has considered factors which may have contributed to this including aircraft and engine performance, pilot handling, and the possibility of a technical failure.

Engine performance

Examination of the engine, propeller and ground marks indicated that the engine was operating with some power at the point of impact. It was not possible to ascertain the position of the throttle or throttle control due to the damage caused by the impact and post-impact fire. While there were a number of distinct propeller strikes on the ground and in the surrounding crop, the dynamic nature of the impact sequence, the orientation of the aircraft at impact and the absence of ground speed information for the accident flight, meant that it was not possible to calculate a meaningful range of engine rpm.

Anecdotal information from witnesses suggested that G-BXON's engine had been developing approximately 2,200 – 2,300 rpm at takeoff setting and the pilot had discussed this with another AOP.9 owner as he was reportedly not satisfied with the engine performance. Pilot B commented that the pilot had specifically asked him to monitor the takeoff rpm on the previous day's flight. He recalled that it was approximately 2,300 rpm, and this was supported by audio analysis of the video recording of that takeoff. The pilot indicated in a text message that the engine performance during the previous day's flight, had been much better than before. Engine speeds recorded during the flight test for the

Permit to Fly indicated that the maximum static engine rpm was 2,200 rpm. The engine performance during climb (2,350 rpm) was average, but the associated ROC (450 fpm) was substantially lower (Table 1).

A detailed engine strip examination identified a number of anomalies. These included poor compression on three out of the four cylinders, which would have limited the engine's ability to develop full power. This was predominantly due to leakage at the exhaust valves, however the presence of oil in some of the cylinders indicates that the piston rings and/or piston may not have been providing adequate sealing. It was possible that the new piston rings had not fully run in to achieve a good gas seal. Additionally, five out of the eight spark plugs exhibited weak and/or intermittent sparks when tested and the magneto timing was not set correctly.

When tested after the accident, the mechanical fuel pumps did not deliver fuel at the required fuel flow rate and examination revealed anomalies with the internal diaphragm, which would have prevented the pumps from functioning correctly. However, it is likely that in the installed condition, gravity-fed fuel from the high wings tanks and the presence of the electrically-driven booster pump in the fuel collector cell, may have, at least partially, compensated for the poor performance of the mechanical fuel pumps.

The timing of the fuel injection pump, which had been replaced a number of times, was found to be incorrectly set and did not coincide with the induction period of the engine. Although fuel would have been delivered to the cylinders it would not have been delivered at the point in the engine cycle to produce optimum engine performance. The fuel injection pump did not display any obvious impact damage and it was considered likely that the incorrect timing could have occurred during installation. The fuel injection pump operated normally when tested but was out of calibration in that it was running lean. Additionally, during testing, leaks were observed from two of the fuel injection nozzles which may also have been present prior to the accident.

Due to the extent of accident damage, it was only possible to examine and test individual components from the aircraft's fuel system; it was not possible to assess whether collectively, the fuel system with its various fuel pumps, could adequately meet the fuel demands of the aircraft's engine. Nor was it possible to make a comparison with the results of the fuel flow checks previously recorded on the supplementary worksheet.

The anomalies identified during the engine examination could account for less-than-ideal engine performance during the accident flight. In contrast, the testing pilot, who was very familiar with the aircraft and its engine in his capacity as its LAA inspector, reported being satisfied with the aircraft and engine performance during the initial test flying and formal flight test. This indicates that either engine performance issues were not present, or not identified, during the test flying. Furthermore, it was reported that additional work was undertaken on the engine between the test flight and the accident flight, which may have had an effect on engine performance.

Notwithstanding these observations, reduced engine performance in isolation would not have accounted for the departure from controlled flight during the accident flight. But its effects, which may have been insidious, could have contributed to the less-than-ideal aircraft performance or served as a distraction to the pilot.

Fuel

Analysis of the fuel used to refuel G-BXON indicated low levels of contamination by a substance consistent with automotive gasoline. It was considered that the jerry cans in which the fuel was stored, may previously have been used to store automotive gasoline. The sample from the fuel injection line was broadly similar to the jerry can sample. It also exhibited particulate contamination and trace contamination including plasticisers. This may have been as a result of the fuel coming into contact with rubber fuel hoses, or plastic storage containers.

An aircraft engine is designed to operate most efficiently on a specific type of fuel conforming to pre-determined specifications. The use of fuel that deviates from these specifications can reduce operating efficiency and, under some conditions, lead to engine failure. It was not possible to determine whether the presence of low levels of contamination in the fuel would have adversely affected engine performance in this case.

Technical failure

The left aileron control rod was found to have separated at the forward end-fitting. Metallurgical analysis determined that all four of the failed attachment rivets had been carrying load at the time of failure, although two also exhibited evidence of pre-existing intergranular corrosion and stress corrosion cracking. At least one third of the fracture surface on the outboard rivet was attributed to a pre-existing intergranular crack, which would have reduced its load-carrying capability. The inboard rivet may also have been subject to intergranular cracking, but mechanical damage on the fracture surface prevented a definitive assessment.

The investigation considered whether the left aileron control rod could have detached in flight and contributed to the departure from controlled flight. The strength of the aileron control rod riveted joint was calculated to be sufficiently strong to carry the maximum expected normal flight loads, even if pre-existing cracking had led to complete failure of two out of the four rivets.

However, the critical load case for the rivets was the maximum pilot effort case and, given the potential for reduced load-carrying capability in two of the rivets, if large forces had been applied to the control stick, the aileron control rod riveted joint may not have been sufficiently strong to withstand such loads. While there was no evidence of a control restriction which might have necessitated application of such loads, it was not possible to definitively rule out the presence of a restriction as any evidence may have been destroyed in the post-impact fire. This scenario was not consistent with the eye-witness description of the takeoff and subsequent departure from controlled flight and is therefore considered unlikely. However, the possibility that the control rod failed due to the pilot applying large forces to the control stick during attempts to recover to controlled flight could not be ruled out.

Examination of the wreckage indicated that the aileron control rod had most likely detached due to impact loads being transmitted, via the aileron mounting structure, to the aileron hinge and control rod when the left wingtip struck the ground.

In addition, examination of the wreckage, although limited due to the extent of fire damage, did not identify any other technical issues which may have contributed to the accident, but there were parts of the primary flight controls, some systems and flight instruments which could not be examined.

LAA flight testing process

Notwithstanding some variation in DA and aircraft weight, G-BXON's FTS showed that its stall speed values were substantially higher, and its ROC substantially lower, than other AOP.9s[45] and the Pilot's Notes figures. Its climb performance was tested over three minutes instead of five minutes, despite it not automatically qualifying for that alleviation. Nevertheless, G-BXON's FTS was reviewed and accepted by the LAA on the basis that it considered that the results did not indicate that the aircraft was unairworthy.

The CAA no longer performs flight testing. However a CAA Permit to Fly flight test for one of the other AOP.9s provided a comparison to the process used for G-BXON. In that example, the CAA testing was carried out by a qualified Test Pilot using a CFS form which had been designed for CofA flight testing. The form allowed the Test Pilot to record expected values, and it also specified permitted deviations from those. The Test Pilot analysed the aircraft's results and made a recommendation for its permit to be issued. In that case, the Test Pilot demonstrated and briefed the owners on their aircraft's wing drop tendency in the stall. Given the less formal nature of the LAA testing process, the LAA stated that whilst an owner and testing pilot would normally discuss a flight test informally, there was no formal mechanism for testing pilots to research expected performance results and compare those with achieved values, nor to brief owners on their aircraft's FTS results. Testing pilots are expected to supply the aircraft's FTS to its owner, who would then be responsible for sending a copy (along with any other requested information) to LAA engineering for review.

Whilst the LAA had a process for continued monitoring an aircraft's climb performance at each permit renewal, there was no formal process, during the initial permit application, to compare achieved performance results with expected values. Instead, it relied on its knowledge of the aircraft type.

Since this accident, the LAA has created a database of flight test performance results for all types and introduced an additional process to compare an aircraft's performance results at initial permit application with others of the same type. In the case of factory-built aircraft, the scheduled performance figures, when available, will also form part of this consideration.

G-BXON's testing pilot recorded on the FTS that no stall warning had been demonstrated and thus he noted '*N/A*' for the stall warning speed. The stall test in the FTS requires that stall warning occurs between 4 KIAS to 12 KIAS above the measured stall speed. However,

Footnote

[45] All of which had the same engine/propeller combination.

the FTS does not make it clear what stall warning, if any, a subject aircraft is required to have, and so the form could be misleading in this respect. The LAA has stated that this requirement refers specifically to artificial stall warning devices. It has clarified the wording on the FTS to emphasise that it relates only to aircraft with such devices, and to reflect that some LAA aircraft may not be so equipped.

Furthermore, the LAA has undertaken to write to owners with any safety related observations on an aircraft's submitted flight test results. This will include highlighting the absence of any stall warning, particularly when the reported characteristics deviate markedly from those normally expected, but which have nevertheless been deemed acceptable by the LAA for permit issue.

G-BXON performance

It was not determined what caused the high stall speed values and low ROC demonstrated during G-BXON's flight test. Due to the extent of the damage, it was not possible to test the ASI calibration, or determine if any aspects of G-BXON's configuration could have contributed to these results.

There was no recorded data for the accident flight. However, information was derived from the video of the pilot's takeoff on the day before and, in the absence of evidence to the contrary, it is assumed that he flew G-BXON during the accident flight in a similar manner.

The AOP.9 Pilot's Notes indicate that, with takeoff flaps set, the power off stall speed is approximately 42 KIAS, and the aircraft can be 'pulled off' during departure at around 45 KIAS. However, G-BXON's demonstrated V_{S1}(t/o) of 50 KIAS was 8 KIAS higher than the Pilot's Notes value and 5 KIAS higher than the speed at which the Pilot's Notes state an AOP.9 can become airborne during departure. The application of engine power may lower an aircraft's stall speed but the power off V_S values provide a stall speed reference for pilots. Furthermore, the example provided in the Pilot's Notes relating to the stall speed under typical approach conditions shows that a power setting of 1,700 rpm reduces V_{S0} by around only 2 KIAS.

During the flight on the previous day, with takeoff flap set, the pilot elected to climb at 60 KIAS and video analysis showed that, for lift off and climb, G-BXON achieved a true airspeed of between 56 and 60 kt. Notwithstanding a slight difference[46] between indicated and true airspeed, this would have provided a minimum margin of around 6 kt above G-BXON's demonstrated power off stall speed in this configuration.

The experienced AOP.9 pilots that were interviewed indicated that, particularly due to its lack of stall warning, they habitually fly the aircraft at higher speeds than those published. Some said they would climb at an airspeed of more than 60 KIAS when departing using takeoff flap on a hot day, and this would give a margin of more than 18 kt against the Pilot's Notes expected V_{S1}(t/o) of 42 KIAS.

Footnote

46 Under normal circumstances, the difference would be insignificant at low altitudes.

Those interviewed highlighted the AOP.9 as being generically low-performing. For G-BXON, this low performance may have been further exacerbated by an underperforming engine. A ROC of 450 fpm was recorded on the FTS and 500 fpm was achieved on the previous day's flight, both figures being substantially less than the Pilot's Notes value. High density altitude conditions present over the weekend of the accident would have affected the aircraft's performance.

As someone reported to 'fly by the numbers', and possibly less by 'feel', if the accident pilot had chosen a target climb airspeed using the Pilot's Notes but was unaware of G-BXON's higher indicated stall speeds, poor ROC, and the issues surrounding AOP.9 handling, then it is likely that he would have been flying closer to the stall regime than he realised. During the accident departure, if the pilot had over-rotated the aircraft without having built up sufficient airspeed, or if he had perceived the ROC to be low and then eased back on the control column to increase it, then the airspeed may have reduced enough for the aircraft to stall. During the takeoff on the previous day, the pilot asked Pilot B to monitor the engine rpm. On the accident flight, the pilot may have conducted the additional monitoring of the engine rpm himself and this could have provided a distraction to his monitoring of the airspeed.

It is not known if the pilot was aware of the AOP.9's stalling characteristics and the absence of stall warning features on G-BXON. The type is prone to dropping a wing during the stall and, if the back pressure on the control column is not promptly released, then a spin may develop. The presence of drooped ailerons and the high power setting used for takeoff further increase the likelihood of a wing drop in the stall. The Pilot's Notes state that stall recovery will involve a height loss of around 200 ft, so particular care should be taken whenever near to the ground at low airspeeds. An instinctive, rather than deliberate, reaction to the associated wing drop and loss of height could involve aileron and nose-up elevator inputs. This would exacerbate any tendency to spin from which, in this instance, there was insufficient height to recover.

The eyewitness description of G-BXON's behaviour during the accident is consistent with the AOP.9 Pilot's Notes description of a stall with an associated wing drop.

Flight preparation

At the time of the accident, the LAA noted on its website that, based on USA data, 20% of homebuilt aircraft accidents occur during the first two flights, and that the same is true of the first flight of any unfamiliar aircraft, whether it is a homebuilt, vintage, or microlight.

The LAA's Pilot Coaching Scheme assists owners in familiarisation with their aircraft but it is not known whether the accident pilot was aware of this. The related documentation reminds pilots not to underestimate the challenges posed by some aircraft types and to recognise that, even for experienced pilots, tuition may be appropriate when first flying a new type.

The investigation did not determine how much preparation the pilot had done for flying the AOP.9. Prior to his first flight on this type, he had performed two flights, in the preceding

90 days on other types. He was reportedly eager to fly his newly-restored aircraft and the agreement to fly with Pilot B occurred a short time before they departed on their 10-minute flight together the day before the accident. Therefore, there would have been limited time for a briefing to take place. On the accident flight, he was accompanied by a passenger who had no pilot qualifications. Both days were warm.

The LAA already promulgates a self-briefing tool for testing pilots and, since the accident, it has produced similar guidance for owners on how to prepare for flying a new type: it has published two magazine articles on the topic and, in December 2018, produced a Technical Leaflet (TL 2.30 '*Converting to a new type*') for use as a preparation tool, similar to the one provided for testing pilots. Subjects addressed include: researching a new aircraft type (eg by reviewing its operating manual, operating limitations and handling peculiarities); the planning and content of a first flight on type to become familiar with the aircraft alongside a suitably experienced pilot; the importance of beneficial weather conditions (eg consideration of density altitude); and consideration of the desirability of carrying passengers both in terms of aircraft weight, and pilot recency and experience on type.

It is likely that the pilot was not prepared for the aircraft to stall after takeoff, and it is not known whether he was aware of G-BXON's higher stall speeds. The absence of any stall warning and the wing dropping would have added to his surprise. Therefore, he is unlikely to have been prepared to take immediate and appropriate recovery action.

The CAA's advice on stall and spin awareness reminds pilots to be prepared, particularly whilst flying at low level, to recognise both the 'approaching' and 'full' stall indicators, and to take immediate recovery action if the aircraft is not performing as expected. This prioritises the recovery of a safe flight path.

Survivability

The aircraft suffered extensive damage during the impact, however the steel tubular structure of the fuselage maintained a substantial 'survivable space'. Although the impact forces were survivable, the post-mortem concluded that the pilot died from burns sustained in the post-impact fire.

The post-mortem report suggested that an injury sustained in the impact may have impeded his ability to exit the aircraft. Additionally, the seat harness QRF found near the left seat may have suffered deformation during the accident and did not release when subsequently operated by the AAIB. Nevertheless, the post-mortem findings supported an indication that the pilot '*died relatively quickly*' after the post-impact fire started. As such it was not determined whether the injury or QRF would have influenced the outcome.

Both occupants were wearing normal clothing which would not have offered any protection from the effects of fire. Prior to this accident, in July 2016, the LAA published an article in its magazine relating to mitigating post-accident survival risks. Since this accident, the LAA has indicated its intention to incorporate advice relating to choice of flying clothing in a new Technical Leaflet.

Other issues identified

Maintenance documentation

The worksheets submitted to the LAA in support of the Permit to Fly application listed the maintenance tasks performed during G-BXON's rebuild. Where the tasks referred to component or system checks, the results of these checks were not initially documented. Results of the fuel flow checks and engine were subsequently provided on a follow-up worksheet, but the results of flight instrument calibrations were not recorded.

The worksheets had been completed by the LAA inspector and each task was certified by him. Although a substantial amount of work on the aircraft would have been conducted by the pilot, the pilot's signature only appeared against a single task relating to duplicate inspections of the flight and engine controls.

In accordance with the LAA inspector's preferred approach, the maintenance tasks had not been individually documented as the restoration had progressed but had instead been collectively grouped together and retrospectively documented. It is evident that the pilot relied on the LAA inspector to document the work undertaken on G-BXON and to manage the Permit to Fly application process on his behalf. The manner in which the worksheets had been documented made it difficult for the investigation to determine the chronology of the work performed on G-BXON. Additionally, it was not possible to differentiate work done by the pilot and certified by the inspector under his LAA remit from work performed by the inspector.

Furthermore, the worksheets submitted in support of G-BXON's Permit to Fly application did not fully reflect the status of the aircraft or all the work which had been undertaken. Substantial work is reported to have been carried out on the aircraft's engine between September 2016 and April 2017. The supplementary worksheet submitted on 10 April 2017 made no reference to this work, and it did not appear to have been recorded elsewhere.

It was not established to what extent the LAA inspector was aware of, or involved in, this additional work or whether this work had been re-inspected. Work on the engine is reported to have included replacement of the fuel injection pump, ignition leads and adjustment of the OPRV. A number of anomalies were noted with these components during the post-accident examination of the engine. This suggests that either the work had not been inspected, or not been inspected effectively.

The initial worksheets dated 16 September 2016 referenced the installation and timing of an overhauled fuel injection pump. However, the fuel injection pump was subsequently replaced some months later. The absence of a formal record of this work meant it was not possible to establish whether the replacement pump had been correctly timed and tested. However, an invoice dated 22 February 2017 to the pilot from the LAA inspector's maintenance company referred, among other items, to investigation of an engine problem and timing and installation of a new fuel [injection] pump.

The LAA process for aircraft build and rebuild projects places the onus of responsibility on the aircraft owner for ensuring that the finished aircraft meets accepted standards for build quality and airworthiness. The investigation found that LAA guidance regarding owner responsibility for the quality and conformity of a completed aircraft project differed for newbuild and rebuild aircraft. In particular, TL 2.21 lacked any specific guidance on this subject, although relevant guidance was available in other TLs.

In October 2018, the LAA revised TL 2.21 to include additional guidance relating to completion of worksheets and the expected level of detail required. The revised TL also includes information on owner responsibility for the quality and conformity of rebuild projects, to reflect guidance already published for newbuild projects.

Permit to fly application process

Throughout G-BXON's Permit to Fly application process LAA Engineering repeatedly sought clarification from the LAA inspector on a number of worksheet items, to ensure that the submitted paperwork met an acceptable standard to form the basis of an LAA recommendation for a Permit to Fly. The LAA commented that the worksheets submitted for G-BXON contained a less than average level of detail. Nonetheless, following receipt of the supplementary worksheet submitted on 10 April 2017, the LAA satisfied itself that the paperwork was adequate and cleared the aircraft to proceed to the flight testing stage.

Although LAA guidance published in TL 2.21 for rebuild projects specified a minimum of five hours flight testing followed by a formal flight test, LAA Engineering did not impose a minimum number of flight testing hours or landings for G-BXON. Instead it left this determination up to the testing pilot, having taken into account his level of experience on type. The LAA was not aware of the additional work undertaken on G-BXON's engine, following submission of the original worksheets in September 2016. It subsequently indicated that had it been aware of the difficulties experienced in getting the engine to run smoothly in the lead up to the flight testing period, it would have specified a minimum number of hours to be flown. While this may not have influenced the outcome of the accident flight, additional flight testing may have allowed any post-rebuild engine performance issues to become evident.

Following the accident, the revised TL 2.21 includes updated information to bring the LAA's published guidance on minimum flight testing hours into line with actual practice and to describe the factors that LAA Engineering takes into account when determining the initial flight test requirements for a given aircraft.

Aileron control rod rivets

The rivets installed in the left aileron control rod were of a different type and lower strength than those specified on the AOP.9 post-modification drawing. The AOP.9 Type Record indicated that the original aileron control rod rivets were AGS 2048-420 and had a reserve factor of 1.004 in the critical loading case. This may provide an explanation for stronger rivets specified in the revised post-modification drawing, but it was not determined whether there was any mandatory requirement for the change to Chobert rivets to have been embodied on G-BXON.

All the rivets from G-BXON appeared to conform with the material properties of the original AGS 2048-420 rivets, but only the green rivets conformed with respect to colour. The two rivets on the left aileron control rod which had suffered corrosive attack were grey and may have been from a different batch, or differed in some other respect, introducing the possibility that they were fitted at a different time.

All eight rivets from the right aileron control rod end-fittings were grey and visually similar to the two grey rivets from the left aileron control rod. One of them had failed and metallurgical analysis determined that the failure was due entirely to intergranular fracture and that the rivet had not been carrying any load when it failed. It was concluded that the rivet had failed at some point prior to the accident flight, but it was not possible to determine when.

There was no reference to work being carried out on either aileron control rod in the worksheets from G-BXON's recent restoration, and the absence of historic technical records and/or worksheets from the previous owners meant it was not possible to determine whether the failed rivets were replacement or original rivets.

A total of three aileron control rod attachment rivets examined exhibited partial, or total, pre-existing intergranular failure as a result of stress corrosion cracking. While it was determined that the aileron control rod joints could sustain normal flight loads, even with two failed rivets, the failure of fasteners on a safety-critical flight control connection is highly undesirable from an aircraft safety and airworthiness perspective. Only the failed rivets were subject to metallurgical examination during the investigation, so it is possible that the remaining rivets, although intact, could exhibit stress corrosion cracking.

Intergranular stress corrosion cracking in these rivets may not be visually evident until the point of final failure and the only means to detect the presence of cracking would be via an inspection using a non-destructive testing (NDT) technique. There is currently no requirement for historic aircraft being restored under the LAA regime to be subject to NDT inspections.

As a result of the findings of this investigation, in January 2019 the LAA issued Airworthiness Information Leaflet MOD/920/001 *'AOP.9 Inspection of rivets securing the aileron operating rod end fittings'* which requires an inspection of the aileron control rod rivets on all AOP.9s with an LAA permit to fly to identify the type and condition of rivets installed, and appropriate rectification according to the findings of the inspection. The LAA has also included additional guidance in the updated TL 2.21 relating to the integrity of riveted joints in rebuilt aircraft. The updated guidance includes the following additional statement:

> *'… at rebuild all rivets should be examined critically and consideration given to replacing rivets that may be internally corroded especially where they carry out a critical function….In particular it would be well worth drilling out and replacing as a matter of course any rivets that are not part of a large multiply-redundant group, and are performing a function that's critical to safety e.g. strut ends, pushrods, wing and tail attachments, engine mount brackets etc, even though they might appear to be still in good condition.'*

Conclusion

The investigation concluded that it was most likely that G-BXON departed from controlled flight because it stalled at a low height after takeoff. G-BXON, as is common to type, did not demonstrate any stall warning in its Permit to Fly flight test. It also demonstrated substantially higher stall speeds and a lower rate of climb in comparison with other AOP.9s and the Pilot's Notes figures. The pilot was likely to have elected to fly at a departure airspeed which he perceived to provide an adequate margin from the stall regime. In the absence of prompt and appropriate pilot actions, recovery from a stall at a low height was unlikely.

Examination of the wreckage, although limited to some extent due to impact and fire damage, did not identify any other technical issues which may have contributed to the accident, but there were some systems and flight instruments which could not be examined.

Although the aircraft's engine was operating at the time of the accident, the investigation identified a number of anomalies which could have contributed to less-than-ideal engine and aircraft performance. In isolation, these would not have accounted directly for the departure from controlled flight but may have served as a distraction to the pilot.

Additionally, the investigation identified issues relating to the documentation of maintenance and the integrity of safety-critical rivets.

The LAA has taken action to reinforce its existing processes and published guidance in areas relating to the Permit to Fly application process, documentation of aircraft maintenance and pilots undertaking their first flights on type. No Safety Recommendations are made.

Safety action

The following safety actions have been taken:

The Light Aircraft Association (LAA) has:

- Created a database of initial flight test performance results and introduced a process to compare future aircraft against other examples of the same type prior to permit issue. In the case of factory-built aircraft, scheduled performance figures, when available, will also form part of this consideration.

- Clarified the wording of the stall requirement in the Flight Test Schedule which relates to the speed at which stall warning will occur. The new wording emphasises that this requirement relates only to aircraft with artificial stall warning devices and reflects that some LAA aircraft may not be so equipped.

- Introduced a procedure whereby, when it issues a newly-constructed or newly-rebuilt aircraft with a Permit to Fly, it will write to the owner with any safety related observations on the submitted flight test results. The observations will include highlighting the absence of any stall warning features, particularly when the reported characteristics deviate markedly from that expected or from published data for the type.

- Produced guidance for pilots preparing for their first flight on a new type: it has published two magazine articles on the topic and has also produced a Technical Leaflet, TL 2.30 '*Converting to a new type*', for use as a preparation tool, similar to the one provided for testing pilots. Subjects addressed include: researching a new aircraft type (eg by reviewing its operating manual, operating limitations and handling peculiarities); the planning and content of a first flight on type to become familiar with the aircraft alongside a suitably experienced pilot; the importance of beneficial weather conditions (eg consideration of density altitude); choice of appropriate flying clothing; and consideration of the desirability of carrying passengers both in terms of aircraft weight, and pilot recency and experience on type.

- In October 2018, revised TL 2.21 *'Rebuilding an aircraft under the LAA system'* to include additional guidance on the completion of worksheets, the expected level of detail to be recorded, and reiterated the respective responsibilities of owners and inspectors for the quality and conformity of rebuild projects. Additional guidance relating to the integrity of riveted joints in rebuilt aircraft was also included, as was updated information to bring the LAA's published guidance on minimum flight testing hours into line with actual practice, and to describe the factors that LAA Engineering considers when determining the initial flight test requirements for a given aircraft.

- In January 2019, issued Airworthiness Information Leaflet MOD/920/001*'AOP.9 Inspection of rivets securing the aileron operating rod end fittings'* which requires an inspection of the aileron control rod rivets on all AOP.9s within its fleet to identify the type and condition of rivets installed, and appropriate rectification according to the findings of the inspection.

Bulletin Correction

A bulletin correction was issued concerning this report prior to publication.

In order to provide additional clarification, the information in the section titled '*Passenger*' (page 36) and the last two sentences in the first paragraph of the '*Engine maintenance*' section (page 52) have been amended.

Full details regarding the correction can be found on the AAIB website (https://www.gov.uk/aaib-reports/aaib-investigation-to-auster-aop-9-g-bxon).

ACCIDENT

Aircraft Type and Registration:	Cessna 152, G-UFCO	
No & Type of Engines:	1 Lycoming O-235-L2C piston engine	
Year of Manufacture:	1978 (Serial no: 152-81734)	
Date & Time (UTC):	19 April 2018 at 1119 hrs	
Location:	Near Crumlin, County Antrim	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - 1
Injuries:	Crew - 1 (Fatal)	Passengers - 1 (Fatal)
Nature of Damage:	Aircraft destroyed	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	77 years	
Commander's Flying Experience:	18,383 hours (of which 900 were on type) Last 90 days - 5 hours Last 28 days - 4 hours	
Information Source:	AAIB Field Investigation	

Synopsis

The purpose of the flight was to carry out aerial photography. During a manoeuvre at low level the aircraft stalled and descended rapidly, passing through some trees, before striking the ground. There was a post-crash fire and neither occupant survived.

History of the flight

Background

The pilot had arranged to hire the aircraft, for a flight with himself and a passenger, from a local flying club based at Newtownards Airport. The passenger was a professional photographer specialising in aerial photography. He would arrange to be flown as a passenger in an aircraft to photograph properties with the intention of subsequently selling the photographs. The passenger had flown regularly with the pilot of G-UFCO, around 15 times a year for the last 14 years. The arrangement was that the passenger would provide a route plan, around various properties, and the pilot would then fly the route. It is not known what, if any, financial arrangements were made between the pilot and the passenger.

On the day of the accident the pilot went in to the clubhouse where he was seen by several people. However, those there could not recollect having seen his passenger, so it is likely that he went directly to meet the pilot at the aircraft.

The weather conditions were fine with good visibility and some scattered cloud.

Accident flight

The aircraft took off from Newtownards at approximately 1047 hrs and flew in a north-westerly direction. At 1049 hrs the aircraft was recorded on radar 1.5 nm north-west of Newtownards Airport at an altitude of about 800 ft amsl. This coincided with the pilot making initial radio contact with Belfast City ATC, who the pilot advised that they were operating a photographic flight near Nutts Corner (a disused airfield located 3 nm south-east of Belfast International Airport). The aircraft subsequently transited the Belfast City Control Zone at an altitude of about 1,300 ft amsl, before being transferred to the Belfast International approach frequency. The pilot requested clearance to operate between Nutts Corner and Loanends (Figure 1 and 2), which was granted and the aircraft entered controlled airspace.

Figure 1

Radar track of flight from Newtownards Airport

At 1058 hrs the pilot was transferred to the Belfast International tower frequency. A few minutes later at 1102 hrs, as the aircraft approached Nutts Corner, the pilot was instructed to hold position as an aircraft was on approach to land at Belfast International Airport. Having held at Nutts Corner for several minutes, flying at an altitude of about 1,100 ft amsl (a height of approximately 650 ft agl), the pilot reported that he was visual with the other aircraft and at 1106 hrs was cleared to proceed towards Loanends (Figure 2).

The aircraft was then flown in a series of clockwise, circular and oval shaped turns at bank angles of up to 30° at heights between approximately 350 ft and 600 ft agl and at an estimated airspeed of about 60 kt TAS; based on a wind[1] from 220° at 11 kt. The passenger was seated in the right seat and therefore clockwise turns would have facilitated a better view of properties during photography.

Footnote

[1] Obtained from the Belfast International Airport METARs timed at 1050 UTC and 1120 UTC.

