Air Accidents Investigation Branch

AAIB Bulletin 2/2023

TO REPORT AN ACCIDENT OR INCIDENT PLEASE CALL OUR 24 HOUR REPORTING LINE

01252 512299

Air Accidents Investigation Branch
Farnborough House
Berkshire Copse Road
Aldershot
Hants GU11 2HH

Tel: 01252 510300
Fax: 01252 376999
Press enquiries: 0207 944 3118/4292
http://www.aaib.gov.uk

AAIB investigations are conducted in accordance with Annex 13 to the ICAO Convention on International Civil Aviation, EU Regulation No 996/2010 (as amended) and The Civil Aviation (Investigation of Air Accidents and Incidents) Regulations 2018.

The sole objective of the investigation of an accident or incident under these Regulations is the prevention of future accidents and incidents. It is not the purpose of such an investigation to apportion blame or liability.

Accordingly, it is inappropriate that AAIB reports should be used to assign fault or blame or determine liability, since neither the investigation nor the reporting process has been undertaken for that purpose.

AAIB Bulletins and Reports are available on the Internet
http://www.aaib.gov.uk

Published 9 February 2023

Cover picture courtesy of Marcus Cook

ISSN 0309-4278

Published by the Air Accidents Investigation Branch, Department for Transport
Printed in the UK on paper containing at least 75% recycled fibre

CONTENTS

SPECIAL BULLETINS / INTERIM REPORTS

SUMMARIES OF AIRCRAFT ACCIDENT ('FORMAL') REPORTS

AAIB FIELD INVESTIGATIONS

AAIB CORRESPONDENCE INVESTIGATIONS

CONTENTS Cont

AAIB CORRESPONDENCE INVESTIGATIONS Cont

(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-23-250, G-BJNZ
No & Type of Engines:	2 Lycoming IO-540-C4B5 piston engines
Year of Manufacture:	1979 (Serial no: 27-7954099)
Date & Time (UTC):	2 April 2022 at 1535 hrs
Location:	Enfield, Greater London
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 3
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to the engines, propellers, landing gear, left flap and underside of the fuselage
Commander's Licence:	Private Pilot's Licence
Commander's Age:	67 years
Commander's Flying Experience:	1,859 hours (of which 1,090 were on type) Last 90 days - 33 hours Last 28 days - 21 hours
Information Source:	AAIB Field investigation

Synopsis

During an IFR flight from Le Touquet to Wellesbourne, the pilot observed oil leaking from the left engine followed by engine vibration. He shut the engine down and descended but elected to continue the flight toward Wellesbourne. On reaching 2,000 ft he found he was unable to maintain level flight on one engine and decided to land in a field.

The investigation found the left engine failed due to a fatigue crack in one of the cylinder barrels. It is likely that the pilot was unable to maintain level flight on the right engine due to a combination of engine wear resulting in reduced power available and the prevailing weather conditions. His decision to continue the flight following the engine shutdown was likely to have been influenced by high workload and plan continuation bias.

The maintenance organisation has taken safety action to enhance its maintenance programme for aircraft fitted with piston engines operating beyond the manufacturer's recommended overhaul life.

History of the flight

The pilot and three passengers were taking part in a flying club 'fly-out' from Wellesbourne Mountford Airfield to Le Touquet in France. The pilot planned to fly in controlled airspace under IFR. The other aircraft involved in the fly-out were all flying under VFR[1]. G-BJNZ's outbound flight to Le Touquet was uneventful, landing in Le Touquet at 0830 hrs.

Footnote

[1] One of the other aircraft taking part in the fly-out, G-EGVA, was involved in a separate accident during the flight to Le Touquet. That accident is subject to a separate AAIB investigation.

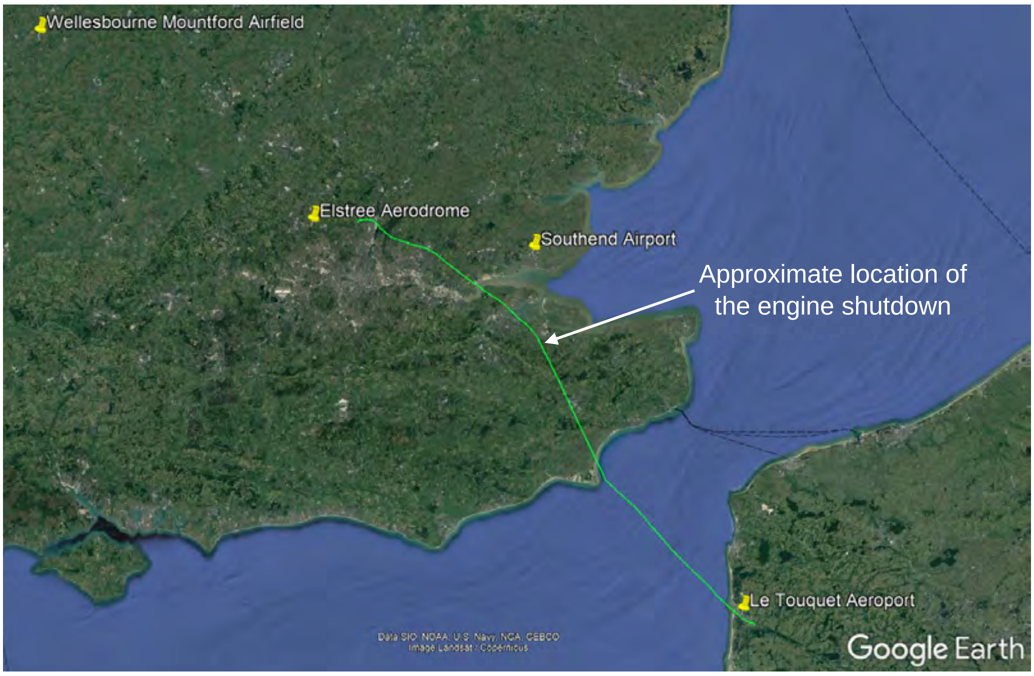


Figure 1

G-BJNZ radar trace showing the intended destination

G-BJNZ took off for the return flight to Wellesbourne at 1422 hrs. The pilot followed a standard instrument departure and climbed to FL90 routing towards Lydd then Detling (the route flown is shown in Figure 1). The pilot reported that at FL90 he was above the convective weather present in the English Channel on the day. As the aircraft approached DET, still at FL90, the pilot observed oil leaking from the left engine (Figure 2). The oil pressure, oil temperature and cylinder head temperature indications were normal, but oil was clearly visible on the engine cowling. Shortly afterwards the left engine started to vibrate, so the pilot elected to shut the engine down and feather the propeller.

The pilot informed ATC that he had shut down the left engine and told them he needed to descend. ATC cleared the aircraft to descend to 5,000 ft and asked the pilot if he wished to declare an emergency and if he would like to divert to Southend Airport which was approximately 15 nm north of his position. The pilot made a PAN call but stated that he was happy to continue to Wellesbourne. He requested a further descent to 4,000 ft, routing to the south of Stapleford Airfield and requested a routing through Luton Airspace, which was granted. The pilot then requested a further descent out of controlled airspace and cancelled his IFR flight plan. ATC queried the pilot about this intention but the pilot confirmed that this was his preference.

The pilot attempted to stop the descent at 2,000 ft amsl but when he tried to fly level the aircraft lost airspeed despite full throttle on the right engine. The pilot was not able to make the aircraft climb or maintain altitude without losing airspeed. By this stage the aircraft was east of Elstree Aerodrome, so the pilot flew directly to Elstree and informed them he needed to land immediately. However, he realised he was losing too much altitude and would not be able to reach the aerodrome.

Figure 2

Photograph taken inflight of the oil leak from the left engine

He identified a grass field on his left side with an upslope and no obstructions, and positioned the aircraft for landing. When he was confident that he would reach the field, he lowered the landing gear. The aircraft then landed heavily in the field and the landing gear collapsed, after which the aircraft slid to a stop in approximately 100 m. When the aircraft stopped the pilot shut off the fuel and electrics. None of the occupants were injured and they were all able to exit the aircraft.

Figure 3

Radar trace following the engine shutdown showing altitude

Information provided by the pilot

The pilot reported that he did not know why the aircraft did not maintain height on one engine. He considered he was experienced at flying the Piper Aztec and had flown this aircraft many times on one engine during training and revalidations without difficulty. He thought the aircraft might have been affected by downdrafts from cumulonimbus activity in the area.

After the off-aerodrome landing the pilot thought about why he had not diverted to the nearest suitable aerodrome after he had shut down the left engine. ATC had asked if he would like to route to Southend. At the time he thought the aircraft was flying normally on one engine and the operating engine was showing no adverse effects, so he believed he could safely continue to his planned destination. He felt his previous experience of flying on one engine during training flights had given him confidence that he could continue safely.

Recorded data

The attitude flown by the aircraft was recorded on radar (Figure 3) and is shown in profile in Figure 4. Average rates of descent are shown in red. The figure shows that on passing 2,000 ft the aircraft initially continued to descend at 200 ft/min before climbing briefly then descending again.

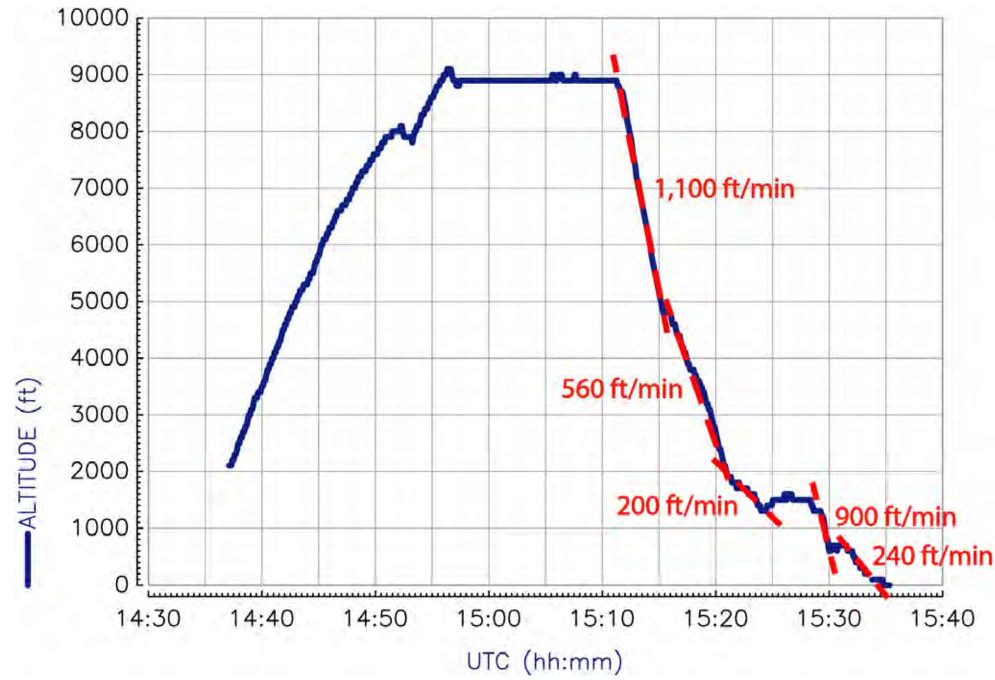


Figure 4

Altitude profile of the accident flight

Accident site

The aircraft landed in a grass field near Enfield, Greater London, approximately 7.8 nm from Elstree Aerodrome (Figure 5). Ground marks made by the aircraft showed that the landing gear had been extended at touchdown, before it had then rapidly collapsed. The right main and nose landing gear legs were pushed upwards into their landing gear wells and the left main leg had detached. The left flap was partially detached from the wing.

Figure 5

G-BJNZ following the forced landing

The left propeller was feathered. The right propeller blades exhibited leading edge damage, chordwise scoring and were bent rearwards, consistent with rotation under low power during the landing roll. The left engine cowlings were removed, revealing that the top section of the No 5 cylinder[2] had fractured and separated from the engine, exposing the top of the piston (Figure 6). One quart of oil remained in the left engine. The right engine was examined and no significant external defects were apparent.

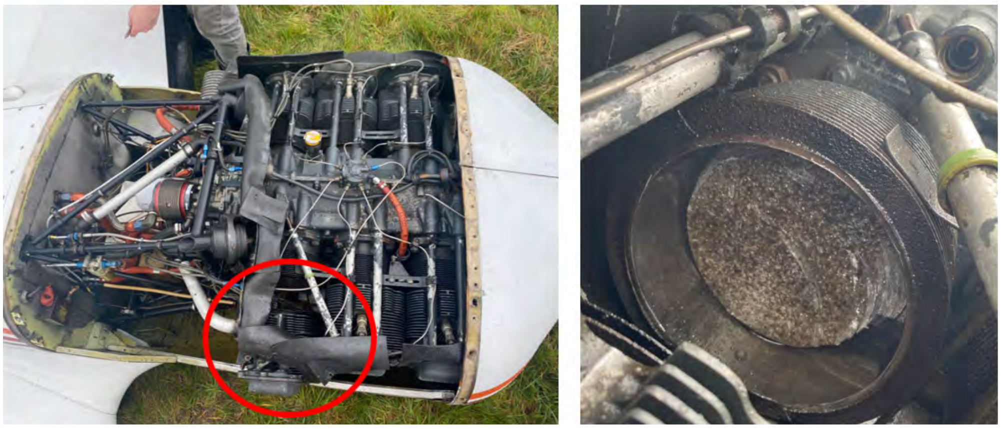


Figure 6

Left engine fractured No 5 cylinder and exposed piston

Footnote

[2] Cylinder 5 is the rear right cylinder, when viewing the engine from above.

Aircraft information

The Piper PA-23-250 is a six-seat light aircraft powered by two piston engines driving variable-pitch constant-speed propellers. As both propellers rotate clockwise, the aircraft's left engine is the 'critical engine'[3]. The aircraft is of conventional light-alloy construction with a retractable tricycle landing gear. The CAA categorises the aircraft as a UK Part 21[4] light aircraft.

At the aircraft's last annual inspection in March 2022, its left and right engines had recorded 2,212.7 hours-in-service. The engines were installed in the aircraft when it was built in 1979. The manufacturer's recommended overhaul life of the engines is 2,000 hours or 12 years, whichever occurs first.

Maintenance programme

The aircraft was subject to a maintenance programme developed to comply with the requirements of Part-ML[5]. The programme contained inspections at 50 hours, 150 hours and annual intervals. The aircraft owner had contracted with a Part-CAO[6] organisation to manage the aircraft's continuing airworthiness and maintenance programme, and to perform the required maintenance.

Part-ML and Part-CAO were introduced by the CAA on 24 March 2021. Prior to this, the CAA approved the maintenance programmes for light aircraft and published Generic Requirements (GRs) that contained additional maintenance requirements. After the introduction of Part-ML, the content of CAA GRs, including GR No 24 (Light Aircraft Piston Engine Overhaul Periods)[7], was no longer mandatory for UK Part 21 aircraft.

GR No 24 provides guidance to aircraft owners and maintenance organisations for the inspection and operation of piston engines where the engines are operated beyond the manufacturer's recommended overhaul periods, either by operating time or calendar time. Appendix 3 of GR No 24 contains information for external and internal condition inspections, oil consumption monitoring and compression checks. This information relating to cylinder corrosion is:

> **3.1 External Condition.** The engine should be examined externally for obvious defects such as a cracked crankcase, excessive play in the propeller shaft, overheating and corrosion, which would make it unacceptable for further use.

Footnote

[3] The critical engine in a multi-engine aircraft is that which, in the event of its failure, requires the greatest control deflections to maintain lateral and directional control.

[4] Aircraft in this category are those that were previously managed by the EASA and were considered as EASA types. They are regulated under UK Regulation (EU) 2018/1139, known as the UK Basic Regulation, and its implementing regulations.

[5] Part-ML contains regulations for the maintenance of light aircraft to ensure that they remain airworthy and are in a condition for safe operation. It also establishes the responsibilities of persons and organisations involved in activities related to the continuing airworthiness of light aircraft.

[6] Part-CAO contains regulations for Combined Airworthiness Organisations (CAOs). CAOs may perform continuing airworthiness management organisation activities, or maintenance organisation activities, or both.

[7] Generic Requirement GR No 24 - Light Aircraft Piston Engine Overhaul Periods, Part 4, CAA CAP 747.

GR No 24 also describes a method to determine the power developed by a piston engine in which the maximum static engine rpm is recorded during a ground engine run, with a controllable-pitch propeller in the full fine position. The result is then compared to a reference speed recorded in the engine logbook. A reduction in engine power will result in a reduction in the maximum static engine rpm and a reduction of more than 3% is considered unacceptable, requiring defect rectification. An alternative method to determine engine power deterioration is to perform a rate-of-climb flight test, and to compare the result with figures in the aircraft's flight manual.

After the introduction of Part-ML, the Part-CAO organisation continued to include maintenance inspections from GR No 24 in G-BJNZ's maintenance programme, because the engines' time-in-service exceeded the manufacturer's recommended overhaul period.

Maintenance history

The maintenance organisation performed an annual inspection and ARC renewal in March 2022. The inspection included engine inspections in accordance with GR No 24 and there were no resulting findings, and the service life of the engines was extended for a further 12 months or 100 hours. A differential-compression test was performed on both engines, with results in a range of 72-80 psi for the left engine and 68-80 psi for the right engine. Neither set of compression test results indicated the need for further investigation of the engine cylinders. The inspection records stated that the oil filter elements were inspected and found to be clean of debris.

The annual inspection also involved ground-running the aircraft's engines and recording engine temperatures, pressures, magneto rpm drops and other data on a worksheet. The worksheet contained boxes for recording the maximum static rpm achieved by each engine, but no entries were recorded.

Aircraft examination

Left engine

The fracture in the No 5 cylinder occurred in the steel cylinder barrel, 13 mm from the point where the aluminium cylinder head is screwed onto the steel barrel (Figure 7). The crack started at the 1 o'clock point on the barrel section, on the upper part of the cylinder.

The fractured cylinder was examined by a metallurgist who concluded that the crack originated at a corrosion pit on the cylinder's outer surface (Figure 8). The steel barrels of all the other cylinders of both engines were inspected and all were observed to be corroded on their outer surfaces.

The fracture propagated by fatigue for approximately 50% of the cylinder cross-section (Figure 9). The fracture then continued to grow in a mixed fatigue-overload mode, before the cylinder finally failed in overload.

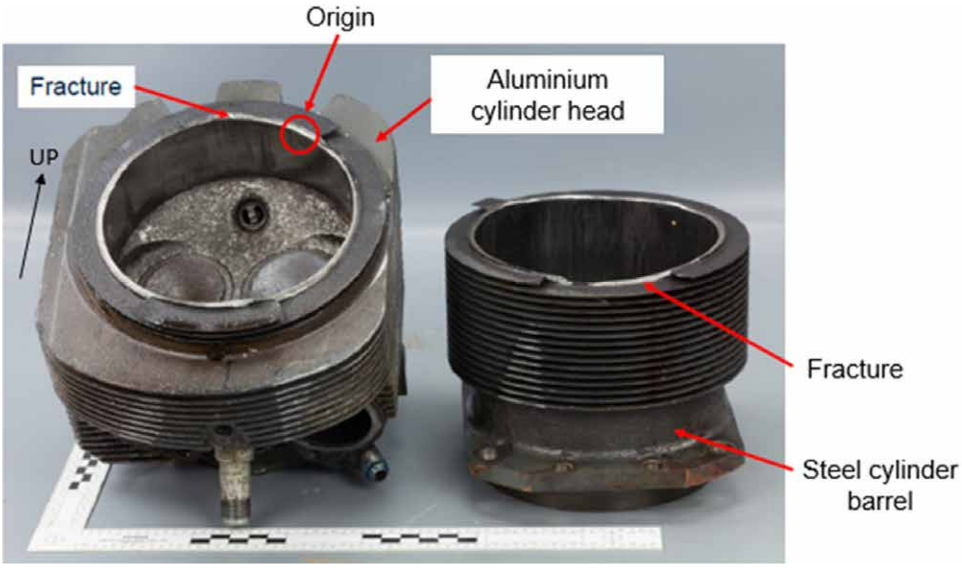


Figure 7

Fracture location in No 5 cylinder (image courtesy QinetiQ)

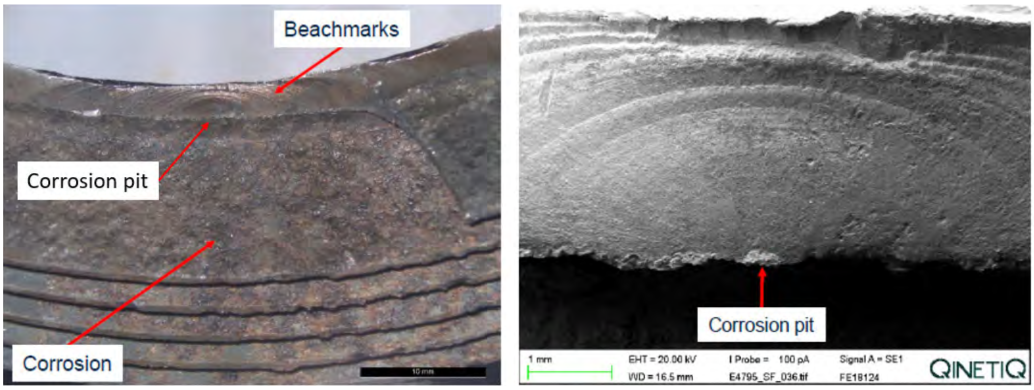


Figure 8

Corrosion pit at crack origin (images courtesy QinetiQ)

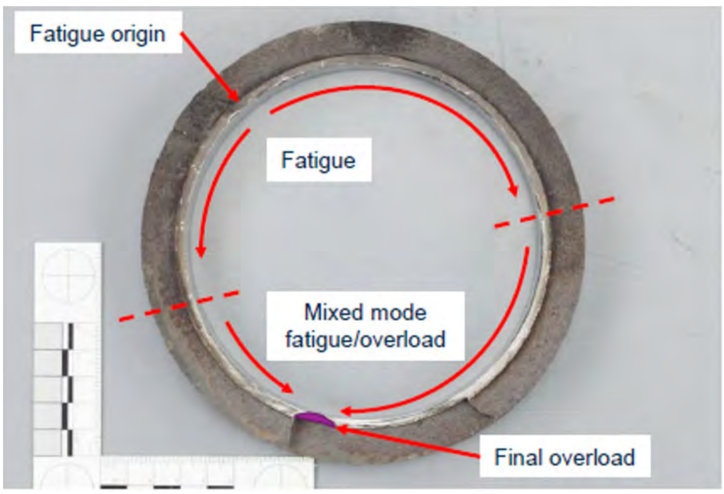


Figure 9

Crack growth progression (image courtesy QinetiQ)

The fracture surface was coated in a layer of lead bromide, a component of exhaust gases. The degree of coating varied along the fracture surface, with the heaviest deposits around the crack initiation site. This indicates that the cracking had occurred progressively, whilst the engine was operating, although it was not possible to accurately state when the cracking had started.

The licenced engineer who carried out the annual inspection stated that he had observed the visible corrosion on the cylinder barrels, but did not consider it sufficient to reject the cylinders. He also stated that cylinder corrosion was a common observation on the general aviation aircraft he performed maintenance on.

Right engine

The right engine was tested on a calibrated dynamometer to determine its power output. The engine initially ran very roughly, preventing safe operation of the dynamometer. The cause of the rough running was traced to three lead-fouled spark plugs[8] and once these were replaced with serviceable plugs the engine ran smoothly. The engine's power output was measured at 203 hp at 2,575 rpm. The engine's stated power output, as recorded on its data plate, is 250 hp at 2,575 rpm. G-BJNZ's right engine therefore produced 47 hp (19%) less than its stated power output.

The engine was disassembled to determine the condition of its components. Severe wear was noted on the second camshaft lobe, which actuates the inlet valves for both the No 1 and No 2 cylinders (Figure 10). The lift of this camshaft lobe was measured to be 0.178", which is approximately 50% of the lift of an unworn camshaft. The other eight camshaft lobes showed minor wear that would not have significantly affected the engine's performance.

The faces of the hydraulic tappet bodies for the No 1 and No 2 inlet valves, which are in direct contact with the second camshaft lobe, exhibited heavy surface spalling (Figure 11). The tappet bodies transmit motion of the camshaft into movement of pushrods that actuate the inlet and exhaust valves. The other tappet bodies exhibited surface spalling and visible wear which would require their rejection at engine overhaul.

Visible wear was also observed in the engine's cylinder bores, piston skirts, exhaust valve guides and crankshaft main bearings. These were assessed as common for an engine of similar operating hours and unlikely to significantly affect the engine's power output. A small quantity of ferrous metal particles was present in the engine's oil filter.

Footnote

8 The lead-fouled spark plugs were the lower spark plug for No 5 cylinder and the upper spark plugs for No 4 and No 6 cylinders.