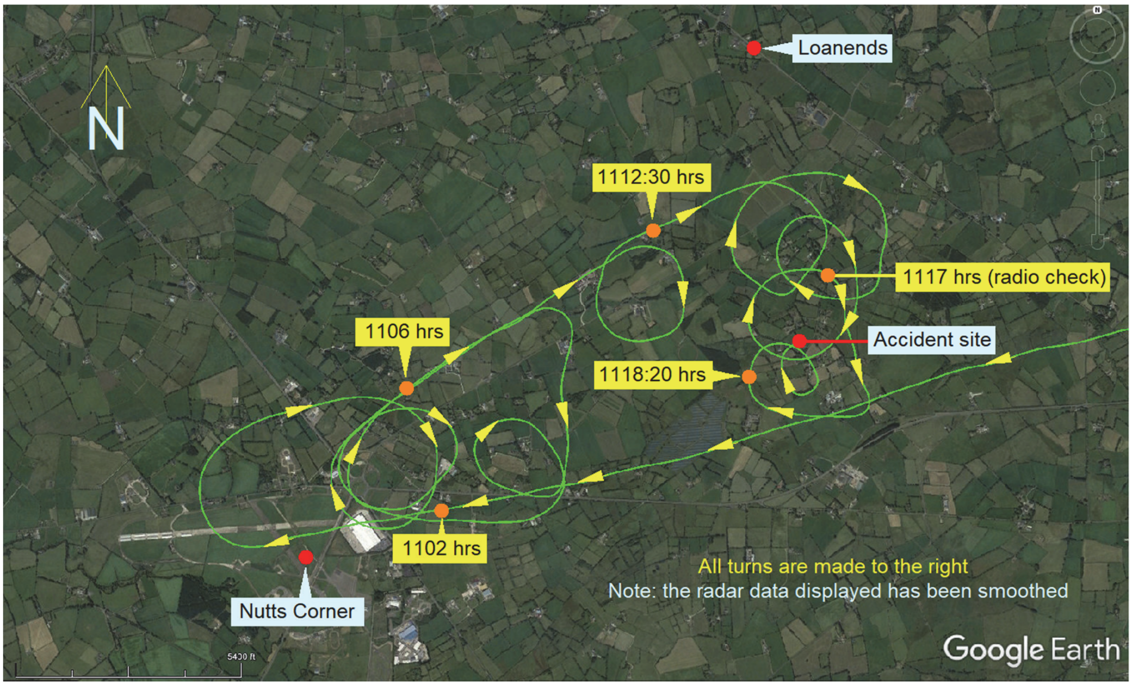


Figure 2

Radar track of the last 19 minutes of the flight

At 1117:10 hrs, the pilot contacted the controller to request a radio check (there had been a period of about 10 minutes with no radio traffic on that frequency). The pilot was advised that they were the only aircraft currently on frequency. This was the last radio communications received from G-UFCO.

Radar recordings showed that during the next 90 seconds the aircraft maintained an altitude of about 900 ft amsl (approximately 400 ft agl), whilst making turns to the right. At 1118:44 hrs the turn rate increased to an estimated bank angle of about 45° right wing down, before reducing to about 20° right bank. The radar data indicates that the aircraft continued with a gradual turn to the right and at 1119:03 hrs the final radar point was recorded. The aircraft was at an altitude of about 810 ft +/- 50 ft (260 ft +/-50 ft agl) (Figure 3).

Witnesses on the ground in the area of the accident saw the aircraft circling. Several reported seeing it flying apparently normally before suddenly "nose-diving" towards the ground. Two witnesses close to the accident site also reported hearing the engine "spluttering" as the aircraft passed overhead at a low height. After the aircraft struck the ground these witnesses heard a "popping" noise and then a larger explosion.

There was an intense fire in the cockpit area and bystanders who arrived on the scene were not able to assist the occupants of the aircraft.

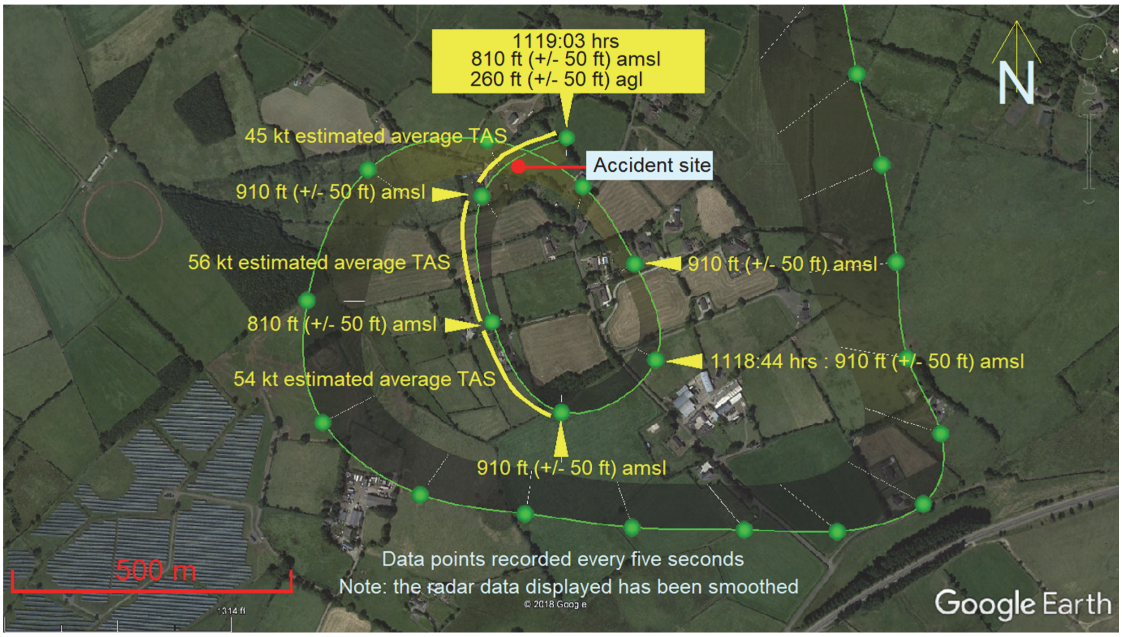


Figure 3

Radar track of the last 120 seconds of the flight

Aircraft information

G-UFCO was a Cessna 152, a two seat, dual control high wing monoplane powered by a horizontally opposed four-cylinder Lycoming piston engine driving a two-blade, fixed pitch propeller.

The aircraft was originally registered in the USA and was transferred to the UK register in June 2015. It had a valid Airworthiness Review Certificate, which was due to expire on 8 July 2018. At the time of the accident the aircraft had accumulated a total of 3,021 airframe hours and 598 engine hours. The last 50-hour check was carried out at 3,006 hours, on 27 March 2018 and the records showed no significant defects recorded. The technical log showed that the aircraft had flown regularly in the days leading up to the accident.

Carburettor heating system

During normal operation, air passes through a filter, is mixed with fuel in the carburettor and then goes into the engine but in certain atmospheric conditions, ice can form in the carburettor, restricting and ultimately preventing, fuel and air from reaching the engine. To provide protection against carburettor icing, the aircraft, in common with other piston engine aircraft, is fitted with a carburettor heating system. The cockpit carburettor heat selector is connected to a flap valve in the air intake box by a cable and lever arm (Figure 4). When the selector is moved to the ON or HOT position, the cable pulls the lever arm, rotating the valve and allowing air heated by the exhaust manifold to flow into the carburettor to melt any ice present.

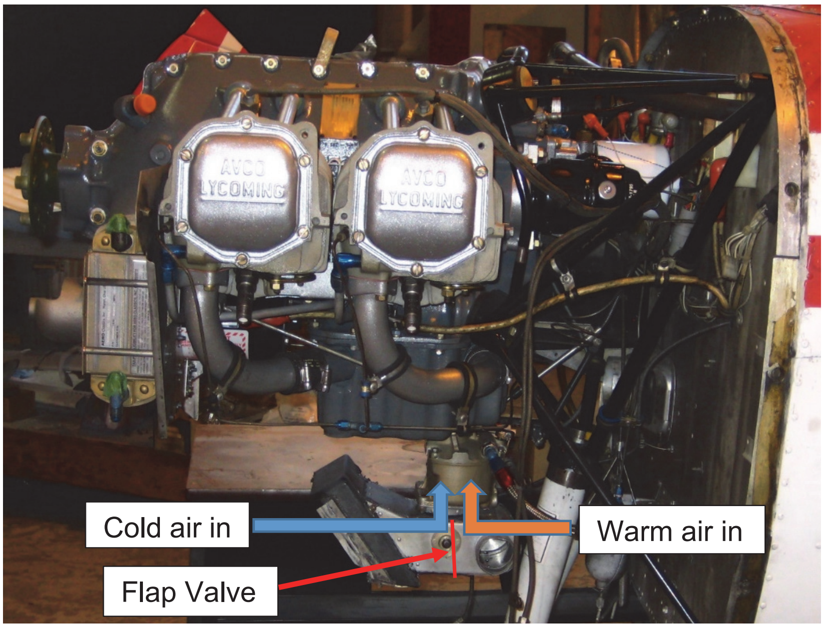


Figure 4
Carburettor heat valve

Flying controls and flaps

The Cessna 152 has conventional flying controls with inputs transmitted to the control surfaces via rods, cables and bell-cranks. It is fitted with inboard trailing edge flaps which are extended and retracted by a screw-jack actuator driven by an electrical motor, mounted in the inboard structure of the right wing. The actuator operates a system of cables and pulleys which move control rods attached to the flaps, with limit switches on the actuator removing electrical power to the motor when the flaps reach the fully extended [DOWN] or fully retracted [UP] position. The flap position is controlled by a cockpit mounted lever with detents at 10°, 20° and 30° increments and a feedback indicator-system which displays the actual flap position.

Stall warning system

The Cessna 152 is fitted with a stall warning system which gives an audio indication to the pilot of an impending aerodynamic stall approximately 5 kt to 10 kt before the stall speed is reached. The system consists of a small orifice in the leading edge of the left wing attached, via a tube, to a pneumatic horn. The horn emits an audible 'whistling' tone when negative air pressure at the wing leading edge causes reverse airflow through the horn.

Stall speeds

It was not possible to calculate the precise weight and balance of the aircraft at the time of the accident, but it was probably close to the maximum takeoff weight of 1,670 lb and towards the forward CG position. A range of stall speeds for the aircraft is shown at Table 1[2].

Footnote

[2] IAS is Indicated Air Speed, the speed displayed on the aircraft instruments. CAS is Calibrated Air Speed, IAS corrected for instrument and sensor position error.

Angle of bank	0°		30°		45°	
	IAS	CAS	IAS	CAS	IAS	CAS
Forward CG	36	48	39	**52**	43	57
Rearward CG	40	48	43	**49**	48	55

Table 1

Stall speeds in kt at maximum takeoff weight 1,670 lb and various angles of bank

Accident site

The aircraft accident site was in a field approximately 4 nm south-east of Belfast International Airport (Figure 5). The aircraft had passed through a stand of trees, which were approximately 30 ft high, before it struck the ground. A one metre section of the right wing was retained in the trees. The ground impact marks, made by the forward fuselage and the wing leading edges, indicated that the aircraft struck the ground in a steep nose-down attitude (Figure 6). The wreckage site was compact, the aircraft was upright with both wings showing evidence of leading edge compression.

Figure 5

Accident site

The aircraft tail section had separated from the fuselage during the impact and the right wing had been bent rearwards, but the remainder of the aircraft was largely intact. There was a post-crash fire which was confined to the cockpit and inboard section of the right wing which contained one of the aircraft's fuel tanks. Six litres of fuel were later recovered from the left wing tank. The left flap was displaced by approximately 5° from the trailing edge of the wing. It was not possible to measure the position of the right flap due to fire damage.

Figure 6
Accident site

Aircraft examination

The continuity of the flying control cables was confirmed before the aircraft was recovered to the AAIB facility for a detailed examination. No examination of the position of the cockpit controls was possible due to the severity of the post-crash fire.

Engine

The engine showed evidence of fire damage to some rear mounted ancillaries including the oil filter and one magneto, but was otherwise in good condition. The engine and carburettor were disassembled and inspected at an approved maintenance organisation under AAIB supervision, no defects were identified. The undamaged magneto was tested and found to be serviceable, the fire damaged magneto could not be tested.

The carburettor throttle valve was found in a position that corresponded to an engine speed of approximately 1,800 rpm although it is possible it may have moved during the accident. The engine manufacturers operating manual for the O-235 engine showed that, at this speed, the engine would be producing approximately 35% of its maximum power.

Carburettor heating system

During removal of the engine, the carburettor heat valve was examined to determine the position of the flap valve. The valve box had deformed during the impact and jammed the flap valve, retaining it in the COLD position (Figure 7).

Figure 7
Carburettor heat valve

Propeller

The propeller was removed from the engine and examined. The engine propeller attachment flange was deformed and five of the six threaded inserts into the flange had been pulled through and the spinner assembly was crushed flat by the impact. One blade tip was bent backwards about 45° from the midpoint of the blade and showed signs of damage from the post-crash fire. There was also was evidence of impact marks and scratches on its leading edge (Figure 8). The other blade was undamaged which was indicative of the engine operating at low power at impact.

Figure 8
Propeller blade comparison

Flaps

The flap system was powered by an electrically driven screw-jack actuator in the right wing. The position of the flaps can be determined by measuring the extension of the actuator, the measured extension on G-UFCO was 9.2 mm (Figure 9).

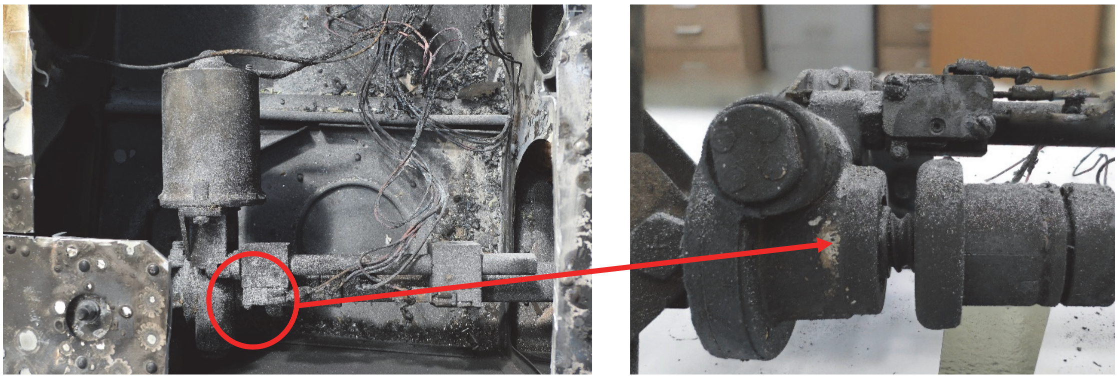


Figure 9
Flap actuator

According to the manufacturer's documentation, the actuator is extended by 4 mm at flaps UP. On the accident site, the left flap was found to be at an angle of 5°, which was calculated to require an actuator extension of 38 mm. It is therefore probable that the flap had moved due to the loss of tension in the control cables as a result of the post-crash fire. Discussion with the manufacturer confirmed that 9.2 mm of actuator extension could be accounted for in the flap rigging tolerances and it is therefore considered that the flaps were set to the UP position at the time of the accident.

Prior report of flap behaviour

On 13 November 2017 an entry was made in the aircraft technical log reporting *'flap oscillation 2-3° noted at flap 20° and flap 10°'*. On 20 November 2017 a note was added, '*fixed*', countersigned by a club instructor. After the accident the AAIB were provided with a video recording of unusual flap retraction behaviour on the aircraft. The video had been recorded several days before the accident. It showed that when the flaps were retracted from the 30° position to the UP position, at both the 20° and 10° positions they would pause, oscillate two to three times, before continuing to retract. This behaviour was only observed when the aircraft was on the ground.

Fire damage prevented any examination or testing of the flap actuation and position indicating system. The aircraft maintenance records showed that the flap position microswitches were last adjusted in September 2016. The flap oscillation was discussed with the aircraft manufacturer. It was suggested by the manufacturer that the oscillation could be caused by slight movement of the control microswitches when the flaps were moving. As there is no evidence that the flaps were moved during the accident sequence there is nothing to suggest this behaviour contributed to the accident.

Stall warning system

The stall warning system was destroyed in the post-crash fire, so it was not possible to verify if the system was operating normally.

Recorded information

Sources of recorded information

A digital camera and two mobile phones were recovered from the wreckage of the cockpit, however damage sustained during the post-crash fire meant that no data could be recovered from these devices.

Recorded radar information (primary and secondary Mode A and C[3]) was available from ground-based sites located at Belfast City and Belfast International Airport. This provided an almost complete recording[4] of the accident flight. The data started at 1049 hrs and ended at 1119:03 hrs, which was shortly before the aircraft struck the ground. RTF ground recordings of the pilot's communications with ATC at Belfast City and Belfast International Airport were also available. (Figures 1, 2 and 3)

Figure 10 is a plot of the estimated TAS and bank angle during the latter stages of the flight. The bank angle is derived from the aircrafts rate of turn and its TAS measured between each radar point, which were five seconds apart.

Interpretation of recorded data

The estimated TAS, derived from radar recordings, show that the aircraft was flying at below normal cruise speed during the latter stages of the flight when it was operating between Nutts Corner and Loanends. The average TAS between the last two data points was calculated to have been about 45 kt[5]. This was the lowest calculated during the flight. The final radar point was 60 m north-east of the accident site (Figure 3).

Descent rate following final radar return

The last radar return was at 1119:03 hrs when the aircraft was at a height of approximately 260 ft agl. Analysis of the Belfast International radar coverage[6] indicates that the radar floor extended to ground level near the area of the accident site. This indicates that the aircraft struck the ground prior to 1119:08 hrs which is when the next radar scan of the area occurred. The average descent rate of the aircraft proceeding the last radar point would have needed to be greater than 3,120 ft/min for the aircraft not to have been recorded on radar at 1119:08 hrs.

Footnote

3 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.
4 The position of the aircraft was recorded once every five seconds by radar.
5 Based on level flight.
6 The lowest altitude at which an aircraft may be detected by radar when the aircraft is at a specific location relative to the radar site.

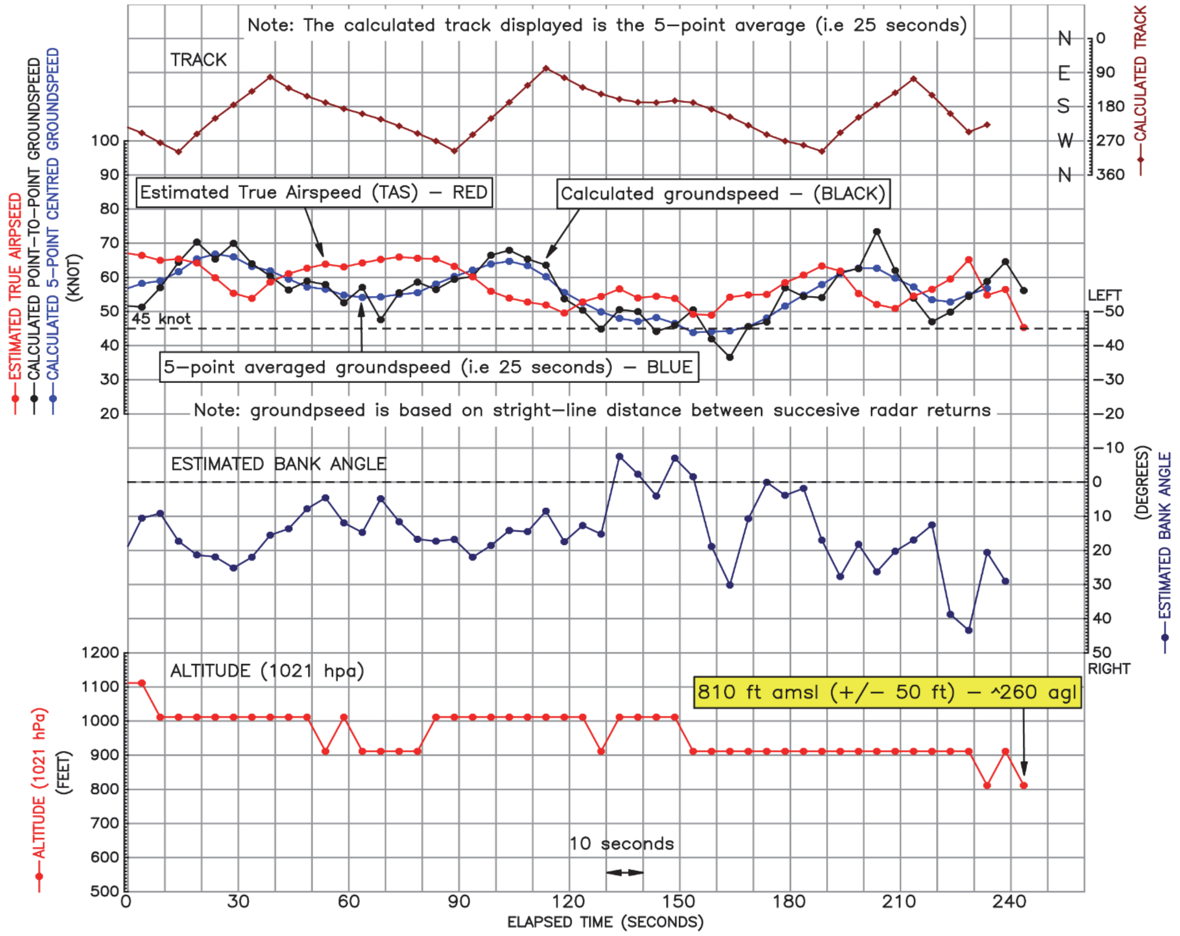


Figure 10

Estimated airspeed and bank angle during latter stages of the flight

Previous flight flown by pilot of G-UFCO

Radar data was analysed for a flight on 5 April 2018 flown by the pilot of G-UFCO and accompanied by the same passenger; this was flown in another Cessna C152 registration G-UFCN.

This flight was operated in an area just to the south-west of Newtownards Airport and was similar to the accident flight with multiple clockwise turns flown at between about 550 ft and 1,250 ft agl (Figure 11).

Meteorology

The 1120 hrs meteorological report from Belfast International Airport, 4 nm north-west of the accident site, was: surface wind from 220° at 11kt, visibility 10 km or more, scattered cloud at 1,900 ft with a temperature of 16°C, a dewpoint of 11°C and a barometric pressure of 1021 hPa.

CCTV footage was obtained from a property near to the accident site which showed scattered cumulus cloud, estimated to be at a height of around 1,500 ft.

Figure 11

Flight flown by pilot of G-UFCO on 5 April 2018

Organisational information

The operator of the aircraft is a flying club with aircraft available for training and private hire, it did not hold an Air Operator's Certificate (AOC) for commercial work. The club stated that they were not aware that their aircraft were being used for photographic flights.

Pilot information

The pilot held a valid Class 2 medical certificate. The pilot's most recent logbook was available for the investigation. The Certificate of Experience lapsed on 30 September 2017 and thus he was required to undertake a flight test with an examiner to re-validate his licence. The test was carried out on 31 March 2018 but was not completed then, at the pilot's request. The examiner recorded that the pilot had been required to repeat one test item on 31 March, steep turns, which were noted as having been flown out of balance. The test was completed subsequently on 5 April 2018.

The pilot recorded photographic flights in his logbook. He had flown with two different photographers since 2003, on flights which varied in duration from 30 minutes to 4 hours. The flights were flown from Newtownards and most of the aircraft used were hired from the flying club which owned G-UFCO.

Other information

Regulations around the conduct of flights

EASA Air Operations Regulation (EU) No 965/2012 Part-SPO (Specialised Operations) applies to any aircraft operation, other than Commercial Air Transport, where the aircraft is used for specialised activities such as agriculture, construction, photography, surveying, observation, patrol and aerial advertisement. EASA Part-SPO became applicable in the UK from 21 April 2017. Specialised Operations may be commercial or non-commercial; where operators are engaged in commercial Specialised Operations in the UK they are required to submit a declaration to the CAA about their operation confirming compliance with relevant aspects of Annex III 9 (Part-ORO) and Annex VIII (Part-SPO) of the EASA Air Operations Regulations. A declaration had not been submitted for this, or previous photographic flights.

For non-commercial Specialised Operations in non-complex aircraft a pilot is required to operate in accordance with Annex VII (Part-NCO) and Subpart-E NCO.SPEC. The regulation includes a requirement for a risk assessment and provides an associated activity checklist which includes, as one item, a consideration of '*the nature of the flight and the risk exposure, e.g. low height*;'

At the time of the accident the definition of 'commercial operation' according to Regulation (EC) No 216/2008[7] Article 3 (Definitions) (i) was:

> *'any operation of an aircraft, in return for remuneration or other valuable consideration, which is available to the public or, when not made available to the public, which is performed under a contract between an operator and a customer, where the latter has no control over the operator.'*

A similar definition is provided for the UK in The Air Navigation Order 2016.

European Regulation (EU) 923/2012, The *Standardised European Rules of the Air* (SERA), stipulates the minimum VFR flight altitude in daylight:

> ***'SERA.5005 Visual flight rules***
>
> *(f) Except when necessary for take-off or landing, or except by permission from the competent authority, a VFR flight shall not be flown:*
>
> *..'at a height less than 150 m (500 ft) above the ground or water, or 150 m (500 ft) above the highest obstacle within a radius of 150 m (500 ft) from the aircraft.'*

Footnote

[7] Superseded by Regulation (EU) 2018/1139, 22 August 2018.

The CAA has established an exception to this 150 m (500 ft) requirement, provided the aircraft is not flown closer than 150 m (500 ft) to any person, vessel, vehicle or structure, except with the permission of the CAA. No such permission had been obtained

Analysis

Accident site

The location of the separated portion of the right wing in trees adjacent to the aircraft's final resting place and the presence of all of the aircraft's remaining structure on site confirmed that there had been no in-flight structural failure. Correct operation and continuity of all flying control surfaces was verified.

The damage to the trees and the ground marks suggest that the aircraft was descending steeply whilst turning to the right which increased as the right wing contacted the trees. Both wings showed uniform leading edge compression from ground impact. This, together with the ground markings showed that both wings stuck the ground at the same time.

Engine examination

No evidence was found of any problems that would have prevented normal operation of the engine. The position of the carburettor throttle valve suggested that the engine had been operating at approximately 35% of its maximum power at the time of the accident. This was supported by the damage observed to the aircraft's propeller which was consistent with an engine operating at low power at impact. If the engine's performance had been affected by carburettor icing, it would be expected that the pilot would have increased engine power and operated the carburettor heat system. The position of both the throttle valve and carburettor heat valve suggest that it was unlikely that carburettor icing was present immediately before the aircraft's final manoeuvre.

Flying controls

Due to the intense post-crash fire it was not possible to verify any of the positions or settings of the flight controls.

Conduct of the flight

The flight was carried out for the purpose of taking aerial photographs. The pilot and passenger had flown together on many similar flights over the last 14 years, thus, they were both familiar with the operation. Information was not available concerning any financial arrangement between them, either for this, or for previous similar flights. Were any '*remuneration or other valuable consideration'* accepted by the pilot then the flight should have been conducted in accordance with the requirements for commercial Specialised Operations. Otherwise it should have been conducted as a non-commercial Specialised Operation in a non-complex aircraft. In either case the pilot would have been required to conduct a risk assessment and to specify how any risk would be mitigated; for example a declaration of a minimum height for aerial photography to address the risks associated with flying at low level.

During the flight the aircraft flew a series of sustained turns, all in a clockwise direction, facilitating the taking of photographs from the passenger (right hand) seat. The orbits were being flown at an average speed of 60 kt TAS and at a height varying between 500 ft and 300 ft agl.

The CAA exception to SERA.5005 (f) allows flight below 500 ft agl in the United Kingdom, but the aircraft must remain 500 ft away from persons, vessels, vehicles and structures. As the aircraft was flown at a height of less than 500 ft agl and in the vicinity of houses for extended periods, it is improbable that the required separation was maintained throughout.

Stall speed

Calibrated (CAS) and True (TAS) airspeed have approximately equivalent values at the speed and altitude at which the aircraft was operating. During the later stages of the flight, the aircraft was flying at around 60 kt TAS and at bank angles of up to about 30°. The effect of a turn is to increase the stall speed.

A speed of 60 kt TAS is about 12 kt above the stall speed for straight and level flight, but at 30° angle of bank, this reduces to an approximate 8 kt to 10 kt margin, and only a 3 kt to 5 kt margin at 45° angle of bank. The stall warner would have activated at between 5 kt to 10 kt before the stall speed is reached. It is likely therefore that for periods during the latter stages of the flight the stall warner would have been sounding. This may have resulted in the pilot and passenger becoming accustomed to the sound of the stall warner, thereby reducing the value of its warning.

With the aircraft in a turn, additional engine power is required to maintain altitude and airspeed, but the evidence shows that the engine was operating at a low power setting. About 20 seconds before the final radar point the bank angle was estimated to have increased to about 45° as the aircraft turned through 180°. The altitude was maintained but the airspeed reduced to below 60 kt. The rate of turn was reduced for a short time and then the bank angle increased again to about 30°. The airspeed reduced below 50 kt TAS and the aircraft would have stalled, resulting in a loss of control with insufficient height to recover.

Conclusion

The aircraft was engaged in aerial photography and thus the flight came within the scope of Specialised Operations. This required a strategy for the evaluation and mitigation of risks, such as those associated with flying at low level. There was no evidence of the required risk assessment having been carried out or for the checklist associated with the mitigations for the particular activity being in place.

The aircraft was flying at low level and low airspeed when, for an undetermined reason, there was a critical reduction in airspeed and a loss of control. There is an increased level of risk associated with flying close to the stalling speed without sufficient height to recover from a stall, particularly when focussed on a task such as taking aerial photographs.

Safety action

> Since the accident the flying club has issued instructions to their pilot members to remind them of their responsibility to understand and comply with the privileges of their licences and ratings. The club flying instructors have been reminded not to authorise any rental flight where there may be any doubt as to its purpose. The club is also re-drafting the flying order book and aircraft hire/rental agreements to make it clearer as to what can and cannot be undertaken in a hired aircraft. Additionally, the club intends to provide warning signage/posters to remind pilots and passengers of the restrictions and implications of travelling for any kind of payment in light aircraft.

ACCIDENT

Aircraft Type and Registration:	Bell 206B3 Jet Ranger III, G-OPEN
No & Type of Engines:	1 Allison 250-C20J turboshaft engine
Year of Manufacture:	1994 (Serial no: 4300)
Date & Time (UTC):	30 May 2018 at 1223 hrs
Location:	Near Aldborough, North Yorkshire
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:	Private Pilot's Licence
Commander's Age:	70 years
Commander's Flying Experience:	255 hours (of which 224 were on type) Last 90 days - 0.5 hours Last 28 days - 0 hours
Information Source:	AAIB Field Investigation

Synopsis

The pilot was flying G-OPEN from Husthwaite to Walton Wood Airfield for its annual maintenance check. The weather conditions en route were challenging with low cloud and reduced visibility. The helicopter was seen by several witnesses to be flying normally before climbing steeply into cloud. It was then seen to emerge from the cloud, rotate through 540°, then descend rapidly, striking the ground in an approximately level attitude. The helicopter became inverted and caught fire. The pilot was fatally injured.