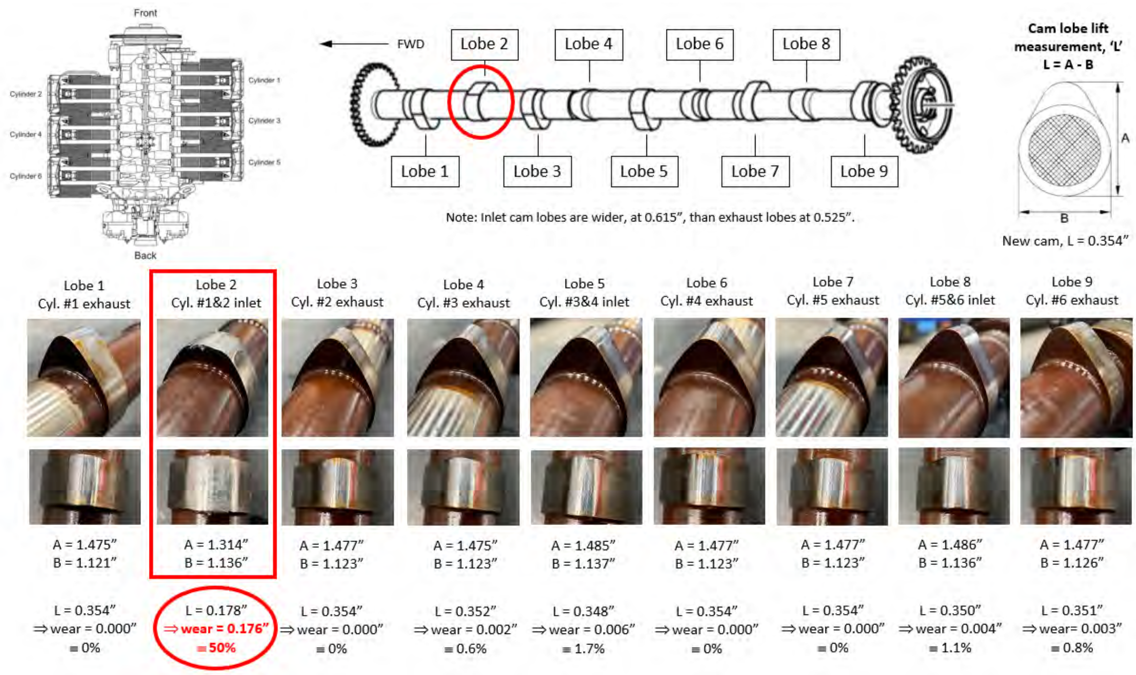


Figure 10

Measured wear of G-BJNZ's right engine camshaft lobes

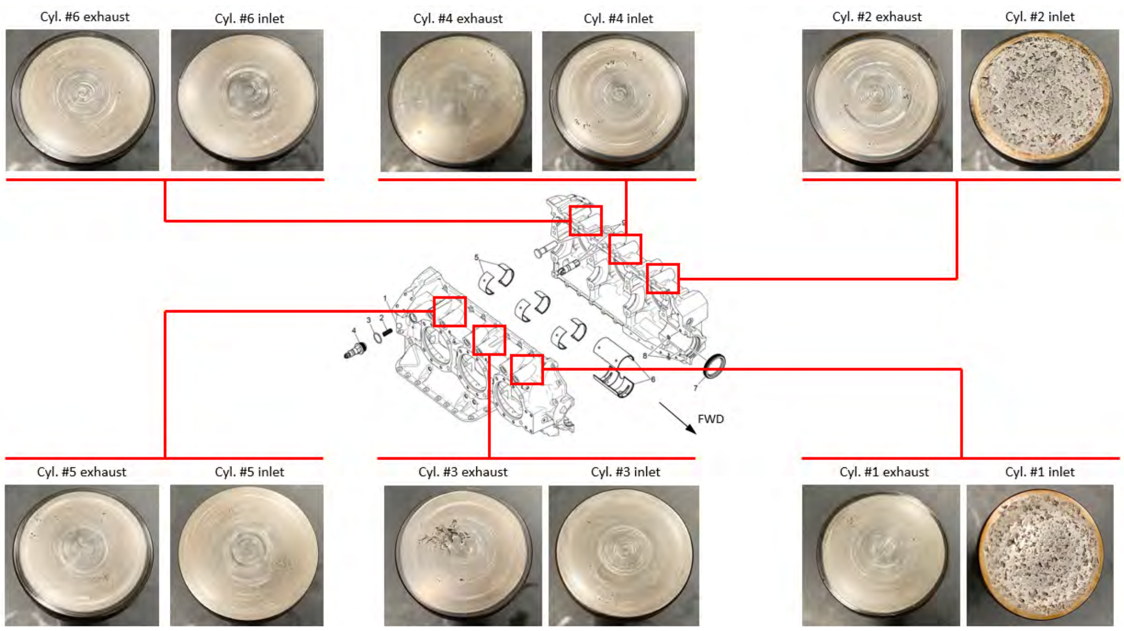


Figure 11

Observed wear of G-BJNZ's right engine tappet bodies

Pilot's operating handbook

The performance section of the Piper Aztec Pilot's Operating Handbook (POH) contains a graph giving expected single engine climb performance. The graph is based on a new aircraft with full throttle, fully rich mixture, cowl flaps fully open on the operative engine, landing gear and flaps retracted, the inoperative propeller feathered and 5º of bank towards the operative engine. At an altitude of 2,000 ft with an outside air temperature of 1ºC and an aircraft mass of 4,950 lbs the predicted climb performance is 250 fpm.

The emergency procedures section of the POH specifies the procedure to be followed following an engine failure during flight. The final line of the procedure states '*Land as soon as practical at the nearest suitable airport*'.

Meteorology

At the time of the accident rain showers where present across much of the UK. In the vicinity of the accident, satellite and radar records show cumuliform cloud and rain showers close to the aircraft's track. Figure 12 shows a weather radar image at 1530 hrs with the aircraft's track overlayed. Figure 2 shows the cloud ahead of the aircraft when the left engine was shutdown.

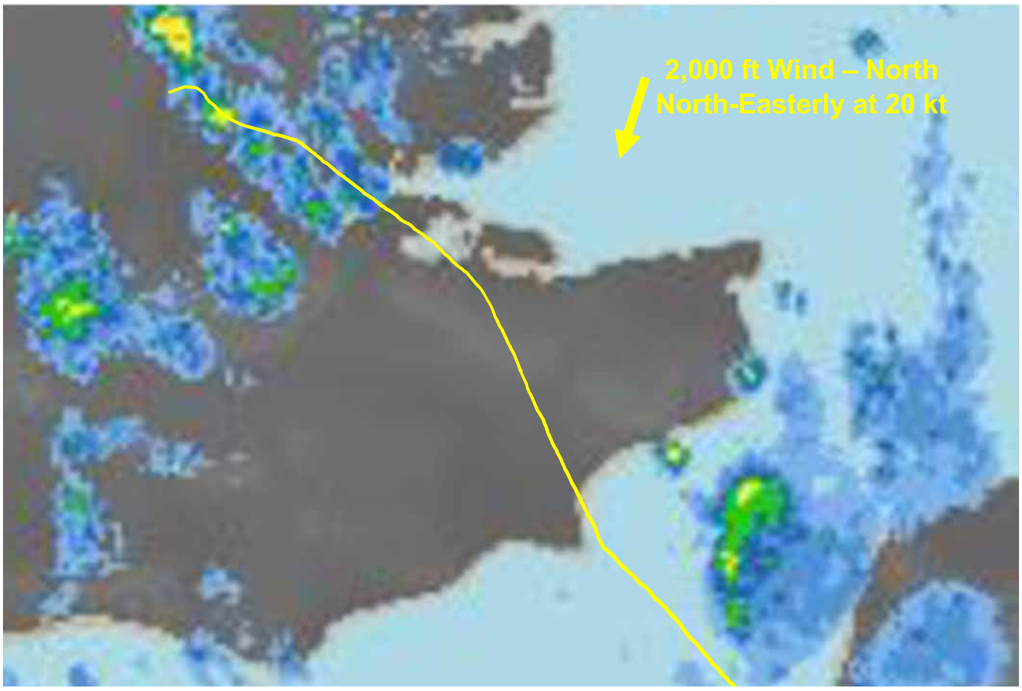


Figure 12

Weather radar image at 1530 hrs with the aircraft's track overlayed

Airports in the vicinity had forecast a risk of moderate showers throughout the period, with a smaller risk of heavier showers or thunderstorms. Towering cumulus was reported on an automatic METAR from London City Airport. Towering cumulus cloud can have strong downdraughts associated with them, which could affect any aircraft that was flying in close proximity.

At 1520 hrs Southend Airport was reporting a surface wind from 080º at 12 kt, visibility of more than 10 km with rain showers in the vicinity, no significant cloud and a temperature of 8ºC.

The wind at 1,000 ft and 2,000 ft was forecast to be north-north-easterly at 20 kt. The temperature at 2,000 ft was forecast to be 1ºC.

Pilot information

The pilot held a private pilot's licence with a valid Multi-Engine Piston (MEP) rating and Instrument Rating (IR SP ME/SE). He was also a multi-engine and single engine class rating instructor. He held a valid Class 2 medical.

Decision making

The following description of pilot decision making was published in a Transportation Safety Board of Canada report into an accident which occurred in February 2018[9].

> *'To make decisions effectively, a pilot needs an accurate understanding of the situation and an appreciation of the implications of the situation, then to formulate a plan and contingencies, and to implement the best course of action. Equally important is a pilot's ability to recognize changes in the situation and to reinitiate the decision-making process to ensure that changes are accounted for and plans modified accordingly. If the potential implications of the situation are not adequately considered during the decision-making process, there is an increased risk that the decision and its associated action will result in an adverse outcome that leads to an undesired aircraft state.*
>
> *A number of different factors can adversely impact a pilot's decision-making process. For example, increased workload can adversely impact a pilot's ability to perceive and evaluate cues from the environment and may result in attentional narrowing. In many cases, this attentional narrowing can lead to confirmation bias, which causes people to seek out cues that support the desired course of action, to the possible exclusion of critical cues that may support an alternate, less desirable hypothesis. The danger this presents is that potentially serious outcomes may not be given the appropriate level of consideration when attempting to determine the best possible course of action.*
>
> *One specific form of confirmation bias is (plan) continuation bias, or plan continuation error. Continuation bias is best described as "the unconscious cognitive bias to continue with the original plan in spite of changing conditions" or "a deep-rooted tendency of individuals to continue their original plan of action even when changing circumstances require a new plan." Once a*

Footnote

[9] Air Transportation Safety Investigation Report A18P0031, '*Loss of control and collision with terrain*', available at https://www.tsb.gc.ca/eng/rapports-reports/aviation/2018/A18P0031/A18P0031.html [accessed 23 June 2022]

plan is made and committed to, it becomes increasingly difficult for stimuli or conditions in the environment to be recognized as necessitating a change to the plan. Often, as workload increases, the stimuli or conditions will appear obvious to people external to the situation; however, it can be very difficult for a pilot caught up in the plan to recognize the saliency of the cues and the need to alter the plan.

When continuation bias interferes with the pilot's ability to detect important cues, or if the pilot fails to recognize the implications of those cues, breakdowns in situational awareness (SA) occur. These breakdowns in SA can result in non-optimal decisions being made, which could compromise safety.

In a NASA and Ames Research Center review of 37 accidents investigated by the U.S. National Transportation Safety Board, it was determined that almost 75% of the tactical decision errors involved in the 37 accidents were related to decisions to continue on the original plan of action despite the presence of cues suggesting an alternative course of action. Dekker (2006) suggests that continuation bias occurs when the cues used to formulate the initial plan are considered to be very strong. For example, if the plan seems like a great plan, based on the information available at the time, subsequent cues that indicate otherwise may not be viewed in an equal light, in terms of decision making.

Therefore, it is important to realize that continuation bias can occur, and it is important for pilots to remain cognizant of the risks of not carefully analysing changes in the situation, and considering the implications of those changes, to determine whether or not a more appropriate revised course of action is appropriate. As workload increases, particularly in a single-pilot scenario, less and less mental capacity is available to process these changes, and to consider the potential impact that they may have on the original plan.'

Analysis

Engine Failure

The left engine failed as a result of a fatigue crack in the steel barrel section of the No 5 cylinder, originating at a corrosion pit. The differential-compression test carried out at the annual inspection did not identify low compression in the cylinder and it is possible that the crack developed during operation of the aircraft after the annual inspection was carried out.

The licenced engineer who carried out the inspection did not consider the surface corrosion present on the cylinders to be a cause for their rejection. The guidance material in GR No 24 relating to corrosion does not contain any quantitative limits on the acceptable degree of cylinder corrosion. Cylinder corrosion is a common observation in the UK general aviation fleet and the CAA stated to the AAIB that assessment of the degree of cylinder corrosion, and any resulting decision to reject cylinders due to excessive corrosion, remains within the engineering judgement of licenced engineers.

Decision making

Once the pilot had shut down the left engine he decided to descend out of controlled airspace and continue the flight to Wellesbourne. However, the POH states that the pilot should land as soon as practical at the nearest suitable airport following an engine shutdown. Southend Airport was the closest airport and had suitable weather. There were also several other suitable airports in the vicinity.

Having suffered an engine failure whilst flying as sole pilot under IFR it is likely the pilot was experiencing a high workload and that this affected his ability to decide on the best course of action. Deciding on, and implementing, a new plan requires cognitive effort. This can be difficult when workload is already high and a pilot has limited spare capacity. Continuing with the current plan can seem like the best choice because doing so does not require additional thought and does not further increase workload. This is known as plan continuation bias. ATC offered a diversion to Southend but the pilot decided not to do this. When workload is high it is easy to discount external cues which suggest an alternative course of action.

Lack of climb performance

The aircraft's right engine was found to produce only 81% of its stated power output when tested after the accident. Severe wear of the second camshaft lobe was identified, which resulted in a significant loss of inlet valve lift for the engine's No 1 and No 2 cylinders. This is likely to account for most of the engine's power deficit, as no other major defects were noted when the engine was examined.

The right engine's power deficit was not identified during the annual maintenance inspection as the maximum static engine rpm was not recorded during engine ground runs. This meant that the opportunity to compare the maximum engine rpm with previous values or the engine logbook reference speed was missed.

When the pilot attempted to fly level at 2,000 ft, rain showers and cumulus cloud were close to the aircraft's track. These are likely to have generated downdrafts and turbulence. Any downdrafts would have further reduced the aircraft's ability to climb.

To achieve the climb performance stated in the POH the aircraft needs to be flown accurately in balance, with 5° bank to the live engine and at the correct speed (V_{YSE}). If the aircraft was flown above or below the correct speed the climb performance would have been reduced. Any turbulence is likely to have made it harder to fly the aircraft accurately.

The left engine is the critical engine, meaning more rudder deflection is required to maintain controlled flight. More rudder deflection means more drag and therefore less climb performance.

It is likely that the lack of climb performance resulted primarily from a reduction in maximum engine power caused by mechanical degradation. The weather conditions are also likely to have made it harder to achieve a positive climb.

Conclusion

The left engine failed due to a fatigue crack in one of the cylinders. It is likely that the pilot was unable to maintain level flight on the right engine because of a combination of engine wear and the weather conditions.

The pilot's decision to continue the flight following the shutdown of the left engine may have been influenced by high workload and plan continuation bias.

Safety actions

The aircraft's maintenance organisation has amended its maintenance programme for aircraft fitted with piston engines operating beyond the manufacturer's recommended overhaul life. The revised maintenance programme includes a rate-of-climb air test to detect a loss of engine power output and introduction of an oil sample analysis monitoring programme.

Published: 5 January 2023.

INCIDENT

Aircraft Type and Registration:	Piper PA-28-161, G-BORL
No & Type of Engines:	1 Lycoming O-320-D3G piston engine
Year of Manufacture:	1978 (Serial no: 28-7816256)
Date & Time (UTC):	29 June 2022 at 1000 hrs
Location:	Blackpool Airport, Lancashire
Type of Flight:	Private
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - 1 (Fatal) 1 (None) Passengers - N/A
Nature of Damage:	None
Instructor's Licence:	Commercial Pilot's Licence
Instructor's Age:	57 years
Instructor's Flying Experience:	8,876 hours Last 90 days - 184 hours Last 28 days - 78 hours
Information Source:	AAIB Field Investigation

Synopsis

A flying instructor, who held a Class 1 Medical, died inflight whilst flying with a qualified pilot. The pilot was able to land the aircraft safely. A post-mortem concluded that the instructor died from acute cardiac failure. The CAA intends to review the circumstance of this incident to determine if anything can be learnt and if any changes should be made to the current guidance.

The circumstances surrounding the occurrence did not fall within the definitions of an accident or serious incident as defined in ICAO Annex 13, however, the Chief Inspector, in exercise of his powers under the Civil Aviation (Investigation of Air Accidents and Incidents) Regulations 2018, initiated an investigation, treating the occurrence as an incident.

History of the flight

A qualified pilot had planned to fly G-BORL from Blackpool Airport to another airfield but when he arrived at the flying club and checked the latest wind, he decided the crosswind was above his personal limit to fly on his own. Still wanting to go flying so that he remained within the flying club's recency requirements the pilot asked an instructor if he would accompany him for a single circuit. The instructor agreed to fit in the circuit after he finished a trial lesson.

Following the trial lesson the instructor met the pilot in G-BORL and the pilot taxied the aircraft out to the runway. The pilot recalled that during the taxi they were talking normally. He recalled telling the instructor he would keep the aircraft into wind for the power checks and the instructor replying, “looks good, there is nothing behind you”. The pilot did not recall the instructor saying anything else after this point.

The pilot recalled that shortly after takeoff from Runway 28 the instructor’s head rolled back. The pilot knew the instructor well and thought he was just pretending to take a nap whilst the pilot flew the circuit, so he did not think anything was wrong at this stage. He proceeded to fly the aircraft round the circuit. As he turned onto base leg the instructor slumped over with his head resting on the pilot’s shoulder. The pilot still thought the instructor was just joking with him and continued to fly the approach. He landed normally on Runway 28 and started to taxi back to the apron. However, the instructor was still resting on his shoulder and was not responding, and the pilot realised something was wrong. He signalled to the airport fire crew, who happened to be working on the apron, who came to assist. The fire crew and the air ambulance medical crew, who are based at the airport, attempted to revive the instructor but he remained unresponsive and they were unable to save him.

Post-mortem report and medical history

The post-mortem concluded that the instructor died from acute cardiac failure. His coronary arteries showed diffuse atheromatous disease (a condition where the arteries become clogged with fatty substances) and there was a coronary thrombus (blood clot) occluding his left main stem artery. Toxicology showed no significant findings.

He had medical history of hypertensive disease (high blood pressure) and had been taking blood pressure medication since 2002.

Instructor information

The instructor was 57 years old. He held a commercial pilot’s licence with valid single and multi-engine piston aircraft ratings, a valid instrument rating and a flight instructor rating. He was employed as a full-time senior flight instructor. He had accumulated a total of 8,876 flying hours.

He held a valid Class 1 Medical and his last aviation medical was on 10 February 2022, approximately 4 months before the incident flight.

People who had spoken to him on the morning of the incident said he was his normal cheerful self and there were no indications that he was feeling unwell. The three people who had flown with him for the trial lesson just prior to the incident flight said he seemed well and nothing abnormal had occurred.

CAA medical department review

The AAIB requested that the CAA’s medical department review the circumstances of this incident and the instructor’s medical history. They made the following observations:

- '*From the evidence provided, it is likely the individual suffered a cardiac arrest as the aircraft took off. The evidence suggests this was not preceded by any cardiac symptoms and the presentation was consistent with a fatal arrhythmia occurring as the heart muscle was starved of oxygen following the occlusion of a coronary artery.*
- *The individual was known to suffer with high blood pressure, had elevated blood lipids and was overweight. He was a non-smoker and had remained under regular review for hypertension by his GP.*
- *His blood pressure had been treated for more than 10 years and was within regulatory limits. Routine ECGs*[1] *had also been carried out in accordance with the regulations and these were normal.*
- *The CAA Hypertension guidelines require further investigations if complications or multiple risk factors exist. There was no evidence of complications however the QRISK*[2]*, as calculated by his GP in January 2022, was 12.2%. At this level, further treatment or investigation may be considered but this had not been carried out at the time of the incident.*
- *The levels of coronary stenosis seen at post mortem were disqualifying. Had he been symptomatic (angina) and investigated, the CAA would not have certified him without treatment (i.e. stenting or bypass).*
- *The CAA continuously reviews the regulation and guidance for aviation medicals in light of the latest research. The CAA intends to review the circumstance of this incident at their cardiac panel to determine if anything can be learnt and if any changes should be made to the current guidance.*'

Other similar events

Cardiac events can be a cause of sudden incapacitation, including death, in both the general population and among aviation personnel. In the last ten years several studies have been published reviewing the risk to commercial aviation of cardiac events in flight crew[3]. The studies highlight that the risk can never be reduced to zero and that in multi-pilot operations the risk is mitigated by having more than one pilot. However, they suggest that the current medical assessments carried out for flight crew manage the risk to an acceptable level[4].

Footnote

1 ECG – Electrocardiogram – a test used to measure the heart's rhythm and electrical activity.

2 QRISK is an assessment tool used to assess an individual's risk of developing cardiovascular disease.

3 [1] Evans S., Radcliffe S-A., (2012). The annual incapacitation rate of commercial pilots. Aviation, *Space and Environmental Medicine,* 83(1), p42–49. https://doi.org/10.3357/ASEM.3134.2012 [accessed January 2023].
[2] Gray G., Davenport E.D., Bron D, et al (2019). The challenge of asymptomatic coronary artery disease in aircrew; detecting plaque before the accident. *Heart*, 105, s17–s24. http://dx.doi.org/10.1136/heartjnl-2018-313053 [accessed January 2023].
[3] Gray G., Bron D., Davenport E.D.*, et al* (2019). Assessing aeromedical risk: a three dimensional risk matrix approach. *Heart,* 105, s9-s16. http://dx.doi.org/10.1136/heartjnl-2018-313052 [accessed January 2023].

4 CAA medical requirements for certification available at https://www.caa.co.uk/aeromedical-examiners/medical-standards/medical/ [accessed January 2023].

A review of CAA Mandatory Occurrence Reports back to 2005 showed there had been three commercial air transport incidents in the UK where a pilot had suffered a heart attack inflight, but on each occasions the other pilot had been able to land the aircraft safely. There were several general aviation accidents where cardiac events were given as a possible cause although in most cases there was insufficient evidence to confirm if this was the primary cause of the accident[5].

Analysis

The flying instructor suffered a sudden fatal heart attack as the aircraft was taking off. On this occasion he was flying with a qualified pilot who was able to land the aircraft safely. However, had this occurred on another flight the outcome could have been different.

Cardiac events are a significant cause of sudden incapacitation, including death, in both the general population and among aviation personnel. In multi-pilot commercial air transport the safety risk is mitigated by the second pilot. However, the risk remains for single-pilot operations.

The CAA reported that they continually review their cardiac guidance in light of the latest research. No tests or assessment can give a 100% reliable detection of cardiac issues and any additional tests or assessment presents a risk to the individual of potentially unnecessary loss of licence. A balance needs to be struck between minimising the risk to flight safety and providing fair and reasonable medical assessment of individuals. The rarity of accidents cause by cardiac events in flight suggests this balance is currently about right, and this is continuously being reviewed by the CAA medical department.

Published: 9 February 2023.

Footnote

[5] The following general aviation accidents which cite cardiac events as a possible cause were reviewed: G-BUWK 4/8/2020, G-ODDS 24/8/2019, G-CFMY 4/5/2019, G-MEPU 28/7/2016, G-VLCC 21/7/2016, G-MYUS 22/8/2012, G-MISS 8/11/2009 and G-ACDJ 18/8/2005.

ACCIDENT

Aircraft Type and Registration:	Enstrom 280FX, G-OJBB
No & Type of Engines:	1 Lycoming HIO-360-F1AD piston engine
Year of Manufacture:	1999 (Serial no: 2084)
Date & Time (UTC):	25 August 2021 at 1618 hrs
Location:	Rhobell Fawr, Dolgellau, Gwynedd
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Minor) Passengers - N/A
Nature of Damage:	Damaged beyond economic repair
Commander's Licence:	Private Pilot's Licence
Commander's Age:	65 years
Commander's Flying Experience:	419 hours (of which 419 were on type) Last 90 days - 12 hours Last 28 days - 4 hours
Information Source:	AAIB Field Investigation

Synopsis

The helicopter suffered a loss of thrust from the tail rotor while hovering close to the ground near a mountain top, resulting in a loss of control and hard landing. Subsequent examination of the tail rotor gearbox revealed damage to the bevel gears and failure of a bearing, which was consistent with a lack of lubrication. The investigation found inconsistencies in the way maintenance was performed on the tail rotor gearbox, compared to the helicopter manufacturer's maintenance instructions. It is likely that insufficient oil was added to the tail rotor gearbox when it was serviced 25 flying hours prior to the accident.

Three Safety Recommendations are made relating to information in the helicopter Maintenance Manual regarding the required oil quantity and maintenance servicing interval for the tail rotor gearbox.

History of the flight

The pilot, who also owned G-OJBB, was making a local flight from Hawarden Airport. The planned route was to fly to the west of Snowdonia National Park, then south to Barmouth where he would turn to the north-east, towards Bala Lake, before returning to Hawarden. Having completed his pre-flight checks, which included checking the tail rotor gearbox (TRGB)[1] and its oil quantity, the helicopter departed Hawarden at 1509 hrs.

Footnote

[1] In this report the terms tail rotor gearbox (TRGB), gearbox and transmission are used interchangeably.

The weather was dry and sunny, with visibility in excess of 9 km, few clouds at 2,900 ft amsl, a temperature of 21 °C, and QNH of 1027 hPa. The pilot was using a GPS navigation application installed on a tablet computer, which also recorded the helicopter's flight path.

The flight to Barmouth was uneventful and, having turned towards the north-east and Bala Lake, the helicopter approached Rhobell Fawr mountain, whose summit is approximately 2,400 ft amsl. As the helicopter approached Rhobell Fawr (Figure 1), the pilot noticed a stone obelisk[2] near its summit and decided to take a closer look. The pilot made a north-easterly approach towards the obelisk, with a recollection that the wind was from the south at about 10 kt. Having flown past the obelisk by about 20 m, he then brought the helicopter into a hover about two to three feet above an area of gently sloping ground. However, uncommanded by the pilot, the helicopter then rapidly yawed to the right before touching down heavily on its skids. The pilot recalled that the helicopter may have then briefly continued to yaw while on the ground before coming to a stop.

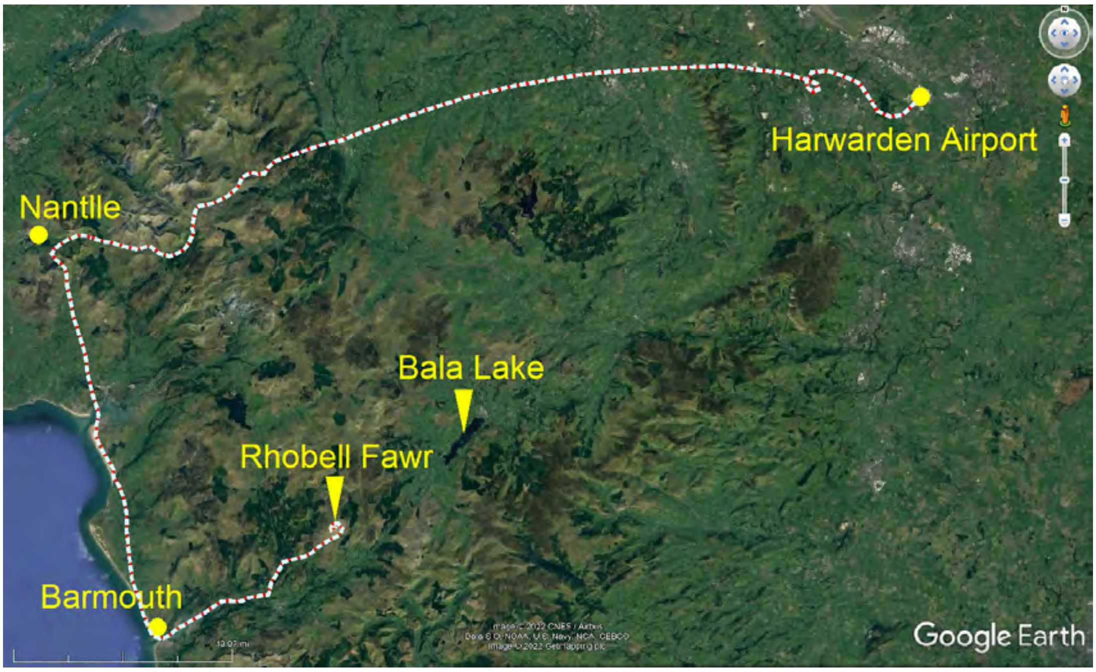


Figure 1

Flight track of G-OJBB (in dotted white/red)

Having selected the fuel and electrical systems off, the pilot vacated the cockpit using the right door. The helicopter's main rotors, tail boom and skids suffered substantial damage (Figures 2 and 3). The pilot sustained minor injuries to his right arm and left leg and was subsequently airlifted from the mountain by a Search and Rescue (SAR) helicopter which flew him to Caernarfon for treatment.

Footnote

[2] Rhobell Fawr triangulation station, also known as a trigonometrical point or informally as a 'trig point', is a fixed surveying point used in geodetic surveying.

The AAIB was notified of the accident and based on the initial information provided, did not deploy to the site, instead giving permission for the wreckage to be recovered by the owner. Two days after the accident, the pilot returned to the helicopter to start preparations for it to be airlifted from the mountain, which included detaching the main rotors and taping up the cockpit doors. During this activity, he did not see any signs of oil leaking, or having leaked, from the helicopter. A few days after this, a video recording of the helicopter while atop the mountain was posted on a social media website by a member of the public. This showed the tail rotor rotating freely in the wind, while the main rotor head remained stationary.

Figure 2

G-OJBB shortly after the accident

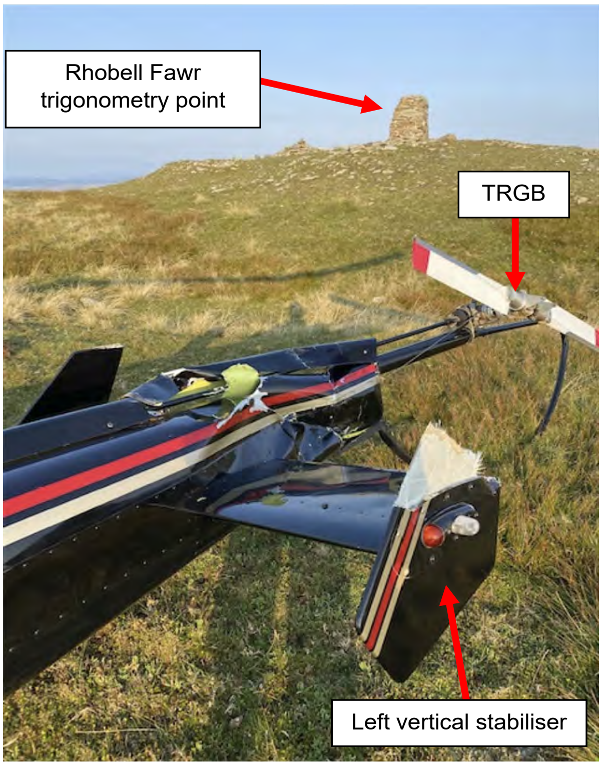


Figure 3

Damage to tail boom and left vertical stabiliser

Aircraft information

General

The Enstrom 280FX is a single engine light helicopter powered by a Lycoming HIO-360-F1AD piston engine. It is fitted with a three-bladed main rotor and a two-bladed teetering tail rotor driven by a TRGB mounted at the aft end of the tail boom (Figure 4). A drive shaft attached to the upper pulley of the main rotor transmission provides input drive to the TRGB. At a nominal engine speed of 3,050 rpm, the main rotor rotates at 351 rpm and the tail rotor at 2,514 rpm.

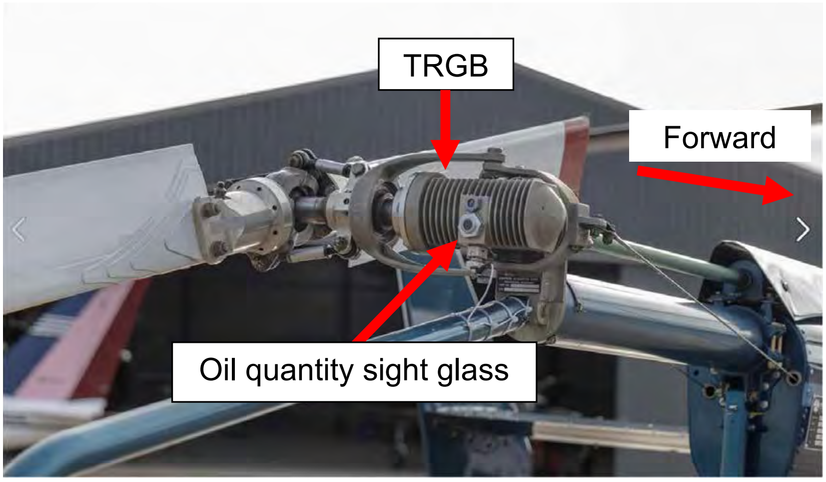


Figure 4
TRGB viewed from rear of 280FX helicopter

TRGB

The TRGB case is manufactured from aluminium and contains an input and output shaft that are each supported by two bearings, with drive between the shafts provided by bevel gears (Figure 5). The same TRGB design is also fitted to Enstrom F-28A, 280, F-28C, 280C and 480 helicopters.

The helicopter manufacturer specified that several alternate bearing part numbers could be used within the TRGB. The two bearings fitted to G-OJBB's input shaft, and the inner bearing on its output shaft, were the same part number[3]. These were fitted with ten balls and a cage manufactured from cotton-fibre reinforced phenolic resin, for which the maximum operating temperature specified by the bearing manufacturer was 107 °C. The outer bearing on the output shaft[4] was fitted with 13 balls and the cage could be manufactured from bronze, nylon or cotton-fibre reinforced phenolic resin. The helicopter manufacturer advised that during normal operation, the TRGB would reach a temperature not exceeding about 30 °C above ambient air temperature[5].

Footnote

[3] Enstrom part number ECD003-13.
[4] Enstrom part number ECD008-11.
[5] This was based on flight test data for its more powerful 480 model of helicopter, that is fitted with a larger rotor that rotated at higher speed than the 280FX.

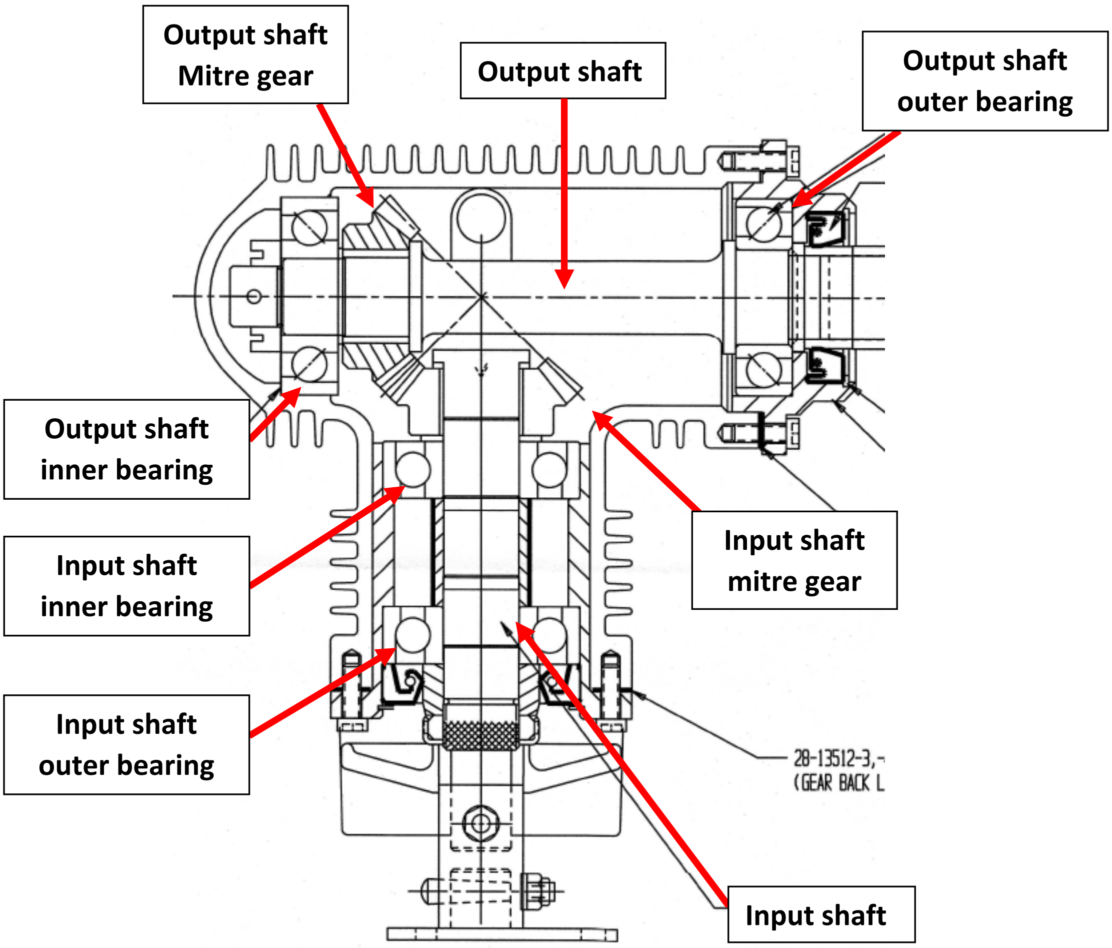


Figure 5

TRGB (reproduced with permission)

The bevel gears and bearings are splash lubricated by oil, with seals fitted to the input and output shafts to prevent oil loss from the unvented TRGB. At the rear of the TRGB case is an oil filler port and below this is an oil quantity sight glass[6] (Figure 6). Early Enstrom helicopters were fitted with a flat sight glass but, in 2008, a dome shaped sight glass was introduced in response to customer feedback, to improve readability. The domed sight glass was fitted to all new TRGB's, and those overhauled by the manufacturer since 2008. G-OJBB was fitted with an original flat sight glass.

On the top of the TRGB case is an inspection plug for the bevel gears, and on the underside, is a quick-disconnect magnetic plug that fits into a self-sealing oil drain plug; this prevents oil loss when the magnetic plug is removed for inspection. The oil circulating within the TRGB enables ferrous metal particles to flow to the magnetic plug. If the particles complete an electrical circuit between the tip of the plug and its outer body, or the case of the gearbox, a TRGB CHIP caution indicator on the cockpit instrument panel will illuminate.

Footnote

[6] The helicopter manufacturer's publications use the terms sight glass and sight gauge interchangeably.

The TRGB CHIP indicator bulb can be tested using a switch on the cockpit instrument panel, but this does not provide an end-to-end electrical test of the system.

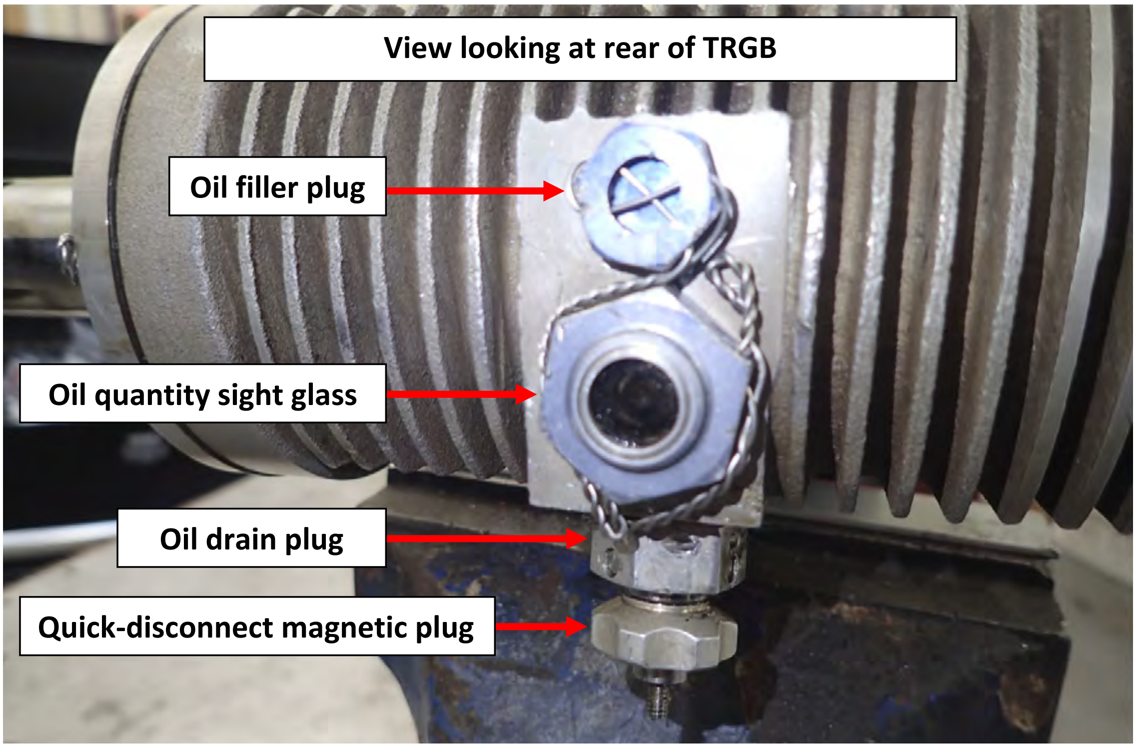


Figure 6

TRGB plugs and sight glass (G-OJBB)

Aircraft examination

Initial examination by pilot and engineer

The helicopter was recovered from the mountain approximately four weeks after the accident, and then transported to its owner's private site. The damage to the helicopter indicated that the main rotors had struck the rear of the tail boom, the tail rotor drive shaft and left rear stabiliser. This had deformed the fuselage, caused the coupling between the main gearbox and tail rotor drive shaft to fail, and severed the upper section of the left vertical stabiliser (Figure 7). The tail rotor blades were intact and their tips undamaged, although one blade had two small indentations adjacent to its leading edge. This was likely to have been caused by the blade striking the severed tip of the left stabiliser.

While the input shaft of the TRGB remained stationary, the output shaft and tail rotor could be turned by hand. The TRGB magnetic plug was subsequently removed and found to be covered in metal particles (Figure 8). The engineer reported that when the plug was initially removed, a few drops of oil dripped from the oil drain plug. The plug was then refitted and the TRGB and tail rotor were sent to the AAIB for detailed examination. Subsequent checks on the helicopter showed that the TRGB CHIP indicator in the cockpit operated correctly when the TRGB magnetic plug connector was electrically shorted to the airframe.

Figure 7
Broken tail rotor driveshaft coupling

Figure 8
TRGB magnetic plug
(Photograph taken shortly after G-OJBB was recovered from Rhobell Fawr)

TRGB examination

The TRGB and tail rotor were free of oil leaks and residue, such as oil staining or splashes on the TRGB case or blades. The TRGB access ports were correctly fitted and appropriately secured with wire locking. The magnetic plug was initially removed to obtain a sample of metallic particles, during which a small amount of oil (about 1 ml) was captured as it dripped from the drain plug. When the magnetic plug was refitted, the oil stopped leaking.

The inside glass of the oil sight glass appeared to be covered in dark brown oil. When the TRGB was tilted forward and backward, it was expected that the appearance of the sight glass would alter, as oil drained away from it, and then covered it over. However, there was no apparent change. The drain plug was then removed, and 16 ml of oil was drained from the TRGB. The oil had a metallic like appearance and when a magnet was passed through it, small metallic particles were evident. Combined with the oil that had dripped when removing the magnetic plug, a total of 17 ml of oil was collected from the TRGB.

Inspection of the bevel gears using a borescope inserted through the inspection port showed that the teeth on both gears exhibited extensive damage, and this allowed the input and output shaft to rotate independently of each other. The TRGB was then disassembled. The shafts, bevel gears, bearings, bearing housings and the internal surface of the TRGB case were coated in an oily sludge which had a metallic appearance.

Following removal of the input and output shaft assemblies, circumferential scoring was evident on the inside of the case, coincident with the position of the heel of the input shaft bevel gear. The scoring on the upper internal surface appeared clean, fresh and free from the oily sludge, while that on the bottom internal surface was coated in the oily sludge.

The teeth on both bevel gears were severely deformed to the extent that they had the appearance of an almost toothless cone (Figure 9).

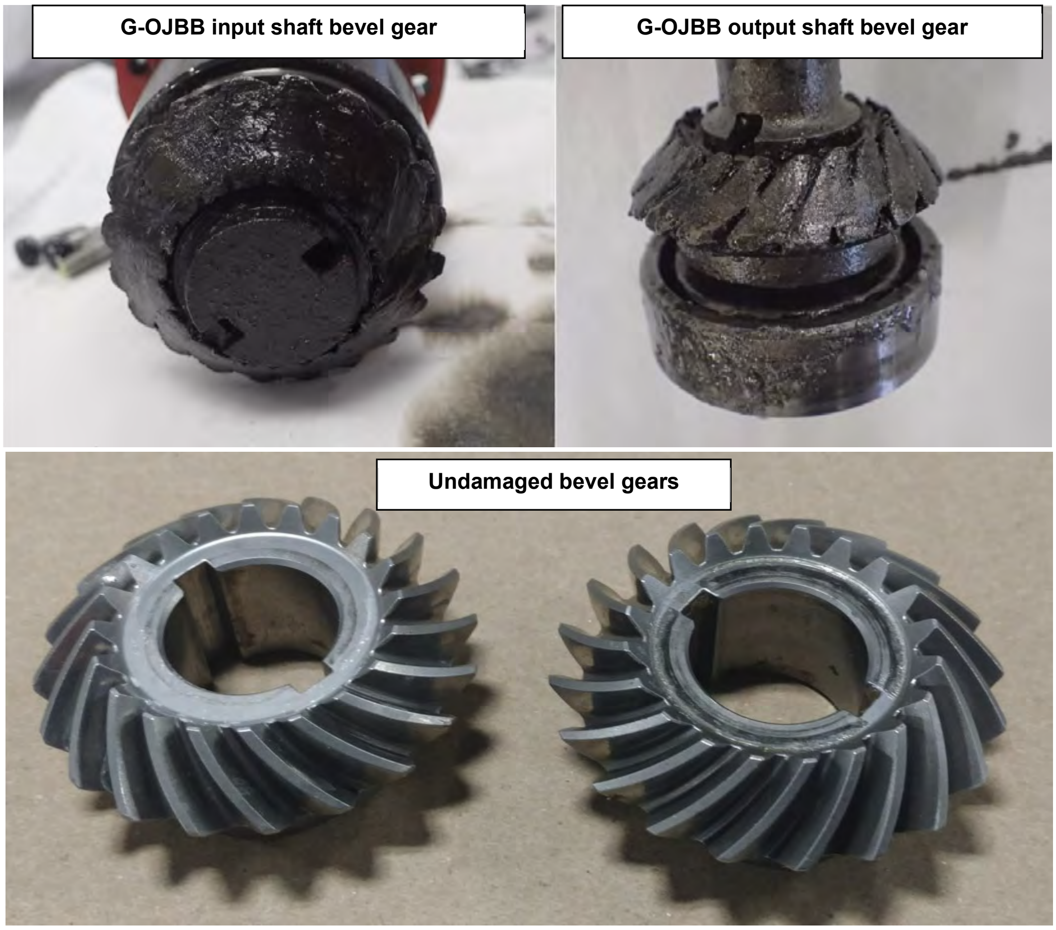


Figure 9

Damage to G-OJBB input and output shaft bevel gears

The two bearings on the output shaft, and the outer bearing on the input shaft, were intact, but felt rough when rotated. The cage of the input shaft, inner bearing had failed such that the 10 balls were no longer symmetrically positioned within the races.

Detailed metallurgical examination

The input shaft bevel gear and the four TRGB bearings were subject to detailed metallurgical examination.

On the input shaft bevel gear, the apexes of the teeth had folded over into the roots and the surface of the gear showed evidence of high temperature oxidation (blueing) in places (Figure 10). The damage to the output shaft bevel gear appeared similar.

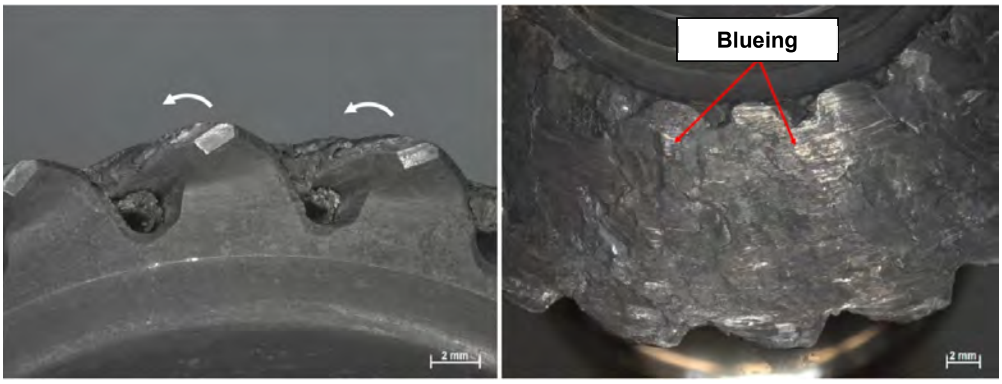


Figure 10

G-OJBB input shaft bevel gear

Input shaft, inner bearing

The bearing was an angular contact bearing having one heavy shoulder (thrust shoulder) and one lighter shoulder (non-thrust shoulder) on the outer race. In the installed position, the thrust shoulder would be on the forward face of the bearing.

Damage was present on the raceway over approximately one quarter of its circumference. The entire circumference of the non-thrust shoulder also exhibited damage (Figure 11).

Figure 11

Outer race of input shaft, inner bearing

Examination of the outer race in the scanning electron microscope (SEM) revealed that the damage in the raceway consisted of tongues of material pushed from the surface and smeared along it. Fragments of a foreign material had also been pressed into the raceway in some areas and Energy Dispersive X-Ray (EDX) analysis showed that it was aluminium. The damage on the non-thrust shoulder was similar but also included fractures, which appeared to have resulted from adhesive wear, with material torn from the surface and then rolled into adjacent areas.

The inner race was damaged around its full circumference, across the rear half of its raceway and rear shoulder. In contrast to the damage observed on the outer race, the inner race damage was heavily oxidised and showed evidence of blueing in places, as well as material tongues rolled into the surface (Figure 12). Material removal in the form of pits was evident in the raceway. The damage on the shoulder was consistent with balls having run along it.

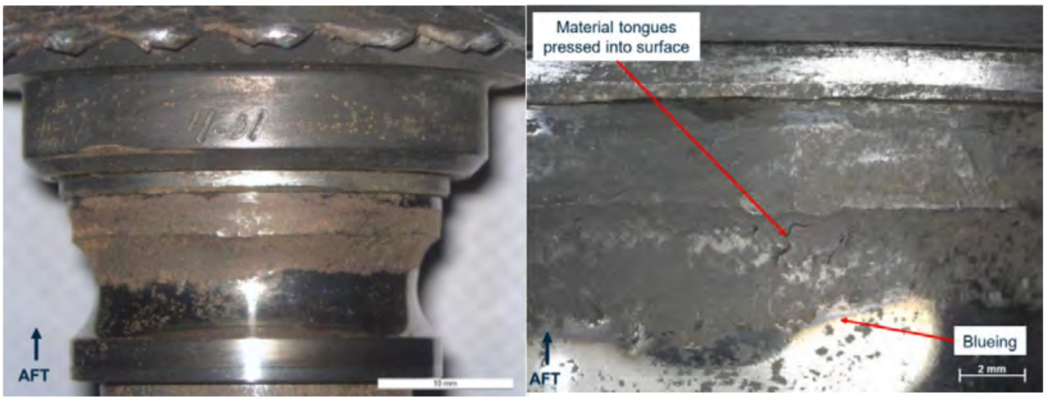


Figure 12

Inner race of input shaft, inner bearing

The surfaces of the 10 balls were deformed, with material removal, surface dents and tongues of smeared material present (Figure 13).