The investigation did not find any evidence of pre-existing defects with the helicopter or its engine. It could not be determined why the helicopter entered cloud but it is probable that the pilot was distracted or became disorientated in the poor weather conditions. Having entered cloud it is likely that the pilot became spatially disorientated and was unable to maintain control of the helicopter.

History of the flight

The pilot was planning to fly G-OPEN from Husthwaite in North Yorkshire, where the helicopter was kept, to Walton Wood airfield for its annual maintenance check which was due the following day. This was a route the pilot had flown many times. The normal routing was to fly initially west-southwest through the gap between RAF Linton-on-Ouse and RAF Topcliffe MATZ[1] then turn left following the A1(M) south towards Walton Wood (Figure 1).

Footnote

[1] Military Air Traffic Zone.

The helicopter's co-owner pulled the helicopter out of the hangar at approximately 0700 hrs and left it on the helipad. The pilot arrived at the property at 0830 hrs but, after completing pre-flight checks, decided the weather was not suitable for the flight and left the property at 0906 hrs. He returned at 1150 hrs and lifted off at 1216 hrs. The cloud base en route was forecast to be between 300 ft and 700 ft with a possibility of visibility below the cloud reducing to 3,000 m.

At 1218 hrs the pilot contacted RAF Linton-on-Ouse ATC and requested a Basic Service. He reported he had just lifted from a private site at Husthwaite, destination Walton Wood, and was routing via Boroughbridge flying through "the gap". He reported he was at an altitude of 700 ft. Linton ATC issued a squawk and provided a Basic Service. The radar track of the route flown (Figure 1) shows that the helicopter flew slightly left of the planned track and penetrated the Linton-on-Ouse MATZ.

Witnesses saw G-OPEN passing above Humberton Farm (approximately 1.2 nm from the accident site) at low level. They reported the helicopter appeared and sounded to be flying normally.

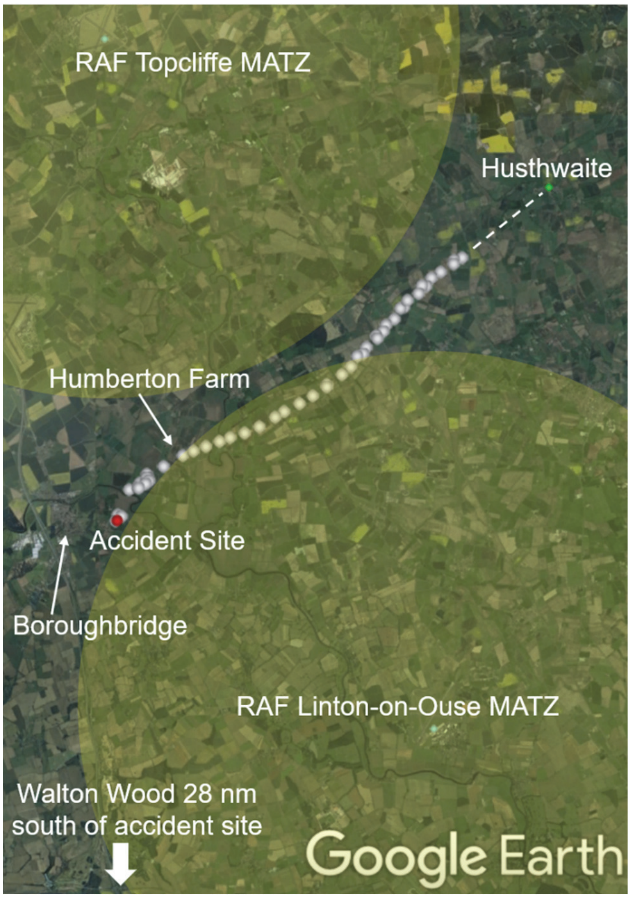


Figure 1

Radar track of G-OPEN
(Map data: Google, Landsat / Copernicus)

At 1223 hrs ATC heard a brief carrier wave transmission, which the controller thought had come from G-OPEN, and seconds later radar contact was lost. At about the same time the accident was reported to the emergency services by several witnesses.

Several witnesses near the accident site reported seeing and hearing the helicopter before the accident. Witnesses reported initially seeing G-OPEN flying normally before it pitched up into a steep climb and entered cloud. The helicopter could still be heard in the cloud and witnesses described it as sounding very loud. One witness described seeing the helicopter emerging from "the mist" and track across the sky at 100 to 150 ft. He described it as "not flying straight but was moving from left to right". As the helicopter moved away from him he described seeing it "spin around anticlockwise [cockpit turning to the left] one and half times before correcting itself". He then described seeing the nose coming up, banking to the left, the nose dropping and the helicopter descending to the ground. The witness recalled it taking approximately 15 seconds from first seeing the helicopter emerge from the mist to the impact. Several witnesses saw the helicopter enter a steep nose-down attitude and descend rapidly. Just before hitting the ground they described seeing the helicopter coming to a level attitude but the rate of descent continuing until impact.

Several witnesses heard the helicopter before the accident. They all described the sounds as very loud, louder than the helicopters they normally hear. Some witnesses described a constant beating sound which sounded like a large military helicopter. Others suggested that it sounded like the engine was struggling and that something was wrong.

Witnesses described the aircraft catching fire as soon as it hit the ground. Several people ran to the accident site, but the fire was too intense to get close to the scene. Emergency services arrived on site at 1233 hrs. An air ambulance attended the scene, landing at 1241 hrs, but the pilot of G-OPEN had suffered fatal injuries. A Coastguard helicopter also attended the scene, landing approximately 40 minutes after the accident.

Recorded information

There was no onboard recorded data available from the aircraft following the accident.

Secondary surveillance radar (SSR) returns from the helicopter were recorded for the flight starting 1.5 nm from the takeoff point and ending in the vicinity of the accident site. The returns included Mode C altitude information (rounded to the nearest 100 ft, ±50 ft) and indicated that the helicopter flew between 520 and 720 ft amsl at an average groundspeed of 97 kt until approximately 1 nm from accident site (Figure 2).

At this point, just over one minute before the last recorded data point, the helicopter was at 520 ft amsl, before climbing to 1,020 ft amsl 16 seconds later. This equates to a climb rate of between 1,500 and 2,250 ft/min, given the ±50 ft resolution of the altitude data. It then descended at a similar rate before climbing to over 800 ft amsl and descending again. The average groundspeed during these climbs and descents was approximately 60 kt. For the period the helicopter was above 920 ft amsl during the first climb the average groundspeed was 30 kt (these groundspeeds are highlighted in Figure 2).

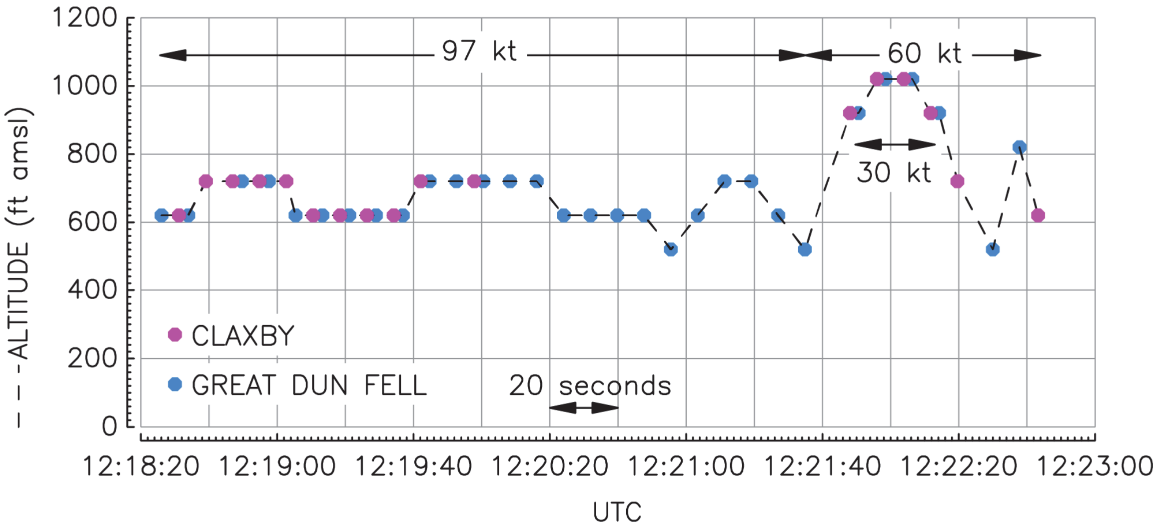


Figure 2

SSR Mode C altitudes for accident flight with average groundspeed indicated (note that the ground height along the route varied from 130 ft at the start to 40 ft near the accident site)

Helicopter information

G-OPEN (Figure 3) was a Bell 206B3, a single-engine light helicopter, powered by a Rolls-Royce (Allison) 250-C20J reverse-flow gas turbine engine, driving a two-bladed main rotor system through the main gearbox (MGB).

Figure 3

G-OPEN

The flying control system on the Bell 206B3 consists of control rods, bellcranks and levers, hydraulically boosted by three hydraulic actuators which transmit the cyclic and collective pitch inputs from the pilot. The tail rotor pitch inputs are operated via control tubes, but with no hydraulic assistance. In the event of a hydraulic system failure, the helicopter can continue to fly in response to the pilot's control inputs.

G-OPEN was fitted with analogue flight instruments and a two-axis Bendix King KAP 150-H autopilot, capable of controlling the helicopter's desired flight path by inputs from mechanical actuators mounted to the pitch and roll flight control linkages. The autopilot was controlled by an autopilot mode control/annunciator panel, mounted on the centre instrument console.

G-OPEN was constructed in 1994 and was first registered in the UK in January 2005 when it was acquired by the current owners, having previously been registered in the USA. The helicopter was being maintained in accordance with an approved maintenance programme and its Airworthiness Review Certificate (ARC) was valid until 12 April 2019. The last scheduled maintenance was a six-months inspection carried out on 13 March 2018 and included a compressor case inspection, an engine oil change and rectification of other minor defects. An engine ground run was carried out following the inspection. Since then, the helicopter had flown for a total of 1 hour 45 minutes on four flights, the most recent of which had been on 3 May 2018. The next scheduled maintenance was an annual inspection due on 31 May 2018. The helicopter was en route to the maintenance facility for this inspection when the accident occurred. G-OPEN had accrued a total of 4,038 flight hours at the time of the accident.

Accident site

The helicopter had come down in an approximately level attitude on flat ground in a crop field, on an heading of about 270°, striking the ground with a high vertical rate of descent and some forward speed (Figure 4). The distribution of wreckage and ground marks indicated that the tail was the first part of the helicopter to strike the ground, followed by the landing gear and main rotor. The helicopter became inverted and caught fire.

The landing gear skids and cross-tubes had separated from the airframe, such that the lower fuselage struck the ground causing the fuel cell to rupture.

Cut marks in the standing crop provided evidence that both the main and tail rotors had been rotating at impact. One of the main rotor blades struck the ground, causing the main rotor assembly to separate from the airframe and the helicopter to become inverted. Both blades were found still attached to the rotor head, approximately 31 m beyond the main wreckage. One blade was largely intact. The other blade exhibited extensive damage and a 75 cm section at the blade tip was absent; this was found approximately 70 m from the main wreckage, having detached and travelled opposite to the helicopter's direction of flight when the blade struck the ground.

The post-impact fire consumed much of the fuselage, cockpit, flight controls and fuel system. The top of the cabin, the flying control components on the transmission deck, together with the engine, sustained crushing damage as a result of the helicopter becoming inverted.

The engine oil tank had burst open; residual oil was present around the tank and an oil film was noted on a number of panels and the vertical fin.

A trail of light debris items was present on both sides of the main wreckage trail. These items included fuselage and engine cowling panels, doors and cabin interior trim.

Figure 4

Aerial view of the accident site

Detailed examination of the wreckage

Airframe – general

The fuselage had suffered extensive fragmentation during the impact, but there were no indications of pre-impact anomalies. The landing gear had splayed and separated from the airframe following the ground impact and both skids were broken in a number of locations. The aft cross-tube exhibited a slight spread but remained close to its normal shape; however, the forward cross-tube was flattened and broken on the left side, indicating that when the landing gear contacted the ground the helicopter was banked left, in a nose-down attitude and had a high rate of descent. All fractures were consistent with overload forces at impact.

Flying controls

All the damage observed in the mechanical elements of the flying controls was consistent with accident forces and exposure to the post-impact fire. All except one of the cyclic control rod connections were recovered from the wreckage and observed to be properly secured. However, the cyclic control bellcrank, to which the missing control connection normally attaches, exhibited an overload fracture similar to that observed at the other control connection locations. It was therefore concluded it had been connected at impact.

The hydraulic fluid reservoir was found empty and the hydraulic oil filter was destroyed in the post-impact fire. The hydraulic servos appeared intact and all hydraulic lines were connected or exhibited fractures consistent with overload forces at impact.

Fuel system

No fuel was recovered from the helicopter due to the post-impact fire and all damage to the fuel system was consistent with impact forces or fire damage.

Main rotor, tail rotor and transmission system

The blade which struck the ground exhibited downwards bending, had a spanwise deflection opposite to the direction of rotation and showed multiple impact damages including skin tears and gouges. This blade also exhibited a chordwise tear, approximately 1.5 m outboard of the mast and the outer portion of the blade remained attached only by a small section of trailing-edge blade skin. The released blade tip exhibited evidence of ground contact. All of these observations are consistent with overload forces experienced at impact.

The other blade was almost completely intact except for some creasing and deformation and the absence of the inboard trim tab, which was found in a different location. This was consistent with damage caused when the blade assembly came to rest after departing the helicopter.

The main rotor mast had severed just below the main rotor hub teeter (static) stops, and the failure was consistent with overload forces from excessive flapping following the ground strike. The teeter stops had made light impressions on the painted surface of the mast. These could be considered consistent with normal operation, or alternatively, could have occurred during the impact sequence. However, there was no indication of heavy 'mast-bumping[2]' contact between the teeter stops and the mast.

The main rotor gearbox was largely intact; however, the casing suffered impact and heat damage exposing the internal gears, which appeared to be in good condition and correctly meshed. The bottom chip detector was found clean while the top one for the mast could not be examined.

The driveshaft from the engine was intact but was disconnected at both ends; however, rotation marks on the isolation mount indicated that the shaft was rotating when it disconnected at impact. Despite impact and heat damage, the freewheel unit operated freely when rotated by hand.

The tail rotor hub and blades remained attached to the tail rotor gearbox assembly. Both blades sustained impact damage and broke chordwise at the root end. The tail rotor driveshaft exhibited torsional twisting and one of the 'Thomas coupling' assemblies was

Footnote

2 Mast bumping is a phenomenon that is associated with low-G manoeuvres or excessive manoeuvring, either intentionally or from over-controlling the helicopter. Mast bumping can cause the main rotor mast to fail due to excessive bending loads, leading to inflight separation of the main rotor.

torn; this was consistent with torsional overload caused by a stoppage from the tail rotor section while power was still being produced by the engine. No chips were present on the tail rotor gearbox chip detector.

Flight instruments

All the helicopter's flight instruments had been severely damaged during the impact and ensuing fire and no useful information could be drawn from them.

Autopilot system and caution and warning panel

The autopilot mode control/annunciator panel on G-OPEN featured six push-button switches to select autopilot operating modes and illuminated captions to annunciate if the autopilot is engaged and which modes are active. Each caption was illuminated by a single incandescent-filament light bulb.

The Caution and Warning Panel (CWP), located on the top of the instrument panel, comprised 20 caution lights, each illuminated by two incandescent-filament light bulbs. On G-OPEN the CWP was configured to display 12 different cautions, and the remaining light positions were spare.

Both the autopilot mode control and CWP panels were disassembled and the light bulbs removed for examination. Although largely intact the bulbs were extensively heat-damaged, which precluded visual examination. They were therefore imaged in a Computed Tomography (CT) scanner. Examination of the images did not show any evidence of filament hot-stretching, which can occur when a lit bulb is subject to very large deceleration forces. While this suggests that none of the bulbs examined were lit at impact, it could not be stated with certainty as it not known whether the impact deceleration forces experienced were sufficiently high to cause hot-stretching.

Engine examination

General

The engine was disassembled at an approved overhaul facility in the presence of representatives from the AAIB, engine and helicopter manufacturers.

The engine and its controls sustained substantial damage when the helicopter became inverted and it was therefore not possible to inspect the integrity of the engine control linkages.

The engine oil reservoir had split open so it was not possible to determine the oil level. The bypass indicator button on the scavenge oil filter was found extended but examination of the filter revealed that residual oil was present, with no debris noted within the filter element.

No cracks or abnormalities were observed on the fuel lines. The power turbine governor, fuel control unit and fuel pump could not be tested due to the extent of the damage sustained but each unit was disassembled. All damage appeared consistent with impact forces and thermal degradation due to the post-impact fire and fire damage. The fuel nozzle, when flow-tested was within the specified limits. The low-pressure fuel filter element displayed thermal damage and no fuel was present within the filter bowl.

The compressor front support exhibited crushing damage and the axial portion of the compressor had separated from the centrifugal impeller shroud, remaining attached to the engine only by the oil and anti-ice supply and scavenge lines (Figure 5). None of the 16attachment bolts were found at the accident site or recovered from the wreckage.

Figure 5
Axial compressor detached from impeller shroud

However, disassembly of the axial compressor showed distinct evidence of rotational damage; the rotor blades from the first three stages of the axial compressor were bent opposite the direction of travel (Figure 6) and all the stator vane stages were bent in the direction of travel (Figure 7). Additionally, the tie bolt was fractured into two pieces.

The centrifugal impeller displayed leading-edge damage consistent with hard-body impact damage and there was evidence of rotational contact between the impeller and the impeller shroud.

Disassembly of the turbine confirmed that the turbine shaft and all blades and nozzle guide vanes were intact. Some circumferential rub marks and scoring were noted on the third and fourth stage turbine wheels.

The magnesium accessory gearbox housing exhibited thermal degradation as a result of the post-impact fire; however, no missing gear teeth or mechanical damage were noted. Both magnetic chip detectors were clear and there was no debris in the pressure oil filter element.

Figure 6
Axial compressor rotor blades

Figure 7
Axial compressor case halves and stator vanes

The starter-generator cooling blades were uniformly fractured at the blade roots and the driveshaft was fractured at the manufactured shear point.

Small fragments of metallic debris were collected from the outer combustion case and compressor discharge tubes. Subsequent laboratory analysis determined that the material was a close match to 17-4PH grade precipitation-hardened stainless steel, consistent with the impeller shroud material, which exhibited scoring damage.

The compressor bleed valve was tested and while the action of the valve appeared satisfactory, the results were out of limits because the internal diaphragm had melted as a result of the fire.

Examination of axial compressor to impeller shroud attachment flange

The helicopter had undergone a six-monthly compressor case inspection in March 2018, during which the 16 axial compressor attachment bolts would have been removed. However, the helicopter had operated four flights totalling 1 hour 45 minutes of flight time since then without any reported issues. The engine manufacturer advised that the compressor would not operate for any length of time if the axial case halves were not securely attached to the front diffuser. The rotor would not be correctly located, either radially or axially and rotor/stator interference would be immediately evident, along with a significant air leak.

Laboratory examination of the axial compressor and impeller shroud attachment flanges identified bending deformation. The location and direction of this deformation indicated that it most likely resulted from the impact damage sustained at the forward end of the axial compressor. Mechanical damage adjacent to a number of the fastener holes, an example of which is shown in Figure 8, was consistent with fasteners being present in those holes at the time of impact.

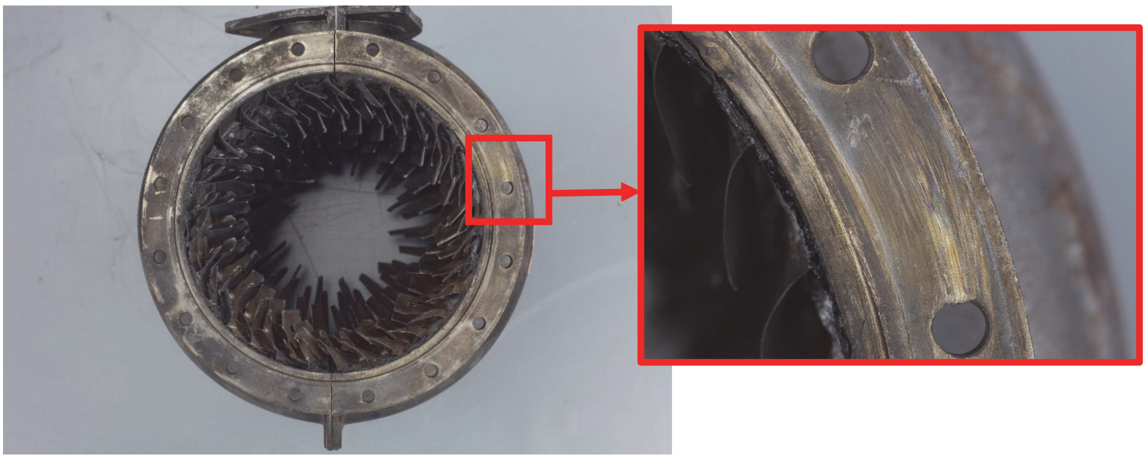


Figure 8

Axial compressor case flange showing mechanical damage at one of the fastener locations

The engine manufacturer indicated that it was aware of one previous Bell 206B3 accident in which the axial compressor had separated from the impeller in a similar manner. The helicopter had departed from controlled flight and struck the ground inverted, after striking electrical power transmission lines during a survey flight. The investigation into that accident[3] determined that the engine had been operating normally at the time the helicopter collided with the power lines and the engine manufacturer considered that the compressor damage was sustained during the impact with the ground.

Footnote

3 Accident to Bell 206B, registration N5016U on 1 May 2010. National Transportation Safety Board (NTSB) report reference WPR10GA097.

Weight and balance

The helicopter was within weight and balance limits throughout the flight and sufficient fuel was loaded for the flight.

Meteorology

Forecast

Forecast information was available from the meteorological office for RAF Linton-on-Ouse and RAF Topcliffe which are close to the initial planned route. RAF Linton-on-Ouse forecast issued at 1053 hrs gave visibility greater than 10 km, cloud base broken[4] at 700 ft, temporarily[5] between 1200 and 1300 hrs cloud base scattered[6] at 500 ft with a 30% probability of visibility reducing to 3,000 m in light rain. RAF Topcliffe forecast issued at 1053 hrs gave visibility greater than 10 km, cloud base broken at 700 ft, temporarily between 1200 and 1500 hrs cloud base scattered at 500 ft with a 30% probability of visibility reducing to 3,000 m in light rain.

Walton Wood airfield, where G-OPEN was intending to land, does not provide weather forecasts. The closest airfield which has meteorological forecasts is Doncaster Sheffield Airport which is 12.5 nm SE of Walton Wood. The forecast for the time of G-OPEN's flight showed cloud base broken at 1,000 ft and visibility greater than 10 km, temporarily reducing to broken cloud at 600 ft and visibility 6,000 m with a 40% probability of broken cloud at 300 ft, visibility 3,000 m in light rain and mist.

It is not known what weather information was reviewed by the pilot prior to undertaking the flight. The pilot had a SkyDemon account, but this had not been accessed for several months. However, there are many other sources of meteorological information which he may have consulted.

Actual weather

A witness reported the visibility at Husthwaite was approximately 3 km when G-OPEN lifted off.

The accident site is located between RAF Linton-on-Ouse (5 nm SE) and RAF Topcliffe (6 nm N). At the time of the accident RAF Linton-on-Ouse was reporting cloud scattered at 500 to 600 ft and overcast between 800 and 1,500 ft with visibility below the cloud greater than 4 km. RAF Topcliffe reported cloud overcast at 300 ft and visibility between 3 and 8 km.

Surface winds reported at RAF Linton-on-Ouse and RAF Topcliffe just before the time of the accident were 330° at 10 kt and 360° at 11 kt respectively.

Footnote

4 Broken cloud is defined as 5 to 7 eighths cloud cover.
5 'Temporarily' means the conditions will not occur for more than one hour at a time and for less than half of the total time indicated.
6 Scattered cloud is defined as 3 to 4 eighths cloud cover.

The air ambulance pilot that landed at the accident site 17 minutes after the accident reported cloud base at 400 to 500 ft with visibility 3 to 5 km on scene. The air ambulance had been operating near Wetherby (south of the accident site) when tasked with attending the accident. They routed to the accident site following the A1(M) north, the same route G-OPEN would have flown in the opposite direction. The air ambulance pilot reported challenging weather conditions which required his local knowledge and air ambulance exemptions to operate.

The air ambulance pilot also commented that the weather at Husthwaite, where G-OPEN departed, may have been better than the accident site as his experience was that weather tended to be better in that area.

A Coastguard helicopter was also tasked with attending the scene, landing approximately 40 minutes after the accident. The Coastguard helicopter pilot confirmed the weather on scene as cloud base 500 to 600 ft with visibility 4 to 5 km.

Pilot information

The pilot held a helicopter Private Pilot's Licence (PPL(H)) with a Bell 206 rating which was valid until 31 August 2018. He initially qualified in 2006.

The pilot's logbook was onboard the helicopter and was damaged in the accident; however, the last few entries were legible and recorded total flying hours of 254.5 hours including 126.1 hours as pilot in command. A statement given to the insurance company in August 2017 confirmed he had a total flying time of 250 hours with 224 hours on type.

The pilot's last flight before the accident was on 13 March 2018, lasting 30 minutes, flying the same route as the accident flight. Prior to this flight, the pilot had not flown since his licence skills test on 11 August 2017. Between 13 April 2017 and 11 August 2017, the pilot had undertaken 18.7 hours of refresher training following two years without flying. The pilot planned to fly on 27 October 2017 but this flight was abandoned due to a flat helicopter battery.

The pilot was not qualified to fly in instrument meteorological conditions. The PPL(H) training syllabus includes 'basic instrument awareness' in case of inadvertently entering into poor visibility or cloud. The pilot's basic instrument awareness was refreshed during the training undertaken in 2017.

Several people who had flown with the pilot commented that he was a "good pilot" who was very conscious of the weather. They described him as "very cautious" and "meticulous with his checks". They observed that he was the type of pilot who only flew in good weather and was "the last person who would fly in poor weather". Some people commented that they were very surprised that the pilot had decided to go ahead with the flight given the prevailing conditions. One of the pilot's previous instructors did note that, like many pilots, the accident pilot's skill levels did seem to drop with lack of flying practice.

On the day of the accident the pilot had arranged for a friend to collect him on arrival at Walton Wood. Several people also commented that the pilot had a busy diary and that it was difficult for him to fit helicopter flying around his other commitments.

Medical

The pilot held a Class 2 medical which was valid until 21 July 2018.

Witnesses who met or spoke to the pilot on the day of the accident reported that he appeared to be in good health. It was reported that he had been suffering from toothache on the day before the accident and had recently experienced a nose bleed. It was also reported that he had suffered a minor knock to the head when he slipped on the stairs on the evening before the accident. Advice from a CAA doctor suggested that these conditions are unlikely to been causal factors in the accident but could have caused a minor distraction during the flight.

Post-mortem report

The post-mortem report stated death was caused by multiple injuries. It also noted evidence of moderate coronary heart disease but indicated that the degree would not usually be expected to cause sudden death or incapacitation, however it might have been symptomatic. Toxicology showed no evidence of alcohol or any other significant drug. Carboxyhaemoglobin saturation was negative, confirming that the pilot died as a result of injuries sustained in the impact, rather than the effects of the post-impact fire.

Other information

Helicopter flight in reduced visual conditions

Helicopters are naturally unstable and require constant input from the pilot or an automatic stabilisation system (not fitted to G-OPEN) to maintain the correct attitude. When flying in visual conditions pilots primarily determine the helicopter attitude using the visual cues from the environment outside the helicopter. As visibility reduces it is much harder for the pilot to determine, and detect small changes in, the attitude and if the attitude is not controlled, control of the helicopter can be lost. Once a helicopter enters cloud no external visual cues are available and the pilot must transition to using the helicopter instruments to determine attitude.

Without adequate visual reference it is very easy for a pilot to become spatially disorientated. Spatial disorientation occurs when a pilot does not correctly sense the aircraft attitude relative to the Earth's surface. Without visual reference the human body uses senses in the ears, skin and muscles to determine 'which way is up'. However, these senses can give incorrect, conflicting or ambiguous information leading to disorientation. Spatial disorientation presents a danger to pilots and can often lead to incorrect control inputs and possible loss of aircraft control.

In 2007 the CAA published a study into the hazard of helicopter flight in degraded visual conditions[7]. The report highlights how challenging it can be for an average pilot to control a helicopter in poor visibility. The UK AIP Aeronautical Information Circular (AIC) P 067/2013 *'Helicopter Flight in Degraded Visual Conditions'*[8] also highlights the challenge of flying a helicopter in degraded visual conditions and how easily a pilot can become disorientated.

'Blade slap'

Witnesses reported hearing a constant loud beating sound from the helicopter. It is likely that this sound was 'blade slap', which can occur when a rotor blade passes through the trailing vortex of the preceding blade. It tends to occur during transient manoeuvres and is often associated with steep turns, with shallow descents and with flaring manoeuvres. It is particularly prevalent on helicopters with two main rotor blades. It creates a loud beating sound, consistent with that described by the witnesses.

Pre-flight risk assessment

A number of tools are available to assist pilots in assessing the risk involved in a particular flight. The use of pre-flight risk assessment is recommended in CAA Safety Notice SN-2017/003[9]. An example, which can be used for general aviation flights, is published by the European Helicopter Safety Team (EHEST)[10]. The tool consists of 27 questions and categories a flight as 'low risk', 'caution' or 'high risk'. The tool also highlights significant risk areas. These tools enable pilot to make decisions about whether to fly or to think how they could modify their plan to reduce the risk.

Analysis

Helicopter and engine

The helicopter's records showed that it had been maintained in accordance with its approved maintenance program and there were no recorded defects at the time of the accident.