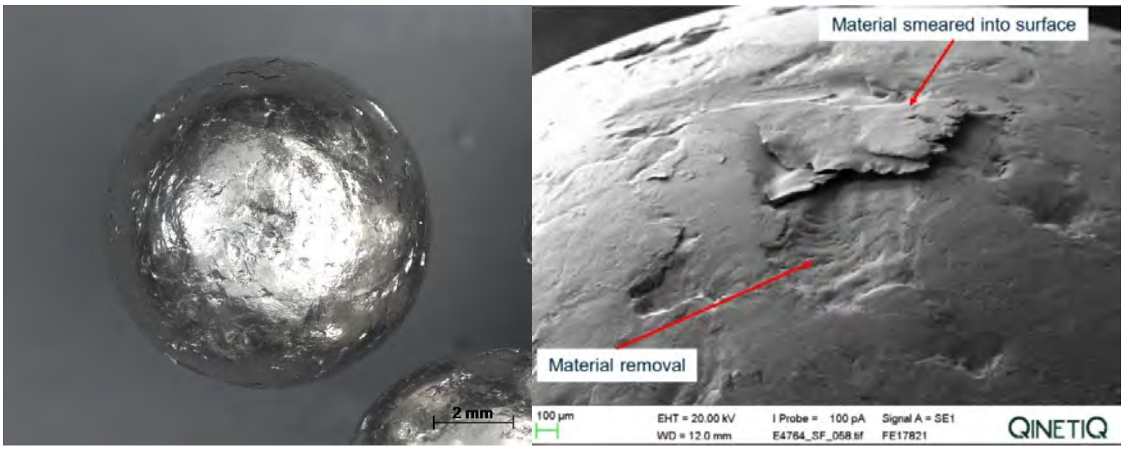


Figure 13

Example of damage to ball from input shaft, inner bearing (left) and detailed SEM view (right)

The bearing cage is a single-piece cotton-fibre reinforced phenolic resin cage, formed from two faces joined by axial posts. The cage had broken into eight pieces; one piece made up the whole of one face and the remaining seven pieces made up the other face (Figure 14). Material loss was evident on the inner circumference of the face that had broken into seven pieces, but not on the inner circumference of the intact face. SEM examination of one of the fractured axial posts showed cotton fibres present with very little phenolic resin visible. Resin was also missing from the sidewall adjacent to the fracture.

Figure 14

Cage from input shaft, inner bearing

Input shaft, outer bearing

The outer race contained a continual track of damage around the circumference of the bearing raceway, at the edge of the non-thrust shoulder. It consisted of tongues of material pushed into the surface and smeared along it. In some areas, it appeared that the material had spalled from the surface.

The inner race did not exhibit any material loss, although metallic debris had been rolled into the surface and indentations (brinelling) were present.

The cage appeared to be undamaged.

Output shaft, inner bearing

The inner race contained two areas of spalling damage and metallic debris had been rolled into the surface and indentations were present. The outer race had similar indentations and metallic debris as the inner race, but no material loss was evident. The cage had one area of mechanical damage.

Output shaft, outer bearing

Both the inner and outer race were in a similar condition, exhibiting surface indentations and metallic debris rolled into the surface. There was no evidence of spalling or smearing present on either raceway. The cage was undamaged.

Testing of G-OJBB's oil sight glass

Examination of the oil sight glass showed that it had dark coloured deposits of oil present on the inside of the glass (Figure 15). The sight glass was fitted to a test container and oil was then gradually added so that when viewed from the inside of the container, the oil level could be set at just below the sight, at its centre and above it. However, when viewing the oil level from the outside of the sight glass, its appearance did not significantly alter such that it was unclear as what level the oil was inside the container.

Figure 15
Oil quantity sight glass removed from G-OJBB's TRGB

The inside of the sight glass was then cleaned, before re-fitting it to the TRGB case, which had also been cleaned. The case was then sealed, and oil gradually added. As the oil quantity increased, it could be observed through the sight glass. Upon reaching the top of the glass, a bubble was present, but this disappeared on tilting the TRGB back and forth.

Testing of the magnetic plug

When the magnetic plug was circulated in the drained oil from the TRGB, metallic particles would collect on its tip, but did not provide an electrical short circuit path. However, upon agitating the metallic particles on the tip of the plug using air flow, it was possible to establish a short circuit.

Manufacturer's oil quantity measurement trial

Using a representative helicopter, the manufacturer performed a series of tests to ascertain the relationship between actual oil quantity and observed quantity using the TRGB sight glass. The helicopter was level on its skids and a flat sight glass was used during the testing, with the results provided in Table 1.

At an oil quantity of 15 ml and 18 ml, the manufacturer indicated that the oil level would drop somewhat during operation of the TRGB as the oil is splashed and lubricated.

Total oil quantity	Findings
15 ml	The oil level was below the level of the sight glass, and just above the bottom of the window in the adjacent magnetic plug housing. The heels of the bevel gear teeth were in the oil, but the oil level appeared to be below the outer race of the bearings closest to the filler port.
18 ml	The oil level was below the level of the sight glass. The magnetic plug was submerged in oil, but the top of the magnetic plug housing was not.
~ 45 ml	The oil level was just visible in the bottom of the sight glass. The magnetic plug was "thoroughly" submerged in oil.
~ 55 ml	The oil level was at approximately the centre of the sight glass.
~ 65 ml	There was a small bubble in the top of the sight glass.
~ 70 ml	The sight glass was full of oil, and no bubble was present.
~ 160 ml	Oil was seeping out of the filler port.

Table 1

Oil quantity test results

The manufacturer subsequently assessed the effect of the helicopter's attitude on the sight glass oil level, with 18 ml of oil in the TRGB. This was done on an F-28F helicopter, which has the same geometry as the 280FX. The TRGB was fitted with a domed sight glass. With the ground handling wheels extended, the helicopter's tail was 1.3° down from level and the oil was not visible in the sight glass (Figure 16). When the tail was lowered until it was approximately 5.5° below level, the oil level was at approximately the centre of the sight glass (Figure 17). Lowering the tail further to 8° below level resulted in only a slight change in the oil level (Figure 18).

Information from helicopter manufacturer's manuals

Pre-flight checks – TRGB

The manufacturer's Rotorcraft Flight Manual (RFM)[7], Section 4-5 *'Pre-flight inspection-Exterior'*, stated that the TRGB should be checked for oil leaks and oil quantity, with Section 8 *'Handling, Servicing and Maintenance'*, providing guidance on the appropriate oil quantity. This stated: '*The gauge should indicate filled at or near the top of the sight gauge with the aircraft in a relatively level position.*'

The helicopter manufacturer advised that its principal flight instructor also taught that the oil quantity "should definitely be more than three quarters full" on the sight glass.

Footnote

[7] Revision 13, which was extant at the time of the accident.

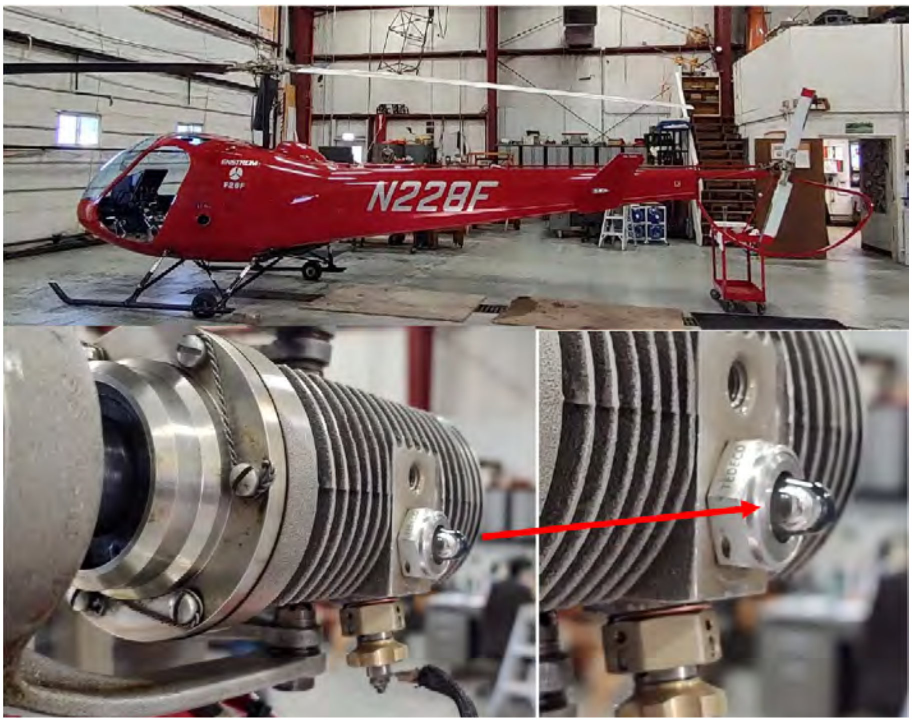


Figure 16

Helicopter at 1.3° tail-down from level

Figure 17

Helicopter at 5.5° tail-down from level

Figure 18
Helicopter at 8° tail-down from level

The RFM also required that the annunciator panel indicators should be checked on the instrument panel prior to flight, which included the TRGB CHIP indicator as fitted to G-OJBB.

Maintenance requirements – TRGB

The helicopter manufacturer's Maintenance Manual (MM)[8] and MM Supplement (MMS), contained multiple references relating to the servicing requirements and required oil quantity for the TRGB. These included the following:

- MM Section 4-2, *'Description-Servicing'* stated: '*Servicing of F-28/280F series helicopter is normally accomplished at specified hourly intervals.'* For the tail rotor transmission, it stated (in Table 4-1) that the oil quantity was '*5 US Ounces/.15 Litres*' and specified (in Table 4-2) the service interval as '*100 hours/As Required*.'

- MM Section 4-15, *'Servicing Tail Rotor Transmission'* included the following note: '*When the tail rotor transmission is properly serviced (5 oz/.147 l), the sight glass will be completely full. The transmission oil level is serviceable until the oil level is at the center* [sic] *of the sight glass.*' The procedure

Footnote

[8] Enstrom F-28 and 280F series maintenance manual, Revision 12, which was extant at the time of the accident.

included advice to raise and lower the tail to '*change the attitude'* of the helicopter, in order to verify the oil level if a bubble was present in the sight glass. It contained the procedural *step: 'Add 5oz./.147l of oil if servicing the transmission after draining or slowly add oil until oil flows from the filler port'.*

- MM Section 4-45, *'Recommended overhaul cycles'* stated that the overhaul period for the TRGB was every '*1200 Hrs'*.
- MMS 25-3, *'Tail Rotor Gearbox Chip Detector'* stated: *'The tail rotor gearbox lubricant should be changed every 100 hours…'.*

Section 4.49 to 4.53 of the MM included periodic inspection checklists to be followed for 50 hr, 100 hr, annual, 200 hr and 400 hr checks.

- MM Section 4-49, *'Periodic Inspection Checklists'* stated: *'Perform a 100 hour inspection as a minimum, to meet the requirements for an Annual inspection'.*
- MM Section 4-51, *'100 Hour/Annual Inspection Guide, Periodic Inspection'* included the following three separate steps for the tail rotor transmission: '*1) Inspect the transmission for leaks… 2) Drain the transmission and inspect the magnetic plug/chip detector for the presence of particles* and *3) Service the transmission*.'

Discussions with the helicopter manufacturer indicated that its intent was for the oil in the gearbox to be replaced every 100 hours or annually, whichever comes first but wording to reflect this did not appear in the MM.

Maintenance requirements – main rotor gearbox

The main rotor gearbox oil quantity is also checked using an oil sight glass. MM Section 4-12, 'Servicing Main Rotor Transmission' stated: *'With the helicopter in a relatively level position, the oil level should be at or near the halfway level of the sight gauge. If oil is visible, no additional oil is required. If oil is not visible, add oil until the oil level is half way up the sight gauge.'*

Metallic chips/particles – MM instructions and guidance

Information regarding metallic particles was provided in MM Section 4-62, *'Main Rotor or Tail Rotor Transmission Chip Indication – Special Instructions'*. This advised that a new or recently overhauled main gearbox or TRGB will often make a magnetic *'fuzz'* which will collect on the magnetic plug as a grey sludge. It described the sludge as *'a mixture of oil and fine metal particles resulting from normal gear operation'* and that this was normal, and the sludge may be cleaned off the plug before refitting it.

If any magnetic particles with a cross section of larger than *'.065 inch/1.65mm'* were found in the main gearbox, or *'.035 inch/.9 mm"* in the TRGB, the aircraft was to be removed from service until further instructions were received from the helicopter manufacturer.

Section 4-62 also stated: *'Sludge normally will not cause a chip indication by itself. There is normally a small particle, flake or sliver on the detector also.'*

MM Section 10-5 *'Tail rotor gearbox'* also provided a troubleshooting guide, that included the following information:

Cause	***Problem***	***Required Action***
Large pieces or slivers of metal flaking from gears or bearings.	*Excessive metal particles on mag plug.*	*Return to factory or overhaul facility for overhaul.*
Fine powdery-type metal can result from normal gear break-in.		*Drain oil from gearbox. Flush with kerosene or equivalent cleaner. Clean map[sic] plug and reinstall. Fill gearbox with oil and recheck mag plug after 10 hours. NOTE: If excessive metal appears at this point, return gearbox for overhaul inspection.*

The MM did not provide photographs that depicted *'excessive metal particles'*, *'fuzz' or 'sludge'*.

Metallic chips/particles – helicopter manufacturer experience

The helicopter manufacturer's experience of TRGBs returned for overhaul because metallic particles had been found, was that the metallic particles were predominantly from the bearings. It advised that no specific bearing position was more prone to releasing metallic particles than others and, in general, pre-existing maintenance requirements had resulted in the removal of gearboxes from service before a failure could occur.

G-OJBB background and operational experience

G-OJBB was manufactured in 1999. In September 2002, at 371 flying hours, the TRGB was replaced with an overhauled unit provided by the helicopter manufacturer.

The pilot purchased G-OJBB in 2014, when it had about 800 hours flight time, and the TRGB about 430 hours since overhaul. It was thereafter operated from Hawarden Airport, where it was also hangered. At the time of the accident, the helicopter had accrued 1,085 flying hours, and the TRGB 723 hours since overhaul.

Since purchasing G-OJBB, the pilot was the only person to have routinely flown it. During his ownership, he reported that the TRGB had been free from oil leaks, with no maintenance required to top up the oil level between annual services. The pilot also reported that he had not observed the TRGB CHIP indicator illuminate, other than when checking its operation prior to flight.

The pilot reported that his initial walk around checks included checking the TRGB oil quantity in the sight glass. He stated that with the helicopter in a level attitude the oil quantity in the TRGB should "be at the centre of the sight glass", which was what he had been taught since learning to fly in an Enstrom 280C in 1996.

G-OJBB maintenance – TRGB

Recent maintenance

G-OJBB's most recent maintenance inspection was carried out on 7 March 2021, at 1,069 flying hours and 697 hours since overhaul of the TRGB. This was an annual inspection and was performed by the same engineer who had maintained G-OJBB since 2015. The engineer stated that during the inspection, he had completed a "full service" on the TRGB, which he explained included draining and replenishing its oil. This was reflected in the maintenance worksheets for the annual inspection which included copies of the 100 hour / annual checklist from the manufacturer's MM and each of the items relating to the servicing of the tail rotor transmission was signed off. The logbook certificate for the annual inspection included the statement *'100 Hr/Annual inspection carried out in accordance with the Enstrom Maintenance Manual.'*

G-OJBB's Airworthiness Review Certificate was valid until 22 March 2022.

Previous maintenance

The engineer stated that he had also changed the oil in G-OJBB's TRGB during the annual maintenance inspections in August 2015 at 889 flying hours, and October 2017 at 988 flying hours. However, he had not changed the TRGB oil during the annual inspections in August 2016, January 2019, and February 2020 due the low utilisation of the helicopter. He considered that changing the oil was only required every 100 hours of operation and G-OJBB never achieved this in the intervals between annual inspections[9].

The engineer was unable to produce the corresponding worksheets for the annual inspections carried out between 2015 and 2020, advising that they had been lost during a flood of his premises. However, he indicated that he would have recorded the work in the same manner as the 2021 annual inspection, by signing the three checklist items for the tail rotor transmission, on those occasions when the TRGB oil had been drained and replaced, and on those when it had only been checked or topped up.

G-OJBB's signed logbook certificates for each of the annual inspections carried out between 2015 and 2020, contained the statements *'12 monthly inspection carried out in accordance with CAA LAMP(H)2007 Iss1[10]'* and *'100Hr inspection carried out in accordance with Enstrom Maintenance Manual.'*

Footnote

9 Since 2015, G-OJBB's annual utilisation varied between 21 and 52 hours.

10 This refers to the CAA Light Aircraft Maintenance Programme (Helicopters), known as LAMP (H), which has since been discontinued, having been supersede by Part-ML.

Engineer's understanding of and approach to TRGB servicing requirements

When questioned about the servicing requirements for the TRGB, the engineer advised that his understanding was that the TRGB fitted to F-28A, 280, F-28C and 280C models of Enstrom helicopters was to be "fully serviced every 100 hours". He explained that due to the relatively low annual flying hours of private owners, it could be several years before he renewed the oil in the TRGB of those helicopters he maintained. He stated that this was based on his interpretation of the MM and pointed out the MM included instructions to change the TRGB oil every 100 hours. He confirmed that this had been his understanding for many years.

When fully servicing the gearbox, the engineer stated that he would drain and renew the oil, clean the sight glass if required, and check for oil leaks after a ground run. He would also check the magnetic plug and the drained oil for magnetic particles. He described that the drained oil was normally dark brown in colour, and he would filter it through fine filter paper to collect any particles, having thinned the oil using AVGAS. Having refitted the drain plug and sight glass, the engineer would check that the helicopter was level and then, having measured 5 fluid ounces of oil into a measuring jug[11], slowly fill the gearbox via its filler port using a syringe. He would then turn the tail rotor several times, to assist in distributing the oil within the gearbox, before checking the sight glass. He stated that he expected the oil quantity "to be in the centre of the sight glass". He stated that sometimes he would get the entire 5 fluid ounces in the TRGB and sometimes he would not; it depended on the exact orientation of the TRGB.

At an annual inspection, when the helicopter had not flown 100 hours since the last TRGB oil change, the engineer stated that he would check the TRGB for oil leaks, check the magnetic plug for metal particles and check that the oil quantity was "at the centre of the sight glass". He advised that occasionally, a few drips of oil could be lost when the magnetic plug was removed, in which case he would top up the oil quantity. However, he stated that this could result in the oil level then increasing above the centre of the sight glass, and if that happened, he would then drain some oil until it was back at the centre.

When checking the magnetic plug, the engineer advised that he would normally expect to see some "fuzz" on it, which he described as "looking like carbon and had hairlines that are black, not shiny". He stated that he would consider this as normal and clean it from the plug before re-fitting it. Some years previously, the engineer had observed large "metallic flakes" during maintenance of two other Enstrom helicopters. Both those gearboxes were removed from service and sent for overhaul. He stated that he had never seen anything similar when inspecting the magnetic plug from G-OJBB.

The engineer further commented that he found the new style dome shaped oil sight glass easier to read than the flat type fitted to G-OJBB. He also said that during each annual inspection of G-OJBB, he would test the electrical chip detector system by touching the tip

Footnote

[11] The jug used by the engineer was scaled with metric and imperial measurements. The engineer advised that he would normally measure quantities using imperial units.

of the magnetic plug against the gearbox case and checking that the TRGB CHIP indicator illuminated in the cockpit.

Maintenance personnel

The engineer was experienced having started working on helicopters in the 1960's and had attended Enstrom training courses in the late 1980's and 1990's, which included maintenance of 280F series helicopters. He also worked on other helicopter types, which included those manufactured by Robinson and Bell. He held a valid EASA Part 66 category B1 aircraft maintenance licence issued by the CAA which entitled him to work on piston and turbine helicopters. He also held a type rating on the Enstrom 480.

The engineer advised that he had previously owned a maintenance organisation which held Part 145 and Part M approvals, and he had maintained helicopters for flying schools and private owners under these approvals. However, he relinquished the approvals around 2015. Thereafter, using the privileges of his licence, he continued to maintain only those helicopters operated privately.

G-OJBB's owner engaged a separate organisation which held a Part M approval to conduct the annual Airworthiness Review on G-OJBB.

Light helicopter maintenance intervals

CAA position

The CAA General Aviation Unit advised that the accepted philosophy in the industry was 100 hour check items should be accomplished at 100 hours or the annual inspection, whichever comes first. It expected this concept to be commonly understood among licensed engineers.

Regulatory requirements

G-OJBB was historically maintained under the UK CAA's generic Light Aircraft Maintenance Programme (Helicopters), known as (LAMP(H)), as well as the aircraft and engine manufacturers' maintenance inspection schedule. On 24 March 2020 Part M Light (Part-ML) under Regulation (EU) 2019/1383[12,13] came into force as the continuing airworthiness standard for all EASA-regulated general aviation light aircraft (including light rotorcraft) and LAMP(H) became obsolete.

Footnote

12 Regulation (EU)2019/1383 came in as an amendment to Regulation (EU) 1321/2014, known as Part M.

13 This is a retained regulation in the UK following the UK's exit from the European Union and is therefore still applicable at the time of publication of this report.

Prior to its withdrawal, LAMP(H) included the following information on maintenance intervals:

The Maintenance Check Cycle

Check title	Content	Period
Pilot pre-flight	Refer to helicopter flight manual	Prior to every flight
Check A	Check A	Prior to first flight of the day
50 hour check	50 hour check items	Not exceeding 50 flying hours or 6 months, whichever is the sooner
100 hour check	50 and 100 hour check items	Not exceeding 100 flying hours
Annual check	50, 100 hour and annual check items	Not exceeding 12 months

The LAMP(H) generic maintenance schedule contained the following single item for transmission servicing in the *'Annual check/Non-Aligned tasks'* section, which applied equally to the main and tail rotor transmissions.

Transmission Lubrication:

84	Transmission oil change. Oil filter and screens. **Note:** In accordance with type design organisation recommendations. Next due:	SERVICE	100 FH or see Note		

The introduction of Part-ML formally transferred responsibility for all aspects of owning and maintaining an aircraft to the aircraft owner, including development of an Aircraft Maintenance Programme (AMP) that does not require an approval from the CAA. This is known as a Self-Declared Maintenance Programme (SDMP). For many aircraft categories, the owner can decide to base the SDMP either on the manufacturer's recommendations or on the EASA published Minimum Inspection Programme (MIP), as long as the SDMP is not less restrictive than the MIP. All applicable aircraft were required to transition to a Part-ML compliant AMP not later than 24 March 2021.

Part-ML does not contain a MIP for rotorcraft and therefore the SDMP must be based on the continuing airworthiness instructions issued by the Design Approval Holder (DAH). Any deviations from the DAH's maintenance recommendations must be documented in the SDMP. G-OJBB transitioned to an SDMP in August 2020, and it was based on the helicopter and engine manufacturer's recommended maintenance schedule. No deviations were documented.

When creating G-OJBB's SDMP the engineer stated that he did not include a documented deviation from the manufacturer's recommended 100 hour/annual inspection checklist, because in practical terms there was no change to the work he had been doing for many years and he believed his interpretation of the maintenance interval was correct. He considered there would be no change to this under the SDMP.

For other aircraft categories which do have a MIP included in Part-ML, the MIP contains the following information with regards to maintenance intervals: *'To be performed at every annual/100 h interval, whichever comes first.'* In the absence of a MIP, no equivalent wording appears in Part-ML relating to light rotorcraft.

Manufacturer position

The helicopter manufacturer indicated that as the checklist for the 100 hour/annual inspection contained an item requiring the TRGB to be drained and refilled, in order to complete an annual inspection in accordance with its instructions, the oil must be changed. It considered this checklist item could not be signed off without completing the step. As many privately owned aircraft never achieve 100 flying hours within a calendar year, the manufacturer stated its intent was that this task would be completed at whichever maintenance interval comes first. The helicopter manufacturer was not aware of this issue having arisen before.

The helicopter manufacturer also indicated that under the FAA airworthiness regime, every aircraft is required to have an annual inspection for renewal of its certificate of airworthiness. The MM Section 4-49 indicated a 100 hour inspection should be completed as a minimum to meet the requirements for an annual inspection.

With specific regards to the implications of the TRGB oil not being replaced for several years, even if the aircraft was below the 100 hour threshold, the helicopter manufacturer advised that more frequent servicing provides more opportunities to identify any problems, defects or degradation within the TRGB. Furthermore, if the extended interval between servicing was due to a prolonged period of disuse, oil would run off the top half of the TRGB bearings and they may become susceptible to corrosion. No other specific issues were identified.

When queried about the engineer's practice of filling the TRGB until oil was halfway up the sight glass, the helicopter manufacturer advised that in its experience, as long as you see oil in the sight glass, it should be enough to provide lubrication. At half sight glass, the TRGB is airworthy, but it is at the bottom limit of what is acceptable and provides no contingency, such as in the case of minor leakage from the internal seals.

Previous event

On 7 July 1994, an Aerospatiale AS355F1 helicopter, registration G-SASU, was performing an air test following maintenance, when the TRGB chip detector warning light illuminated. The aircraft yawed left while also rolling violently to the right, but the pilot was able to regain sufficient control to land the helicopter safely. The AAIB investigation[14] of this incident identified that oil had leaked out the TRGB during maintenance, but this had gone undetected as the oil sight glass was darkly stained, providing an illusion that the oil level was satisfactory. The TRGB had subsequently overheated and damage within the TRGB led to a loss of tail rotor thrust.

Footnote

[14] https://www.gov.uk/aaib-reports/aerospatiale-as355f1-ecureuil-ii-g-sasu-7-july-1994 [accessed 30 August 2022].

Analysis

Introduction

When G-OJBB's TRGB was drained at the AAIB facilities, approximately 17 ml of oil was recovered. This was substantially less than the required amount specified by the helicopter manufacturer and would have been insufficient to lubricate and cool the TRGB bearings and bevel gears. Physical evidence from the examination of the TRGB examination was consistent with failure of the input shaft inner bearing due to overheating, resulting from a lack of lubrication.

TRGB failure

Reduced lubrication would have caused increased friction in the rolling elements of the bearings, resulting in excessive temperatures. Evidence of overheating (blueing) and oxidation on the inner race of the input shaft inner bearing indicated that the bearing had been running hot. An absence of similar indications on the outer race suggested that the inner race was running hotter than the outer race; possibly because the outer race was in contact with the TRGB casing that is air cooled. The bearing cage showed evidence of resin loss, indicating that it had likely exceeded its maximum operating temperature of 107 ºC. This would have made the cage brittle. Increased drag on the cage by the balls due to a lack of lubrication is likely to have caused the cage to fail, especially in its embrittled condition. The final failure may have been precipitated by the higher loads that would have been placed on the transmission as the pilot brought the helicopter into the hover.

Once the bearing cage had failed, the balls within the bearing would no longer be separated or equally spaced. This would allow contact between adjacent balls (with an associated increase in friction and temperature), unequal loading, and damage to both the raceways and balls. Damage observed on the shoulders of both raceways provided evidence that the balls had moved out of the raceway. Either this, or grouping together of all the balls, is likely to have caused the input shaft to move out of axial alignment. Loss of alignment would alter the normal engagement of the input and output bevel gears so that they could move apart. This in turn would result in increased contact between the tips of the teeth, leading to skipping and deformation. When the deformation progressed to the extent that the gears were effectively 'toothless' (Figure 7), there would have been no effective connection between the TRGB input and output shafts. At this point, the anti-torque thrust from the tail rotor would have been lost, resulting in the rapid rotation of the helicopter and subsequent loss of control.

Examination of the remaining TRGB bearings showed that two of the three exhibited a similar pattern of spalling and smearing damage as the input shaft inner bearing but were at a less advanced stage of degradation.

Magnetic plug chip detector operation

The metallic fragments in the TRGB oil would have been created when ferrous bearing material was liberated as a result of spalling during the bearing failure sequence. From the photograph of the magnetic plug taken shortly after the helicopter was recovered (Figure 6) and from the extent of damage subsequently found within the TRGB, it was considered that the TRGB CHIP indicator light in the cockpit should have illuminated. However, the pilot reported that he had not seen it illuminate during either the accident flight, or any preceding, flight.

Testing of the indicator light and associated wiring to the plug by the engineer did not identify a fault in the system. The AAIB found during testing that when the magnetic plug was drawn through the TRGB oil to collect metallic particles on its tip, a short circuit path was not established. However, following agitation of the particles, a short circuit was then created. Therefore, it is possible that the TRGB CHIP indicator light did not illuminate because the low quantity of oil found in the TRGB, which may not have been sufficient to submerge the plug when the TRGB was operating, either did not provide sufficient agitation of the particles or did not enable larger debris to reach the plug.

TRGB servicing information in the maintenance manual

The engineer's target fill level when replenishing the TRGB oil was the centre of the sight glass. This differed from the MM Section 4-15 servicing requirement which stated: *Add 5oz./.147 l of oil if servicing the transmission after draining or slowly add oil until oil flows from the filler port'.*

It was not clear how the engineer had come to this understanding, but the investigation considered factors which may have contributed. Of note is that the target oil level for the main rotor gearbox is at the centre of the sight glass, and this may have been a source of confusion. Additionally, MM Section 4-15 included a note which stated that: *'When the tail rotor transmission is properly serviced (5 oz/.147 l), the sight glass will be completely full. The* [tail rotor] *transmission oil level is serviceable until the oil level is at the center* [sic] *of the sight glass.*' The language employed in the second sentence of this note focuses solely on the serviceable condition. It does not draw attention to the point at which the TRGB oil level would become unserviceable, nor contain any cautions or warnings regarding the TRGB oil level. Nor did this section highlight the different target fill levels for the main and tail rotor gearboxes. Therefore, the following Safety Recommendation is made:

Safety Recommendation: 2023-001

It is recommended that Enstrom Helicopter Corporation amends the wording in Section 4-15 of the Enstrom F28F and 280F series Maintenance Manual, to clearly identify the minimum and maximum oil levels required for tail rotor gearbox operation.

The MM was not consistent in the quantity of oil specified for the TRGB, with three differing values quoted: '*5 ounces/.15 litres*', '*5 US Ounces/.15 Litres*' and '*5 oz /.147* l'. Although the difference between 5 US ounces and 5 imperial ounces is less than 6 ml, and which alone would not result in significant underfilling of the TRGB oil level such that it was unserviceable, it could result in less than the optimum amount of oil being added during maintenance. Additionally, inconsistency in the specified quantity could create confusion.

Therefore, the following Safety Recommendation is made:

Safety Recommendation: 2023-002

It is recommended that Enstrom Helicopter Corporation amends the Enstrom F28F and 280F series Maintenance Manual to achieve a consistent reference to the required quantity of oil for the tail rotor gearbox.

100 hour and annual maintenance requirements

The engineer stated that he changed G-OJBB's TRGB oil every 100 hours, indicating that this was his interpretation of the information in the MM. The helicopter manufacturer indicated that the intent of the MM instructions was for the TRGB oil to be replaced every 100 hours or annually, which ever came sooner. However, the MM and MMS did not include specific wording to this effect.

Servicing intervals for the TRGB were specified in the MM and MMS as '*100 hours/As Required*' and '*… every 100 hours*'. While MM Section 4-49, indicated that a 100 hour inspection should be completed as a minimum to meet the requirements for an annual inspection, no equivalent statement appeared in the 100 hour/annual checklist itself.

Up to August 2020 G-OJBB was maintained under the CAA's LAMP(H), which stated that 50 hour, 100 hour and annual check items should be accomplished at an annual inspection. For the task specifically relating to transmission oil change it stipulated a maintenance interval of 100 hours or *'in accordance with the type design organisation recommendations.'* G-OJBB's maintenance programme (SDMP) at the time of the accident was based entirely on the helicopter and engine manufacturer's recommended maintenance schedule.

Part-ML does not define a MIP for light rotorcraft and therefore contains no additional requirements for the periodicity of specific maintenance inspections. The absence of such information in regulation places emphasis on the need for clarity in the manufacturer's maintenance instructions, therefore, the following Safety Recommendation is made:

Safety Recommendation: 2023-003

It is recommended that Enstrom Helicopter Corporation amends the 100 hr/Annual checklist and other related sections of the Enstrom F28F and 280F series Maintenance Manual to clearly reflect the intended periodicity for changing the tail rotor transmission oil.

Based on the engineer's stated approach, G-OJBB's TRGB oil is likely to have been replaced a maximum of three times between 2015 and March 2021, with 41 months between the previous change in 2017 and that in 2021. The manufacturer advised that routine changing of the oil every 100 hours, or every calendar year for low utilisation helicopters, provides more opportunities to identify any problems, defects or degradation within the TRGB. If the helicopter was not flying routinely between oil changes, the TRGB bearings may become susceptible to corrosion. But aside from those issues, it did not identify specific concerns with the cooling or lubricating performance of the oil if maintained at a serviceable level.

Maintenance documents

There were three tasks in the 100 hour/annual checklist relating to the TRGB. The worksheets for the annual inspections between 2015 and 2020 were not available to the investigation, but the engineer advised that he would sign off all three tasks, even on those occasions where he did not drain and replenish the TRGB oil. The signed logbook certificates for the annual inspections between 2015 and 2021 contained a statement that the work had been carried out in accordance with the MM, and no deviation was documented in the SDMP relating to changing the TRGB oil. Therefore, even if the previous worksheets had been available, these would not have provided clarification of when the TRGB oil had or had not been replaced. This information was only available due to the engineer's recollection of having changed the oil and his stated approach to servicing intervals.

March 2021 annual inspection

G-OJBB's most recent annual inspection in March 2021 was carried out four months and 25 flying hours before the accident, during which the engineer stated he drained and replaced the TRGB oil.

The engineer reported that he had not been alerted to anything unusual when he examined the magnetic plug and the drained oil. He stated that he normally expected to see some "fuzz" on the magnetic plug, which he described as "looking like carbon and had hairlines that are black, not shiny". The MM described that TRGBs in normal service may generate fuzz or grey sludge which was a mixture of oil and fine metal particles. The findings of the engineer appear consistent with the MM information, but the MM did not contain any images which may help identify the different types of metallic particles or debris.

Based on the available information, since 2015 when the engineer had started servicing G-OJBB, the TRGB had been operated with an oil level which was at, or close to the centre of the sight glass. This was at, or close to, the level below which the helicopter manufacturer considered the TRGB oil level to be unserviceable. Despite this, and the infrequent changing of the oil, there was no reported evidence that it had resulted in anything other than normal wear products being apparent on the magnetic plug, up to and including the annual inspection in March 2021.

The engineer described his approach to refilling the TRGB as measuring 5 imperial fluid ounces (142 ml) into a measuring jug and then using a syringe to add oil through the filler port. In aiming to achieve an oil level at the centre of the sight glass (which the helicopter manufacturer indicated to be about 55 ml), this would result in a substantial amount of oil being left in the jug.

Following the accident approximately 17 ml of oil was recovered from the TRGB. This was 130 ml (88%) less than the amount specified in the MM and 38 ml (~70%) less than the 55 ml required to fill the oil level to the centre of the sight glass. There was no evidence of oil having leaked from the TRGB at any point prior to or after the accident, other than a few drops when the magnetic plug had been initially checked, which raised the possibility that on this occasion, the engineer added even less oil than he was normally accustomed to doing.

The sight glass was found to be covered in dark deposits. Testing showed that in this condition, it did not provide a clear indication of the actual oil level. The engineer could not recall if he had cleaned the sight glass during the annual inspection. If not, it is possible that the deposits on the glass affected the engineer's ability to read the oil level. Several similarities were noted with a previous serious incident investigated by the AAIB on another helicopter type, which resulted in an insufficient quantity of oil in the TRGB. In that case the sight glass was darkly stained and gave the illusion of a satisfactory oil level.

The flat sight glass fitted to G-OJBB was acknowledged by the engineer and the helicopter manufacturer to be more difficult to read than the domed style sight glass fitted to some Enstrom helicopters. However, when the sight glass from G-OJBB was cleaned and tested, the oil level was apparent.

Pilot's understanding of oil level and measurement

The pilot stated that since learning to fly an Enstrom 280C helicopter in 1996, he had been taught that the TRGB oil level was to be at the centre of the sight glass. It was not established why this misunderstanding came about, although one possibility is that the check had inadvertently been aligned with the main rotor transmission oil level, which is to be at the centre of the sight glass.

With 18 ml of oil in the TRGB, an amount close to that recovered from the TRGB after the accident, the manufacturer demonstrated that the helicopter's tail would have to be about 5.5° below level, in order for the oil level to be at the centre of the sight glass. At this attitude, the helicopter is noticeably nose-high/ tail-low (Figure 17) and the skids no longer parallel to the ground. The pilot did not report having to lower the helicopter's tail more than normal when checking the TRGB oil level following its return from the annual inspection in March 2021. However, if deposits had been present on the sight glass, this may have affected the pilot's ability to correctly read the oil level and may explain why he did not identify the low oil level during pre-flight checks.

Conclusion

The helicopter suffered a loss of tail rotor drive close to the ground, following a failure of the TRGB. The quantity of oil found in the TRGB was insufficient to have provided adequate cooling and lubrication of its bearings and gears. This led to the break-up of one of the internal bearings and ultimately to a loss of output from the TRGB. There were several inconsistencies between the way maintenance was performed on the TRGB and the prescribed procedures in the maintenance manual.

Published: 5 January 2023.

ACCIDENT

Aircraft Type and Registration:	DG-300 Elan, G-CKJH
No & Type of Engines:	None
Year of Manufacture:	2004 (Serial no: 3E506)
Date & Time (UTC):	7 July 2022 at 1730 hrs
Location:	Near Winchcombe, Gloucestershire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Fatal) Passengers - N/A
Nature of Damage:	Impact damage to lower forward fuselage, broken canopy, and damage to both wings. Main landing gear forced back into wheel well
Commander's Licence:	N/A
Commander's Age:	85 years
Commander's Flying Experience:	Approximately 3,900 hours Last 90 days - 24 hours Last 28 days - 13 hours
Information Source:	AAIB Field Investigation

Synopsis

With the end of the flying day approaching, the pilot of G-CKJH decided to land in a field. The field chosen was uphill with a rough surface which the pilot had not fully appreciated until he was committed to the landing. On the first touchdown, the glider landed heavily and bounced. The pilot felt his neck had been injured in this first touchdown. The glider ended up embedded in a stock fence. The pilot was able to extract himself from the glider but after a few steps he began to lose feeling in his limbs and fell to the ground. Having been discovered by the landowner, he was flown by air ambulance to hospital where scans revealed a fracture in his C7 vertebrae and a large haematoma which was pressing on his spinal cord causing the paralysis. Although the pilot began to recover feeling in his limbs, complications from his injuries and underlying medical conditions lead to his death 20 days after the accident.

Given the experience of the pilot, the choice of field was out of character. However, the position of the sun, the size and colour of other fields and their crops as well as the possibility of dehydration during a warm day may have contributed to the decisions that the pilot made.

History of the flight

The pilot of G-CKJH was taking part in an annual gliding competition from Long Mynd Airfield, Shropshire. Having received their briefing on the day's competition, the pilots taking part then waited for the weather to improve before launching for their flights. With an improvement in the weather, G-CKJH launched from the airfield at 1448 hrs. Having thermalled near the airfield to gain height, the pilot then set off in a roughly south-easterly direction. Over the next one and a half hours the flight continued in that south-easterly direction, reaching a maximum altitude during the flight of approximately 4,000 ft. As the glider approached Cheltenham at around 1720 hrs, the pilot turned east, passing to the north of Winchcombe. The pilot decided that he needed to land the glider as the day was drawing to a close and he was aware that he would not be able to make it back to the launch site. Having completed a 360° turn to the right, he made an approach to a field. Although he realised once on the approach that the field was rough and sloped steeply upwards, he was committed to landing.

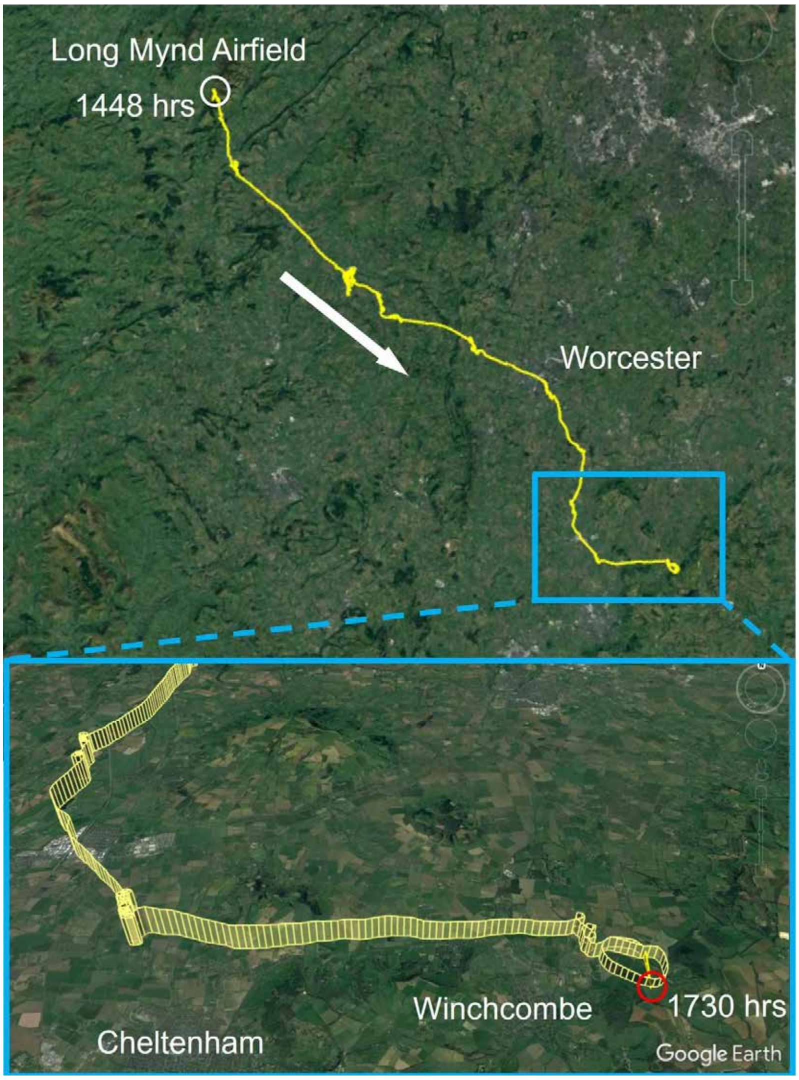


Figure 1

Ground track of accident flight recorded on IGC logger

The glider touched down in the field at 1730 hrs and immediately struck something causing the glider to jerk violently. The glider came to rest embedded in a stock fence at the top of the field. The violent jerk on the initial touchdown had caused a neck injury to the pilot. He was able to extract himself from the cockpit, by climbing through the broken canopy, and climb over the fence but soon started to lose feeling and function below the neck. He had managed to send a message with his location to his retrieval team, but they were a significant distance away. The owner of the field noticed a large white object whilst driving home and went to investigate, finding the pilot laying near the glider, conscious but paralysed. The pilot was airlifted to hospital but died 20 days later due to complications from his injury.

Accident site

The glider came to rest in a hedge at the uphill end of a grass field at Haile on the Hill, approximately 6 nm northeast of Cheltenham, Gloucestershire (Figure 2). The hedge contained a wire stock fence which the nose of the glider penetrated, breaking the canopy transparency and trapping the canopy frame in the closed position.

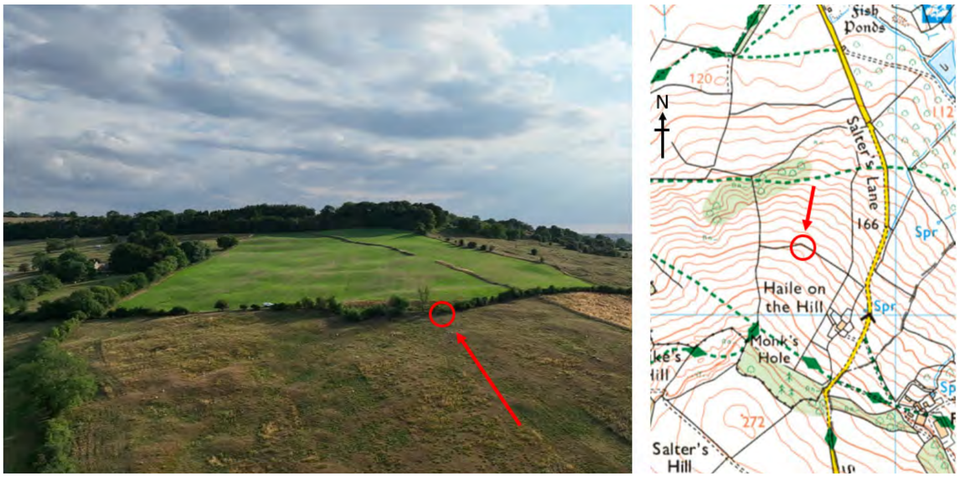


Figure 2

Accident site looking south (left image) and accident location (right image), with approach direction into field indicated with a red arrow. © 2022 Ordnance Survey

The surface of the field was undulating grass pasture, with a steep upslope of approximately 20% (Figure 3).

Figure 3

Accident site, looking north-west

Recorded information

An IGC flight recorder and a FLARM[1] unit (which also logged flight data as an IGC file) were recovered from the glider. Both units were downloaded, and the recorded ground track log of the accident flight is illustrated in Figure 1.

Figure 4 plots the track angle, groundspeed and vertical speed, derived from the flight path data in the IGC file, together with the altitude and ground height below the glider, for the last part of the flight as the glider circled and descended toward the landing field. The circuit was at about 1,300 ft amsl (between 800 and 1,000 ft agl over undulating terrain). The descent started from 1,200 ft amsl (about 550 ft higher than the accident site elevation), during which the vertical decent rate peaked at about 1,900 ft/min before reducing to about zero, and the groundspeed from just under 90 kt to about 50 kt.

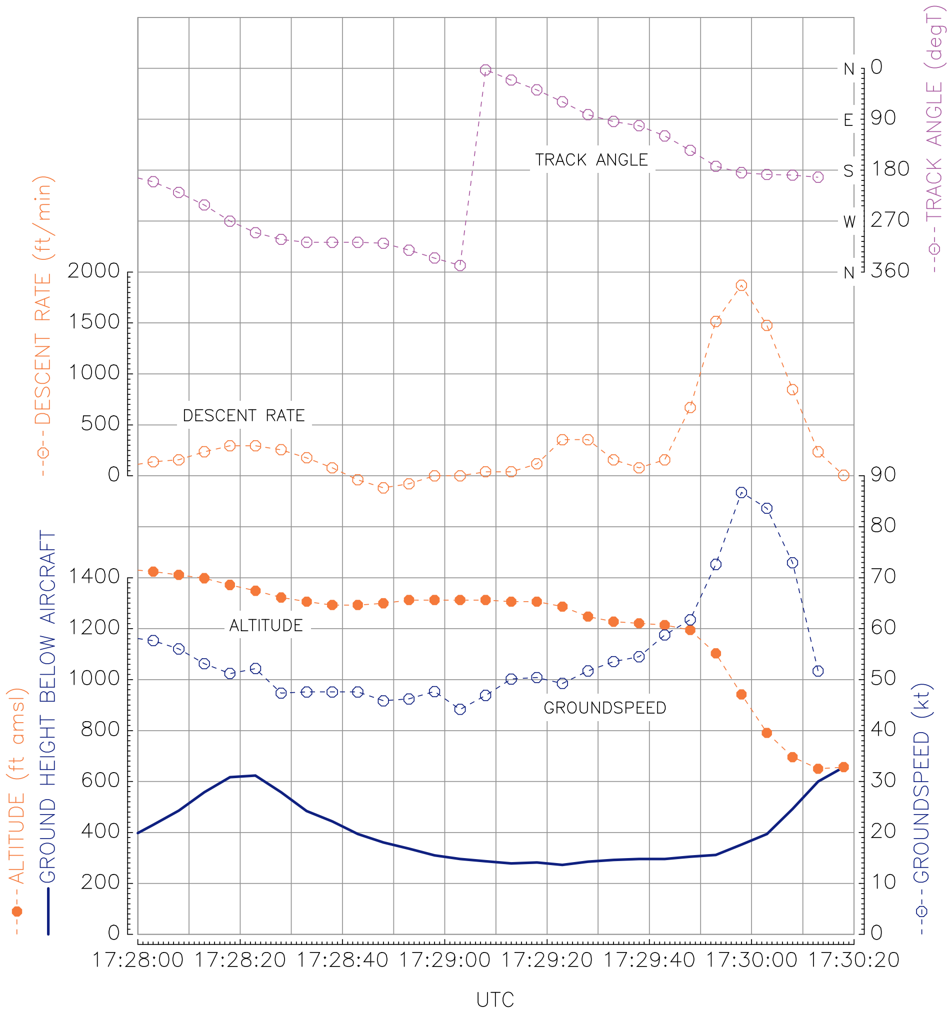


Figure 4

IGC recorded/derived data for circuit and descent to field

Footnote

1 FLARM (an acronym based on 'flight alarm') is the proprietary name for an electronic device which is in use as a means of alerting pilots of small aircraft, particularly gliders, to potential collisions with other aircraft which are similarly equipped.

The pilot was also using an IGC approved flight computer with moving map display. The unit could be connected to the glider to ensure its battery remained charged; however, the pilot had noted that the device did not seem to be charging properly. The investigation was provided with a copy of the IGC file from the device which showed that it had stopped recording to the west of Worcester, about 40 minutes before the accident. There were no other electronic navigation devices on the aircraft although a paper aeronautical chart was recovered from the wreckage.

Aircraft information

The DG-300 Elan is a single-seat glider constructed mainly from glass fibre composite materials. It has a wingspan of 15 m and a retractable main landing gear. The cockpit has a single-piece canopy that hinges upwards at the nose to provide entry and egress. An annual maintenance inspection was completed on 15 November 2021 and the glider had a valid Airworthiness Review Certificate when the accident occurred.

Aircraft examination

All parts of the glider were present at the accident site and the flying controls were found to be correctly connected prior to disassembly and recovery of the glider. It had sustained impact damage to the wings and forward fuselage caused by sudden deceleration into the hedge and wire fencing during the accident. The lower fuselage skin was fractured and had surface scoring caused by a heavy impact with the ground whilst the glider was yawed to the right by approximately 20°. The main landing gear had been extended prior to landing but impact forces had pushed the wheel rearwards, into the wheel well. The wheel brake was examined and found to function correctly when tested.

The cockpit was fitted with an energy-absorbing cushion of 30 mm thickness. The energy-absorbing foam was examined and found to be in good condition. The four-point seat harness and buckle were in good condition with no evidence of overload damage.