The investigation did not identify any defects which would have prevented the helicopter from responding normally to the pilot's control inputs. The evidence found at the accident site showed that the helicopter struck the ground with a high descent rate. Examination of the wreckage and ground marks indicated that both the main and tail rotors were operating under power at the time of impact.

There was no evidence of pre-impact damage or a pre-existing defect which would have prevented the engine from responding normally to control inputs. The damage observed

Footnote

[7] CAA Paper 2007/03 Helicopter Flight in Degraded Visual Conditions available at https://publicapps.caa.co.uk/docs/33/Paper200703.pdf (accessed February 2019).

[8] UK AIP Aeronautical Information Circulars available at http://www.nats-uk.ead-it.com (accessed February 2019).

[9] CAA Safety Notice SN-2017/003 - http://publicapps.caa.co.uk/docs/33/SafetyNotice2017003.pdf (accessed February 2019).

[10] EHEST Pre-flight Risk Assessment Checklist - https://www.easa.europa.eu/document-library/general-publications/ehest-pre-departure-risk-assessment-checklist (accessed February 2019).

to the engine was consistent with it operating normally immediately prior to the impact, as evidenced by rotational damage to the axial compressor, the impeller and its shroud, the turbine and the starter-generator cooling blades.

The axial compressor had separated from the impeller. It was concluded that bending loads arising from the impact damage sustained to G-OPEN's compressor front support housing caused the attachment bolts to fail, leading to separation of the axial compressor.

The evidence provided by examination of the lightbulbs from the autopilot mode control panel and the CWP was not sufficiently conclusive to determine whether the autopilot was engaged or whether any warnings were illuminated on the CWP, at the time of impact.

Weather conditions

The forecast weather for the destination and airfields en route showed cloud ceiling between 700 ft and 1,000 ft and a probability of cloud base reducing to 300 ft. The visibility below the cloud was forecast to be 6,000 m or greater with a probability of visibility reducing to 3,000 m. The actual weather conditions on the intended route were described by an experienced pilot as "very challenging".

The route was typically flown at approximately 1,500 ft. These weather conditions meant that the pilot would have needed to fly much lower to remain clear of cloud. Flying lower increases workload because a pilot needs to be more aware of terrain and obstacles and it is harder to see a clear horizon, making it more difficult to hold the helicopter at the correct attitude. It is also more challenging to navigate as a pilot cannot see as far and landmarks are harder to locate.

Whilst these weather conditions were above the legal weather minimums for a VFR flight, the low cloud base and reduced visibility would have made the flying conditions challenging.

Pilot recency

The pilot had not flown for 77 days prior to the accident flight and had only flown for 30 minutes in the last 10 months. The weather conditions during this 30 minute flight had been good. Pilots who knew the accident pilot described him as a competent pilot; however, like most pilots, his flying skills would have deteriorated with lack of practice.

There are no recency requirements for pilots of privately-owned helicopters flying solo. To fly with passengers, EASA regulations require the pilot to have completed three takeoffs and landings within the preceding 90 days. If an aircraft is hired from a commercial organisation, recency requirements are normally specified. Although these vary between organisations, a typical recency requirement would be to have flown within the last 28 days.

The pilot's lack of recency is likely to have made the flight more challenging and increased his workload.

Decision to fly

The purpose of the flight was to take the helicopter for its annual maintenance check, which was due the following day. This may have created a perception that the flight needed to go ahead on this day. However, the maintenance company stated that an extension could have been obtained and that this had been done in the past and the co-owner indicated that he would have been able to operate the flight at another time.

The pilot reportedly had a busy diary. He had arranged for a friend to collect him from Walton Wood and if he had not undertaken the flight it is likely that it would have been many days before he could find another opportunity to fly. These factors may have contributed to his decision to go ahead with the flight.

It is not known what meteorological information the pilot consulted prior to the flight, however, forecasts suggested a cloud base en route of between 300 ft and 700 ft. Without being qualified to fly on instruments, a pilot would need to fly below this altitude.

The combination of poor weather, low recency and perceived need to undertake the flight on this day would have contributed to the risk involved in this flight. The pilot was described as someone who only flew in good weather. A number of people who knew the pilot were very surprised he had decided to go ahead with the flight given the prevailing conditions.

The EHEST flight risk assessment tool was later used by the AAIB to assess the accident flight. Although the answers were not known for some of the questions, the tool would likely have categorised this flight as 'caution'. It is not known whether the pilot was aware of this pre-flight risk assessment tool or if he had used it before. Routine use of such a tool may cause a pilot to reconsider undertaking a flight that is categorised as 'caution' or 'high risk' or to take steps to mitigate some of the risks.

Accident flight

The pilot contacted RAF Linton-on-Ouse ATC at 1218 hrs to request a Basic Service. At this time the pilot did not report any problems. The helicopter was seen 1.2 nm from the accident scene and appeared to the witnesses to be flying normally although lower than they were used to seeing helicopters. The initial flight is recorded on radar at an altitude of 520 to 720 ft and a groundspeed of approximately 100 kt.

In the last minute before the accident, radar shows the aircraft descending to 520 ft, climbing to 1,020 ft and then descending back to 520 ft and the ground speed reducing to below 30 kt. It is not known whether these were intentional or unintentional climbs and descents. These were not observed by any witnesses, so it is not known whether the helicopter entered cloud at this time. It is possible the pilot was experiencing a varying cloud base and was changing height to remain clear of cloud. If the pilot was experiencing reducing visibility it would be logical to reduce speed, so this may have been the reason for the reducing ground speed. Alternatively, the pilot may have been becoming disorientated in the challenging weather conditions and was not aware of the change in altitude. The radar trace shows the helicopter flew left of his intended route and entered RAF Linton-on-Ouse MATZ (Figure 1).

ATC reported that it is not unusual for aircraft to enter the MATZ whilst transiting the gap, but the slight deviation from the planned track is a possible further indication that the pilot was disorientated.

As the helicopter approached Boroughbridge witnesses saw the helicopter pitch up and climb into cloud. The last radar point also shows the helicopter was at a height above the base of the cloud. The pilot was not qualified to fly in cloud, so it is unlikely that this was intentional. There are several possible explanations for the climb into cloud;

a) Spatial disorientation – It is possible that the pilot experienced a degraded visual environment and had become disorientated. Without a clear view it is difficult for a pilot who is not experienced in instrument flying to maintain the correct attitude. It is possible that the pitch up into cloud was the pilot attempting to maintain what he perceived as the correct attitude.

b) Distraction – It is possible that the pilot made an inadvertent control input which caused the helicopter to climb into cloud. This could occur if the pilot was distracted or was reaching to retrieve something in the cockpit.

c) Avoiding action – ATC confirmed that there was no other traffic shown on radar in the area at the time of the accident. However, it is possible that the pilot saw a bird which caused him to take avoiding action. Birds are a significant hazard for helicopters and it would be normal for pilots to avoid a collision.

d) Medical – The post-mortem did not reveal any condition which would explain the sudden pitch up into cloud. The pilot was suffering from a few minor conditions which could have caused a distraction.

e) Technical failure – There was no evidence of any malfunction that would account for the pitch up and climb into cloud. It is possible that a minor malfunction occurred which caused a distraction resulting in an inadvertent climb, however, there was no evidence of this.

Having entered cloud, it is challenging to continue to control a helicopter without experience and training in instrument flying. It is likely that the pilot would have experienced spatial disorientation when deprived of the normal visual cues. The pilot was not qualified to fly in instrument conditions; he would have received training in how to manage inadvertent entry into cloud but this is normally practiced from level flight. Having entered cloud in a steep climb it would be much more challenging to regain control.

Numerous witnesses reported hearing the helicopter whilst in cloud and it was reported as sounding very loud. No evidence was found of a mechanical failure of the helicopter which would account for the noise reported by the witnesses. It is likely that the noise was caused by a combination of 'blade slap', by the helicopter being at low altitude and the pilot making large control inputs whilst trying to control the helicopter.

The helicopter was seen by one witness to emerge from cloud and track across the sky before spinning one and half times and then rapidly descending. Numerous witnesses saw the helicopter in its final descent. With a cloud base of 400 to 500 ft over the accident site the pilot would have had very little time to regain control of the helicopter having exited the cloud. It is likely that the pilot was unable to regain control before the impact with the ground.

Conclusion

The investigation did not identify any evidence of pre-existing technical defects with the helicopter or its engine.

It could not be determined why the pilot decided to undertake the flight on this day. The combination of poor weather, low recency and perceived need to complete the flight would have contributed to the risk.

The helicopter was seen to climb into cloud prior to the accident. It could not be determined why the helicopter entered cloud but it is probable that the pilot was distracted or became disorientated and entered cloud inadvertently.

Having entered cloud it is likely that the pilot became spatially disorientated and was unable to maintain control of the helicopter. Having exited the cloud with a low cloud base it is likely the pilot did not have sufficient time to regain control before impact with the ground.

This accident highlights the importance of adequate pre-flight risk assessment and the hazard of flying helicopters in poor weather without adequate recency and experience.

AAIB Correspondence Reports

These are reports on accidents and incidents which were not subject to a Field Investigation.

They are wholly, or largely, based on information provided by the aircraft commander in an Aircraft Accident Report Form (AARF) and in some cases additional information from other sources.

The accuracy of the information provided cannot be assured.

ACCIDENT

Aircraft Type and Registration:	AW109SP GrandNew, G-FRRN
No & Type of Engines:	2 Pratt & Whitney Canada PW207C turboshaft engines
Year of Manufacture:	2017 (Serial no: 22371)
Date & Time (UTC):	19 November 2018 at 0902 hrs
Location:	London Heliport (Battersea)
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to rotor brake requiring replacement
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	71 years
Commander's Flying Experience:	14,142 hours (of which 391 were on type) Last 90 days - 55 hours Last 28 days - 3 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The pilot was starting the helicopter in order to depart from the heliport before it closed. Having completed his checks and been given permission to start, the pilot started the No 1 engine. He was alerted by the marshaller and by ATC that smoke was coming from the rotor head. He shut down the engine and, whilst completing the checks, noticed that the rotor brake was on.

History of the flight

G-FRRN had flown from Denham Airfield to London Heliport, Battersea arriving at 0854 hrs. The helicopter had been flown into the heliport by another pilot with the incident pilot sitting in the left seat. After the helicopter had been shut down and the passengers and the other pilot had disembarked, the incident pilot moved to the right seat in preparation for the flight back to Denham.

The incident pilot was told by the controllers at the heliport that it would shortly be closing due to a requirement for ATC breaks. There would be a wait of 30 minutes unless G-FRRN could depart before the closure. The pilot decided that it would be best to depart before the heliport closed and began to complete his before start checks.

The pilot was given permission to start from ATC once another helicopter had parked on the adjacent landing spot. As engine No 1 started and the rotors began to turn, the pilot was alerted by the marshaller and ATC that smoke was visible from the top of the helicopter. He immediately shut down the engine thinking that he had an engine fire. He was about the dry-crank the engine to dissipate any residual fuel when he noticed that the rotor brake was on.

The heliport fire service and the local fire brigade attended the scene, and it was soon clear that there had been no fire; although parts of the rotor head were hot. After opening all the cowls the temperature decreased and the helicopter was moved from the parking spots.

Examination by the maintenance organisation found the helicopter to be largely undamaged except for the rotor brake system, which was replaced before the helicopter was returned to service.

Helicopter information

The AW109SP is a modern, four-bladed helicopter with a fully articulated main rotor. It is designed to be operated by a single pilot but has dual cockpit controls. With a fully articulated rotor system, each rotor blade is attached to the rotor hub by a series of hinges which allow the blade to move independently. The rotor brake, which is fitted to allow the blades to be stopped more rapidly after engine shutdown, is a hydraulically operated calliper acting on a disc secured to the tail rotor drive pinion. The rotor brake handle is in the centre overhead console of the flight deck on the left of the engine control levers and, with the rotor brake off, the handle is fully forward. There is no requirement to have the rotor brake on when the aircraft is parked unless there is a very strong wind.

As part of the pre-start procedures the rotor brake is applied to check that a yellow caution message, ROTOR BRAKE, illuminates. The message indicates that the rotor brake lever is not in the off position or that the rotor brake system is degraded. The rotor brake is not to be applied when the rotor rpm, N_R, is greater than 40%. When the rotor brake is on or the brake pads are not in the fully retracted position, a red message, ROTOR BRAKE ON, appears on the right electronic display unit in the centre of the instrument panel.

Some helicopters have a sensor in the rotor brake system (such as in the lever itself) to prevent starting with the rotor brake on, but no such system is fitted to this helicopter type.

Human factors

The AW109SP is designed to be flown by a single pilot and the checks are generally performed from memory without reference to a written checklist.

The incident pilot did not tend to leave the rotor brake on after shutdown, selecting it off once the rotors stopped. The pilot who flew G-FRRN into Battersea tended to leave the rotor brake on after shutdown. With the checks before start completed rapidly from memory, the incident pilot missed the fact that the rotor brake was on because he was not expecting to see the handle in that position. The rotor brake handle can be difficult to see from the right-hand seat because it is partially obscured by the engine control levers.

Analysis

The pilot was keen to depart from the heliport before it closed. Although checking the disengagement of the rotor brake was part of the before start checklist, it was not the pilot's usual practise to leave it on. The checks were completed from memory, with time pressure to start and take off as soon as possible. The helicopter is not designed with a system to prevent the pilot starting the engine with the rotor brake on, and the rotor brake lever can be difficult to see from the right seat. The pilot did not notice that the rotor brake was on before he started the first engine.

The attentiveness of the marshaller and ATC personnel meant that the pilot was alerted quickly to the smoke coming from the rotor head. He rapidly shut down the helicopter which probably prevented much greater damage.

Conclusion

A combination of factors led to the pilot starting an engine with the rotor brake on. The helicopter was not fitted with any system that would have stopped the engine starting, although a caption would have been visible on the electronic display on the instrument panel.

SERIOUS INCIDENT

Aircraft Type and Registration:	Dornier Alpha Jet FB, OE-FAS
No & Type of Engines:	2 SNECMA Larzac 04-C20 turbofan engines
Year of Manufacture:	1980
Date & Time (UTC):	13 July 2018 at 1345 hrs
Location:	Farnborough Airport, Hampshire
Type of Flight:	Flight display
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	None
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	40 years
Commander's Flying Experience:	2,300 hours (of which 182 were on type) Last 90 days - 35 hours Last 28 days - 14 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The aircraft had been conducting a display routine making use of smoke produced by two oil-fuelled smoke generators, mounted on the wing pylons. The pilot had switched off the smoke generators as the aircraft turned onto the final approach to land and he observed the smoke stop using the cockpit-mounted mirrors. During the approach, spectators observed flames coming from both smoke generators. The pilot became aware of the flames during the landing roll and isolated the smoke generation system using the circuit breakers. After briefly extinguishing the flames reappeared, so the pilot declared a MAYDAY. The flames self-extinguished before AFRS reached the aircraft. An examination by the operator's engineers did not find any defect with the generators and all subsequent operation of the system has been normal.

The event is thought to have been caused by the smoke generators being switched off as they ran out of fuel, which caused a small quantity of fuel to pool in the smoke generator nozzle which then ignited due to the residual heat present in the nozzle.

ACCIDENT

Aircraft Type and Registration:	Boeing A75N1 Stearman, G-CIOC
No & Type of Engines:	1 Lycoming R-680-E3A piston engine
Year of Manufacture:	1942 (Serial no: 75-4961)
Date & Time (UTC):	22 July 2018 at 1630 hrs
Location:	Wickenby Airport, Lincolnshire
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Torn fabric on lower right wing in two places and leading edge damage to right aileron
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	64 years
Commander's Flying Experience:	3,300 hours (of which 383 were on type) Last 90 days - 114 hours Last 28 days - 65 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The pilot was conducting wing walking flights and had already completed nine flights that day without incident. On the tenth flight, whilst landing on grass Runway 34, the aircraft overran, crossing hard Runway 03/21. It then continued onto the grass beyond, clipping a runway marker board at an estimated speed of 5 to 7 kt.

The weather conditions at the time were hot, with calm winds and thermal activity, requiring greater concentration by the pilot and thus fatigue may have been a causal factor.

ACCIDENT

Aircraft Type and Registration:	Cirrus SR22, G-SRTT
No & Type of Engines:	1 Teledyne Continental IO-550-N46 piston engine
Year of Manufacture:	2007 (Serial no: 2421)
Date & Time (UTC):	9 June 2018 at 1039 hrs
Location:	Benington, Hertfordshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Minor damge to fuselage at the lower left engine mount and where the CAPS cables pulled out of the structure; engine severely damaged
Commander's Licence:	Private Pilot's Licence
Commander's Age:	60 years
Commander's Flying Experience:	284 hours (of which 4 were on type) Last 90 days - 18 hours Last 28 days - 4 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot, AAIB enquires and examination of the engine

Synopsis

Approximately eight minutes into a cross-country flight there was a catastrophic engine failure. At a height of approximately 800 ft agl the pilot successfully operated the aircraft's parachute recovery system and the aircraft descended into a field near the village of Benington (Figure 1). The engine failure most probably occurred because of an insufficient quantity of oil.

History of the flight

The pilot reported that he was conducting a VFR flight from North Weald Airfield to Retford Gamston Airfield and was accompanied by a passenger, who also held a private pilot's licence. The wind was approximately 5 kt from 070°. Approximately six minutes into the flight, and while at a cruise height of approximately 1,500 ft agl, the engine oil low pressure warning light illuminated. The engine oil pressure gauge, which would normally have indicated 45 to 50 psi, indicated approximately 9 psi. The pilot reduced the engine power, which reduced the airspeed from approximately 130 kt to 90 kt, and made a turn with the intention of returning to North Weald.

Figure 1

G-SRTT descending under the parachute
(Photograph used with permission)

Shortly after the pilot informed Farnborough Radar of his engine problem and intentions, the engine started to run rough, there was a loss of power and grey smoke and oil started to come out from the engine cowlings. At this stage the pilot had entered a shallow descent in order to maintain his airspeed. The rough running developed into severe banging, there was a further loss of engine power and the smoke became denser to the extent that the pilot had difficulty in seeing through the windscreen. The aircraft was now at a height of approximately 1,100 ft agl and while there were a number of large fields within glide range, with the smoke obscuring his forward visibility the pilot was not confident that he could make a safe landing. He was also concerned that an engine fire might develop. The passenger, on the pilot's instructions, made a MAYDAY call to Farnborough Radar while the pilot checked that the area below the aircraft was clear and operated the Cirrus Aircraft Parachute System (CAPS) at a height of approximately 800 ft agl.

The CAPS operated normally, and the aircraft descended into a field on the eastern edge of the village of Benington (Figure 2). The pilot and passenger were uninjured.

Figure 2
Accident site

Aircraft information

General

The Cirrus SR22 is a four-seat light aircraft equipped with a single piston engine fitted with an oil-operated variable pitch propeller. The cockpit is equipped with two electronic displays: a Primary Flight Display (PFD) and a Multifunctional Display (MFD). Also mounted on the instrument panel is an annunciator panel that contains a red oil warning light that illuminates when the oil pressure is below 10 psi.

Cirrus Aircraft Parachute System (CAPS)

The Cirrus SR22 is fitted with CAPS, a ballistic parachute recovery system, which is designed to bring the aircraft and occupants to the ground in the event of a life-threatening emergency. Its deployment has been demonstrated in straight and level flight at a speed of 133 kt with a loss of height of 400 ft. In the event of an engine failure, Cirrus Aircraft provide the following advice in their document *'Guide to CAPS'* (Figure 3).

Takeoff Briefing

A Cirrus pilot is more likely to deploy CAPS quickly during a total loss of engine power or other emergency if a takeoff briefing is conducted prior to takeoff.

Height Above Ground Level (AGL)	Recommended Response
0' – 500' (600' G5)	Land Straight Ahead*
500' (600' G5) – 2000'	Deploy CAPS Immediately
2000' or Greater	Troubleshoot, Use CAPS as Required

*Activate CAPS immediately if no other survivable alternative exists.

Figure 3
Extract from Cirrus aircraft document – Guide to CAPS

Engine

General

The aircraft was equipped with a Teledyne Continental IO-550-N46 six-cylinder, fuel-injected engine. The engine had been fitted with two Tornado Alley intercoolers and turbochargers by the aircraft manufacturer under a Supplementary Type Certificate. At the time of the accident the engine had operated for approximately 1,280 hours since new.

The last significant maintenance on the engine occurred during the annual inspection carried out in June 2014, approximately 430 engine hours prior to the accident, when the No 2 and No 4 cylinders were found to be cracked. Both cylinders were replaced without disturbing the piston connecting rods.

The engine was last inspected during the 50-hour servicing carried out approximately two weeks prior to the accident. The inspection revealed no evidence of an oil leak from the engine or propeller, or burnt oil residue in the exhaust system.

Capacity of the engine oil system

The Continental IO-550-N46 engine fitted to the Cirrus SR22 has a certified oil capacity of 8 US quarts, whereas the IO-550 engine used in other aircraft installations has a 12 US quart system with the extra 4 US quarts used for cooling. The aircraft manufacturer advised that the IO-550-N engine was reduced to 8 US quarts (slightly smaller sump) as the SR22 cowling provided better aerodynamic cooling.

Regarding the oil system, the Pilot's Operating Handbook (POH) provides the following caution:

> *'The engine should not be operated with less than six quarts of oil. Seven quarts (dipstick indication) is recommended for extended flight.'*

The pilot on the accident flight informed the AAIB that he checked the oil level during the pre-flight walk round and it was full at 8 US quarts. He also reported that there was no evidence of oil leaks on the outside of the aircraft.

Description of the engine oil system

The engine is provided with a wet-sump, high-pressure oil system for engine lubrication and cooling (Figure 4). The engine oil, which is contained in the oil sump, is drawn through a screen into the oil suction tube to the inlet of the positive displacement oil pump. Pressurised oil from the pump outlet is directed past the oil pressure relief valve to the oil filter. From the oil filter, pressurised oil flows through a crankcase passage to the oil cooler.

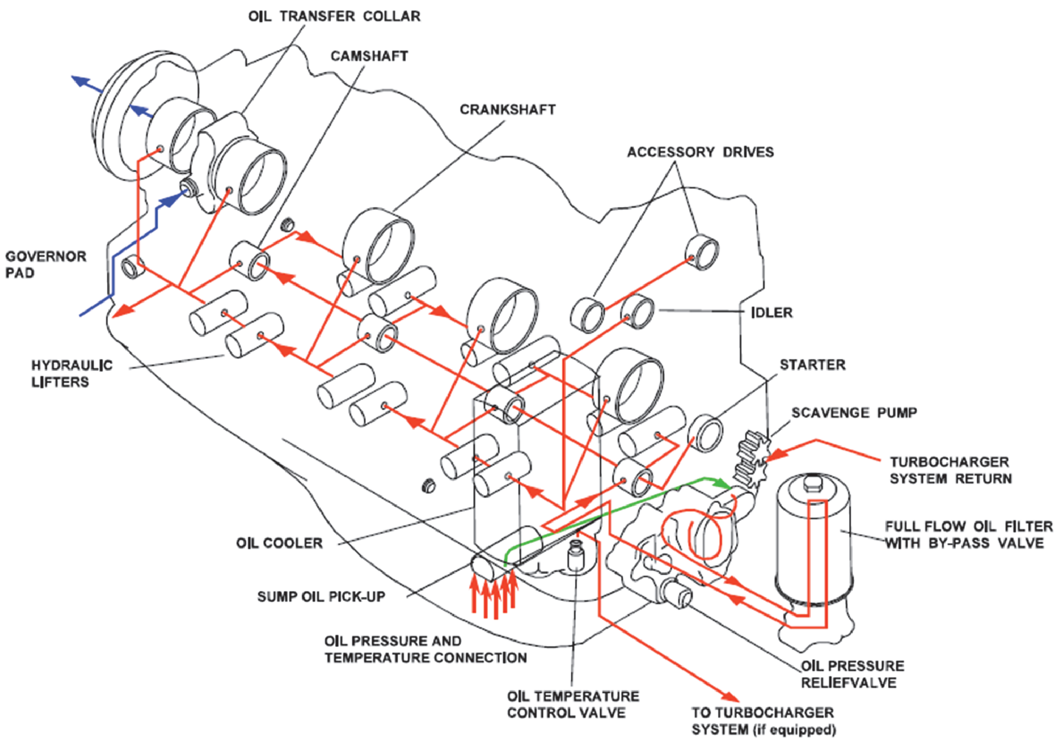
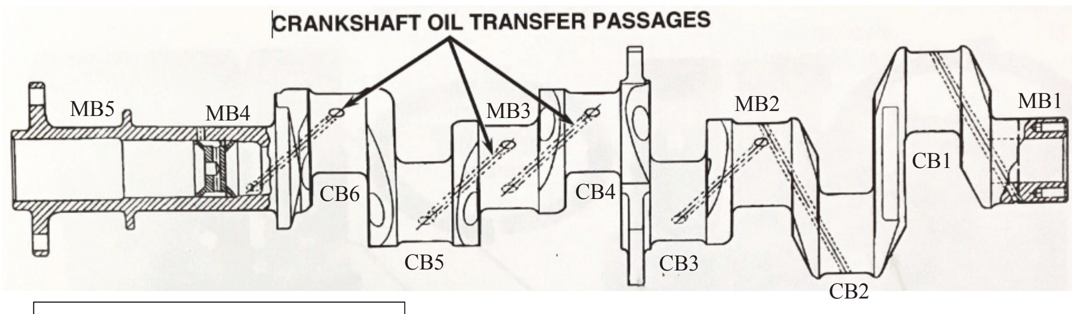


Figure 4

Engine oil system

From the oil cooler the oil is directed to the oil galley in the left side of the crankcase and the camshaft. The oil in the left side of the crankcase is directed to all the main bearings and then feeds through galleys in the crankshaft to each of the connecting rods (Figure 5). The oil lubricating the main bearings is also directed to the oil squirt nozzles that spray a mist of oil onto the bottom side of the pistons to lubricate the cylinder walls and piston pins; gravity returns the oil to the sump. Oil that passes through the left side of the crankcase is also used for the propeller governor operation. Oil is also passed though the camshaft to the right side of the crankcase to lubricate the valve lifters and other cylinder components.



MB = Main crankshaft bearing
CB = Connecting rod bearing

Figure 5

Crankshaft oil transfer passages

The oil pressure is sensed by a transducer located between the oil cooler and crankshaft oil gallery and the oil temperature by a sensor located in the sump.

Engine limitations

The POH provides the following engine operating limitations:

Oil Temperature …………..240°F (115°C) maximum
Minimum oil pressure …….10 psi

Engine indications

The SR22 is equipped with engine instrumentation and warning lights to monitor the engine performance. A data acquisition unit converts analogue signals from the cylinder head temperature (CHT), exhaust gas temperature (EGT), manifold air pressure (MAP), oil pressure, oil temperature and tachometer to digital format which is then transmitted to the MFD and the PFD. The engine oil pressure is continuously displayed in the engine data block located in the lower right corner of the PFD. System health, caution, and warning messages are displayed in colour-coded advisory boxes in the lower right corner of the MFD (Figure 6). In addition, the text of the engine parameters displayed on the PFD changes to the corresponding colour of the advisory box during an annunciation event.

Figure 6

Multi Functional Display

If the oil pressure falls below 30 psi or exceeds 75 psi, the MFD will display '*Check Oil Press'* in a yellow advisory box in the lower right corner of the MFD. If the oil pressure falls below 10 psi or exceeds 99 psi, the MFD will display *'Check Oil Press'* in a red advisory box.

An annunciator panel located in front of the pilot contains an oil warning light which illuminates when either the oil pressure or oil temperature warning messages are generated.

Emergency procedures for low engine oil pressure

Regarding low oil pressure, the POH provides the following guidance to the pilot:

> *'If low oil pressure is accompanied by a rise in oil temperature, the engine has probably lost a significant amount of its oil and engine failure may be imminent. Immediately reduce engine power to idle and selected a suitable forced landing field.*
>
> ***Note***
>
> *If low oil pressure is accompanied by normal oil temperature, it is possible that the oil pressure sensor, gauge, or relief valve is malfunctioning. In any case, land as soon as practical and determine cause.'*

Engine data

The aircraft MFD has a Flight Data Logging feature which automatically stores critical flight and engine data on a compact flash card.

The engine data for the accident flight is plotted in Figure 7. The data shows that the engine had been running for 11 minutes before the rpm and MAP increased for takeoff. During this period the oil temperature rose progressively to 162°F and the oil pressure reduced to approximately 45 psi before peaking at 58 psi as the engine speed was increased to 2,670 rpm. Over the next 13 minutes, the oil temperature continued to increase, peaking at 198°F. Approximately 6 minutes after the start of the takeoff run, the oil pressure reduced to 30 psi (yellow warning) and 2 minutes later reduced to 10 psi (red warning). The engine stopped rotating approximately 13 minutes after the takeoff run commenced. During the flight the CHTs peaked at 346°F, and the EGTs at 1,436°F.

Apart from the reducing oil pressure, all the parameters indicate that the engine was operating normally until 30 seconds before the engine stopped, when the EGTs started to decrease. The engine data for the four flights prior to the accident fight appeared to be normal with the oil pressure remaining at around 50 psi during the cruise. The oil temperature during the previous flights peaked at between 184°F and 195°F; on the accident flight the oil temperature peaked at 198°F.

Examination of the aircraft and engine

Examination of the aircraft at the accident site

The engineering organisation who recovered the aircraft reported that the only significant damage to the aircraft was to the area of the fuselage adjacent to the lower left engine mount and the areas where the cables for the CAPS had been pulled out of the airframe. The CAPS had operated as designed.

Engine oil had leaked onto the ground from the sump, which had been punctured during the impact. There was a hole in the crankcase next to the No 4 cylinder through which the oil had leaked out of the engine in flight. There was no other evidence of an oil leak from the engine or propeller. The engineering organisation also reported there was no evidence of residues in the exhaust to indicate that oil had been burnt in the combustion chambers. The engine could not be rotated by hand.