Survivability

The pilot recalled that he felt the damage to his neck occur during the sudden jerk during the first touchdown. Examination when he reached the hospital noted a fracture in the C7 vertebrae. The pilot was able to extract himself from the cockpit and move a short distance from the glider before being paralysed. This would indicate that he did not suffer a spinal cord injury due to the fracture. Hospital scans showed a large haematoma, caused by bleeding into the spinal column pressing on the spinal cord, to be the cause of the paralysis.

Although the pilot began to regain feeling in his limbs, complications from the injury and longer-term medical conditions caused a deterioration in his health and he died in hospital 20 days after the accident.

Medical history

The pilot had been suffering from a condition known as ankylosing spondylitis for many years. This is a long-term condition in which the spine and other parts of the body become inflamed. It often causes the fusion of bones in the spine. It can lead to the weakening of bones (osteoporosis) and spinal fractures. Whilst the progress of the condition in the pilot had seemed to have reached a plateau, it is likely that his spine was significantly weaker than those without the condition. The pilot's age also meant that his bones were likely to be less dense than someone of a younger age.

The C7 vertebrae is the lowest part of the cervical spine at the base of the neck which supports the head and neck. A fracture of C7 is most often caused by a high energy trauma such as a car accident. In this case it was likely a whiplash type movement was responsible for the injury. The ankylosing spondylitis made the pilot's spine stiff and inflexible meaning the pilots neck was not able to flex or extend to any great extent. Often described as 'chalk stick' or 'carrot stick' fractures they are the result of the fused segments of the spine acting as a lever arm. This then places greater than normal stresses on the spine. These fractures can often occur following minimal trauma due to the altered biomechanics of the spine.

Meteorology

A high-pressure system was centred to the west of the UK giving generally fine and settled weather. There was some low cloud around the launch site in the morning but as the temperature rose, the cloud dissipated leaving a fine and warm afternoon. No cloud was observed in the area below 5,000 ft altitude. The wind was light but from the northwest. A consistent temperature of 22°C was recorded throughout the late afternoon. The sun and the air temperature would have made the cockpit warm even with the ventilation window open. The pilot was carrying refreshments including fluid for drinking, but the investigation was unable to establish how much the pilot had consumed during the flight.

At the time of the accident, the sun was at a bearing of 270° and 29° above the horizon. During the final approach, with the pilot flying south, the sun would have been at his right shoulder. Sunset was at 2028 hrs.

Field choice

The pilot had extensive gliding experience including field landings (of which he had completed over 220). He had been gliding for over 70 years and had been a regular participant in competition gliding throughout the UK. There was some suggestion from witnesses who had spoken to the pilot after the accident that he had intended to head for a gliding club which was approximately north of his final position by 11 nm.

The pilot noted after the accident that that there were some larger, flatter fields lower down in the valley, but they had corn growing in them, so he chose a pasture on the side of the hill (Figure 1). Information provided to the investigation showed that nearly all the flatter fields had unharvested crop in them which was mature and yellow in colour. Other flatter grass grazing fields were also by and large yellow in colour due to the extended drought and hot weather of 2022.

The pilot described to friends during his period in hospital after the accident that he had not appreciated the rough surface of the field, nor just how steep it was until he was on his final approach. At this point the pilot was committed to landing in the field, although he did close the airbrakes to try and land further up the field in what he considered to be a slightly smoother area.

Landing on an upslope always presents several challenges for a pilot. The visual illusion created by the upslope can make the pilot think they are higher than they are, this makes judging any flare more difficult. The flare also needs to be started sooner due to the rising ground below and of a greater pitch due to the relative change in attitude required. These factors can lead to a heavier landing on an upslope than might have occurred on a flat surface.

Analysis

The pilot was a very experienced glider pilot, current and well-practised in field landings. Given his experience, the choice of landing field would seem inexplicable. There are several factors which could have played a part in the pilot choosing an unsuitable field.

The pilot felt that the day was drawing to a close and that it was time to land. He had suggested to friends that he might have been planning to land at another gliding club which was approximately 11 nm to the north of the accident site. It is possible that after the failure of the GPS in the cockpit, the pilot was not able to locate the gliding site before he felt he needed to land.

The day had been warm with sunshine throughout the flight and so it is likely that the cockpit would have been quite hot. Whilst the pilot had taken refreshments with him, it is unknown whether dehydration could have affected his decision making at the end of the flight. The wind was light and from the north-west. The approach and landing were effectively downwind but the windspeed was so light that it was not considered as a factor in the accident.

Whilst positioning for the field landing the pilot completed a 360° turn to the right. This turn would have put him through the 270° heading in which he would have been looking into sun in front of the aircraft. It is possible that whilst completing this turn and identifying the field he intended to land in, the position of the sun affected how well he could assess the slope and surface of fields around him. He told friends that he avoided larger and flatter fields in the valley as they had crops growing in them. Once he had committed to the field and was on his final approach, the position of the sun on his right shoulder would have had less effect on his visual picture and he realised that the field was steeper and rougher than he had thought.

Once the pilot was on his final approach he was committed to landing in the chosen field. With a significant upslope, the field presented challenges for the pilot in judging his approach and flare. Given the severity of the slope, the landing may have been heavier than expected due to a late and/or insufficient flare. This would have been further exacerbated by the rough and uneven surface. Damage to the glider would indicate that it suffered a heavy impact with the ground whilst yawed to the right. The initial impact was of sufficient energy to cause a fracture to the pilot's C7 vertebrae. Whilst this injury is most often seen in high energy trauma, given the pilot's medical history and age, this force might not have needed to be of great magnitude to cause the injury.

No defects with the glider were identified that could have contributed to the accident.

Conclusion

Having reached the end of the gliding day, the pilot elected to land the glider in a field. The field chosen had a rough surface and a steep slope which the pilot did not fully appreciate until he was committed to the landing. Having touched down heavily, the pilot's neck was injured and, although he was able to extract himself from the glider, he soon lost feeling in his limbs. He was airlifted to hospital but died of complications from his injury and underlying medical conditions.

Published: 19 January 2023.

ACCIDENT

Aircraft Type and Registration:	Grob G103C Twin III Acro, G-CFWC	
No & Type of Engines:	N/A	
Year of Manufacture:	1990 (Serial no: 34154)	
Date & Time (UTC):	13 June 2021 at 1200 hrs	
Location:	Usk Airfield, Monmouthshire	
Type of Flight:	Private	
Persons on Board:	Crew - 2	Passengers - None
Injuries:	Crew - 2 (Serious)	Passengers - N/A
Nature of Damage:	Aircraft destroyed	
Commander's Licence:	BGA Assistant Instructor Rating	
Commander's Age:	60 years	
Commander's Flying Experience:	906 hours (of which 400 were on type) Last 90 days - 40 hours Last 28 days - 22 hours	
Information Source:	AAIB Field Investigation	

Synopsis

The accident occurred during a simulated failed winch launch. The glider was initially flown away from the airfield at a low height and, whilst turning back to land, stalled and collided with trees on the edge of the airfield. Both occupants were seriously injured. With assistance from the BGA, the gliding club has taken safety action to improvement elements of the club's operation.

History of the flight

On the morning of the accident the resident gliding club held its usual morning brief at 1000 hrs. This was attended by a club pilot who had intended to fly his own glider that day but, on learning the weather was not favourable for his planned flight, decided to re-validate his use of winch launches from the airfield instead. This was agreed with one of the club's instructors at the end of the brief, to be done using G-CFWC, a club glider.

The first four flights of the day from the airfield involved the instructor flying with an ab initio student, conducting two practice circuits followed by two practice failed winch launches. The flights were all flown in G-CFWC and went without incident. The simulated winch failures were from launches from Runway 28 at a height of about 400 ft agl. After each simulated failure the glider was initially turned to the right before turning left and landing back on the airfield in the opposite direction to which it had departed.

After the final flight with the ab initio student, the glider was re-positioned ready for launch with the club pilot, for his re-validation flight with the instructor. The instructor met the pilot at the aircraft and advised him that they would do two simulated failed winch launches. The instructor also briefed the winch operator of this intention. No other brief of the exercise was conducted, although the pilot ran through, as part of his pre-takeoff checks, what he would do in the eventuality of a failure on launch.

At 1137 hrs the glider commenced its winch launch from Runway 28 with the pilot, who was occupying the front seat, in control. The instructor reported that at a height of about 150 feet he jettisoned the winch cable to simulate a launch failure. The pilot stated that he reacted by rapidly lowering the nose, with the aircraft quickly achieving safe flying speed. The instructor could not recall to what extent the aircraft had been pitched down as he was concentrating on how much landing distance on Runway 28 still remained ahead. Witnesses on the ground reported seeing the glider pitch down when the cable released, but that it had appeared to adopt a gliding, rather than a more nose-down recovery attitude.

The pilot did not believe he had sufficient distance to land safely straight ahead, but that he did have sufficient distance to land the glider in an area of the airfield extending to the left (south) of the end of Runway 28 (Figure 1). He turned the glider to the right, flying away from the airfield to position it for a landing across the airfield at the end of Runway 28.

Figure 1

Usk Airfield outlined in white - Runway 28 marked in red - accident site in yellow

The instructor was expecting the pilot to land straight ahead on the remaining runway due to the aircraft's low height and had been surprised by the turn. Witnesses on the ground also reported that they considered there was sufficient distance remaining for the glider to land straight ahead on the remaining runway.

The glider continued to fly away from the airfield for a few seconds before being turned left back towards it again. By this time, the aircraft was sufficiently low that it was in danger of colliding with trees at the edge of the airfield. Accounts differed between the two occupants as to when the instructor took control, however the instructor stated that it was at this point that he had taken control of the aircraft, attempting to turn further left between a gap in the trees. He reported the turn had tightened whilst at the same time the nose dropped. The glider then hit a tree before striking the ground, seriously injuring both occupants.

Accident site

The glider had come to rest against a fence on the northern edge of the airfield, with the right wing overhanging the bank of an adjacent stream. Damage to the leading edge of the left wing at approximately two thirds span was consistent with it having struck a small elder tree on the bank of a stream at the edge of the airfield (Figure 2).

A flattened area of vegetation on the stream bank corresponded to the shape of the left wing and debris in the vicinity of the tree was matched to the left wing leading edge. Corresponding strike marks on the tree indicated that the glider was approximately at ground level when it struck the tree. The impact caused the glider to pivot sharply around the tree before coming to rest in its final position.

The left wing had separated from the fuselage such that it remained attached only by the aileron and airbrake control rods. The right wing was intact, with the exception of damage to the trailing edge where the wing had struck a fence post as it came to rest.

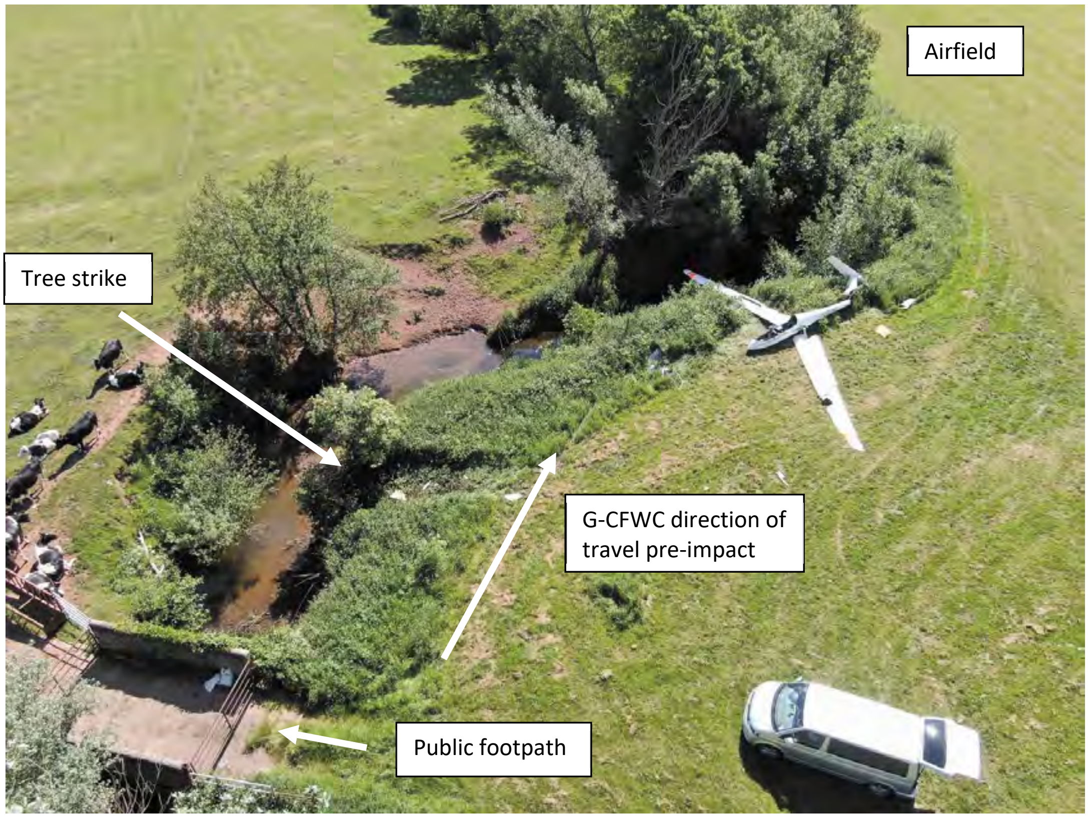


Figure 2
Accident site

The first ground mark in the direction of travel, had been made by the tailwheel and base of the fin and likely occurred just before, or coincident with the left wing striking the tree. The transparency from an inspection window at the base of the vertical fin was found in this ground mark.

The rear fuselage had failed just forward of the tail fin, with the tail assembly remaining attached only by the rudder and elevator control rods, electrical wires and pitot/static lines. The leading edge of the horizontal tailplane showed evidence of having struck the ground and the pitot and total energy probes on the leading edge of the vertical fin were bent. The rudder had detached.

Both front and rear cockpits had retained their basic shape and structural integrity. The rear canopy remained intact while the front canopy had broken into large pieces.

The presence of all major components of the glider and the compact distribution of wreckage indicated that the glider had been structurally intact prior to striking the tree and ground. Ground marks indicated that it had been in an approximately level pitch, slightly left-wing-low attitude at impact.

Recorded information

Sources of recorded information

The aircraft was fitted with a LX Nav manufactured FLARM[1] Powermouse unit that had recorded a GPS derived track log of the accident flight and the previous flights earlier the same day. A recording of the FLARM unit's transmissions[2] made during the accident flight was also obtained. The data sources provided a comprehensive record of the accident flight and closely correlated with the witness statements and the final position of the aircraft.

Summary of recorded data

The recorded data indicates that the aircraft had reached a height of about 160 ft agl (Point A - Figures 2 and 3) whilst initially maintaining the runway track, but after a few seconds the aircraft made a right turn onto a track of 350° (Point B - Figures 3 and 4) whilst also starting to descend.

When the aircraft was at a height of about 110 ft agl and 80 m beyond the airfield's northern boundary, a left turn, back towards the airfield, was initiated (Point C - Figures 3 and 4). At this point the glider flew approximately level for several seconds with the groundspeed starting to reduce. Shortly after entering the turn and from a height of 100 ft agl, the aircraft's descent rate suddenly increased to about 2,000 fpm (Point D - Figures 3 and 4).

Footnote

1 FLARM is a flight alarm system that transmits the position and altitude of an aircraft over a low-powered, short-range radio as part of an electronic conspicuity system that can alert pilots to the proximity to other suitably equipped aircraft.

2 Data recorded by the Open Glider Network (OGN) http://wiki.glidernet.org/ [accessed July 2021].

The recorded data showed that shortly before striking the tree, the aircraft's rate of descent reduced to approximately 700 fpm.

The total flight time was just under 30 seconds.

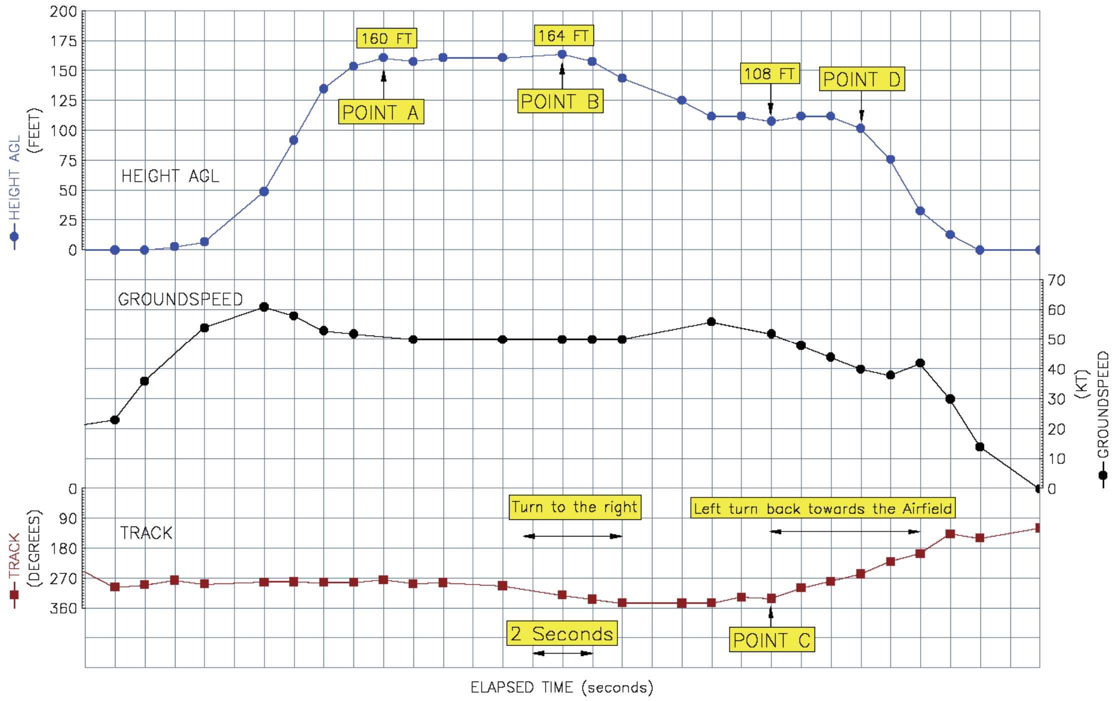


Figure 3

Recorded GPS data

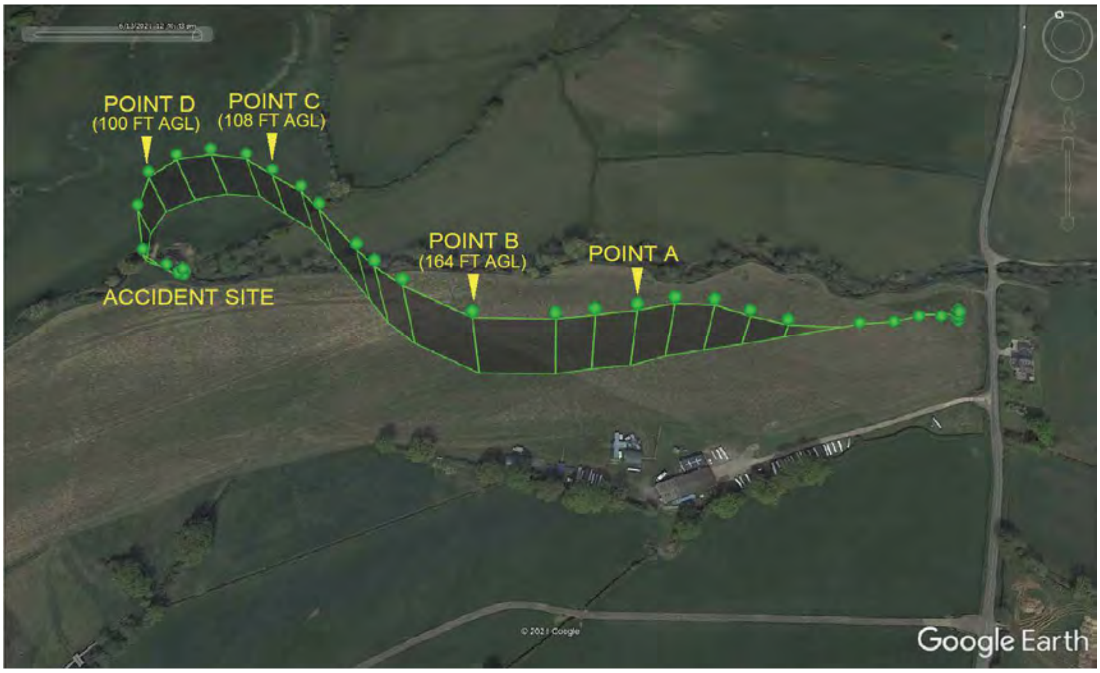


Figure 4

Recorded GPS flightpath of aircraft

Aircraft information

The Grob G103C Twin III Acro is a two-seat, mid-wing glider with a T-tail and is of predominantly glass fibre construction. The landing gear is comprised of three non-retractable wheels.

The flight controls are actuated using a combination of pushrods and bellcranks. The rudder uses control cables in addition to pushrods.

G-CFWC was owned and operated by the resident gliding club and was used primarily for instructional flights. It was manufactured in 1990 and at the time of the accident had accumulated 7,167 flying hours and 14,611 launches. The last annual inspection and Airworthiness Review Certificate (ARC) renewal had been carried out on 10 July 2020.

Aircraft examination

Examination of the flight control runs showed that continuity was maintained, with the exception of the aileron control connection between the fuselage and right wing, which was disconnected. Distortion to the bellcrank, its integral bearing and the control connection indicated that the connection failed as a result of impact loads, when the left wing struck the tree. The resulting distortion of the aileron control rod within the left wing, would have imparted substantial loads on the right aileron control rod and bellcrank.

No defects were found which could have affected the controllability of the glider.

Survivability

The pilot and instructor received serious neck and back injuries in the accident.

Both were wearing five-point harnesses. The fabric harness straps were undamaged and in good condition and the structural attachment points had remained intact and secure. The quick release fitting on each harness operated correctly.

Both seats remained intact. The BGA[3] recommends the use of energy absorbing seat cushions as a means of reducing spinal injuries during a hard landing or accident. The gliding club's Operations Manual strongly recommended the use of energy-absorbing seat cushions in all gliders and provided such cushions for use in its club gliders. The seats in G-CFWC had been re-upholstered in 2012 and energy absorbing foam was incorporated at that time, therefore separate cushions were not required. Examination showed that the energy absorbing foam used in the re-upholstering had been fitted on top of an existing layer of standard compressible foam. The BGA guidance explained the detrimental effects of using foams that do not remain compressed in an impact and the need to replace them with energy-absorbing types. In particular, it stated:

Footnote

[3] https://members.gliding.co.uk/library/safety-briefings/safety-foam/ [accessed January 2023].

> *'Try to avoid installing an energy-absorbing cushion on top of existing material that is not viscoelastic or that does not remain fully compressed in flight. In a crash loading, the original material will not go rigid immediately and may produce an effect similar to a bounce. This is because you and your energy-absorbing cushion may initially move on without decelerating as you compress the material whilst the underlying glider structure starts to decelerate immediately in the crash – maybe bouncing back up.'*

It was not determined to what extent, if any, the particular arrangement of foam on G-CFWC's seats may have reduced or contributed to the injuries sustained by the occupants.

Meteorology

There was a light easterly wind during the morning of the accident of 5 kt and below, with no significant cloud and good visibility.

Airfield information

Usk Airfield is a grass airfield from which the resident gliding club was the sole operator. The layout of the airfield accommodated a takeoff and landing strip orientated 100/280º. The airfield extended to the south at the end of the takeoff run from Runway 28, providing another area capable of being used as a landing area if necessary.

The airfield was bounded by hedgerows containing mature trees. Beyond these were fields, with those to the west providing more favourable forced landing options, due to their size, than those to the east. The gliding club used both winch launches and aerotows.

On the day of the accident, the tug aircraft being used for the aero tows was not as powerful as the normal club aircraft. As a result, they had opted to use Runway 28, despite the wind direction, in case of problems with launches as it offered more options for forced landing away from the airfield.

Pilot backgrounds

The instructor was 60 years old and had started gliding in 1993, since when he had gained 906 hours total flying time, including 338 hours instructional time. He held a BGA Silver C badge and qualified as an assistant gliding instructor in 2007. He had been flying from Usk Airfield for a number of years, being familiar with both aero tows and winch launches from the airfield.

The pilot was 84 years old and had starting gliding whilst in his early twenties. He had also flown light aircraft for three years whilst at university with an RAF University Air Squadron. He later stopped flying for 37 years, but starting gliding again at Usk Airfield in 2010. He had previously been an assistant gliding instructor for 13 years and, in total, had flown gliders for 22 years with a total flying time of 535 hours. At the time of the accident, he held a BGA Silver Badge.

The pilot owned his own Cirrus glider and would normally use aerotows to launch the glider. He had last undertaken a winch launch some months before the accident. Due to the COVID-19 pandemic, his flying activities at the club had been severely curtailed and he had not flown between 27 September 2020 and 26 April 2021. On 26 April he had, as with all other club members, been required to undertake a check flight as part of the club's return to normal flying. This had been undertaken with the Chief Flying Instructor (CFI) in G-CFWC using an aerotow, with the pilot being cleared to resume solo flying. However, the CFI required the pilot to carry out a winch check flight with an instructor, due to the length of time since his last winch launch, before using winch launches again.

Since his check flight, the pilot had completed two further flights, on 2 May and 30 May, both using aerotows and without incident.

Pilot age and recency requirements

The gliding club operations manual contained information on recency requirements which related to both qualification and age. Age-related requirements fell into four categories: under 18 years, 18-75 years, 75-79 years, and 80 years and above. It was reported by the club that whilst subjective in nature, the requirements were intended to take into account the possible effects on pilot performance due to age. Both the pilot and instructor met with these requirements.

An AAIB investigation into another glider accident[4] on 26 August 2020 included consideration of pilot age as a possible factor. The report stated:

> *'Older pilots are not necessarily less-safe pilots and poor decision making can affect pilots of all age and experience levels. Nonetheless, age-related deterioration in eyesight, hearing, mobility, memory, cognition and decision making are recognised as having an impact on piloting ability.'*

Winch launch failures

Gliders at Usk would normally release from a launch at between 700-900 ft agl, depending on the conditions. Instructors at the airfield described winch launches falling into three categories, depending on the height at which they happen. Those occurring below 250 ft agl were considered low failures with the glider normally having sufficient distance remaining on the airfield to land straight ahead. Those occurring above 300 ft agl were considered high failures with the glider having sufficient height to be able to carry out a low circuit to land. Where the glider was between the two ie 250-300 ft, this presented a more difficult scenario requiring quick assessment of whether to land straight ahead or position the glider in the height remaining to land elsewhere.

When carrying out winch launch validation flights a pilot would not normally know at which height the instructor would choose to carry out the simulated failure.

Footnote

4 AAIB Reference Number 26884, G-CFST, 26 August 2020

The BGA Instructor Manual contained information on the handling of launch failures. It gave the following requirements for a safe outcome:

- recover to the appropriate recovery attitude while checking airspeed
- wait to regain the approach speed
- assess the situation
- plan a safe approach and landing
- release the wire
- check the airspeed again
- continue to monitor it
- fly the approach and landing or a circuit variation to it

The manual stated:

> *'As the glider adopts a steep climbing attitude during a winch launch, should the launch fail, a positive move forwards of the control stick is required without delay to place the glider in a nose down attitude sufficient to regain airspeed. This attitude is steeper than the attitude experienced during a normal approach and is termed the 'recovery attitude'. If the attitude is not achieved quickly there is a danger of the glider stalling.'*

The manual further stated that the first question the pilot should consider is whether they can land ahead. It added that if the nose isn't lowered sufficiently, it can change the perspective of the airfield, making it appear that there is insufficient room to land ahead. It continued that even in cases which at first seem marginal there is usually enough room to land safely. It conceded however that at small or restricted sites the decision to land ahead remains difficult. The manual also considered the opportunity to turn if choosing to not land straight ahead and emphasised the need to maintain appropriate airspeed if doing so.

Club information

The gliding club was affiliated to the BGA and had carried out periodic safety reviews as part of the BGA safety oversight programme. It had suffered three other accidents investigated by the AAIB since 2016[5] and, as a result of the accident to G-CFWC, the club consulted with the BGA to seek assistance in identifying and addressing any existing operational and technical safety issues. As a result, a further review was conducted by the BGA after the accident. A number of actions were taken which included:

- Review of the club safety management, including consultation with club members to improve the overall safety culture.
- Review of the club Operations Manual.

Footnote

[5] G-BLCV – 5 April 2016, G-KHEH – 10 June 2018, G-DDGX – 27 July 2019

- Engagement with the BGA Training Manager.
- Practice days undertaken by instructors in cable break procedures.
- Winch launches towards the west stopped due to the limited number of options for recovery from failed winch launches in that direction.

The BGA advised that it would continue its collaboration with the club, providing any necessary guidance and support to ensure successful implementation of these actions.

Analysis

The investigation found no technical issues which may have contributed to the accident. Examination of the glider did not identify any pre-existing defects which would have affected its controllability. The damage to the glider and flight controls was consistent with having been sustained during the impact sequence. Ground marks, together with the distribution and condition of the wreckage also showed that the glider was structurally intact prior to the collision with the tree and ground.

The occupants had suffered serious injuries. BGA guidance discusses the potential issues of using energy absorbing seat foam on top of more compressible foams which may already be present. It was not determined if the presence of compressible foam on G-CFWC's seats may have limited the effectiveness of the energy absorbing foam in reducing the severity of the injuries sustained by the occupants.

The pilot being checked was confident that he had carried out the appropriate recovery manoeuvre when the instructor simulated the winch failure. He was equally confident that he had positioned the glider appropriately to carry out a landing in the 'dogleg' area of the airfield.

By contrast, the witnesses watching from the airfield considered that the glider had not adopted a sufficiently nose-down recovery attitude. They had also expected the glider to land in the area remaining immediately ahead which, to them, seemed more than adequate.

The glider's initial recovery attitude had not been obvious to the instructor, who had been concentrating instead on the landing area still remaining at the time he initiated the simulated winch failure. He had been taken by surprise when the pilot turned away from the airfield, having expected him to land straight ahead.

Based on the position of the glider at the time of the cable release, determined both from eyewitnesses and recorded data, there would have been sufficient distance available to land the glider straight ahead, as the instructor had anticipated. It is possible the pilot's assessment that there was insufficient distance had been made because he had not lowered the nose sufficiently, creating a more restricted view of the area ahead.

The instructor was candid in his own recollection of meetings he had attended where the importance of early intervention by instructors had been stressed. He reported he had not done so in this case due to the experience of the pilot and he had only intervened when he considered they were unlikely to make the airfield. Whilst there are differing recollections of who was flying the glider when it turned back towards the airfield, it is clear that the glider had by then descended too low to make it to the airfield safely. The reduction in descent rate seen on the data may have been an attempt to maintain altitude but this resulted in a loss of airspeed. This reduction in airspeed at such a low height put the glider in a precarious position, being too low and too slow to conduct an effective recovery. The instructor had instinctively pulled back on the controls just prior to impact in an attempt to cushion the landing. Despite this, the impact forces experienced by the aircraft were still sufficient to cause significant injuries.

The pilot had passed a check flight with the club's CFI not long before the accident without any apparent issues. It was not possible to make an objective assessment of whether his age or lack of recent flying experience contributed to his ability to assess the glider's attitude and position when recovering from the simulated winch failure.

Although the flight was intended as a re-validation check, there was no briefing other than that undertaken at the aircraft itself just prior to the flight. This largely relied on the pilot's pre-takeoff brief to the instructor of what he would do in the event of a winch failure. A more comprehensive brief in a suitable location would have allowed for a more thorough assessment by the instructor of the pilot's knowledge of the exercise they were about to undertake. This would have been even more important because the exercise itself represented a more hazardous type of operation than normal.

Following the accident, the gliding club worked with the BGA to review the safety of its operation and they put in place a number of safety actions. These actions were intended to address the areas in need of immediate improvement with a more long-term engagement aimed at achieving a continued improvement in safety.

Conclusion

The practice of winch launch failures is a common training exercise with suitable guidance existing for those undertaking it. At the initiation of the failure there was sufficient distance available for the glider to have been landed straight ahead, although the pilot manoeuvred the glider to land on a different part of the airfield. There were differing accounts of subsequent events, but the glider then became too slow to maintain controlled flight and too low to return safely to the airfield.

It was not determined to what extent, if any, the particular arrangement of foam on G-CFWC's seats may have reduced or contributed to the injuries sustained by the occupants.

Safety Actions

The gliding club took the decision to seek assistance from the BGA in assessing the safety of its operation. The BGA, in turn, was proactive in its response in facilitating improvement of elements of the club's operation. The resulting safety actions included:

- Club operations manual re-written for clarity
- Improved engagement with club member on safety matters
- Review and changes to some airfield and flight operations
- Instructor refresher training from the BGA
- Review of resourcing current and future training needs within the club

Published: 19 January 2023.

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.

SERIOUS INCIDENT

Aircraft Type and Registration:	AW189, G-MCGV
No & Type of Engines:	2 General Electric Co CT7-2E1 turboshaft engines
Year of Manufacture:	2017 (Serial no: 92008)
Date & Time (UTC):	7 January 2022 at 1622 hrs
Location:	Lydd Airport, Kent
Type of Flight:	Training
Persons on Board:	Crew - 4 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Collapsed heating duct, contamination of cockpit and cabin by insulation particles
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	51 years
Commander's Flying Experience:	5,823 hours (of which 963 were on type) Last 90 days - 79 hours Last 28 days - 14 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

A heating duct failed in flight releasing fragments of duct insulation material into the cabin and cockpit, causing respiratory irritation to the occupants. The aircraft landed safely. Similar heating duct failures had previously occurred in several of the operator's other AW189 aircraft and were investigated by the AAIB (AAIB Bulletin 4/2022 report AAIB-27128 refers). As a result of those failures the aircraft manufacturer had published a service bulletin to inspect and modify the installation of the heating duct and this had been embodied on G-MCGV.

At the time of publication of this report, the aircraft manufacturer has stated its intention to publish a revision to its service bulletin to make the installation of the existing duct configuration more robust, as an interim solution. In parallel, the duct manufacturer is redesigning the heating duct.

The operator has also taken action to replace the heating ducts on those aircraft in its fleet which had not already experienced a duct failure.

History of the flight

Following completion of a SAR training sortie involving winching operations, the cabin and cockpit heating was selected ON for the return transit to the helicopter's base at Lydd.

Approximately 6 nm from Lydd, the rear crew seated in the cabin alerted the flight crew to the presence of 'fibres floating in the air' which were causing respiratory irritation. The flight crew selected the heating and ventilation system to OFF and donned PPE face masks, which were carried in the cockpit. Given the proximity to Lydd, the commander elected to expedite the approach and perform a running landing. During the approach the non-flying pilot experienced some mild respiratory irritation, but the commander who was pilot-flying reported that he was not noticeably affected. Upon landing, the cabin doors and storm windows were opened for ventilation and to clear the contamination.

Subsequent examination showed that the aft heating duct had failed, allowing duct insulation material to be drawn into the heating and ventilation system.

Previous events

General

The operator had experienced several previous heating duct failures on its AW189 fleet. Two of these failures, occurring on G-MCGU on 4 March 2021 and G-MCGT on 17 April 2021, were the subject of an AAIB investigation. AAIB report AAIB-27128, published in AAIB Bulletin 4/2022 refers[1].

Previous investigation findings

The failed ducts from G-MCGU and G-MCGT were subject to detailed examination at the aircraft manufacturer's laboratory which determined that failure occurred due to nonuniform adhesion on the bonding surfaces between the rigid and flexible duct sections. The details are reported in AAIB-27128. The collapse of the duct led to fragments of duct insulation material being discharged through the cabin in cockpit heating vents, causing respiratory irritation to the occupants and, in the case of G-MCGU, the presence of smoke which necessitated an emergency landing.

Previous safety action

On 23 July 2021, the aircraft manufacturer published service bulletin (SB) 189-296 *'ATA 21 – Heating duct rear avionic bay inspection'* requiring operators to perform a one-off inspection of the heating duct and to modify the duct installation. Any findings made during the inspection were to be notified to the aircraft manufacturer and could result in an instruction to replace the duct. The modified installation involved repositioning an existing 'P-clamp' at one of the bonded joints and introducing an additional fixing at another joint. This requirement applied irrespective of whether the duct was replaced following inspection. The compliance instructions required embodiment of the SB within 400 flight hours or 12 months from date of publication, whichever occurred first.

The SB was intended as an interim solution, while the aircraft manufacturer worked with the duct manufacturer to achieve a permanent solution.

Footnote

[1] https://www.gov.uk/aaib-reports/aaib-investigation-to-leonardo-aw189-g-mcgu [accessed December 2022].

SB 189-296 was embodied on G-MCGV on 30 October 2021. The inspection did not reveal any findings but the duct fixings were modified in accordance with the SB instructions. G-MCGV subsequently experienced a duct failure on 7 January 2022, 71 flying hours earlier after embodiment of the SB. G-MCGV's heating duct had failed in a similar manner to those from G-MCGU and G-MCGT.

Aircraft information

The AW189 heating and ventilation system is described in AAIB-27128. Figure 1 shows the heating duct.

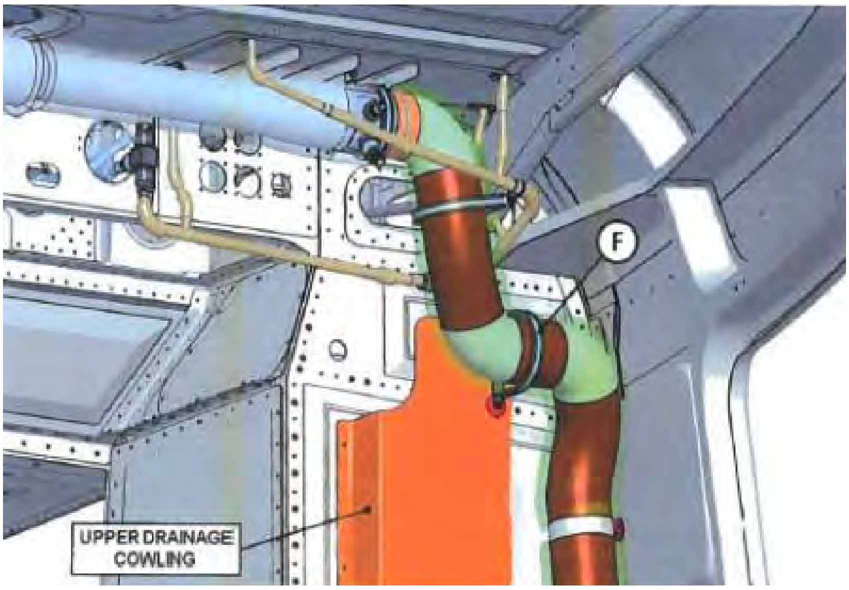


Figure 1

Heating duct on AW189 showing flexible sections in brown and rigid sections in green (Circle 'F' indicates a securing 'P-clamp')

Component examination by duct manufacturer

Following the aircraft manufacturer's laboratory examination of the failed ducts from G-MCGU and G-MCGT, they were sent to the duct manufacturer for further examination along with the failed duct from G-MCGV. The duct manufacturer determined that the relevant manufacturing processes and procedures were followed and the ducts met the applicable drawing specification. It also reviewed the bonding of the duct joints, the manufacturing instructions, the aircraft installation and the qualification test data for the ducts. While recognising that non-uniform adhesion of the bonded joints was evident on the failed ducts, the duct manufacturer considered that it did not mean this was the single causal factor resulting in the failure of the ducts. It indicated that redesign considerations would take account of improving the strength of the bond between the flexible and rigid sections of duct, reducing the number of joints and relocating clamping positions to rigid duct elements, thereby reducing the ability of the duct to creep along the clamp over a number of flight cycles.

The duct manufacturer commented that the same duct type is used on the AW139 and AW169 helicopters and it was qualified for use on the AW189 by similarity with the AW139, without further testing. The duct manufacturer was not aware of any duct failures other than those on AW189s within this operator's fleet. It commented that the air pressure and flow rate through the heating duct were higher on the AW189 than on the AW139/AW169 which may have contributed to failure of the bonded joints on the duct.

Safety actions

Aircraft manufacturer and its suppliers

As a result of the duct failure on G-MCGV, the aircraft manufacturer plans to publish Revision A of SB189-296 in the fourth quarter of 2022, to provide further instructions on the installation of the heating duct. Revision A will require removal of the duct from the aircraft and reinforcement of the duct joints by the application of aramid lacing tape and silicon covered glass cloth tape. It will also require additional fixing points to be added and will introduce a change to the sequence of the duct installation instructions to avoid introducing any pre-load on the duct. The intention is that helicopters already compliant with the original issue of SB 189-296 must also comply with Revision A.

The aircraft manufacturer considers that SB 189-296 Revision A will be an interim solution to make the present duct configuration more robust. In parallel, the heating duct is being redesigned by the duct manufacturer as a long term solution. At the time of publication of this report, the installation drawings for the redesigned duct are undergoing approval and qualification/testing for the new design of duct is planned to take place throughout the remainder of 2022. The aircraft manufacturer intends to issue a separate SB for replacement of the present duct configuration with the new design in 2023.

Operator

Separately, following the duct failure on G-MCGV, in March 2022 the operator issued an internal Technical Directive requiring replacement of the heating duct on the remaining AW189s in its fleet that had not previously had the duct replaced following a duct failure. The ducts will be replaced on applicable aircraft at the next annual inspection and the replacement programme will be complete by January 2023. The aircraft manufacturer requested the removed ducts to be returned to the duct manufacturer so that their condition can be assessed against aircraft operating hours.

Discussion

Following the duct failures on G-MCGU and G-MCGT, reported in AAIB-27128, the aircraft manufacturer issued SB 189-296 to inspect and modify the duct fixings, with the intention of reducing the likelihood of future duct failures, while it worked with its suppliers to achieve a permanent solution. The subsequent duct failure on G-MCGV demonstrated that SB 189-296 did not achieve the intended effect.

The heating duct did not undergo specific qualification testing for use in the AW189 heating and ventilation system, having been qualified by similarity to the AW139. The function and geometry of the duct is similar on all three helicopter types, but on the AW189 the duct experiences higher pressure and flow rates, which likely places increased loading on the bonded joints. To date, all reported duct failures have occurred within one SAR operator's fleet. It is not fully understood why this is the case.

The safety actions currently in progress by the aircraft and duct manufacturers are intended, firstly, to reinforce the strength of the bonded duct joints and improve the installation. It is ultimately intended to introduce a more robust duct design. Qualification testing on the redesigned duct is planned to take place in conditions representative of in-service environmental conditions.

Conclusion

The heating duct on G-MCGV failed despite having been subject to a service bulletin intended to improve the installation of the duct. As a result of this and previous duct failures, the duct is being redesigned to strengthen the bonded joints between the flexible and rigid portions of the duct. In the interim, the aircraft installation of the existing duct configuration will also be modified to improve the routing and restraint of the duct, thereby reducing the loading on the duct joints.

ACCIDENT

Aircraft Type and Registration:	Beechcraft 200, G-GHSV
No & Type of Engines:	2 Pratt & Whitney Canada PT6A-61 turboprop engines
Year of Manufacture:	1980 (Serial no: BB-622)
Date & Time (UTC):	3 January 2022 at 1118 hrs
Location:	Exeter Airport, Devon
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to cargo pod, fuselage, belly ribs, gear doors and flaps
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	66 years
Commander's Flying Experience:	16,300 hours (of which 2,000 were on type) Last 90 days - 50 hours Last 28 days - 18 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot with additional enquiries by the AAIB

Synopsis

The aircraft had diverted to Exeter due to having an unsafe left main landing gear indication when it was lowered during approach to Alderney, the original destination. After a flypast of Exeter tower, observers confirmed the gear was down, so the pilot continued to land. During the landing roll the left main landing gear collapsed. It was likely that the left main landing gear down-lock system had lost adjustment. This resulted in the drag brace folding and loading the landing gear actuator, causing it to buckle.

History of the flight

The pilot was positioning the aircraft from Lydd to Alderney. As he approached Alderney he selected the landing gear down and heard the gear lowering as normal, but once the cycle had completed the left main landing gear green light, which indicates that the gear is down and locked, did not illuminate.

The pilot confirmed that the bulb worked before re-cycling the landing gear. Again, the left main landing gear green light did not illuminate. A go-around was undertaken and the pilot decided to divert to Exeter, where the aircraft was maintained, and alerted air traffic of his intensions. The pilot retracted the landing gear with no apparent issues.

The aircraft was cleared to FL100 and given direct passage to Exeter. The pilot declared a MAYDAY, advising ATC of the unsafe gear indication. He completed a flypast of the tower and observers on the ground confirmed that the left main landing gear was lowered. The pilot made a normal approach and landing on Runway 26. He recalled that he touched down softly and as the aircraft weight was taken by the landing gear, he could feel the left main gear collapse. He reported that he held the left wing up as long as possible, but eventually the wing and belly pod contacted the runway. The tips of the left propeller also struck the runway. Once the aircraft had come to rest the pilot shut down the right engine and made the aircraft safe before exiting.

Aircraft information

The Beechcraft 200, a member of the Super King Air family of aircraft, is a pressurised twin turboprop powered utility aircraft. It has a retractable tricycle landing gear with the main gear positioned below each engine. G-GHSV was fitted with an electro-mechanical landing gear system[1], which was controlled by a switch on the pilot's right sub panel. The system incorporates an electric motor which drives torque shafts to ball screw actuators positioned on the left and right main gear, duplex chains drive a ball screw actuator which moves nose gear (Figure 1).

A manual gear extension handle, situated in the cockpit, can be used to lower the landing gear in the event of a fault.

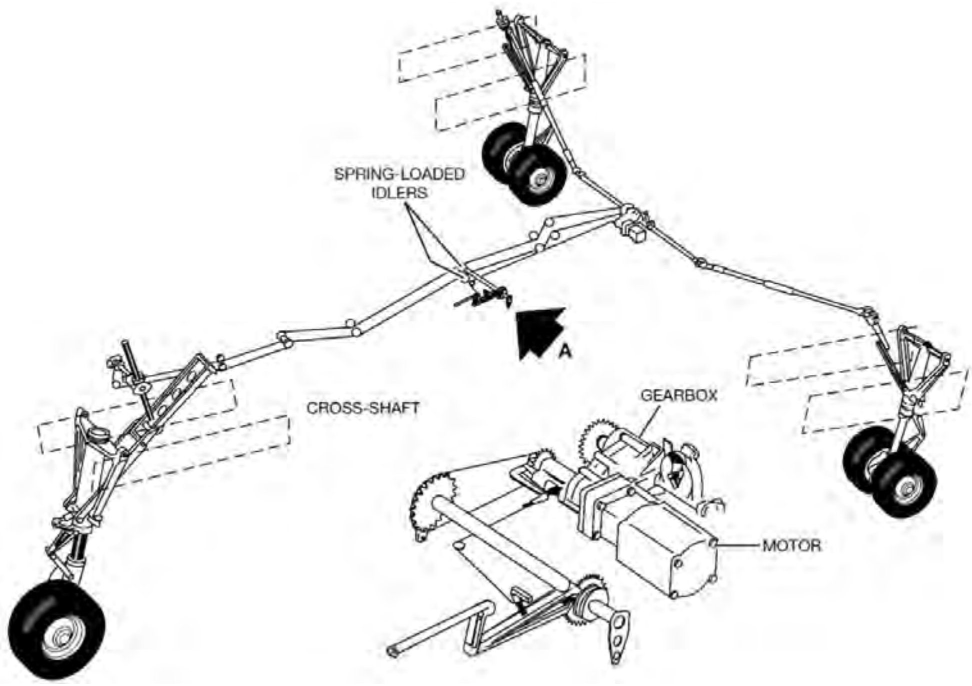


Figure 1

Super King Air electro-mechanical landing gear arrangement showing manual lowering system

Footnote

1 Other King Air aircraft use a hydraulic landing gear system.

Main landing gear down-locks are provided by notched hook and plate attachments on the drag braces (Figure 2). As the landing gear extends, a link mechanism, connected to the actuator, positions the notched hook to engage with the plate attachment at the extent of travel. When the gear is down and locked the notched hook contacts a down-lock indicator switch which when depressed illuminates its respective green landing gear light in the cockpit.

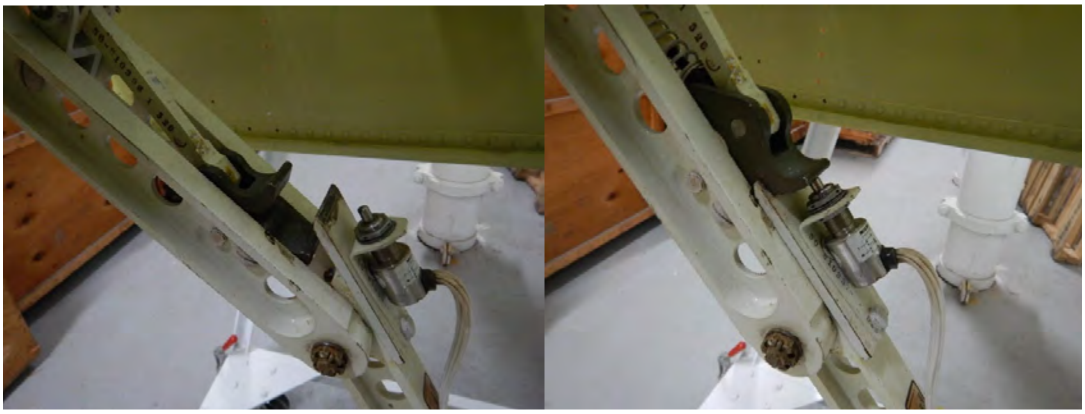


Figure 2

Beechcraft 200 landing gear mock-up showing down-lock operation;
Left image: during travel right image: locked

G-GHSV had been fitted with overhauled landing gear actuators in February 2020, 170 flying hours before the accident. At the time they were fitted, the down-lock rigging was set. No further maintenance of the actuation system was required until 30 months after the installation, which would have been in August 2022.

At the time of the accident the aircraft's certificate of airworthiness was valid and its airworthiness review certificate was in date.

Aircraft examination

The aircraft was recovered to a maintenance facility where the landing gear could be examined. With the aircraft jacked, the left main landing gear lowered under gravity revealing that the actuator shaft had failed close to rod end clevis. The down-lock mechanism was also damaged and was missing the hook and lever attachment on the notched hook (Figure 3). The missing components from the down-lock mechanism were not recovered after the accident.

The damaged actuator was removed from the aircraft and examined in a laboratory where it was discovered that the actuator shaft had failed in buckling around its thinnest section. The actuator shaft had also bent where it exited the actuator body when fully extended. The actuator trunnions had fractured (Figure 4).

The fractures on the down-lock notched hook were assessed to have been in sheer overload with no evidence of pre-existing cracks (Figure 5).