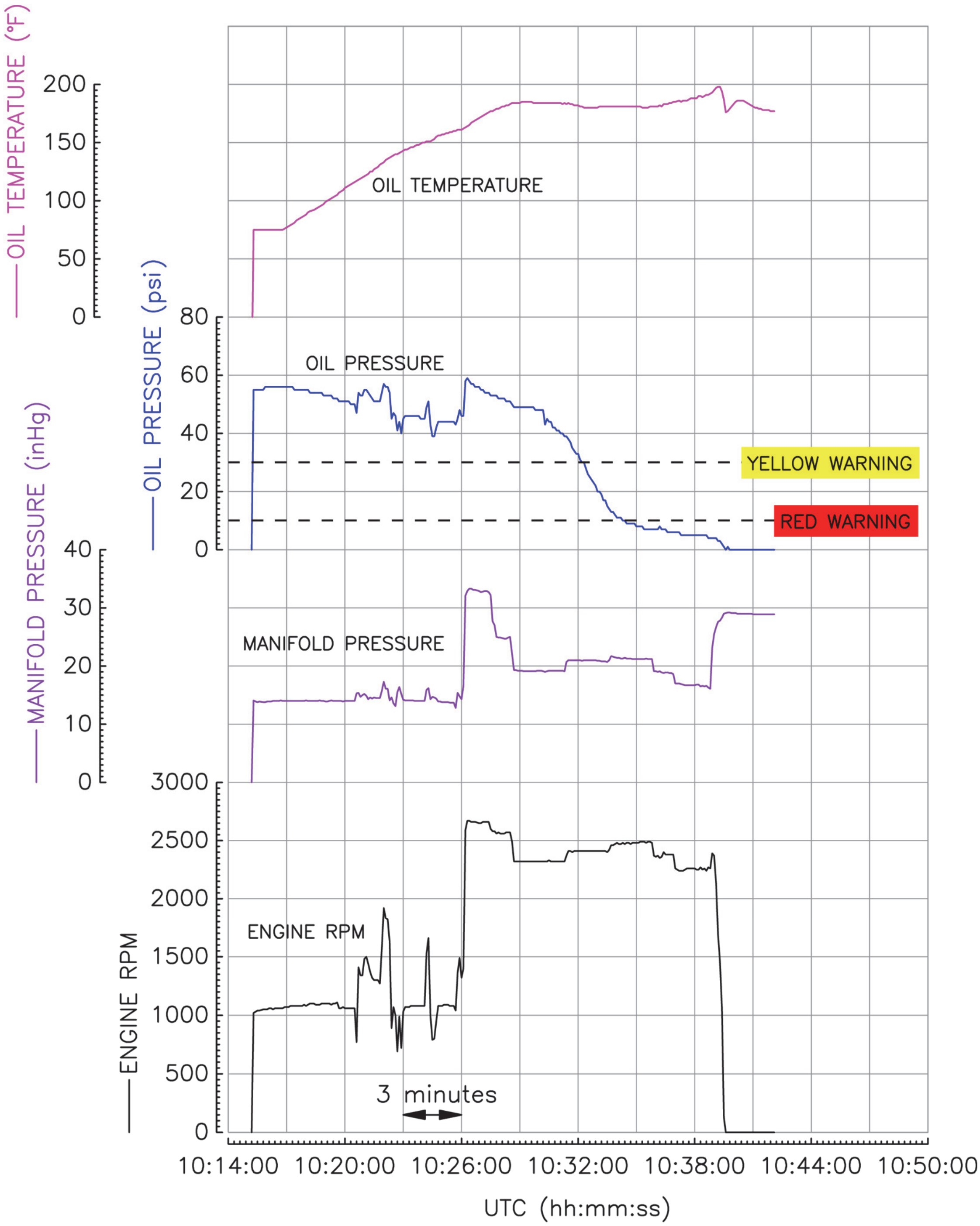


Figure 7

Engine data from accident flight

Examination of the engine by the AAIB

An examination of the engine was carried out by the AAIB at the engine overhaul facility. For reference, the parts of a generic piston and connecting rod assembly are shown at Figure 8.

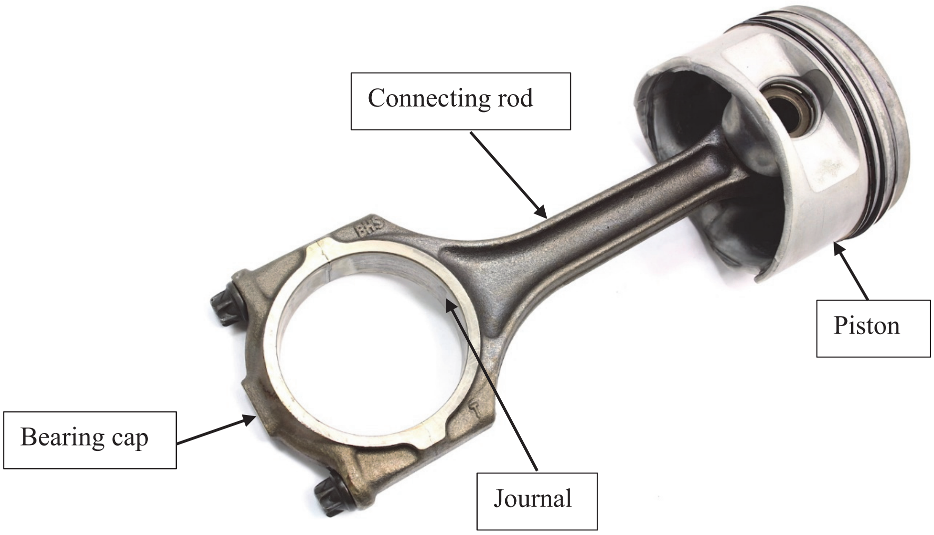


Figure 8
Generic piston and connecting rod

The bearing caps on the No 3 and No 4 piston connecting rods had become disconnected. Damage to the No 4 connecting rod indicated that it had then been struck by the crankshaft with sufficient force for it to knock a hole approximately 10 cm by 8 cm in the crankcase beneath the No 4 cylinder (Figure 9).

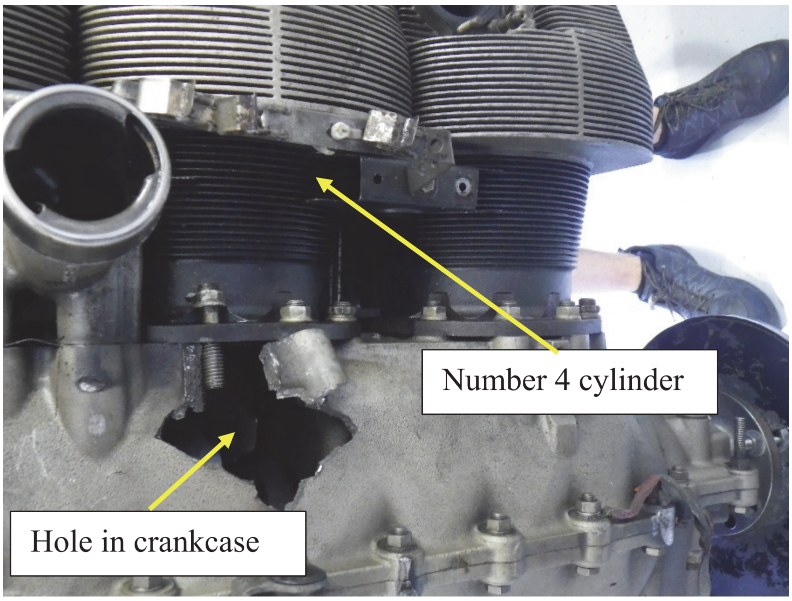


Figure 9
Hole in the crankcase caused by the No 4 connecting rod

The No 2 piston connecting rod was seized on the crankshaft and the No 5 piston connecting rod was partially seized. The No 1 and No 6 connecting rods rotated normally. Except for the No 1 connecting rod, there was discoloration and corrosion on the bottom part of all the connecting rods, which was greatest on the inner four connecting rods (Figure 10). The bearing material on all the overheated connecting rods had extruded out of the bearing caps leaving the connecting rods running on the steel shells. There was no evidence that any of the bearings had rotated in their journals.

The crankshaft counterweights were intact and there was no evidence of overheating on the cylinders, pistons or valve assemblies.

Figure 10

Corrosion and discoloration on connecting rod and bearing cap

The bottom of the No 3 connecting rod and bearing cap had broken into four parts and the remnants of the bolts exhibited failure in overload. The skirt on the piston had also broken off (Figure 11). The No 4 bearing cap was intact, and distorted, and had separated from the connecting rod. The parts of the two bolts that remained in the bearing cap also exhibited necking associated with failure in overload.

Figure 11

Damage to No 3 and No 4 connecting rod and bearing caps

Parts of two bolts, that had failed in overload, a nut containing part of a bolt that had failed in shear and a broken part of a nut where found in the engine (Figure 12).

Figure 12
Parts of failed nuts and bolts recovered from the engine

Overall condition of the engine

There were multiple sites of impact damage within the crankcase and on the bottoms of the pistons, caused by flying debris. The oil galleries in the crankshaft were checked and found to be clear. There was oil throughout the engine and debris from the crankcase was found in the oil filter. The remainder of the oil system, including the bypass and relief vales were intact and operated normally. There was no evidence of an oil leak in the turbochargers.

There was no evidence of overheating in the cylinders or pistons, or at the ends of the crankshaft. All the piston rings and oil scrapers were intact and there was no evidence of oil having been burnt in any of the combustion chambers.

Metallurgist report

Metallurgists from QinetiQ examined the failed bolts, the parts that were recovered from the No 2 and 3 connecting rods, and photographs of the crankshaft taken by the AAIB.

The parts had been badly damaged and based on the evidence available they concluded that the main bearings on the No 3 and 4 connecting rods had overheated sufficiently to cause the bearing material to melt and the strength of the steel bolts to reduce such that they failed in overload.

Engine oil consumption

No complete record had been kept of either the engine oil level or oil replenishments. Pilots of this aircraft on previous flights stated that the engine oil level was satisfactory at the start of the flight, there was no evidence of oil leaks and no additional oil was added to the engine.

Analysis

Engine failure

Examination of the engine revealed that the temperature at the bottom of a number of the connecting rods had been sufficient for the bearing material to melt and for the No 3 and 4 connecting rod cap bolts to fail in overload. There was no evidence of overheating in any other part of the engine and no fault was found in the engine lubrication system. The engine manufacturer advised that the heat damage along the crankshaft and the failure of the connecting rod bearings was consistent with the engine having been operating with a low level of oil.

With insufficient oil to cool and lubricate the bearings, the temperature of the bearing material would increase and start to melt, causing the gap between the bearing surface and the crankshaft to increase. This would result in an increase in vibration and a drop in the oil pressure which would affect the cooling and lubrication of other parts of the engine. Once all the bearing material had melted, the connecting rod would be left running on the steel bearing shell, which would have caused a further increase in temperature sufficient to reduce the tensile strength of the cap bolts so that they failed under normal loads.

The engine data indicates that the rise in temperature at the connecting rod bearings, and subsequent failure of the cap bolts, occurred over a short period of time and before there was sufficient heat transfer from the crankshaft to affect the temperature of the oil in the engine sump where the temperature sensor is located.

Loss of oil

Apart from the oil that had been lost through the hole in the crankcase, caused by the failed No 4 connecting rod, there was no other evidence of the engine having sustained an oil leak during the accident flight. Nor was there any evidence that the engine had been burning oil.

Actions of the pilot

The pilot was aware of the decreasing oil pressure, without a corresponding increase in temperature, and considered that he acted in accordance with the POH to land as soon as practicable. However, once the connecting rod failed he not only had insufficient power to maintain height but his forward visibility was affected by the smoke from the engine. He was also concerned at the possibility of an engine fire. The pilot acted in accordance with the recommendation from Cirrus to operate CAPS immediately if the engine failure occurs between 500 to 2,000 ft agl. The CAPS was deployed at approximately 800 ft agl and the aircraft descended into a field approximately 120 m from the village of Bennington without injury to the pilot or passenger.

Conclusion

The pilot activated the CAPS following an engine failure in accordance with the POH and advice by the aircraft manufacturer. The engine failure was due to overheating of the connecting rod cap bolts as a result of insufficient cooling by the engine oil.

AAIB comment

This accident highlights the importance of understanding the sensitivity of an engine's oil capacity and oil level during flight. The engine in the Cirrus SR22 has a certified oil capacity of 8 US quarts and a drop from the maximum level can increase the risk of the bearings starting to overheat and fail.

It is also worth emphasising that a drop in oil pressure, without a corresponding increase in oil temperature, does not necessarily indicate that the fault is caused by an oil sensor or gauge and, therefore, a pilot should land as soon as safely practical. In considering whether to make a field landing, a pilot would need to consider the risk of continued flight to a suitable airfield against the risk of a precautionary landing in a field.

Bulletin correction

Following further discussion with the pilot, the conclusion to this report now reads:

> **Conclusion**
>
> The pilot activated the CAPS following an engine failure in accordance with the POH and advice by the aircraft manufacturer. The engine failure was due to overheating of the connecting rod cap bolts as a result of insufficient cooling by the engine oil.

The online version of this report was corrected prior to publication.

SERIOUS INCIDENT

Aircraft Type and Registration:	DHC-1 Chipmunk 22, G-BCPU
No & Type of Engines:	1 De Havilland Gipsy Major piston engine
Year of Manufacture:	1953 (Serial no: C1/0839)
Date & Time (UTC):	8 September 2018 at 1235 hrs
Location:	Near White Waltham Airfield, Berkshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	None
Commander's Licence:	Comercial Pilot's Licence
Commander's Age:	49 years
Commander's Flying Experience:	1,024 hours (of which 300 were on type) Last 90 days - 34 hours Last 28 days - 15 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

During an aerobatic display the aircraft failed to respond to the pilot's control inputs due to a restriction in the rudder control circuit caused by a loose article. The pilot was able regain control of the aircraft and made a successful landing.

History of the flight

After completing the final manoeuvre of a display sequence, an aileron roll at 600 ft agl, the aircraft continued to roll and pitch nose-down despite the pilot's control inputs. The pilot reduced power and declared a MAYDAY. The pilot identified a restriction in the rudder controls which, after vigorous movement of all of the flying controls, cleared. The pilot regained control of the aircraft at 50 ft agl and, after turning the aircraft back towards the airfield, completed an uneventful emergency landing.

An inspection of the aircraft, carried out immediately after the flight, showed that the flying controls appeared to operate normally and were undamaged. A detailed inspection of the aircraft completed a few days after the event confirmed that there were no defects with the flying controls. However, a partially crushed pen was found within the fuselage. The damage to the pen indicated that it was the probable cause of the control restriction. The pilot reported that, prior to the incident flight, a pen top had been recovered from the rear cockpit of the aircraft during the pre-flight loose article check but no other articles had been seen.

As a result of the incident, the pilot has introduced more rigorous pre- and post-flight inspections of the aircraft for loose articles and only allows pens to be carried if they are securely tied to the pilot's or student's flying suit.

INCIDENT

Aircraft Type and Registration:	Eurofox 912(S), G-CHUP
No & Type of Engines:	1 Rotax 912ULS/EP915ECi piston engine
Year of Manufacture:	2013 (Serial no: LAA 376-15188)
Date & Time (UTC):	4 January 2019 at 1000 hrs
Location:	Nympsfield Airfield, Gloucestershire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Propeller damaged
Commander's Licence:	Light Aircraft Pilot License
Commander's Age:	73 years
Commander's Flying Experience:	746 hours (of which 14 were on type) Last 90 days - 2 hours Last 28 days - 0 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The pilot attempted to start the aircraft for its first flight of the day, using the standard starting procedure with the throttle set slightly open, brakes on and the control column held back. After several unsuccessful attempts to start the engine, he pumped the throttle whilst turning the starter key whereupon the engine started and immediately ran at high power, causing the aircraft to pitch forward onto its nose, severely damaging the propeller.

The pilot stated that in his opinion the incident was caused by his incorrect use of the throttle during the engine start. He considered that it was a mistake to engage the starter whilst pumping the throttle and that he believed the throttle was almost fully open when the engine eventually started. He added that he was relatively inexperienced with fuel-injected engines and was more familiar with carburettor engines, where pumping the throttle can be used to prime the engine during starting. The aircraft's engine manual recommends setting the throttle 1 to 2 cm open during starting, and the pilot stated that he has now highlighted this on his engine start checklist.

ACCIDENT

Aircraft Type and Registration:	Extra 400, D-EXKG
No & Type of Engines:	1 Teledyne Continental TSIOL-550-C piston engine
Year of Manufacture:	2003 (Serial no: 26)
Date & Time (UTC):	13 July 2018 at 1257 hrs
Location:	Oban Airport, Argyll and Bute
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 2
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to propeller and front wheel, and shockloaded engine
Commander's Licence:	Private Pilot's Licence
Commander's Age:	53 years
Commander's Flying Experience:	1,244 hours (of which 20 were on type) Last 90 days - 33 hours Last 28 days - 19 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

During the takeoff roll, the pilot became concerned about a flock of birds on the end of the runway and chose to abort the takeoff. At this point the IAS was above the normal takeoff speed. The aircraft failed to stop by the end of the paved surface, overran the runway and struck the airfield boundary fence before coming to a stop in an area of bushes just prior to the shoreline. The pilot believed that the brakes became overheated and ineffective.

History of the flight

The flight was planned from Oban to Shoreham with three people on board and one dog. For departure the aircraft was close to its Maximum Takeoff Weight (MTOW) and the pilot backtracked to use the full length of Runway 19. At the threshold, he applied the brakes and advanced the throttle to an intermediate position. With all indications normal he released the brakes and applied full throttle, planning to accelerate to 85 kt for takeoff. The Pilots Operating Handbook (POH) for the aircraft gives a lift-off speed of 73 kt at the MTOW of 1,999 kg. The pilot stated that, in his view, aircraft performance was very poor at the lift-off speed indicated in the POH and that he always used higher speeds. At approximately 80 kt the pilot became aware of a flock of birds at low level over the end of the runway. He was concerned that the aircraft would not have sufficient performance to climb above the birds and so decided to stop.

The pilot was cognisant of the fact that locking the wheels would radically reduce braking performance and tried to avoid this while still applying significant braking effort. However, the aircraft failed to stop by the end of the paved surface, overran the runway and struck the airfield boundary fence before coming to a stop in an area of bushes just prior to the shoreline (Figure 1).

Figure 1
Aircraft on the Shoreline

Using figures from performance tables in the POH, it was determined that an approximate takeoff run for an aircraft lifting off at 73 kt would be 480 m. An approximate landing roll at the same mass would be 280 m. In this case, the braking effort was commenced from approximately 80 kt, so the distances to accelerate and stop would have been greater, but the manufacturer was unable to provide an accurate total distance. Runway 19 at Oban is 1,246 m long.

The pilot reported that in the last 25 m of the runway the brakes became ineffective and he believed that they had become overheated. The aircraft struck the bushes and the perimeter fence at approximately 5 kt. All those on board exited the aircraft without assistance and were clear of the aircraft when the airport RFFS arrived on scene.

Conclusion

Distracted by the presence of birds over the end of the runway the pilot made a decision to abort the takeoff at high speed but was unable to stop before overrunning the end of the runway.

ACCIDENT

Aircraft Type and Registration:	Grumman AA-5 Traveller, G-BEZF
No & Type of Engines:	1 Lycoming O-320-E2G piston engine
Year of Manufacture:	1974 (Serial no: AA5-0538)
Date & Time (UTC):	2 September 2018 at 1020 hrs
Location:	Turweston Aerodrome, Buckinghamshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Scratches to propeller; damage to elevator of parked aircraft
Commander's Licence:	Private Pilot's Licence
Commander's Age:	42 years
Commander's Flying Experience:	166 hours (of which 98 were on type) Last 90 days - 6 hours Last 28 days - 0 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The pilot planned to fly from Turweston Aerodrome to Coventry Airport and was accompanied by another pilot, who occupied the right seat. Following a walk-round inspection and pushback, he completed the pre-start checklist and started the engine. Upon receipt of taxi clearance, the pilot released the brakes and opened the throttle to commence taxi, but the aircraft veered sharply to the left. He initially applied full pressure to the right brake pedal but when the aircraft did not respond, applied full pressure to both brake pedals. The pilot judged that the aircraft was going to strike a parked aircraft so he closed the throttle, while the accompanying pilot selected the mixture to OFF. Although the engine had stopped, the propeller was still rotating when G-BEZF struck the parked aircraft. Both occupants were uninjured and exited the aircraft without assistance.

The pilot reported that the collision had resulted from a brake failure, which prevented him from steering or stopping the aircraft. He commented that checking the brake pressure prior to engine start may have identified the fault prior to commencing taxi. Following the accident, another syndicate member tried the brakes with the aircraft stationary and the engine off and noted that the left side brake pedals felt very soft, while those on the right side felt normal. The syndicate member subsequently reported that the aircraft maintainer found no faults when he checked the brakes and assessed that the 'feel' of the brake pedals was within normal experience.

Bulletin Correction

A bulletin correction was issued concerning this report prior to publication - full details can be found on the AAIB website (https://www.gov.uk/aaib-reports/aaib-investigation-to-grumman-aa-5-traveller-g-bezf).

ACCIDENT

Aircraft Type and Registration:	Jabiru SK, G-OJAB
No & Type of Engines:	1 Jabiru 2200A piston engine
Year of Manufacture:	1996 (Serial no: PFA 274-13031)
Date & Time (UTC):	25 July 2018 at 0815 hrs
Location:	Private Strip, Higham, Kent
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Nose landing gear, engine cowlings and propeller damaged
Commander's Licence:	Private Pilot's Licence
Commander's Age:	43 years
Commander's Flying Experience:	321 hours (of which 39 were on type) Last 90 days - 6 hours Last 28 days - 4 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The aircraft was operating a private flight from Southery Airfield, Norfolk to a private strip at Higham, Kent. The pilot had not been to Higham before, so he overflew the strip to assess the runway and radioed the owner to determine if it was clear for him to land. The pilot reported that the aircraft landed approximately ¼ of the distance along Runway 17 and, given the short runway length, he applied the brakes firmly. He reported that the braking force was greater than expected, which he attributed to the hard, dry surface conditions. The nose landing gear collapsed and the aircraft veered to the left. The pilot was uninjured and exited the aircraft without assistance. He considered that the sudden braking had put excess force on the nose landing gear leg, causing it to fail. He commented that in future he would apply less than full braking force, or apply the brakes in small bursts if more urgent braking was required.

ACCIDENT

Aircraft Type and Registration:	Piper J5A Cub Cruiser, G-BSXT
No & Type of Engines:	Rolls Royce O-200A
Year of Manufacture:	1940 (Serial no: 5-498)
Date & Time (UTC):	20 July 2018 at 1310 hrs
Location:	Felthorpe Airfield, Norwich
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Right wing and left rear fuselage damaged
Commander's Licence:	FAA Private Pilot's Licence
Commander's Age:	73 years
Commander's Flying Experience:	876 hours (of which 0 were on type) Last 90 days - 4 hours Last 28 days - 2 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and enquiries made by AAIB

Synopsis

During a check flight, a newly repaired Piper J5A Cub Cruiser overran the runway and struck a gate at Felthorpe Airfield near Norwich. This was because the aircraft was travelling too fast in the final stage of the landing. It floated a long distance and landed a long way down the runway. The pilot had no time on type and the aircraft had heel brake controls that he found difficult to use.

The LAA did not have the opportunity to assess the suitability of the check pilot, in part due to a misunderstanding between the LAA and one of its Inspectors about what airworthiness process to follow. In response to this accident, the importance of clear and unambiguous communications with members has been reinforced at LAA HQ. The LAA has also informed inspectors of the circumstances of this event and issued a decision-making flow chart to help them determine what process should be followed.

History of the flight

The flight took place at Felthorpe Airfield, where there was a light headwind of 3 to 5 kt along the runway.

The aircraft had been repaired recently following a stalled landing accident. It was authorised by an LAA Inspector for check flying on 9 July 2018.

Check flying of a newly repaired LAA aircraft is intended to[1]:

- Check the aircraft is basically flyable.
- Check each of the systems.
- Set up and trim the aircraft properly.
- Complete the LAA test schedule.

The pilot was the owner of the aircraft and had performed most of the repair work. On 20 July 2018 he considered the weather suitable for the first check flight.

The pilot planned to do between three and five circuits and landings using Runway 23 before performing a "full check flight" and completing the LAA test schedule with the LAA Inspector on board. As the aircraft had been rebuilt, the pilot was unsure of the stall speed. He wanted to "add a margin of safety" so decided to approach at 60 mph and land at 55 mph.

The ground run, takeoff and circuits were normal. The pilot attempted two approaches and considered the aircraft too high and too fast (65 mph) so elected to go around. On the third approach, he was comfortable with speed and height and elected to land.

After flaring, the aircraft floated for some distance before making a three-point touch down. The aircraft was still moving at speed and the pilot applied full brake but was already over half way along the 487 m runway.

At the end of the runway there was a hedge with a public road behind. The pilot decided to turn to increase the landing distance. He turned the aircraft gradually to the right using braking and rudder. There was a fence ahead so he "attempted to ground loop" to the right. Full depression of the brake was not enough to turn the aircraft in time.

The aircraft struck a gate with the right fore and aft wing struts causing it to swing to the right and its left wing tip hit a tree. The right wing and left rear fuselage were damaged (Figures 1 and 2).

Footnote

[1] LAA (2008) Initial test flying of LAA aircraft. TL 1.19 Issue 1. http://www.lightaircraftassociation.co.uk/engineering/TechnicalLeaflets/Building,%20Buying%20or%20Importing/TL%201.19%20Initial%20Test%20Flying%20of%20LAA%20Aircraft.pdf (accessed on 12/12/2018)

Figure 1
G-BSXT after the accident

Figure 2
Damage to the right wing

Accident site

Figure 3 shows significant locations in the accident sequence.

Figure 3

Sequence of the accident and accident site (edited image from Google Earth)

Aircraft information

The Piper Cub Cruiser J5A is a high wing, strut-braced monoplane with a steel frame, fabric covered, fuselage. G-BSXT had been modified to replace the original engine with a Rolls Royce 0-200A engine.

G-BSXT was originally registered in the UK under LAA administered permit to fly arrangements. It was exported to the Republic of Ireland in 2013 and registered there as EI-AXT. Due to its export, the LAA permit to fly was revoked. It was involved in a landing accident in 2016. In 2017 the pilot purchased it and re-registered it in UK using the original registration of G-BSXT. It was repaired by the pilot with some tasks done by contractors.

The aircraft's main wheels were fitted with brakes which were operated by the pilot's heels.

According to a manual published by Piper Aircraft Corporation, the landing speed for the Piper Cub Super Cruiser is 45 mph[2]. According to the 1940 edition of *Jane's All The World's Aircraft*, the landing speed for the lighter J5A variant is 40 mph[3].

Footnote

[2] Piper Aircraft Corporation (1945). *How to fly a Piper Cub.*

[3] Grey, C.G and Bridgman, L (1941). *Jane's All The World's Aircraft 1940*. Sampson Low Marston and Co. Thanks to the Royal Aeronautical Society National Aerospace Library for providing access to this publication.

Airfield information

Felthorpe is an unlicensed airfield, 4 nm north-north-west of Norwich that has two grass runways.

Personnel

Pilot

The pilot was the owner of the aircraft. He reported that he was an FAA licenced engineer for 15 to 20 years and had been an LAA member and inspector for 2 to 3 years.

He had received training and endorsement and flown as pilot in command in a Stinson 108 tail wheel aircraft in 1993. He had no experience in the Piper Cub Cruiser. His recent experience was on a Cessna 172 which has a tricycle undercarriage.

G-BSXT was the first aircraft the pilot had owned that would be administered under the LAA permit to fly arrangements.

LAA Inspector

The LAA Inspector ran an aircraft inspection and maintenance business. He stated he is also an EASA licensed engineer for single engine light aircraft and an inspector for the LAA, BMAA and BGA.

LAA processes and guidance

The LAA administer permits to fly for some types of aircraft on behalf of the CAA.

To be considered airworthy, LAA aircraft require a non-expiring permit to fly issued by the CAA on the recommendation of the LAA and an annual certificate of validity. When an aircraft owner wishes their aircraft to be managed under LAA arrangements, they must make an application to the LAA. Each application is considered on an individual basis and the LAA specifies what process needs to be followed to obtain a permit to fly and certificate of validity. There are various routes depending on the type and history of the aircraft.

The pilot planned for G-BSXT to be managed under the permit to fly arrangements administered by the LAA. He had not yet officially applied to the LAA.

Process followed for G-BSXT

The pilot and LAA Inspector were following the process for renewal (revalidation) of a permit to fly.

The renewal process consists of inspection of the aircraft and its paperwork by an LAA inspector and a check flight or flights. In the renewal process, check flights may be authorised by an LAA inspector providing that the certificate of validity has not expired by more than 12 months. The *'Form LAA/FWR 1 October 2017 version'* documents the process.

An LAA inspector signs Section 4 of Form LAA/FWR 1 to certify that the aircraft and its paperwork has been inspected and is considered fit for the annual check flight. The top of this section states the 12-month expiry rule in red italic text. It also refers to guidance notes on the final page of the form. The 12-month rule is restated and expanded in the guidance notes as follows:

> *'Where a check flight for renewal of a permit to fly is to be conducted any time more than twelve months after the expiry of the permit to fly, then Section 4 will have to be completed by LAA Engineering before flight.'*

In this situation the LAA assesses the application form and any related documentation. If satisfied, the LAA issues a similar Permit Flight Release Certificate, an appropriate check flight schedule and any special check flight requirements.

The guidance notes also state:

> *'Persons acceptable to conduct this check flight are qualified pilots with a minimum total experience of 100 hours flying including 10 hours on type or a similar type.'*

LAA technical leaflet TL1.19[4], '*Initial test flying of LAA aircraft*' states:

> *'The choice of pilots for carrying out test flying is another issue where owners put forward their suggestion and LAA Engineering have to vet the proposal, based on the previous flying experience of the person put forward, currency on aeroplanes of the type concerned, or at least, similar or related types…'*

Very similar guidance, including that relating to flying experience is also given in LAA technical leaflet TL2.06 issue 3[5].

On 9 July 2018, the LAA aircraft worksheet and check flight authorisation were signed indicating that the pilot and the LAA Inspector considered the aircraft was fit for a check flight. However, the aircraft did not have a permit to fly because it was revoked when the aircraft was exported.

Applicable process for G-BSXT

According to the LAA this aircraft should have followed the process for the issue of a new permit. Under the new permit process, a Certificate of Clearance must be issued by the LAA before a check flight. Part of this process is intended to assess the suitability of the

Footnote

4 LAA (2008). Technical Leaflet TL 1.19. *Initial test flying of LAA aircraft.* Issue 1. http://www.lightaircraftassociation.co.uk/engineering/TechnicalLeaflets/Building,%20Buying%20or%20Importing/TL%201.19%20Initial%20Test%20Flying%20of%20LAA%20Aircraft.pdf (accessed on 13 December 2018)

5 LAA (2008). Technical leaflet TL 2.06. The permit renewal test flight fixed wing aircraft. Issue 3, 1 Jan 2008. http://www.lightaircraftassociation.co.uk/engineering/TechnicalLeaflets/Operating%20An%20Aircraft/TL%202.06%20Annual%20Permit%20Renewal%20Flight%20Test.pdf (accessed on 15 January 2019)

nominated check pilot[6]. Based on the nature of the aircraft and the repair work that had been undertaken, the written minimum requirements for the check pilot would have been the same as for the renewal process (100 hours total and 10 hours on type or similar)[7]. However, in practice, pilots for the testing of recently built, imported or repaired aircraft are assessed on a case by case basis.

Flying guidance for aircraft owners

At the time of the accident, the LAA did not provide guidance for owners regarding first flights on type. The LAA are not responsible for pilot licensing or training. The LAA offers an optional Pilot Coaching Scheme where qualified instructors provide tuition on flying new types of aircraft[8].

Pilot's comments

The pilot had conducted self-study familiarisation training regarding the performance and landing technique for the Piper Cub Cruiser using various sources. He found that most sources advocated a 55 mph final approach speed. He also found sources that quoted stall speeds of up to 49 mph.

He had concluded that the landing area available at Felthorpe was sufficient. The pilot said that he had not gained any instruction on type because it was not required by the insurance company. The consensus among his flying community peers was that the type was very easy to fly. He also stated he was not sure where he could obtain instruction.

The pilot said he intended to add 5 mph to what he believed to be the recommended landing speed for the aircraft. He reflected that he had overcompensated for stall speed and made assumptions that the landing drag would be greater than it was.

The pilot indicated that the brakes were effective and no problems with them were identified after the accident. However, he found it difficult to use the brake and rudder at the same time because heel brakes were unfamiliar to him.

The pilot did not consider there to be any problems with the aircraft that may have contributed to the accident.

The pilot commented that he was not aware of the guidance in Section 4 of Form LAA/FWR 1 stating the 12-month expiry rule. He accepted the permit flight release certificate without question.

Footnote

6 LAA Flight Testing Guidance for new permits: http://www.lightaircraftassociation.co.uk/engineering/Warning%20FlightTesting/LAAFT_NEW.html (accessed on 19 October 2018)
7 LAA exposition, section 5.5, p30.
8 LAA Pilot Coaching Scheme. http://www.lightaircraftassociation.co.uk/PCS/pcs.html (accessed on 13 December 2018)

LAA Inspector's comments

The LAA Inspector said that he telephoned the LAA when he became involved with the aircraft and spoke to the LAA Chief Inspector. After this conversation he had the impression that the aircraft should follow the normal permit renewal process. The LAA Inspector followed this process on approximately one aircraft per month.

He was aware that G-BSXT had previously held a permit to fly but did not investigate further. He indicated that he did not read the text on Section 4 of the permit renewal form that stated that LAA Inspectors cannot authorise a check flight if the permit to fly has expired by more than 12 months.

LAA Chief Inspector's comments

The LAA Chief Inspector stated he was aware that the pilot had imported an aircraft and was repairing it. He recalled several conversations with the pilot. He could not specifically recall any conversations with the LAA Inspector about the aircraft but stated he had no doubt that he did talk to him.

CAA Safety Sense Leaflets

Safety Sense Leaflet 7 – '*Aircraft performance*' offers practical guidance on how to fulfil the pilot's responsibility to check aircraft performance, including landing distances. It states:

> *'When landing at places where the length is not generous, make sure that you touch down on or very close to your aiming point (beware of displaced thresholds). If you've misjudged it, make an early decision to go around – don't float half way along the runway before deciding.'*[9]

Safety Sense Leaflet 12 – '*Strip flying*' similarly advises:

> *'If your approach is bad, or a touchdown at the correct place is unlikely, make an early decision to go-around.'*[10]

Analysis

The pilot decided to land at a speed he believed was 5 mph higher than the recommended speed. According to figures found during the investigation, it may have been as much as 15 mph higher than the appropriate landing speed. This resulted in a much longer float and therefore landing distance required. The pilot did not decide to go around after recognising the long float. He had already performed two go-arounds and it appears that he performed the third approach with a mindset that he would definitely land.

Footnote

9 Safety sense leaflet 7: *Aircraft performance*. http://publicapps.caa.co.uk/docs/33/20130121SSL07.pdf (accessed on 14 November 2018)

10 Safety sense leaflet 12: *Strip flying*. http://publicapps.caa.co.uk/docs/33/20130121SSL12.pdf (accessed on 14 November 2018)

The pilot's tailwheel training was a long time ago on a different aircraft, so the skills acquired would have faded and may not have been relevant to the Piper Cub Cruiser. The pilot's lack of time on type contributed to the outcome. His difficulty using the brakes may also have contributed to his inability to stop in the available distance.

The pilot and the LAA Inspector were both mistaken about the airworthiness process required before flying. The airworthiness of the aircraft was the pilot's responsibility as the owner. The work on the aircraft was considered by the pilot to be straightforward and this may have created an expectation that the application process would be straightforward as well. In addition, the pilot had asked for the assistance of the LAA Inspector who was much more experienced with LAA processes. The pilot relied on this guidance. The LAA Inspector believed that the required process was normal permit renewal. This may have been the result of miscommunication between him and LAA headquarters. The misunderstanding resulted in a flight that did not comply with the regulations.

Both the process followed, and the new permit processes, incorporated the same written guidance regarding the minimum experience of the check flight pilot. The pilot did meet the written minimum criteria for performing the check flight because it does not include any requirement for how recently the pilot has flown the type or a similar type.

The LAA Inspector stated that he had not read the clause about the 12-month limit. This may have been due to over-familiarity with the form because he used it so frequently. This could have caused him to focus on the parts he needed to complete and to disregard the static parts of the form that he had often seen before. This clause would have prompted him to realise that the renewal process was not appropriate for the aircraft. Had the new permit process been applied instead, the chance of an accident may have been reduced because the LAA probably would have considered the nominated pilot to be unsuitable due to lack of recent time on type.

Conclusion

The pilot was unable to land and stop the aircraft in the distance available because the landing speed was too high, and touchdown occurred approximately half way along the 487 m runway. The pilot had selected a higher than recommended landing speed to compensate for not knowing the stall speed of the aircraft, which was newly repaired. The pilot's lack of experience on type contributed. His difficulty using the heel brake controls may also have contributed.

The airworthiness process followed for the aircraft was not the appropriate one. As a result, the LAA did not have the opportunity to assess the suitability of the check pilot. The opportunity for the accident would have been reduced if they had considered the pilot's lack of currency on type and required he have instruction or use an alternative pilot for the check flight.

Safety actions

In response to this accident, the LAA has re-emphasised to its staff the importance of clear and unambiguous conversations between LAA headquarters, aircraft owners and LAA inspectors.

The LAA has also produced a communication for LAA inspectors that describes this event and provides advice regarding inspector responsibilities in this type of case. It has also produced a decision-making flow chart to assist inspectors to determine what process should be followed.

As a safety action in response to the accident involving G-BXON, the LAA has published Technical Leaflet 2.30 *Converting to a new type*[11]. This contains relevant guidance for pilots transitioning between aircraft types.

Footnote

[11] LAA (2018). Technical Leaflet 2.30. *Converting to a new type.* Issue 1. 19 December 2018. http://www.lightaircraftassociation.co.uk/engineering/TechnicalLeaflets/Operating%20An%20Aircraft/TL%202.30%20Converting%20to%20a%20New%20Type.pdf (accessed on 15/01/2019).

ACCIDENT

Aircraft Type and Registration:	Piper PA-28-140 Cherokee, G-AYIG
No & Type of Engines:	1 Lycoming O-320-E2A piston engine
Year of Manufacture:	1970 (Serial no: 28-26878)
Date & Time (UTC):	18 October 2018 at 1322 hrs
Location:	West Wales Airport
Type of Flight:	Private
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to propeller and nosewheel; multiple scrapes on both wings
Commander's Licence:	Private Pilot's Licence
Commander's Age:	77 years
Commander's Flying Experience:	1,065 hours (of which 547 were on type) Last 90 days - 8 hours Last 28 days - 4 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The pilot was completing his third circuit and planned to execute a practice forced landing (PFL) on Runway 07 from mid-way along the downwind leg. There was some right drift on short final on the previous landings, so he offset the PFL approach to the left of the runway extended centreline. The expected right drift did not occur, so the pilot rolled the aircraft to the right to regain the centreline. The aircraft's response was greater than expected, possibly due to the northerly crosswind lifting the left wing, causing the right wing, and the propeller to contact the runway surface. The aircraft slewed across the runway, departing the left side. It skidded left as it rotated to the right, returning to the runway as it did so. The left wing then contacted the runway surface before the aircraft came to rest (Figure 1).

The pilot commented that he had overestimated the effect of the crosswind and his attempt to re-align with the runway centreline caused the aircraft to roll excessively. He suggested a number of factors which may have contributed to the event. Most significantly, he identified that he was overly confident that he could recover the situation once it had diverged from the initial plan, so continued to attempt to land the aircraft rather than going around.

Figure 1

G-AYIG once it had come to rest (note the ground marks showing the path of travel)

ACCIDENT

Aircraft Type and Registration:	Piper PA-28-161 Cherokee Warrior II, G-BSZT	
No & Type of Engines:	1 Lycoming O-320-D3G piston engine	
Year of Manufacture:	1981 (Serial no: 28-8116027)	
Date & Time (UTC):	26 October 2018 at 1004 hrs	
Location:	Shoreham Airport, West Sussex	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - 3
Injuries:	Crew - None	Passengers - None
Nature of Damage:	Damage to engine cowlings, exhaust and broken nose leg	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	47 years	
Commander's Flying Experience:	141 hours (of which 66 were on type) Last 90 days - 5 hours Last 28 days - 2 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

Synopsis

As the aircraft rotated during takeoff, a gust of wind caused it to yaw to the left, which together with the crosswind meant the aircraft left the runway and came to rest in a ditch. None of the occupants were injured.

History of the flight

The pilot hired the aircraft to take two friends and a child for a sightseeing flight in the local area. He usually flew a different aircraft type but this was in maintenance and was not available. He had not flown the PA-28 for seven months.

Having completed the checks on the aircraft and started the engine, the pilot requested taxi clearance and was given instructions to proceed to the holding point for Runway 24. On reaching Runway 24, the pilot carried out the power checks on the aircraft and was then informed that the runway had changed to Runway 02. He made a 180° turn on the taxiway and proceeded to the holding point for Runway 02. He completed the power checks again before telling the tower that he was ready for departure.

The pilot was cleared for takeoff and, after checking the wind was within limits, commenced his takeoff roll. As he reached a speed of 70 KIAS he began to pull back gently on the control column. As the nose pitched up through approximately 3°, a gust of wind caused the aircraft to yaw to the left. The pilot attempted to put the nosewheel back onto the runway by pushing on the control column, but the aircraft departed the runway to the left. Witnesses reported seeing the aircraft bounce across the grass, possibly becoming airborne momentarily due to the rough surface. They also noted that the aircraft seemed to continue at high speed for some time with no apparent reduction in power. Eventually the aircraft was seen to slow but the pilot found it difficult to stop the aircraft before it struck undergrowth. The aircraft then ran into a ditch at slow speed as shown in Figures 1 and 2.

None of the aircraft occupants were injured and they were able to vacate the aircraft without assistance.

Figure 1
G-BSZT came to rest in a ditch

Figure 2
G-BSZT with the takeoff runway visible behind

Meteorology

Weather reports from Shoreham on the day of the accident showed that the wind was 290° at 13 kt at 0950 hrs, and 310°at 8 kt at 1050 hrs. This would have meant a maximum cross wind of 13 kt from the left on Runway 02. There were some showers in the vicinity of the airport which was reflected in the forecast for the day which included rain showers.

Analysis

The pilot was unable to keep the aircraft on the runway during the final stages of the takeoff roll. With showers in the vicinity of the airfield, he may have encountered a gust of wind unexpectedly which combined with the crosswind from the left and caused the aircraft to yaw to the left and leave the runway. With the wheels on the grass, the pilot was unable to stop the aircraft before it struck undergrowth and came to rest in a ditch.

Although the pilot had recent flying experience, he had not flown this aircraft type for seven months and may have underestimated the amount of rudder needed to compensate for the crosswind.

Conclusion

The aircraft left the runway, probably due to the effects of the crosswind. The pilot and passengers were unhurt.

ACCIDENT

Aircraft Type and Registration:	Piper PA-28-181 Cherokee Archer III, G-BXTW
No & Type of Engines:	1 Lycoming O-360-A4M piston engine
Year of Manufacture:	1998 (Serial no: 2843137)
Date & Time (UTC):	22 November 2018 at 1250 hrs
Location:	Compton Abbas Airfield, Dorset
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to right wing and tailplane
Commander's Licence:	Private Pilot's Licence
Commander's Age:	81 years
Commander's Flying Experience:	3,165 hours (of which 3,100 were on type) Last 90 days - 5 hours Last 28 days - 2 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and further enquires by the AAIB

Synopsis

On approach to Runway 08 at Compton Abbas Airfield the aircraft descended below and to the right of the normal approach path and collided with a tree. The pilot was able to correct the approach path and land normally. After the accident he was not able to identify any reason why he did not notice that the aircraft was not on the correct approach path.

History of the flight

The pilot was flying back from Wolverhampton Halfpenny Green Airport in the West Midlands to Compton Abbas Airfield, Dorset where the aircraft was based; a route the pilot had flown many times. The pilot held a valid instrument rating (restricted)[1] and flew most of the route above cloud. He descended below the cloud, using a radar service, before joining left base for Runway 08 at Compton Abbas.

The pilot reported that he thought the approach was "normal" until he heard a bang and realised he had hit the top of trees located to the right and below the approach path. He applied power and left bank to return to the correct path. The aircraft landed normally. Damage was found to the leading edge and tip of the right wing, and to the tailplane (Figure 1).

Footnote

[1] An 'Instrument Rating (Restricted)' allows the holder to exercise the privileges of an instrument rating in UK airspace only. The holder must not fly IFR in Class A, B or C airspace and cannot takeoff or land in visibility less than 1,800 meters.

Figure 1

G-BXTW after the accident showing damage to right wing and tailplane

Meteorology

The weather was described as hazy, with a cloud base between 1,500 ft and 2,000 ft and a light easterly breeze.

Airfield information

Compton Abbas Airfield has an elevation of 811 ft. The terrain approaching Runway 08 slopes up from the north and west, which can give an unusual visual perspective on the approach. However, the accident pilot was familiar with this airfield and the visual picture on this approach.

The trees the aircraft struck are located to the right of the approach path (Figure 2). The airfield operator reported that aircraft normally clear these trees by approximately 100 ft to 150 ft and that they are located approximately 100 m to the right of the straight-in approach to Runway 08.

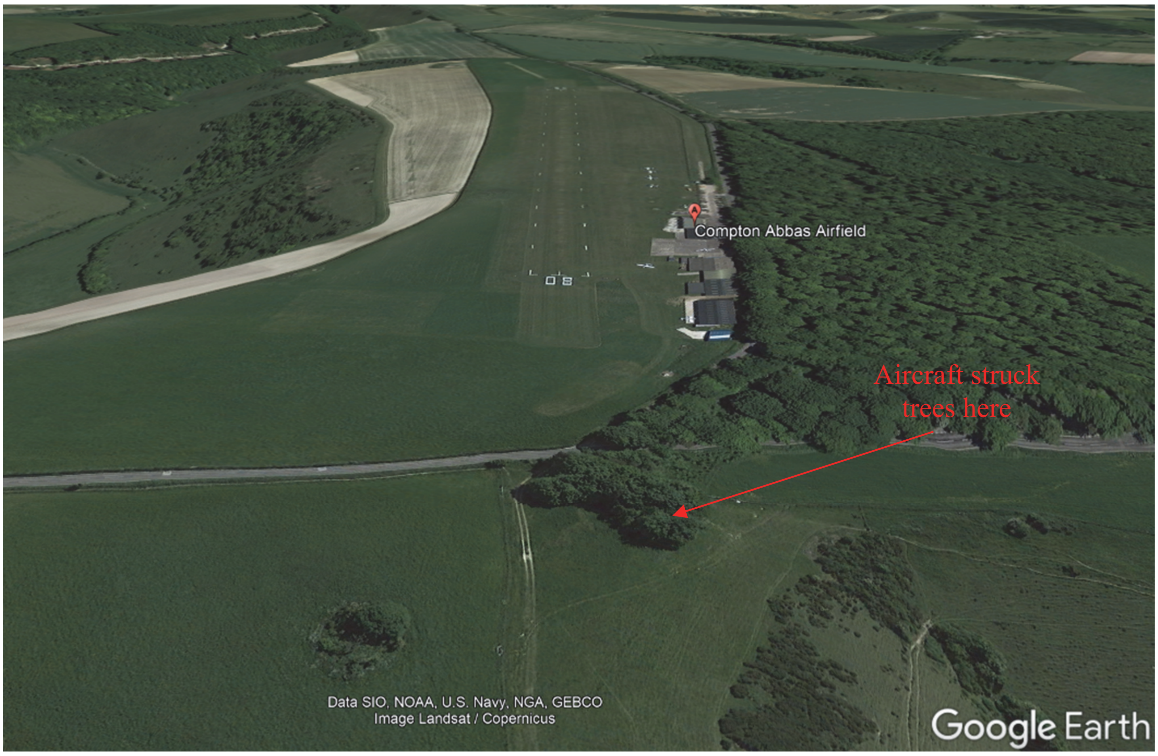


Figure 2

Compton Abbas Airfield (viewed from the east)

The aerodrome operator has asked the land owner to prune these trees to reduce the chance of a similar accident occurring again.

Personnel

The pilot was experienced flying this aircraft into Compton Abbas having originally learnt to fly at the airfield and having flown there regularly for many years. However, he had flown less in the last year.

The pilot reported that some personal issues were on his mind and this may have distracted him on the approach.

Analysis

The pilot allowed the aircraft to descend below and to the right of the normal approach path causing the aircraft to strike a tree. After the accident, he could not identify any reason why he did not notice he was not on the correct profile. He reflected that personal matters were on his mind and this may have distracted him on the approach.

ACCIDENT

Aircraft Type and Registration:	Piper PA-28R-200-2 Cherokee Arrow II, G-EDVL
No & Type of Engines:	1 Lycoming IO-360-C1C piston engine
Year of Manufacture:	1972 (Serial no: 28R-7235245)
Date & Time (UTC):	18 June 2018 at 1735 hrs
Location:	Redhill Aerodrome, Surrey
Type of Flight:	Training
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Right main landing gear trunnion failed, right wing skin damaged
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	69 years
Commander's Flying Experience:	11,034 hours (of which 200 were on type) Last 90 days - 168 hours Last 28 days - 76 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft suffered a failure of the right main landing gear forward trunnion while taxiing from the taxiway onto a grass area used for pre-takeoff power checks. The failure of the trunnion was caused by the progression of a fatigue crack within the trunnion and subsequent failure of the trunnion in overload. The most probable reason for the initiation of the fatigue crack is likely to have been an unreported heavy landing.

History of the flight

The aircraft was scheduled to carry out a flight as part of the student pilot's training to obtain a 'complex' aircraft rating on his PPL. No defects were observed during the pre-flight inspection and after the completion of the start-up procedure ATC cleared the aircraft to taxi on the grass across Runway 18/36 and onto Taxiway A to the A2 holding point in preparation for takeoff from Runway 26R. The aircraft was taxied slowly across the grass, which the student reported was somewhat uneven, onto Taxiway A. As the aircraft approached the A2 holding point the student slowed the aircraft and turned the aircraft onto a grass area used for carrying out pre-takeoff power checks. He reported hearing a "thump", followed shortly by the aircraft's right wing dropping. The aircraft was brought to a halt, ATC were informed of the problem and the instructor left the cockpit to inspect the aircraft. Looking under the wing, from the leading edge of the wing outboard of the fuel tank, the instructor observed that the landing gear leg had moved from its normal position, at which point the student noticed a small hole in the upper surface of the wing. The aircraft was shut down and ATC informed of the situation. The aircraft was subsequently recovered to a hangar by its maintenance organisation.

Piper PA-28R landing gear

The Piper PA-28R is a variant of the PA-28 fitted with retractable tricycle landing gear, designed to operate from paved and unpaved surfaces. The main landing gear retracts inboard, into bays within the wing structure. Each main landing gear leg is held in place by two trunnions, secured to the rear face of the forward wing spar and the forward face of the rear spar (Figure 1).

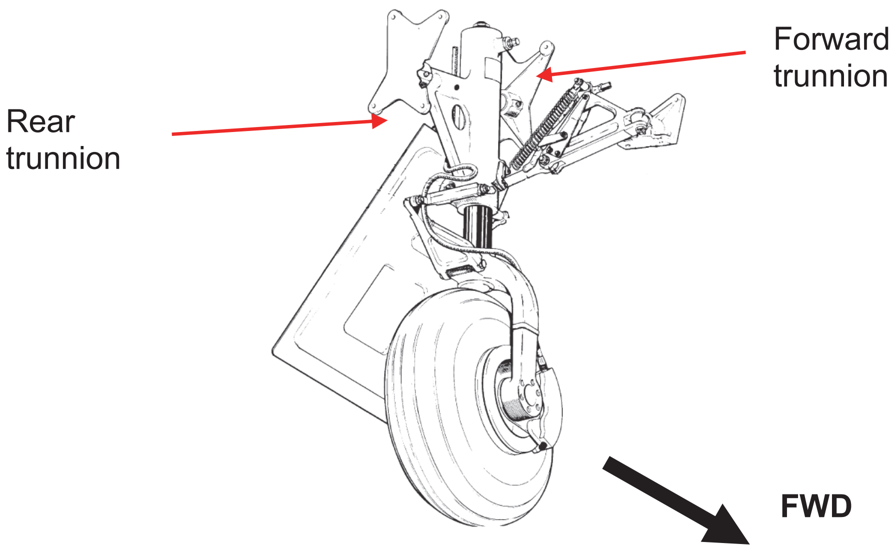


Figure 1
PA-28R main landing gear

Investigation

Examination of the aircraft showed that the forward trunnion of the right main landing gear leg had failed (Figure 2), which allowed the landing gear leg to rotate rearwards, which resulted in the right wing dropping and the top of the landing gear leg piercing the wing skin. A small section of material had separated from the trunnion and was not recovered. The remains of the trunnion were removed and examined by the AAIB.

Examination of the fracture faces showed that most of the fracture surfaces had suffered from mechanical damage but appeared to show the characteristics of failure in overload. One area was identified which showed the characteristics of crack propagation in fatigue (Figure 3) although damage to the fracture face prevented the identification of the crack initiation site. This area was associated with the area of missing material.

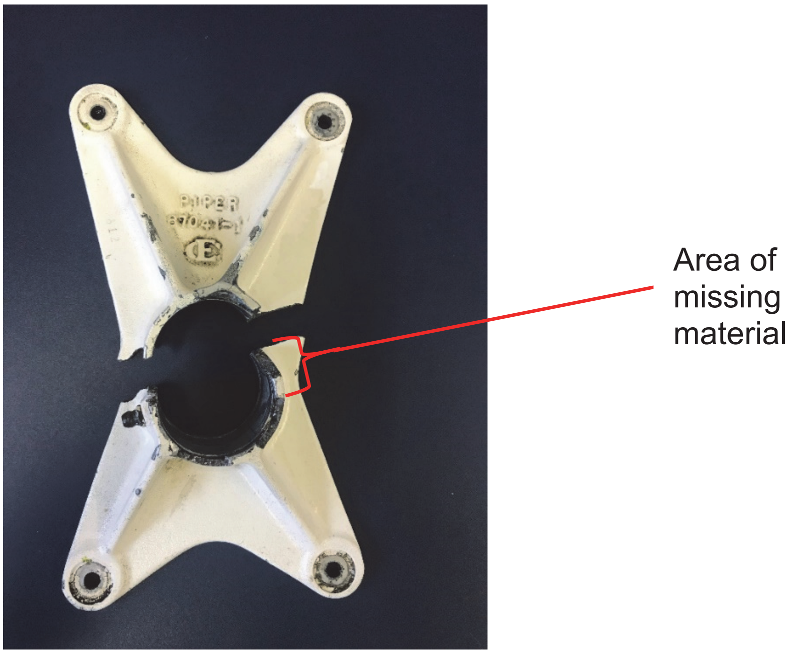


Figure 2

Failed right main landing gear forward trunnion

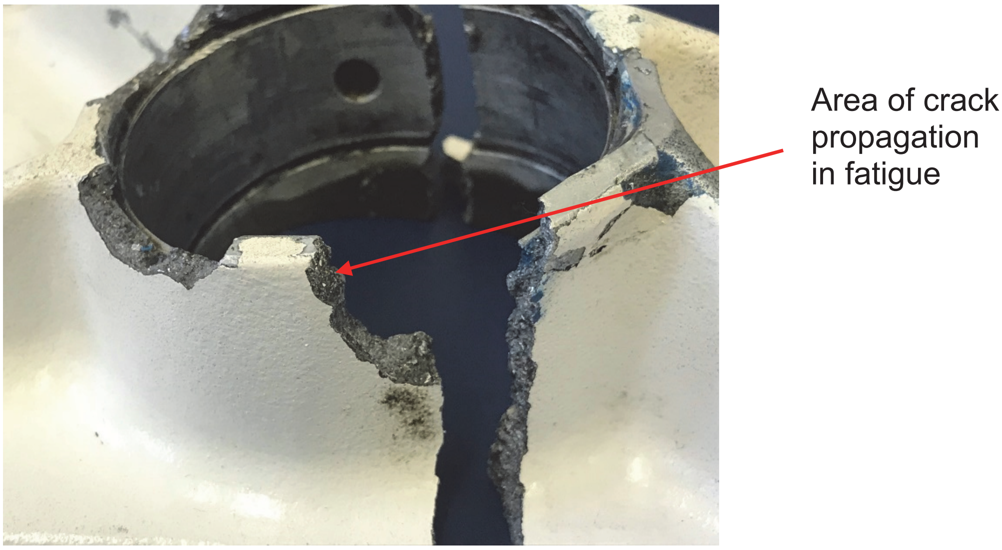


Figure 3

Area of missing material from trunnion

The maintenance organisation confirmed that a visual inspection of the trunnions was completed during the annual inspection, carried out on 6 March 2018. No evidence of cracking or deterioration was observed during this inspection. The location of the forward trunnion means that a visual inspection of the trunnion during a pre-flight inspection is not practical.

Aircraft operation

Redhill Aerodrome has three grass-surfaced runways and several paved taxiways and aircraft stands. It is normal practice for aircraft to be cleared by ATC to taxi to and from their parking areas across the grassed areas and runways. Whilst the runway surfaces are maintained, the surrounding grassed areas can be uneven, typical for a grass-surfaced airfield.

Operation from uneven ground such as unpaved or grass surfaced airfields presents an increased risk of propeller ground strikes and landing gear damage. The flying club which operated G-EDVL had published instructions requiring pilots to taxi at a '*walking pace*' over such ground to minimise this possibility.

Examination of the aircraft's log book showed that on many occasions the aircraft operated from other grass-surfaced airfields in addition to Redhill. The maintenance organisation was not aware of any damage to the aircraft caused as a result of operating from grass airfields and there had been no reports of hard landings or operation from runways with unusually uneven surfaces.

Analysis

The accident was caused by the failure of the right main landing gear forward trunnion while the aircraft was taxiing. The failure allowed the landing gear leg to pivot forwards piercing the right-wing skin and causing the right wing to drop.

The fracture faces of the failed trunnion showed evidence of failure in overload together with one area which showed the characteristics of crack progression in fatigue. The initiation of the fatigue crack could not be identified due to mechanical damage of the fracture surface.

It is likely that the crack then progressed through the parent material with the normal loads experienced during the aircraft's operation. When the crack had reached a sufficient length to compromise the overall strength of the trunnion, the remaining material failed in overload.

No evidence of cracking within the trunnion had been observed during the aircraft's annual inspection and the location of the trunnion means that it is not possible to carry out a visual inspection of it during a pre-flight check.

The PA-28R landing gear was designed to allow the type to operate from unpaved airfields. It is therefore probable that the initiation of the fatigue crack within the trunnion was the result of an unreported abnormal event, such as a heavy landing or rapid taxiing across uneven ground.

ACCIDENT

Aircraft Type and Registration:	Piper PA-34-200T Seneca II, G-FILE
No & Type of Engines:	2 Continental Motors Corp TSIO-360-EB piston engines
Year of Manufacture:	1980 (Serial no: 34-8070108)
Date & Time (UTC):	11 July 2018 at 1003 hrs
Location:	Cotswold (Kemble) Airport, Gloucestershire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 2
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to left propeller, underside of left wing and aileron, rear fuselage
Commander's Licence:	Private Pilot's Licence
Commander's Age:	64 years
Commander's Flying Experience:	922 hours (of which 127 were on type) Last 90 days - 11 hours Last 28 days - 8 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The pilot was making a normal approach to Runway 08 at Cotswold Airport with the intention to perform a 'touch-and-go'. As the aircraft touched down he felt the wing drop as the left main landing gear collapsed. The pilot maintained the aircraft on the runway until the left wing and propeller contacted the runway, the aircraft veered to the left and came to a halt. It was found that both main landing gear downlocks were not engaged. It has not been possible to determine the cause of the main landing gears unlocking.

History of the flight

The pilot and two passengers departed Bristol Airport at 0930 hrs for a flight to Cotswold (Kemble) Airport and were planning to return later that day. The pilot configured the aircraft for landing with the intention to perform a 'touch-and-go' on Runway 08. The wind was 6 kt from 060°. The pilot confirmed that he had three GREEN landing gear indications and touched down successfully at approximately 90 kt IAS at 1002 hrs. Before reapplying power for the takeoff, the pilot raised the flaps and as he did so, noticed the left wing drop. He corrected this by using the ailerons and aborted the takeoff. The pilot maintained the aircraft on the runway until the left wing and propeller contacted the runway and the aircraft veered to the left. It came to rest on the grass between the tarmac and grass runways with the left main landing gear collapsed. The pilot and passengers exited unaided and without injury.

Accident site

Examination of the runway showed impact marks from the left propeller after the aircraft had passed the intersection with Taxiway Bravo (Figure 1). There were 15 strike marks and the spacing was consistent with an aircraft speed of 70-80 kt. Further along the runway there were more strike marks along with scraping from the left wing and aileron and the aft fuselage. The aircraft halted facing north-west on the grass between the tarmac and grass runways.

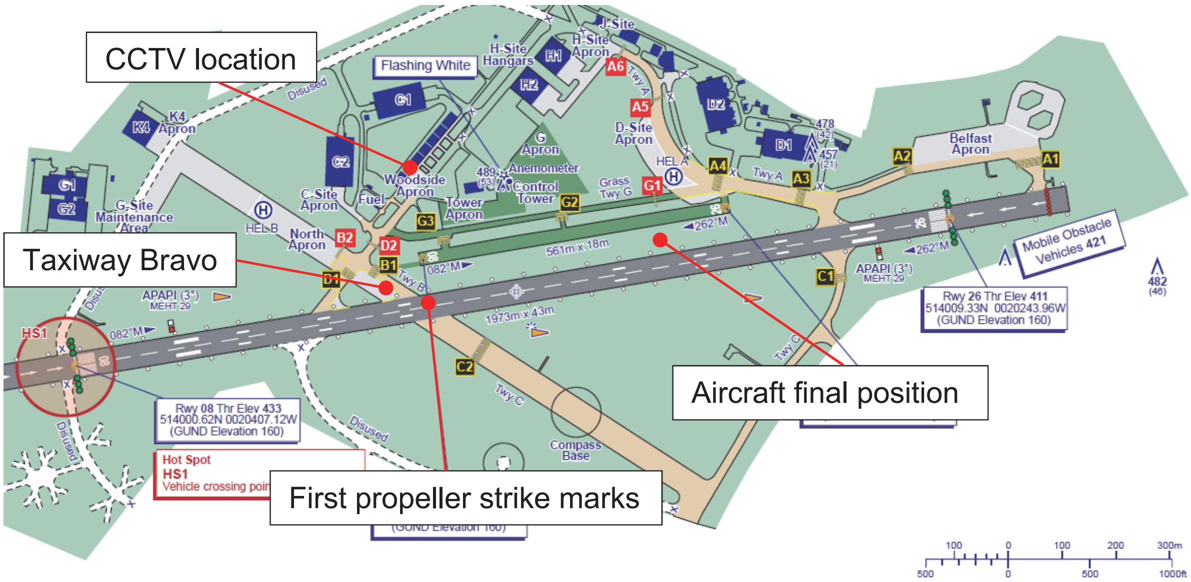


Figure 1

Cotswold Airport

Aircraft Information

The landing gear on the Piper PA-34 Seneca II is a fully retractable, hydraulic tricycle configuration. It is raised and lowered by an electrically-driven, reversible hydraulic pump and each leg is held in the down position by a spring-loaded downlock hook. Once the downlocks engage the pump switches off and three GREEN indications are illuminated in the cockpit. In the event of a loss of hydraulic power there is a system which releases the hydraulic pressure and allows the landing gears to extend under gravity.

Aircraft recovery

As the aircraft was lifted by a recovery vehicle, the right main landing gear collapsed, however the nose landing gear remained down. The aircraft was examined at the accident site and it was found that neither downlock on the main landing gears was engaged. The recovery team attempted to lock the landing gear down but were prevented by hydraulic pressure in the system, stopping the downlocks from engaging. The cockpit emergency landing gear release lever was operated, which released the pressure, and the downlocks engaged. The aircraft was then towed to a storage facility at the airfield.

Aircraft examination

Both main landing gears and associated linkages were examined, with no defects found that could have caused the landing gears to unlock. The operation of the microswitches and the GREEN indicators in the cockpit were checked and no defects were found. The tips of the left propeller blade were eroded from contact with the runway, along with the left aileron and its hinges and a section of the aft fuselage (Figure 2).

Figure 2
Aircraft damage

Recorded information

A closed-circuit camera mounted on a hanger at the Woodside Apron captured the landing from Taxiway Delta until the aircraft veered off the runway (Figure 3). The footage is consistent with the left wing dropping with propeller contact, correcting and then contact further along the runway.

Figure 3
Landing Sequence

Analysis

The pilot stated that on the approach he saw the three GREEN 'landing gear down' indicators. It is possible that during of the landing sequence, there was a short application of hydraulic pressure to the landing gear retraction system which was sufficient only to start the retraction sequence. This could have unlocked the main landing gears but stopped before the gears started to raise. This pressure would then have been released during the recovery of the aircraft when the emergency landing gear release was operated. The cause of such pressure in the retraction system could not be determined.

Two similar incidents of PA-34 main landing gear collapse have been reported in AAIB Bulletins.

G-FILE	14 Oct 1988	Bulletin 3/1989	Right main landing gear collapse
G-BEHU	20 Sept 2002	Bulletin 4/2003	Left main landing gear collapse

In both incidents, despite extensive examination and testing, no cause could be found for the unlocking of the landing gear.

Conclusion

At an unknown point after the pilot had confirmed three GREENS, the main landing gear became unlocked, which led to the left landing gear collapsing during landing. While the aircraft was being recovered, it was found that there was pressure in the hydraulic system preventing the leading gear downlocks from engaging. This pressure was released by the emergency landing gear extension system and the locks engaged. Subsequent examination found no defects with the landing gear and the cause of the pressure which unlocked the landing gear could not be determined. Despite a similar incident to the same aircraft in 1988 no further action is to be taken as the aircraft is beyond economic repair.

ACCIDENT

Aircraft Type and Registration:	Robinson R22 Beta, G-MACA	
No & Type of Engines:	1 Lycoming O-360-J2A piston engine	
Year of Manufacture:	2005 (Serial no: 3836)	
Date & Time (UTC):	13 September 2018 at 13:40 hrs	
Location:	Gregston House, Haighton, Lancashire	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - 1
Injuries:	Crew - Minor	Passengers - Minor
Nature of Damage:	Main rotors and fuselage severely damaged	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	56 years	
Commander's Flying Experience:	135 hours (of which 135 were on type) Last 90 days - 2 hours Last 28 days - 1 hour	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

Synopsis

While in a hover at about 9 ft, the pilot reports that the helicopter was struck by a gust of wind and he was unable to correct the resulting roll before the left landing skid struck the ground.

History of the flight

The pilot had flown the helicopter to a friend's house with the intention of landing in its grounds, which he had done on several previous occasions. The helicopter was brought to a low hover in a field adjacent to the house, the pilot then hover taxied it over a low fence into the grounds and landed.

The pilot had then intended to shut down the helicopter but the owner of the property, who had come onto the patio of the house, gave the pilot a 'thumbs up' signal followed by a signal to take off. The pilot applied collective and the helicopter rose into a ground effect hover where he confirmed that the engine was performing normally. The helicopter then rose to a height of about 9 ft and the pilot initiated a pedal turn to the left in preparation for departure. The pilot reports that as the helicopter turned it was struck by a large gust of wind from the right, which caused the helicopter to roll rapidly to the left. The pilot was unable to correct the roll, despite his control inputs, before the left landing skid struck the ground, followed by the main rotor blades. The helicopter came to rest on its side. Both occupants suffered minor injuries and were assisted from the helicopter by the owner of the house.

ACCIDENT

Aircraft Type and Registration:	Siai Marchetti S.205 20/R, G-BFAP
No & Type of Engines:	1 Lycoming IO-360-A1A piston engine
Year of Manufacture:	1969 (Serial no: 4-213)
Date & Time (UTC):	6 August 2018 at 1450 hrs
Location:	Leicester Airport
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Propeller damaged, engine shock-loaded and lower fusleage skin damaged
Commander's Licence:	Other
Commander's Age:	86 years
Commander's Flying Experience:	1,627 hours (of which 813 were on type) Last 90 days - 4 hours Last 28 days - 2 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The pilot reported that, in preparation for landing at Leicester, the pre-landing checklist was completed on the downwind leg of the circuit; this includes extending the landing gear. Prior to touchdown, the pilot reduced the engine power to idle and rotated the aircraft into the flare to land. The aircraft settled onto the runway with the landing gear retracted and skidded along the paved surface before coming to a halt. The pilot commented that the landing gear warning horn, which should be triggered if the landing gear is UP and landing flap is selected with the engine at idle power, did not operate at any point during the flare. The reason for the horn failing to operate was not identified.

ACCIDENT

Aircraft Type and Registration:	Skystar Kitfox Mk 7, G-FBCY
No & Type of Engines:	1 Rotax 912ULS piston engine
Year of Manufacture:	2015 (Serial no: PFA 172D-14696)
Date & Time (UTC):	5 August 2018 at 1730 hrs
Location:	Field near Rugby, Warwickshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - 1 (Minor) Passengers - 1 (Minor)
Nature of Damage:	Propeller, engine, nosewheel strut and right wing
Commander's Licence:	Private Pilot's Licence
Commander's Age:	64 years
Commander's Flying Experience:	246 hours (of which 49 were on type) Last 90 days - 4 hours Last 28 days - 1 hour
Information Source:	Aircraft Accident Report Form submitted by the pilot and subsequent AAIB enquiries

Synopsis

While returning to its home airstrip, the aircraft experienced a loss of engine thrust coincident with an uncommanded increase in engine speed. The pilot made a forced landing in a ploughed field during which the nosewheel collapsed, resulting in substantial damage to the aircraft. Subsequent examination of the propeller hub revealed that the threads on the lead screw within the propeller pitch-change mechanism had been stripped. This had caused the propeller blades to move to a very fine pitch setting, leading to the loss of thrust.

History of the flight

The aircraft was operating a flight from Old Warden Aerodrome to Peter Hall Lane farm strip near Coventry. Shortly after reducing engine power to descend in preparation for landing, the pilot heard a loud "pop" and a red warning light illuminated on the engine monitor. Coincident with this, the engine speed increased from 5,200 to 7,000 rpm. The engine appeared to be running well, however it was apparent that no thrust was being produced. The pilot spent some time trying to diagnose and troubleshoot the problem. He considered that either the drive to the propeller, or the automatic propeller pitch control had failed, and he attempted to manually select the propeller pitch to the fully coarse setting, but this had no effect.

The aircraft was overhead a built-up area at this time, so the pilot turned towards open ground and selected a field in which to make a forced landing. The field had been ploughed and had a slight uphill gradient. After touching down, the nosewheel collapsed and the propeller struck the ground (Figure 1). The pilot and his passenger suffered only minor injuries and were able to exit the aircraft unaided.

Figure 1
G-FBCY after landing

Aircraft information

The Skystar Kitfox Mk7 is a kit-built aircraft and the build project for G-FBCY commenced in 2007 and was completed in 2015. G-FBCY was equipped with a Rotax 912 ULS engine and a three-bladed Arplast PV50 electrically-controlled 'in-flight adjustable' propeller, which was purchased new in 2008. A Smart Avionics CSC-1/P constant speed controller (CSC) was also fitted so that the propeller could be operated as a constant speed/variable pitch propeller. The CSC can be operated in manual mode, where the pilot selects the propeller pitch or in automatic mode, where the propeller pitch-change mechanism continually makes small adjustments to maintain a constant propeller speed, appropriate to the phase of flight. The owner of G-FBCY, who was also the accident pilot, reported that he routinely used the CSC in automatic mode.

G-FBCY received its initial Permit to Fly in August 2015, and since then had accrued 65 flying hours. In June 2017, at 45 flight hours, the owner had re-lubricated the propeller hub which he reported included removing, inspecting and lubricating the lead screw from the propeller pitch-change mechanism. This task was signed off by his LAA Inspector, but the Inspector did not specifically inspect the lead screw. The last permit renewal took place on 25 May 2018.

In July 2018, the propeller was removed to facilitate removal of the engine gearbox for overhaul. It was subsequently refitted by the pilot and inspected by his LAA Inspector on 4 August 2018. The accident flight was the first flight following reinstallation of the gearbox.

Aircraft examination

Following the accident, LAA Engineering participated in an inspection of the aircraft and strip examination of the propeller hub. Initial examination of the propeller pitch-change mechanism indicated that the propeller blades had been in the full coarse setting at impact. The gearbox and clutch were examined and tested at the original overhaul facility and both were found to operate as expected. This indicated that there were no issues with the engine drive to the propeller.

Further examination and disassembly of the propeller pitch-change mechanism identified that the screw thread was stripped on the lead screw within the motor, such that the blade pitch was free to move at will (Figure 2). It was considered that this had allowed the propeller blades to migrate beyond the electrical fine pitch limit microswitch, into a super-fine pitch regime, leading to a loss of thrust. Following a period running at excessive speed, the engine would have begun to fail. As the engine stopped developing power and the rpm dropped, it is likely that aerodynamic loading on the propeller blades caused them to move back towards a coarse pitch setting.

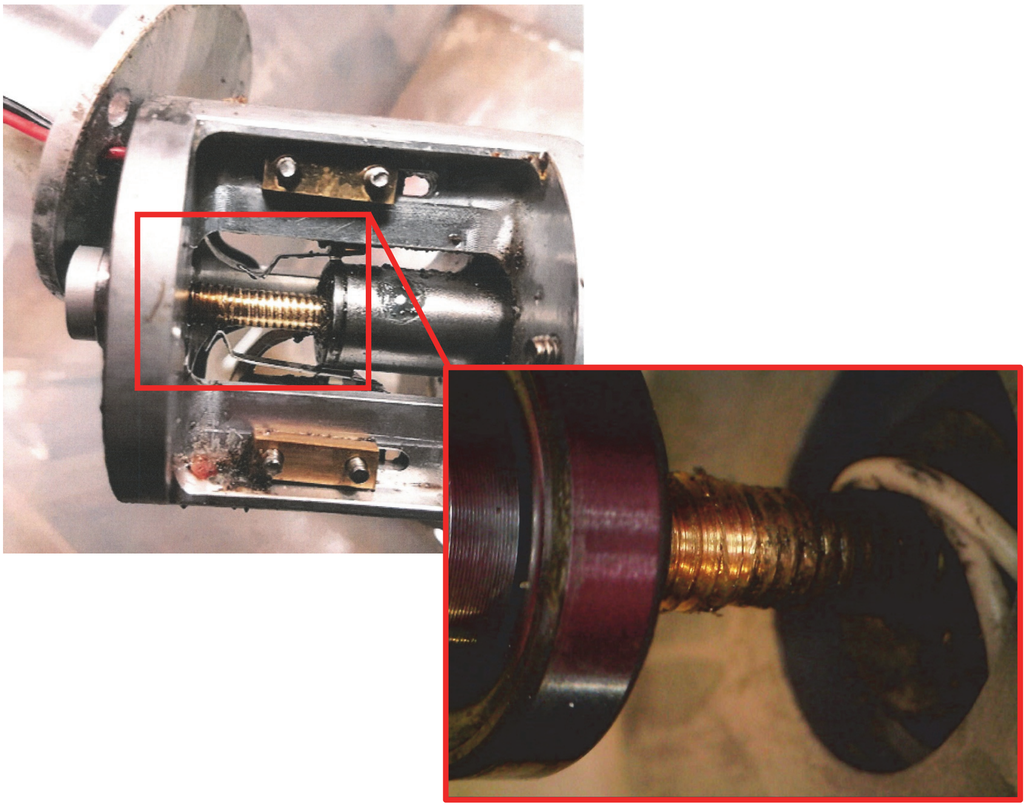


Figure 2

Motor from G-FBCY's propeller pitch-change mechanism showing the stripped thread on the lead screw *(Photographs courtesy of pilot / LAA)*

Previous incidents

In 2008, the LAA published a '*Safety Spot*' article in their monthly magazine regarding a similar accident which occurred on a Europa aircraft equipped with an Arplast PV50 propeller. In that case, the propeller pitch-change mechanism also failed in such a way that it allowed the propeller to set itself to a very fine pitch setting, resulting in the propeller producing insufficient thrust to sustain flight and necessitating a forced landing. It transpired that the lead screw within the propeller pitch-change mechanism had failed as a result of lack of lubrication and the fine pitch stops, which should have prevented the blades going into this super-fine regime, had been incorrectly set.

The propeller manufacturer's service instructions required the lead screw to be removed, cleaned, inspected and lubricated every 50 hours, but these service instructions had not been correctly followed, leading to a lack of adequate lubrication. As a result of that incident, on 6 February 2008 the LAA published Airworthiness Information Leaflet (AIL) MOD/PROP/08-007 titled *'Arplast – variable pitch propeller essential in-service inspection',* requiring inspection and lubrication of the propeller lead screw on the Arplast PV50 propeller. The inspection was to be accomplished at installation, after the first 25 hours and then each subsequent 50 hours. In addition, the AIL required checking and, where necessary, adjustment of the mechanical fine pitch stops on the propeller in accordance with instructions produced by the then UK sales agent for the propeller.

The LAA reported that the AIL was sent to owners of all aircraft fitted with the Arplast PV50 propeller at that time but was not subsequently posted on the LAA website, or otherwise made available to owners of similarly equipped aircraft coming on to the LAA system after that date.

In the intervening period between 2008 and the accident to G-FBCY, the LAA reported that it was not aware of any other incidents or failures involving this propeller type.

The LAA advised that it currently relies on its paper-based Inspector's manual, known as 'SPARS' to promulgate safety information about propellers to all its Inspectors. Inspectors are required to keep the manual updated and to sign-off each aircraft as compliant with the requirements of SPARS at each permit renewal. The importance of having correctly adjusted pitch stops is discussed in the '*propeller*' section of SPARS, and in particular for the Arplast PV50 it states:

> *'Propeller pitch stops must be checked to ensure that the pitch range available does not exceed that which allows safe flight.'*

Discussion

Although G-FBCY's build had been ongoing since 2007, it was not completed until 2015 and the aircraft had only amassed 65 flying hours at the time of the accident. As G-FBCY was undergoing build when the LAA issued the AIL in 2008 detailing the inspection and adjustment of the mechanical pitch stops on the Arplast PV50 propeller, the AIL was not sent to G-FBCY's owner. As the AIL was not made available on the LAA website thereafter, despite searching for any relevant information, the owner was not aware of the AIL or the requirement to adjust the mechanical fine pitch stops. Nonetheless, information relating to the pitch stops on the Arplast PV50 had been promulgated in the LAA SPARS document.

Following the loss of thrust, presented with the unusual and confusing situation in which the engine seemed to be operating normally, albeit overspeeding, the pilot considered that he may have spent too much time trying to diagnose and manage the situation before making the decision to execute a forced landing. He subsequently estimated that the engine may have been running for more than one minute in excess of 7,000 rpm. The aircraft lost height and speed during this time and as a result the forced landing was more hurried than he would have liked, which may have contributed to the nosewheel collapse after touchdown.

Conclusion

This accident highlights the importance of promptly selecting a suitable landing site and establishing a glide approach following a loss of engine power or thrust, and only thereafter attempting to diagnose or fix the problem if time and height are available.

Safety actions

Prior to this accident, the LAA had embarked on a long-term project to transfer aircraft, engine and propeller information from SPARS to a web-based Type Acceptance Data Sheets (TADS) system, in order to make this information, including AILs, easily available to its members. This activity is ongoing and the transfer of aircraft-specific data is almost complete, and it is planned that the transfer of engine and propeller information will follow. It is envisaged that the propeller TADS will include any relevant limitations or modifications for each propeller type and the LAA considers that this will provide a useful reference for aircraft owners when deciding what propellers to fit to their aircraft.

The LAA also intends to reissue the AIL originally issued in 2008 for the Arplast PV50 propeller and is currently identifying all LAA aircraft to which this propeller is fitted. Owners of projects still under construction who may have this propeller but who have not yet identified the propeller type to the LAA, will be identified when an application for an initial permit to fly or modification is made.

The LAA published a '*Safety Spot*' article in the November 2018 issue its '*Light Aircraft*' magazine, to alert owners to the issues arising from this accident.

ACCIDENT

Aircraft Type and Registration:	Slingsby T61F Venture T Mk 2, G-BUGT
No & Type of Engines:	1 Rollason RS MK 2 piston engine
Year of Manufacture:	1977 (Serial no: 1871)
Date & Time (UTC):	9 December 2018 at 1335 hrs
Location:	Field near Rufforth Airfield, York
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Wings twisted and broken. One propeller blade damaged, minor damage to rear fuselage
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	44 years
Commander's Flying Experience:	106 hours (of which 80 were on type) Last 90 days - 10 hours Last 28 days - 2 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and aircraft inspection report

G-BUGT's departure from Runway 35 was delayed because the runway was occupied, and the pilot applied carburettor heat while waiting. When the runway was clear, the pilot lined up and applied full throttle without stopping. At approximately 150 to 200 ft, the pilot felt a complete loss of power and executed a forced landing. The aircraft touched down close to the field boundary (Figure 1). The pilot "attempted a hop" through a gap but the wings struck bushes (Figure 2). After stopping, the pilot noticed that the carburettor heat was still selected ON.

Inspection of the aircraft engine and associated systems revealed no faults which would explain the power loss. Tests of carburettor heat effectiveness on two other Slingsby Ventures indicated that full carburettor heat resulted in a drop of up to 600 rpm, and extended use in flight resulted in rough running and climb was not possible. The tests did not replicate a total loss of power. Full power was always restored when the carburettor heat was returned to cold.

The pilot commented that he should have repeated the pre-takeoff checks immediately before takeoff, which would have revealed that the carburettor heat was on. Checking the rpm achieved during the takeoff roll may help to identify an engine that is not performing as required.

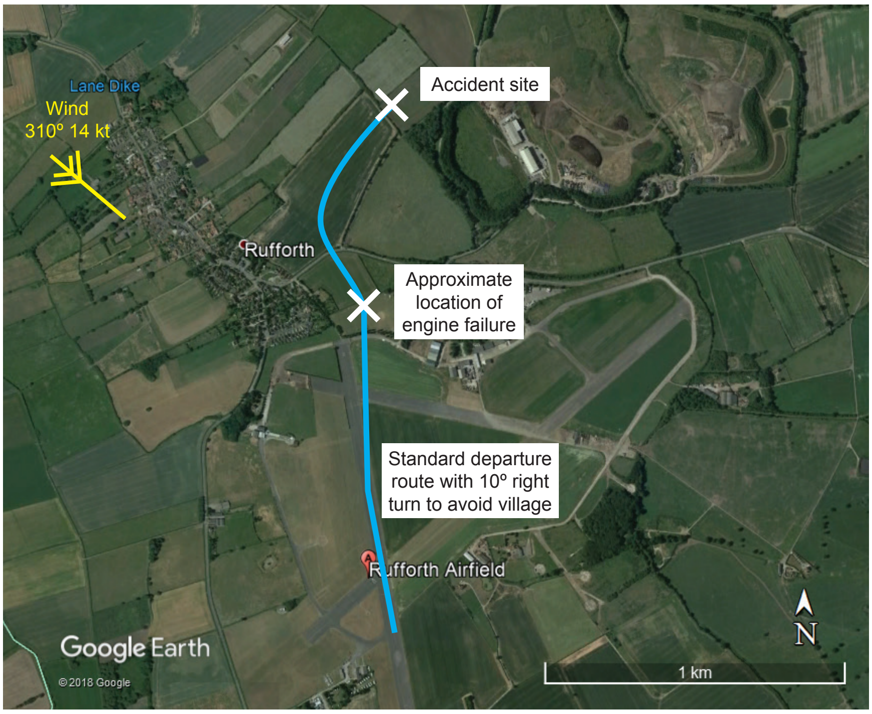


Figure 1
Location of the accident site

Figure 2
G-BUGT after the accident

Bulletin Correction

Rufforth Airfield was inadvertently referred to as RAF Rufforth when the March Bulletin was sent for printing. The online verision of the report was amended prior to publication.

ACCIDENT

Aircraft Type and Registration:	Vans RV-12, G-CMKL	
No & Type of Engines:	1 Rotax 912 ULS piston engine	
Year of Manufacture:	2015 (Serial no: LAA 363-15252)	
Date & Time (UTC):	28 October 2018 at 1600 hrs	
Location:	Midlem Airfield, near Selkirk	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - None
Injuries:	Crew - None	Passengers - N/A
Nature of Damage:	Propeller strike and bent nose landing gear leg	
Commander's Licence:	Light Aircraft Pilot's Licence	
Commander's Age:	66 years	
Commander's Flying Experience:	734 hours (of which 2 were on type) Last 90 days - 20 hours Last 28 days - 15 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

The aircraft was landing on Runway 06 at Midlem Airfield in good weather conditions after its maiden flight. During the landing roll, the aircraft drifted to the left due to the downslope across the runway. It departed the runway and came to rest in a shallow ditch. The propeller struck the ground, shock loading the engine and the nose landing gear leg was bent. The pilot was uninjured and able to vacate the aircraft unaided through the normal exit.

The pilot candidly made the following assessment to highlight what he considers are the safety lessons which could help prevent a similar accident:

"1/ I should have made myself aware of the dangers of running off the main runway, i.e. ditches;

2/ Despite extensive taxi trials, I underestimated the effect of the sloping runway on landing;

3/ On reflection I should have been more aggressive on the brakes at touchdown;

4/ Knowing I was a touch fast, should have gone around."

ACCIDENT

Aircraft Type and Registration:	Denney Kitfox Mk 2, G-BSDD
No & Type of Engines:	1 Rotax 582 piston engine
Year of Manufacture:	1995 (Serial no: PFA 172-11797)
Date & Time (UTC):	30 October 2018 at 1458 hrs
Location:	Field behind John Ruskin School, Coniston, Cumbria
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Left wing tip distortion, left landing gear collapse and propeller strike
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	62 years
Commander's Flying Experience:	148 hours (of which 57 were on type) Last 90 days - 10 hours Last 28 days - 3 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The pilot was attempting a precautionary landing due to his concern about a fuel leakage. In the latter stages of his descent, near to the ground, the left wing stalled, and the aircraft struck the ground damaging the wing tip, propeller and landing gear. The pilot considers the cause of the accident to have been his failure to monitor airspeed during the final stages of the approach.

History of the flight

The aircraft was being flown on a local flight in the Lake District when the pilot became aware of a "drip" near the fuel priming pump. It was significant enough for him to initiate a precautionary landing to investigate. He selected a suitable field near Lake Coniston and began his descent. On base leg he committed to landing the aircraft and configured it accordingly. As he turned the aircraft onto final approach, he noted his airspeed was at first 48 mph and rising, to slow the aircraft he fully extended the flaps. He noticed two trees either side of his flight path and considered it an unnecessary risk to attempt to fly between them, so applied a small amount of power to overfly them. He then closed the throttle and continued his descent to land. Between 15 to 20 ft above the ground the left wing dropped, the aircraft entered a left descending turn and the wing tip struck the ground. The aircraft continued to turn, at which point the propeller hit the ground and the left landing gear strut collapsed. The pilot made the aircraft safe and vacated uninjured.

Discussion and pilot's comments

The pilot decided to carry out the precautionary landing due to his concern that the fuel leakage would worsen and result in an engine stoppage. He estimated the leakage rate was two drips per second, which he later found to be coming from shaft seals of the hand priming pump.

From the description of the event by the pilot, it would appear the left wing stalled near the ground as the aircraft landed. The pilot considers that several factors led to the stall. The prime cause was that he did not monitor his airspeed in the latter stages of his approach. He used the flaps as "airbrakes" rather than lift augmentation devices.

He usually applied a small "burst of power" to control a three-point landing, normally with one stage of flap into wind, and had never encountered a wing stall when landing. In his opinion, this gave him the false sense that this aircraft never drops a wing when configured correctly, but he now acknowledges this was an incorrect assumption at low speed and full flap.

The primer pump leakage was considered by the pilot to have been due to premature wear of its shaft seals. The limited capabilities of the lightweight battery fitted in this aircraft meant the pilot had to operate the primer pump whilst cranking as an aid to starting the engine from cold. In the pilot's opinion, it was this technique that led to the premature wear of the seals.

ACCIDENT

Aircraft Type and Registration:	Ikarus C42 FB80 Bravo, G-SAMC
No & Type of Engines:	1 Rotax 912-UL piston engine
Year of Manufacture:	2012 (Serial no: 1207-7213)
Date & Time (UTC):	25 August 2018 at 1140 hrs
Location:	Compton Abbas Airfield, Dorset
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to nose leg, propeller, main landing gear and left wing
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	53 years
Commander's Flying Experience:	68 hours (of which 68 were on type) Last 90 days - 14 hours Last 28 days - 6 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft bounced twice following the initial touchdown at Compton Abbas Airfield. The right wing then started to lift, which the pilot controlled with rudder and at the same time applied full power to go around. However, the aircraft continued to descend and landed heavily, sustaining damage. The pilot and passenger were uninjured.

Description of Compton Abbas Airfield

Compton Abbas Airfield is situated on high ground with trees to the south of the main runway and sloping ground to the north (Figure 1). It has one grass runway, 08/26, with a Landing Distance Available of 803 m and an unlicensed extension of 100 m at each end. A wind sock is located at each end of the runway and aircraft are parked parallel to the south side of the runway.

The airfield operates General Aviation (GA) and microlight circuits (Figure 1). The airfield plate advises microlight and GA traffic to join dead-side and to cross the upwind runway numbers at 800 ft QFE. Microlight aircraft using the microlight circuit are required to descend to 600 ft on the crosswind and to give way to aircraft using the GA circuit, particularly on the base and final legs.

The airfield operates an Air/Ground VHF communication service, 'Compton Radio'.

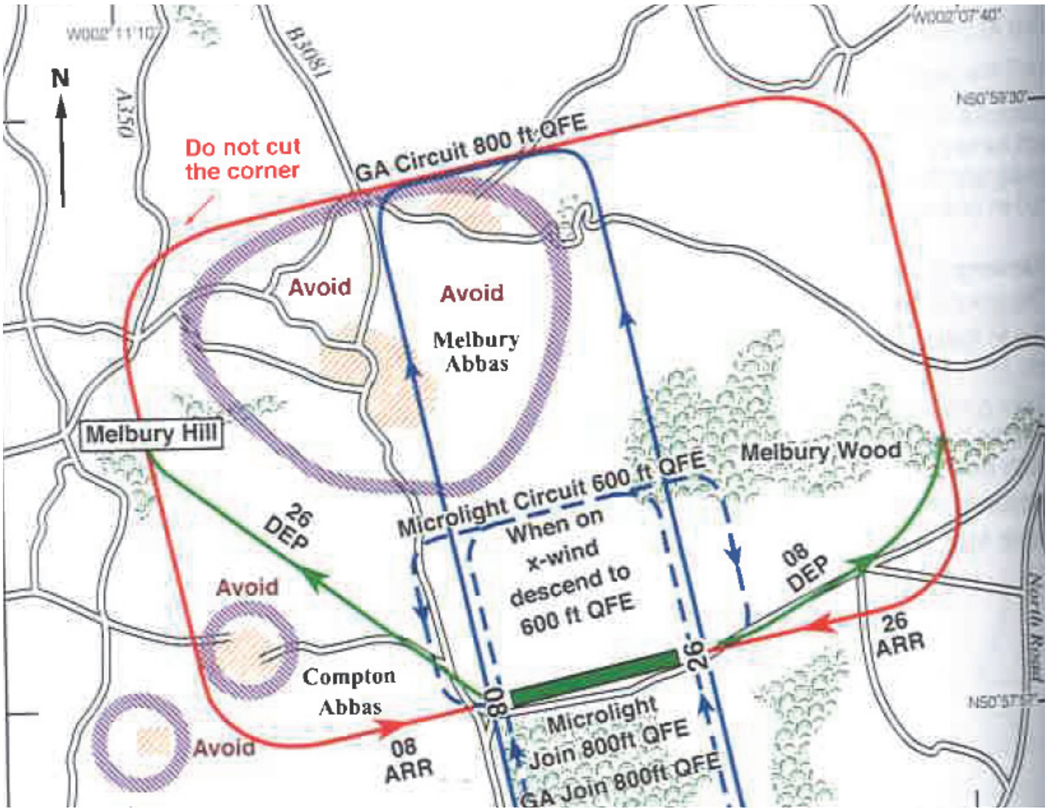


Figure 1

GA and microlight circuit patterns at Compton Abbas Airfield

History of the flight

The pilot had recently obtained her NPPL (A) licence and had 19 hours as PIC on the Ikarus C42. She had previously flown into Compton Abbas as a passenger on a GA aircraft, which is why she chose this destination, but this was her first landing as the handling pilot at this airfield. This was also the passenger's first flight in a light aircraft; the pilot reported that the passenger was of great assistance in helping her look for other aircraft flying in the circuit at Compton Abbas.

The pilot departed Membury Airfield for a flight around the south of England and changed radio frequency to Compton Radio when approximately 10 nm from the airfield. From the communication on the radio the pilot was aware that there was a high level of activity and joined the microlight circuit from the south to land on Runway 26, aware that there was one other microlight ahead and several aircraft in the GA circuit. As the pilot turned onto base leg the radio operator informed her of conflicting traffic joining from the south. The pilot was unsuccessful in sighting the traffic and realised when approaching the turn onto the final approach that she was too high and therefore flew onto the dead-side before repositioning onto the microlight circuit.

During the second circuit the pilot observed an aircraft landing on Runway 26 and extended her downwind leg because she did not want to go around again. There were also several aircraft transmitting their positions from both circuits and it was difficult keeping track as to where each aircraft was. Nevertheless, she continued the circuit and was on the final approach at approximately 300 ft before the aircraft ahead cleared the runway. The radio operator had given the wind as "north-west 10 kt", which was a little stronger than the pilot expected from information passed to other aircraft. The pilot later stated that she did not correctly make the mental connection between the wind direction of north-west and the compass direction of 315°, with the result that she underestimated the strength of the crosswind. The pilot configured the aircraft with two stages of flaps and prepared to land in what she believed was a light crosswind. The pilot reported that she felt the workload was very high.

The pilot reported that, in her recollection, the aircraft then touched down shortly after the runway threshold but unexpectedly lifted off again. The plane then touched down and bounced a second time. At this point the pilot became concerned and no longer focused on the crosswind but instead applied a small amount of power to control the third touchdown. The right wing then started to lift, which the pilot attempted to correct with full right rudder while at the same time applying full power to commence a go-around. However, by this stage the airspeed was very low and the aircraft descended heavily onto the runway, breaking the nose landing gear leg. The aircraft slewed to the left side of the runway, stopping short of the parked aircraft.

Pilot's home airfield

The pilot had learned to fly at an unlicensed airfield that did not have a notified ground frequency. Instead pilots at this airfield would broadcast on SAFETYCOM (135.475 MHz) at key points in the circuit to inform other pilots of their position. The wind conditions would also be estimated by the pilot from the two windsocks located on the airfield.

Radio communication

Compton Abbas operates an Air/Ground communication service (Compton Radio) provided by a radio operator who would hold a CAA Certificate of Competence to operate radio equipment on aviation frequencies. CAP 452 (Aeronautical Radio Station Operators Guide). provides a glossary of terms to be used during radio communications and states that *'the wind direction for landing and take-off'* should be given in '*degrees magnetic'.* However, there is an exception regarding the format of wind reports for airfields such as Compton Abbas which do not have wind direction dials and rely on the use of windsocks.

Analysis - Human factors

An experienced individual has greater capacity to deal effectively with an accumulation of tasks before their performance starts to become affected. The pilot on this accident flight would have been used to interpreting the wind conditions at her home airfield from the wind sock and by the heading of the aircraft during the final approach. The fact that on this occasion she had difficulty in forming a mental picture when the wind direction was passed as "north-west" is an indicator that her workload was sufficiently high to affect her performance.

There were a number of factors during this flight which on their own would not have presented a problem, but the cumulative effect may have placed the pilot under some pressure with the consequence that she made the decision to go around from the second approach too late.

Task-related factors included:

- The airfield operated two circuit patterns.
- The circuit was busy.
- The wind information was passed to the pilot in a form that required her to make a mental computation that she was unused to doing.
- The aircraft was part-way down the final approach before the aircraft ahead cleared the runway.

Factors that reduced the pilot's ability to cope with the situation included:

- The pilot was relatively inexperienced.
- The pilot made a mental decision after the first go-around to land from the second approach.

The resulting effect on the pilot's performance was:

- The pilot had difficulty identifying the position of some of the traffic in the circuit from the radio communication.
- The pilot miscalculated the crosswind.
- The aircraft bounced several times during the second landing.
- The pilot made a late decision to go around.

AAIB comment

This accident shows how an accumulation of small tasks and events can reach the stage where a pilot's performance is affected. While each individual has a different threshold, low experience or a lack of recent currency (not relevant in this accident) are factors that can affect the number of tasks an individual can handle before their performance is affected. In this case the pilot might have given herself more time to complete the numerous tasks and establish a stable approach by flying the GA circuit.

Given their low inertia, microlights can slow down quickly when power is reduced during the flare. It is therefore important to be prepared to make an early decision to apply full power and go around following a bounced landing.

ACCIDENT

Aircraft Type and Registration:	Jabiru UL-D, G-EUAN	
No & Type of Engines:	1 Jabiru 2200B piston engine	
Year of Manufacture:	2007 (Serial no: 666)	
Date & Time (UTC):	30 September 2018 at 1541 hrs	
Location:	Rochester Airport, Kent	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - 1
Injuries:	Crew - None	Passengers - None
Nature of Damage:	Damage to propeller and nose gear collapsed	
Commander's Licence:	National Private Pilot's Licence (Microlight)	
Commander's Age:	42 years	
Commander's Flying Experience:	105 hours (of which 7 were on type) Last 90 days - 14 hours Last 28 days - 5 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

Synopsis

After carrying out a go-around after being too high on final approach the pilot flew a second circuit. The second approach felt normal but after landing the nosewheel bounced up and down and then the nose gear collapsed. The pilot considered he might have rushed the landing because his passenger was feeling airsick. An unapproved solid nosewheel tyre had been fitted which may have contributed to the nose gear collapse.

History of the flight

The pilot had obtained his National Private Pilot's Licence (Microlight) on the X-Air microlight. He also had experience on the Eurostar, Ikarus C42 and Flight Design CTSW. He had undertaken 2 hours transition training with an instructor on the Jabiru and had logged 6 hours 40 minutes on type at the time of the accident.

After an uneventful cross-country flight from Clacton to Rochester the aircraft entered the circuit for a landing on Runway 34 grass. The wind was from 330° at 5 to 10 kt. The passenger was feeling airsick, so the pilot was keen to land. Once on final approach he realised that he was too high, which he later attributed to trying to rush the approach. He initiated a go-around and flew another circuit. The second approach felt normal and he made what he thought was a normal landing. However, he then felt a jolt which he stated was similar to "driving over a speed bump". The nosewheel came up and then touched down again. Before he could react, it bounced a few times and the nosewheel collapsed.

The propeller dug into the ground but the aircraft came to rest with the engine still running. The pilot stopped the engine and vacated the aircraft with his passenger.

The pilot could not recall his approach speed but he considered he might have been rushing the landing because of his airsick passenger.

Aircraft examination

The aircraft was examined and repaired by the UK distributor for Jabiru. They stated that an unapproved solid nosewheel tyre had been fitted. It had the appearance of a normal tyre with a pressure rating on the sidewall, but it had been filled with rubber. They stated that it weighed 1.2 kg more than a standard nosewheel tyre with an innertube, and that it had no suspension characteristic. They estimated that the tyre would normally contribute about 20% of the total suspension, but not with a solid tyre.

Aircraft owner's comments on the solid nosewheel tyre

The aircraft owner, who was not the pilot in the accident landing, stated that he had owned the aircraft for 10 to 12 years and had suffered 7 or 8 nosewheel tyre punctures during that time. It was never clear to him what had caused the punctures apart from finding pinprick holes in the inner tube. A flying instructor who owned a Jabiru in Spain told him that he had fitted a solid nosewheel tyre and had not had any problems, so he suggested to the owner that he fit one too. The owner asked the instructor if this was approved and was told that it was.

The owner fitted the solid tyre about 9 months before the accident and had logged about 20 hours without any issues.

Light Aircraft Association comments on the solid nosewheel tyre

The Light Aircraft Association (LAA) was consulted by the AAIB about the solid nosewheel tyre. They stated that such a tyre was not an approved modification to the Jabiru. They have decided to issue an LAA Airworthiness Alert directed at all Jabiru types to explain that the use of solid tyres was not acceptable on this type. They also plan to write to owners of the Jabiru UL-D to advise them that solid tyres are not acceptable and, if fitted, must be replaced before further flight.

Analysis

The nose gear collapse on landing was probably caused by a combination of a heavy nose gear touchdown and the fitment of a solid tyre. The LAA is planning to take appropriate action to address the fitment of solid tyres. The heavy nose gear touchdown was probably the result of the pilot's rushed landing due to his passenger feeling airsick.

ACCIDENT

Aircraft Type and Registration:	Quik GT450, G-DTAR
No & Type of Engines:	1 Rotax 912S piston engine
Year of Manufacture:	2008 (Serial no: 8416)
Date & Time (UTC):	15 September 2018 at 1625 hrs
Location:	Perth Airfield, Perth
Type of Flight:	Training
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to landing gear and minor distortion of underside
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	62 years
Commander's Flying Experience:	1,268 hours (of which 872 were on type) Last 90 days - 80 hours Last 28 days - 28 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The instructor was conducting training, flying circuits using Runway 27 at Perth Airport. During a downwind leg, a helicopter departed the airport from a pad south of the runway. The wind was estimated to be from 240° at less than 5 kt. The instructor discussed the wake turbulence risk but assessed that it would have dissipated before they reached the runway. When they encountered turbulence a few feet above the runway, the instructor applied full power, but the aircraft made heavy contact with the runway before continuing the go-around. In the circuit, he released the throttle which had become stuck at cruise power, before carrying out a successful glide landing.

CAA Safety Sense leaflet 15c "*Wake Vortex*" and NATS Aeronautical Information Circular P 001/2015, "*Wake turbulence*" provide pertinent information. Helicopters generate vortices radially in the hover. In forward flight, helicopters generate trailing vortices either side of the disk, much like wingtip vortices of a heavier aircraft. These descend and if they reach the ground will split and move sideways at approximately 5 kt in still air. When generated close to the ground, vortices can persist for about 80 seconds. In this case, the prevailing light winds would have been favourable for sustaining a vortex and drifting it towards the runway.

ACCIDENT

Aircraft Type and Registration:	RAF 2000 GTX-SE, G-BXDE
No & Type of Engines:	1 Subaru EJ22 piston engine
Year of Manufacture:	2000 (Serial no: PFA G/13-1280)
Date & Time (UTC):	14 September 2018 at 0955 hrs
Location:	North Weald Airfield, Essex
Type of Flight:	Private
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - 1 (Serious) 1 (Minor) Passengers - N/A
Nature of Damage:	Extensive
Commander's Licence:	Private Pilot's Licence
Commander's Age:	62 years
Commander's Flying Experience:	904 hours (of which 100 were on type) Last 90 days - 16 hours Last 28 days - 5 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and further enquires by the AAIB

Synopsis

G-BXDE was being flown for the purpose of revalidating the owner's gyroplane rating. As the gyroplane became airborne it rolled to the right and turned through 180° before descending back to the ground. It struck the ground on its right side to the right of the runway. The examiner sustained serious injuries.

The investigation concluded that the gyroplane took off with insufficient rotor speed and excessive airspeed. It is possible that the gust lock had been left engaged, restricting the movement of the control stick.

History of the flight

The gyroplane was being flown from North Weald Airfield for the purpose of revalidating the pilot's gyroplane rating. The examiner, who was also an LAA inspector, was familiar with the gyroplane having previously inspected it for the renewal of its permit to fly. The visibility was reported as good and the surface wind was 230° at 14 kt.

The pilot arrived at the airfield and prepared the gyroplane for flight. On arrival the examiner completed his own pre-flight check of the gyroplane. They briefed to fly for approximately one hour, including some general handling in the local area followed by circuits back at the airfield. They both boarded the gyroplane and the pilot adjusted the pitch and roll trims for flight with two occupants. He recalled that he released the gust lock as he boarded the gyroplane. The examiner recalled that as they were about to start he noticed that the rotor brake was still applied. He pointed this out to the pilot who tried to release it. However, the brake was very stiff and required two hands to release. The pilot recalled checking the flight controls for full and free motion whilst parked, but he did not recall repeating this check prior to commencing the takeoff roll.

Taxiing to the runway was uneventful. On reaching the holding point a light twin engined aircraft was also waiting to depart. The pilot asked the other aircraft if they would like to depart first but they declined and allowed the gyroplane to depart.

The pilot lined up on Runway 20 and spun-up the rotor whilst applying full forward stick, he then applied aft stick as he commenced the takeoff roll. The pilot recalled that he thought the initial takeoff roll was normal and that he was holding the stick fully aft, but the gyroplane did not lift off at 40 mph as he expected. He remembered seeing the airspeed pass 60 mph whilst still on the ground. He did not recall the gyroplane becoming airborne, but remembers it climbing and rolling to the right before it descended back to the ground.

The examiner recalled seeing a rotor speed of 130 rpm as the gyroplane started the takeoff roll and he noticed that the stick was not fully aft. He recalled that he was monitoring the airspeed and rotor rpm; he saw rotor speed reach 150 rpm but the airspeed was much higher than normal. He remembered seeing the airspeed reach 70 mph whilst still on the ground; the highest rotor speed he remembered seeing was 150 rpm. He recalled the gyroplane “leaping into the air”, then rolling to the right and completing a 180° turn to the right. He thought they reached approximately 50 ft before descending to the ground. He stated that the takeoff roll and accident sequence happened very quickly and that he did not have time to intervene.

The gyroplane initially struck the ground on its right side, on the grass to the right of Runway 20. It stopped on the parallel taxiway (Figure 2). The pilot was able to exit the gyroplane unaided and helped the examiner out. The examiner suffered three broken vertebrae and multiple cuts and bruises. The pilot suffered minor injuries.

The accident was witnessed by the radio operator in the control tower. He reported seeing the gyrocopter become airborne after a takeoff roll of approximately 300 m. He saw the gyroplane climb to approximately 50 ft before banking and yawing to the left. It then banked to the right with 50° - 70° angle of bank and descended, hitting the ground on the front right side. He recalled noticing that during the takeoff roll the rotor disc was not tilted back in the way he normally saw gyroplanes takeoff.

Aircraft information

The RAF 2000 is a two-seat gyroplane with an enclosed cockpit (Figure 1). It is powered by a Subaru EJ22 ‘flat four’ liquid cooled engine with a three-bladed propeller. The aircraft is kit built and flown under a LAA permit to fly.

The LAA TADS[1] for the RAF 2000 specifies that V_{NE} is 70 mph. This limitation was introduced after a previous accident which highlighted significant control difficulties above this speed; reported in AAIB bulletin 9/2007.

Figure 1
G-BXDE before the accident flight

Examiner's comments

The examiner stated the normal takeoff technique is to place the stick fully forward and engage the pre-rotator then, at 100 rpm bring the stick fully aft to allow the rotor to continue to spin-up. When the rotor speed reaches approximately 150 rpm, release the brakes and apply full power then, at 200 rpm, release the pre-rotator. Once the nose starts to lift, apply forward stick to accelerate in ground effect expecting to see the rotor at 270 – 320 rpm.

After the accident the examiner concluded that the gust lock had been left on. He thought that the pilot had reapplied the gust lock whilst trying to release the rotor brake and had forgotten to release it again. He believes this was why the rotor disc was not tilted back correctly and consequently why the rotor speed did not increase as expected. He reported that the controls have some "slack" with the gust lock engaged so the pilot may not have realised that the gust lock was engaged. He reported that the controls normally have approximately 11 inches of travel from full forward to full aft, so the stick is normally a long way back on the takeoff roll.

He reflected that as an examiner he was focusing on observing what the pilot was doing and was not ready to take control when the takeoff did not process as expected.

Footnote

1 LAA Type Acceptance Data Sheet -http://www.lightaircraftassociation.co.uk/engineering/TADs/G13%20RAF%202000.pdf (assessed 18 October 2018)

Aircraft examination

The pilot examined the gyroplane after the accident and found the gust lock was not engaged (Figure 3). However, it could not be determined if the gust lock had disengaged during the accident sequence.

Figure 2
G-BXDE after the accident

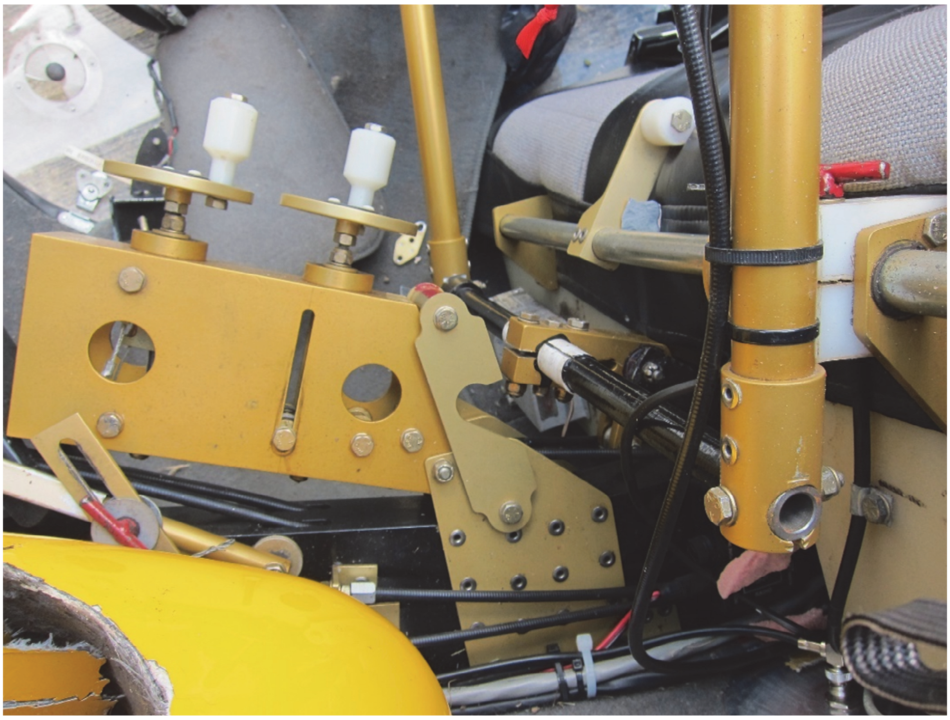


Figure 3
Photo taken after the accident showing the gust lock disengaged

Distraction

It is possible that the gust lock had been left on because the pilot was distracted by unexpectedly needing to release the rotor brake.

Distractions are anything that draws attention away from the task at hand. The FAA's Safety Document – '*Avoid the Dirty Dozen*'[2] suggests that distractions are the principal reason for forgetting things, including what has or has not been done. The document recommends mitigating the hazard by using checklists and going back several steps when restarting a task.

Analysis

The accident occurred because the rotor speed and airspeed were not appropriately managed during the takeoff roll leading to the gyroplane becoming airborne with insufficient rotor speed and excessive airspeed. After the accident the pilot reflected that he needed to pay more attention to the airspeed and rotor speed on the takeoff roll and abort the takeoff if they are not normal.

The examiner believes that the gust lock was left engaged which is why the rotor disc was not tipped fully back during the takeoff roll. After the accident the gust lock was found disengaged but it is possible that this happened during the accident sequence. The pilot recalls disengaging the gust lock when he boarded the gyroplane. However, he may have reapplied the lock whilst trying to release the rotor brake. It is possible this distraction and change of routine meant that the gust lock was left engaged. The flight controls were not checked for full and free motion prior to commencing the takeoff. If the gust lock had been left engaged, a full and free check is likely to have uncovered this omission.

When the gyroplane lined up for takeoff there was another aircraft waiting to depart. It is possible that the presence of another aircraft caused the pilot to expedite his takeoff. This subconscious pressure to depart may have contributed to the accident.

The examiner stated that he was focusing on observing the pilot during the takeoff and was not ready to take control when the takeoff did not proceed as expected. This highlights the importance of agreeing before the flight how and when an examiner may intervene to maintain a safe operation.

The CAA Handling Sense Leaflet 04 – '*Gyroplane Handling Performance*'[3] highlights the importance of thinking, before every takeoff, when and how to abort the takeoff.

Conclusion

The accident occurred because the rotor speed and airspeed were not appropriately managed during the takeoff roll. It is possible that the gust lock had been left engaged preventing the rotor disc from being tilted fully back on the takeoff roll, leading to the low rotor speed.

Footnote

2 https://www.faasafety.gov/files/gslac/library/documents/2012/Nov/71574/DirtyDozenWeb3.pdf (assessed on 17 January 2019)
3 http://publicapps.caa.co.uk/docs/33/20120816HSL04.pdf (assessed on 17 January 2019)

ACCIDENT

Aircraft Type and Registration:	(UAS) Yuneec Typhoon H480
No & Type of Engines:	6 electric motors
Year of Manufacture:	2017
Date & Time (UTC):	26 September 2018 at 13:29 hrs
Location:	RAF St Athan, Wales
Type of Flight:	Aerial Work
Persons on Board:	Crew - None Passengers - None
Injuries:	Crew - N/A Passengers - N/A
Nature of Damage:	Damaged beyond economic repair
Commander's Licence:	CAA Remote Pilot Competence
Commander's Age:	50 years
Commander's Flying Experience:	Last 90 days - 7 hours 4 minutes Last 28 days - 2 hours 27 minutes
Information Source:	Aircraft Accident Report Form submitted by the pilot

The unmanned aircraft (UA) had been flown on several occasions earlier in the day providing aerial imagery for a multi-agency exercise. Prior to the accident flight a new, fully-charged, battery had been installed and no problems were identified during the pre-flight checks. The UA had completed a flight of approximately 12 minutes duration and was returning to the landing site when, at a height of approximately 30 feet, it tilted forward and then "flew into the ground". The UA suffered significant damage but no one was injured and no vehicles or property were damaged. The UA was returned to the manufacturer's agent for testing. No pre-accident defects were identified during the tests. Data, recovered from the UA, showed that during the incident flight no error messages were generated but as it descended to a height of 37 feet electrical power was lost. The manufacturer confirmed that it is possible to operate the Typhoon H480 without the battery being fully installed and secure. Movement of an insecure battery in-flight has previously resulted in a small number of crashes due to electrical power loss.

Miscellaneous

This section contains Addenda, Corrections and a list of the ten most recent Aircraft Accident ('Formal') Reports published by the AAIB.

The complete reports can be downloaded from the AAIB website (www.aaib.gov.uk).

TEN MOST RECENTLY PUBLISHED FORMAL REPORTS ISSUED BY THE AIR ACCIDENTS INVESTIGATION BRANCH

2/2014 Eurocopter EC225 LP Super Puma G-REDW, 34 nm east of Aberdeen, Scotland on 10 May 2012 and G-CHCN, 32 nm south-west of Sumburgh, Shetland Islands on 22 October 2012.

Published June 2014.

3/2014 Agusta A109E, G-CRST Near Vauxhall Bridge, Central London on 16 January 2013.

Published September 2014.

1/2015 Airbus A319-131, G-EUOE London Heathrow Airport on 24 May 2013.

Published July 2015.

2/2015 Boeing B787-8, ET-AOP London Heathrow Airport on 12 July 2013.

Published August 2015.

3/2015 Eurocopter (Deutschland) EC135 T2+, G-SPAO Glasgow City Centre, Scotland on 29 November 2013.

Published October 2015.

1/2016 AS332 L2 Super Puma, G-WNSB on approach to Sumburgh Airport on 23 August 2013.

Published March 2016.

2/2016 Saab 2000, G-LGNO approximately 7 nm east of Sumburgh Airport, Shetland on 15 December 2014.

Published September 2016.

1/2017 Hawker Hunter T7, G-BXFI near Shoreham Airport on 22 August 2015.

Published March 2017.

1/2018 Sikorsky S-92A, G-WNSR West Franklin wellhead platform, North Sea on 28 December 2016.

Published March 2018.

2/2018 Boeing 737-86J, C-FWGH Belfast International Airport on 21 July 2017.

Published November 2018.

Unabridged versions of all AAIB Formal Reports, published back to and including 1971, are available in full on the AAIB Website

http://www.aaib.gov.uk

GLOSSARY OF ABBREVIATIONS

aal	above airfield level
ACAS	Airborne Collision Avoidance System
ACARS	Automatic Communications And Reporting System
ADF	Automatic Direction Finding equipment
AFIS(O)	Aerodrome Flight Information Service (Officer)
agl	above ground level
AIC	Aeronautical Information Circular
amsl	above mean sea level
AOM	Aerodrome Operating Minima
APU	Auxiliary Power Unit
ASI	airspeed indicator
ATC(C)(O)	Air Traffic Control (Centre)(Officer)
ATIS	Automatic Terminal Information Service
ATPL	Airline Transport Pilot's Licence
BMAA	British Microlight Aircraft Association
BGA	British Gliding Association
BBAC	British Balloon and Airship Club
BHPA	British Hang Gliding & Paragliding Association
CAA	Civil Aviation Authority
CAVOK	Ceiling And Visibility OK (for VFR flight)
CAS	calibrated airspeed
cc	cubic centimetres
CG	Centre of Gravity
cm	centimetre(s)
CPL	Commercial Pilot's Licence
°C,F,M,T	Celsius, Fahrenheit, magnetic, true
CVR	Cockpit Voice Recorder
DME	Distance Measuring Equipment
EAS	equivalent airspeed
EASA	European Aviation Safety Agency
ECAM	Electronic Centralised Aircraft Monitoring
EGPWS	Enhanced GPWS
EGT	Exhaust Gas Temperature
EICAS	Engine Indication and Crew Alerting System
EPR	Engine Pressure Ratio
ETA	Estimated Time of Arrival
ETD	Estimated Time of Departure
FAA	Federal Aviation Administration (USA)
FDR	Flight Data Recorder
FIR	Flight Information Region
FL	Flight Level
ft	feet
ft/min	feet per minute
g	acceleration due to Earth's gravity
GPS	Global Positioning System
GPWS	Ground Proximity Warning System
hrs	hours (clock time as in 1200 hrs)
HP	high pressure
hPa	hectopascal (equivalent unit to mb)
IAS	indicated airspeed
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
IP	Intermediate Pressure
IR	Instrument Rating
ISA	International Standard Atmosphere
kg	kilogram(s)
KCAS	knots calibrated airspeed
KIAS	knots indicated airspeed
KTAS	knots true airspeed
km	kilometre(s)
kt	knot(s)
lb	pound(s)
LP	low pressure
LAA	Light Aircraft Association
LDA	Landing Distance Available
LPC	Licence Proficiency Check
m	metre(s)
MDA	Minimum Descent Altitude
METAR	a timed aerodrome meteorological report
min	minutes
mm	millimetre(s)
mph	miles per hour
MTWA	Maximum Total Weight Authorised
N	Newtons
N_R	Main rotor rotation speed (rotorcraft)
N_g	Gas generator rotation speed (rotorcraft)
N_1	engine fan or LP compressor speed
NDB	Non-Directional radio Beacon
nm	nautical mile(s)
NOTAM	Notice to Airmen
OAT	Outside Air Temperature
OPC	Operator Proficiency Check
PAPI	Precision Approach Path Indicator
PF	Pilot Flying
PIC	Pilot in Command
PM	Pilot Monitoring
POH	Pilot's Operating Handbook
PPL	Private Pilot's Licence
psi	pounds per square inch
QFE	altimeter pressure setting to indicate height above aerodrome
QNH	altimeter pressure setting to indicate elevation amsl
RA	Resolution Advisory
RFFS	Rescue and Fire Fighting Service
rpm	revolutions per minute
RTF	radiotelephony
RVR	Runway Visual Range
SAR	Search and Rescue
SB	Service Bulletin
SSR	Secondary Surveillance Radar
TA	Traffic Advisory
TAF	Terminal Aerodrome Forecast
TAS	true airspeed
TAWS	Terrain Awareness and Warning System
TCAS	Traffic Collision Avoidance System
TGT	Turbine Gas Temperature
TODA	Takeoff Distance Available
UAS	Unmanned Aircraft System
UHF	Ultra High Frequency
USG	US gallons
UTC	Co-ordinated Universal Time (GMT)
V	Volt(s)
V_1	Takeoff decision speed
V_2	Takeoff safety speed
V_R	Rotation speed
V_{REF}	Reference airspeed (approach)
V_{NE}	Never Exceed airspeed
VASI	Visual Approach Slope Indicator
VFR	Visual Flight Rules
VHF	Very High Frequency
VMC	Visual Meteorological Conditions
VOR	VHF Omnidirectional radio Range

Air Accidents Investigation Branch