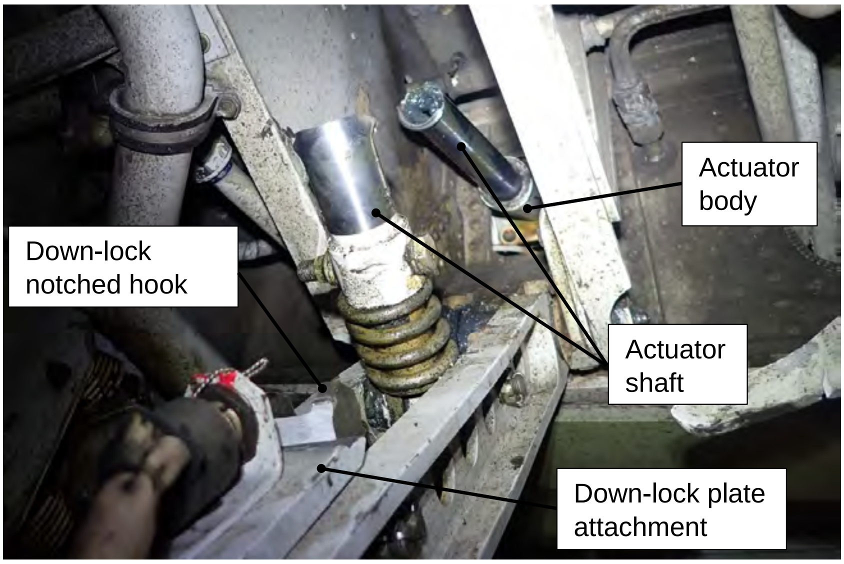


Figure 3

Left main gear fracture actuator and damaged down-lock

Figure 4

Left main landing gear actuator with actuator shaft removed form actuator body

Figure 5

Damaged notched hook

Analysis

The damage to the down-lock mechanism suggests that when the landing gear was lowered the locking plate did not fully engage with the notched hook and therefore the landing gear remained in an unlocked condition. When the aircraft landed, the unlocked drag brace started to fold. As it did so it forced the locking plate through the partially engaged hook, causing the hook to fracture. The drag brace continued to fold loading the actuator, causing it to buckle. This loaded the lever attachment of the notched hook, causing it to fail as the gear continued to collapse.

It is likely that the down-lock rigging had lost adjustment which manifested itself in the left main gear down-lock not fully engaging. This, in turn, resulted in the left main gear green light not illuminating, as the hook did not contact the indicator switch.

Due to the damage to the components, the cause of the loss of rigging adjustment could not be established. The rigging had been set at the time the actuator had been installed some 170 hours before the accident. It is therefore unlikely that it had been incorrectly rigged at the time of installation.

SERIOUS INCIDENT

Aircraft Type and Registration:	AS-350, D-HKMB
No & Type of Engines:	1 Arriel 2D turbine engine
Year of Manufacture:	2013
Date & Time (UTC):	17 September 2022 at 1045 hrs
Location:	Auchmacoy, Aberdeenshire
Type of Flight:	Specialised operations
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:	73 years
Commander's Flying Experience:	23,700 hours (of which 20,000 were on type) Last 90 days - 32 hours Last 28 days - 20 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The helicopter was conducting a survey operation which required flight on closely-spaced parallel tracks at low height. During the turn between two tracks it descended, and the underslung sensor array struck an electricity supply pylon. The impact severed the electricity supply cables causing a loss of power to approximately 1,682 properties. The pilot was unaware of the event and continued his planned sortie.

Following this event, the CAA stipulated enhanced risk mitigation measures for such operations.

History of the flight

The helicopter was operating from a field location near Auchmahoy in Aberdeenshire. It departed from the field location at 1002 hrs and commenced its survey operation using an underslung antenna. This required flying closely-spaced parallel tracks at low height to allow the survey antenna to operate effectively. An overview of the intended survey area and the incident flight is at Figure 1.

The planned height of the antenna above ground was 35 to 45 m and the antennae was suspended 50 m below the helicopter. Therefore, the helicopter would be operating approximately 280 to 300 ft agl. The planned speed for the survey was 35 to 45 kt.

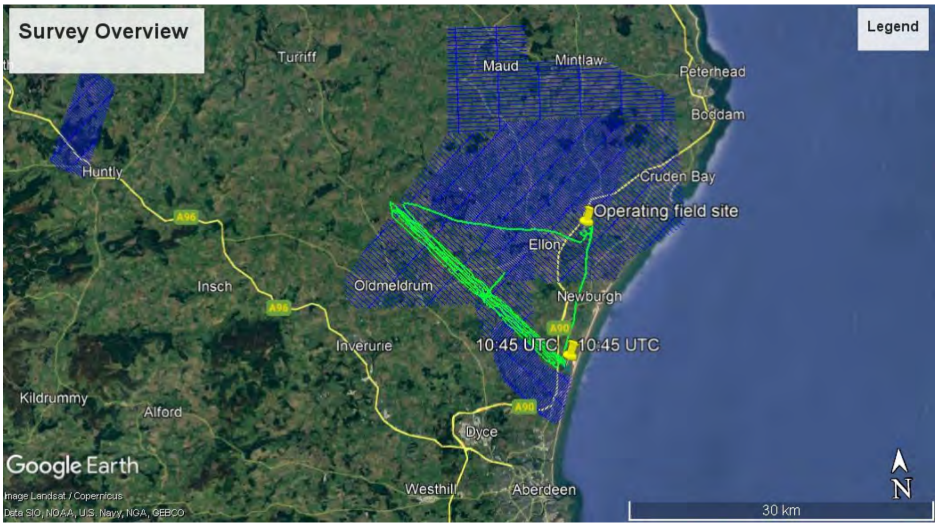


Figure1

Survey Overview
Blue Grid - Planned survey area, Green line - Incident flight

At 1045 hrs the pilot was manoeuvring the helicopter from one planned survey track to the next. To ensure he stayed clear of buildings he had reduced speed to minimise the turning radius. As the speed reduced, the power required to maintain level flight would have increased as translational lift reduced. During the manoeuvre the helicopter lost height and the underslung antenna array struck a 8 m (26 ft) tall electricity supply pylon north of Balmedie (Figures 1 and 2). The collision severed the power cables and interrupted the power supply to 1,682 properties. An expanded view of the incident area is at Figure 2. The pilot stated that he was unaware that the antenna had struck the pylon, so continued the sortie as planned, and was only made aware of the event after landing at the operating field location.

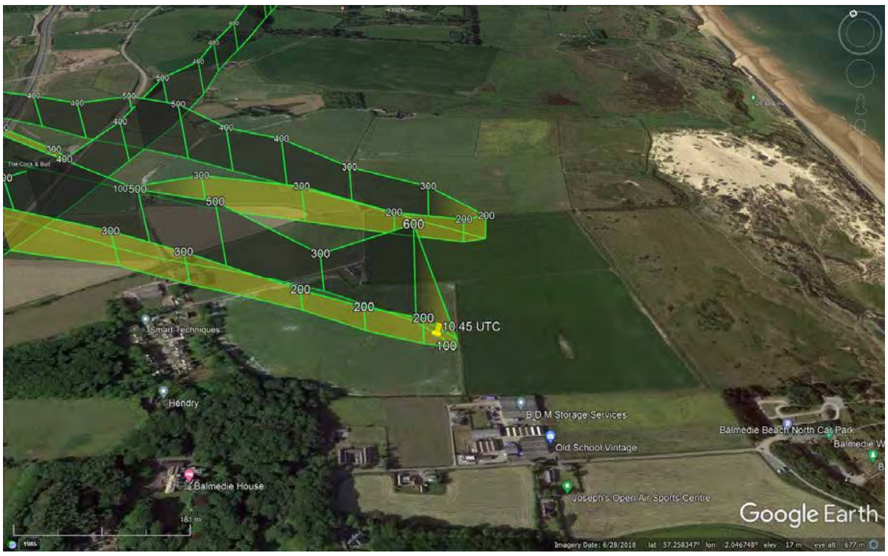


Figure 2

Flight path, with incident at 1045 hrs, showing barometric altitudes

Underslung antenna array information

To conduct the geophysical survey the helicopter carried an underslung antenna array (Figure 3). The whole system including its internal generator weighs 780 kg. To avoid the structure of the helicopter affecting the measurements taken by the system the antenna is carried 50 m below the aircraft. The antenna frame is 28 m long, 16.5 m wide, and covers an area of 340 m^2. The operator had no specific flight test data related to the load but stated that the Rotorcraft Flight Manual limited the speed to 80 kt for underslung loads but gave no limit for angle of bank.

The antenna transmits an electromagnetic signal which is reflected from the ground. The reflected signal is used to indicate the conductivity of the different layers of the ground and forms the basis for a geological interpretation of what is contained in the layers. The incident occurred during the first scheduled survey using the system in the UK, although the system has been operated globally for 17 years and has covered 1.3 million km of survey lines.

Figure 3
Antenna suspended from an AS350

Organisational information

To facilitate the operation of the survey antenna at the required heights the operator made an application to the CAA for a permission against the terms of SERA 5005. This rule requires aircraft to approach no closer than 500 ft to any vehicle, vessel, person or structure. The application made a request to operate the underslung load at 80 ft agl and the helicopter at 100 to 200 ft agl. It stated that built up areas would not be overflown, and all cities, villages or single houses would be circumnavigated. The application form required the submission of a detailed risk assessment for the proposed activity and, in response, the operator submitted its Standard Operating Procedure (SOP) for operating with the antenna system.

The SOP analyses risk based on the interaction between the likelihood and severity of a hazardous event. Specific events in a risk register are analysed to give a risk rating. If the risk is in either the medium or high category, then additional control measures are required to reduce the risk to an acceptable level.

The risk analysis placed contact with obstacles in the high-risk category and therefore specific measures were required to alleviate the risk. The operator's mitigating measures were:

1. Flight experience
2. Experience with helicopter type/with kind of operations
3. Procedure (SOP)
4. Flight preparation
5. Suitable landing and takeoff sites
6. Preparation of landing site, ground communication (if possible)
7. Weather limits
8. Emergency response plan

With these mitigations in place, the risk register recorded the risk category as low. The mitigations used were generic and made no reference to the identification of obstacle hazards in the survey area, for example through the use of maps with powerline overlays (aviation charts generally only show known obstacles above 300 ft).

CAA Permission

The CAA granted a Permission for the operation to be conducted as follows:

‘a) *no flight pursuant to this Permission shall take place over a congested area, along a motorway, major arterial road or railway;*

b) no helicopter shall fly pursuant to this Permission closer than 60 metres (200 feet) to any person, vessel, vehicle or structure;

c) no flight shall be made pursuant to this Permission at night;

d) no flight shall be made under any structure or wires;

e) flight pursuant to this Permission shall be flown only within the areas outlined in the .kmz file "Q1597_GBR_Aberdeenshire_NewExco" and in accordance with the procedures, conditions and limitations specified in the company document "AIR-OPS-SOP 004-Skytem-Stand 9- 211009", supplied to the CAA with the email "Airborne Survey flights permission low level" dated 26 April 2022;

f) *before any flight is made pursuant to this Permission, the operator shall inform the local police authority, and if possible, the Local Authority of each intended flight;*

g) *the operator shall record the time at which the helicopter takes off and the time at which it lands in relation to any flight made pursuant to this Permission together with details of the location by map grid reference of the area or areas over which such flights were undertaken;*

h) *any record required to be made pursuant to this Permission shall be retained by the operator for 12 months and shall, within a reasonable time of being demanded by an authorised person, be produced by the operator to that authorised person;*

i) *before any flight is made pursuant to this Permission, the Operator shall take NOTAM action as appropriate to the route and location.'*

The operator complied with the requirements at f) and i), to file NOTAMS and inform the local authorities of the survey activity. Following the incident, the CAA withdrew the Permission to operate to 200 ft from vehicle, vessel, person or structure.

Aircraft performance

The SOP for the operation with the underslung antenna array recognised that significant portions of such flights would be carried out within the avoidance zone of the Height/Velocity diagram[1]. The Height/Velocity diagram for the AS350 is at Figure 4 and the avoidance zone is shown by a 'Z'. Within the avoidance zone if an engine failure occurs a safe landing is unlikely. This risk is also addressed in the risk register and classified in the high category. The suggested mitigations are good maintenance, using trained, experienced pilots and avoiding built up areas, houses and roads. If an engine failure occurs within the Height/Velocity diagram avoidance zone, the aircraft has insufficient performance to affect a safe landing. A twin engine helicopter would have much reduced exposure to the risk of engine failure but would carry a much greater commercial cost.

Analysis

The underslung antenna struck an electricity pylon as the helicopter manoeuvred between survey lines. The pilot had reduced speed to minimise the turn radius to keep the antenna clear of buildings. However, it is likely as the speed reduced and the power demand consequently increased the pilot did not accurately control the height of the aircraft and allowed the descent. The antenna was therefore below its intended survey height and struck a pylon that was 8 m tall, severing the power cables. Unaware of the collision the pilot continued his planned survey.

Footnote

1 The Height-Velocity diagram is a performance chart that shows combinations of height and forward speed (including hover) from which, after an engine failure, a safe landing cannot be made.

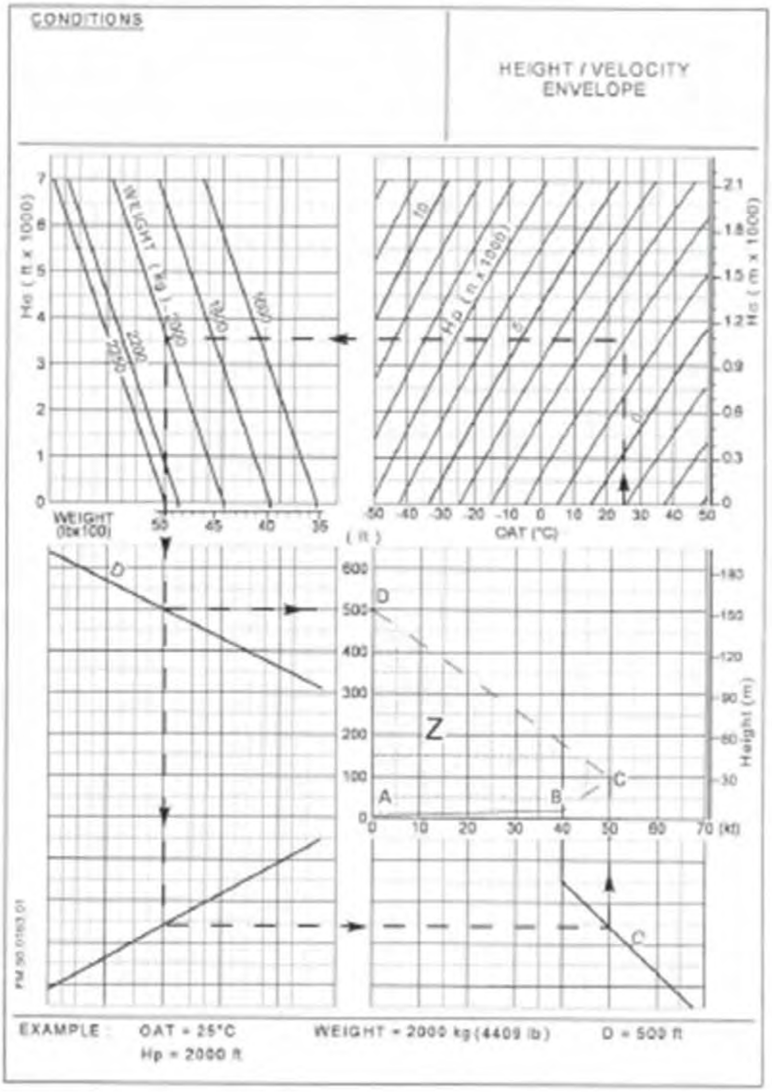


Figure 4
AS350 Height/Velocity diagram

The maps available to the pilot showed only the major power cables and so in his pre-flight preparation he would have been unaware of the presence of the pylon involved in the incident. Avoiding the lower height power cables during the survey relied on the single pilot acquiring such obstructions visually. Given the demanding nature of the intended task, carrying the antenna at only 80 ft agl, the pilot's routine workload was high, which may explain why he did not recognise the presence of the pylons and their proximity to his manoeuvre. The generic mitigations in the operator's risk register, and 'flight preparation' in particular, were ineffective at identifying that a relevant obstacle existed on the route and, thereby, preventing the collision.

At low speed and height the helicopter was operating within the unsafe area of the Height/Velocity diagram. As a result, if the aircraft suffered an engine failure, then a safe landing would be unlikely. As the aircraft would lack the performance to achieve a safe landing the training and experience of the pilot, suggested by the operator as a mitigation would not be effective. This could be alleviated by using a twin engine aircraft but would incur significantly increased commercial costs.

Conclusion

The pilot was not aware of a height loss during a low speed manoeuvre between planned lines of an aerial survey. As a result of the height loss, the aircraft's underslung load was below its intended height and struck an electricity pylon that had not been identified as a relevant obstacle on the route.

Safety actions

Following the CAA's withdrawal of the Permission to operate below the SERA 5005 limitations, the operator cancelled the remainder of the survey. The CAA issued the operator with an enhanced requirement for mitigations that would be required for any similar operation in future, as follows:

1. The Risk Assessment to be revaluated and have more detail.
2. The 60 m lateral distance from the Load to be included in the SOPs / RAs, matching the more specific 60 m 'bubble' of the new Permission.
3. A 45 m agl minimum height limitation for the load.
4. The use of an observer in the left seat. This crew member would be responsible for lookout, obstruction identification and having mapping with an obstruction overlay.
5. Mapping, ideally digital, with obstruction overlay to be used for both planning and whilst in flight.
6. The pre-flight planning processes should be demonstrated to the CAA before operations commence.
7. The quality and acceptability of the obstruction data and mapping should be demonstrated to the CAA before operations commence.

ACCIDENT

Aircraft Type and Registration:	Beech F33A, G-MOAC
No & Type of Engines:	1 Continental Motors Corp IO-550-B piston engine
Year of Manufacture:	1989 (Serial no: CE-1349)
Date & Time (UTC):	9 September 2022 at 1615 hrs
Location:	Alderney Airport, Guernsey
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 2
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to leading edge of right wing and outer leading edge of left wing. Aircraft damaged beyond economic repair
Commander's Licence:	Private Pilot's Licence
Commander's Age:	83 years
Commander's Flying Experience:	2,520 hours (of which 2,313 were on type) Last 90 days - 13 hours Last 28 days - 4 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft was approaching Runway 26 at Alderney. The pilot lost sight of the runway due to the glare from the sun and descended below the glide path. The aircraft struck the runway approach lights with both wings and the propellor before reaching the threshold. The aircraft was extensively damaged but all those on board were uninjured.

History of the flight

The aircraft (Figure1) departed Guernsey at approximately 1630 hrs for the short flight to its home airfield of Alderney. The pilot recalled descending to 1,000 ft on a QFE of 1002 hPa and joining downwind for Runway 26. He stated that his usual practice was to set the QNH on both altimeters for departure, but to set the QFE on only the main altimeter for an approach.

The pilot stated that the visibility was good with no low cloud and that the runway was clearly visible from the downwind leg. The pilot recalled turning onto base leg and believed he was correctly positioned. He then turned onto final at 500 ft QFE at 75 kt. There was some glare from the low evening sun, but the pilot continued the approach on the centreline. The glare significantly reduced the pilot's vision ahead but he could see the approach lights and so knew that the runway lights were on. He did not recall seeing the APAPI (Abbreviated

Precision approach Path Indicator)[1] lights. He continued the approach expecting the runway edge and threshold lights to become visible. As the glare continued to reduce the pilot's visibility, he concentrated on looking out to visually acquire the runway lights. As he did so the aircraft descended below the glidepath and struck the approach lights.

Figure 1
Beechcraft Bonanza

The aircraft struck the last three approach lights before the threshold and then a threshold light before reaching the runway. It ran for a short distance along Runway 26, before exiting the runway to the right onto the grass and coming to a stop on grass Runway 03/21. The aircraft's fuel tanks were ruptured by the collisions with the lights and fuel was spilled on to the grass next to the approach lights and onto the surface of Runway 26. Air Traffic Control (ATC) at Alderney were not immediately aware of the collision with the lights but alerted the RFFS when the aircraft left Runway 26 and the pilot stopped responding to ATC calls on RTF. When the aircraft stopped on the grass runway, ATC directed the RFFS to attend and on reaching the aircraft they found all three occupants had already disembarked the aircraft and were uninjured.

The aircraft was 33 years old, and the pilot considered that micro scratches on the transparency would have exacerbated the glare effects and compounded the difficulties of seeing the runway on final approach.

Aerodrome information

Alderney Airport (Figure 2) is the only airport on Alderney. The main runway, 08/26, is 880 m (2,887 ft) long and is mainly asphalt. Runway 26 has an APAPI glidepath indicator positioned 150 m from the threshold and adjacent to the touchdown markings. The approach lighting system on Runway 26 consists of a series of high intensity centreline lights with one cross

Footnote

[1] Abbreviated Precision Approach Path Indicator. A lighting system which gives pilots guidance to their vertical position relative to a runway. The system on Runway 26 at Alderney is set to indicate a 3° glidepath.

bar, extending 420 m from the threshold. The ground slopes up towards the Runway 26 threshold and therefore the approach lights are mounted on pylons. The first of the three light masts that the aircraft struck was 175 m from the threshold.

Figure 2

Alderney Airport Chart

Accident site

The light masts are shown in Figure 3 in sequence with 1 being the first mast struck.

Figure 3

Approach light positions

A cross section view of the approach lights is shown in Figure 4. The lights were mounted on masts to give the correct perspective to pilots.

Mast 1 was severed approximately half way up and so the aircraft was already below the level of the runway at that point. Mast 2 appeared to have been struck low down and ground marks suggested it was likely the aircraft touched the ground at this point. It is probable that the most serious damage to the right wing occurred at Mast 2, still approximately 117 m from the runway threshold. The fuel spill trail began at Mast 2 and continued until the aircraft was 90 m along the runway surface.

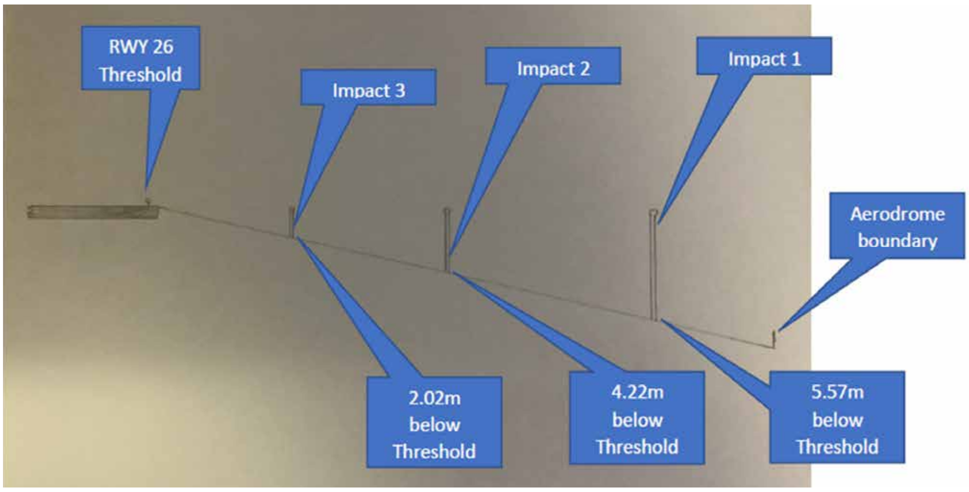


Figure 4

Cross section of the approach showing mast position

Figure 5 shows an image, taken by the RFFS, of a view from the approach lights looking toward the Runway 26 threshold.

Figure 5

View towards Runway 26 threshold

The sun is relatively low in the sky and aligned with the runway.

Aircraft information

The aircraft was not examined by the AAIB but the airport authority supplied pictures of the damage. Figure 6 shows the damage to left wing believed to have been sustained during the collision with Mast 1.

Figure 6
Left wing leading edge damage

The most serious damage was likely sustained on the right wing when the aircraft struck Mast 2 and this is shown at Figure 7.

There were several other areas of impact damage on the aircraft including to the propellor blades.

Figure7
Right wing root damage

Analysis

The flight proceeded normally, in good weather, until final approach to Runway 26 at Alderney. The sun was low in the sky and aligned with the runway, and the glare of the sun, exacerbated by micro scratches on the aircraft windshield, caused the pilot to lose sight of the runway. The pilot stated that he turned onto final approach at 500 ft QFE.

The pilot could see the approach lights and continued his approach on the centreline. He could not, however, see the threshold lights, the runway edge lights or the APAPIs. The APAPIs would have given an accurate indication of the aircraft's vertical position with respect to the glidepath. With the lack of the vertical information and the degraded visual references it is likely that the pilot allowed the aircraft to descend well below the glidepath.

The aircraft descended below the glidepath and the level of the airfield, and struck the final three approach lighting masts. The aircraft was extensively damaged but did run onto the runway surface before exiting onto the grass.

Despite the poor visual references, the pilot did not consider a go-around as he was sure the aircraft was correctly positioned.

Conclusion

The pilot lost visual references and descended below the glidepath on final approach due to the glare of the sun on a scratched windshield. The aircraft struck the last three approach lighting masts and a threshold light, suffering extensive damage.

SERIOUS INCIDENT

Aircraft Type and Registration:	DHC-1 Chipmunk 22, G-BXHA
No & Type of Engines:	1 De Havilland Gipsy Major 10 Mk 2 piston engine
Year of Manufacture:	1952 (Serial no: C1/0801)
Date & Time (UTC):	22 March 2022 at 1410 hrs
Location:	Sevenoaks, Kent
Type of Flight:	Training
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Cracked propeller and boss blocks
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	38 years
Commander's Flying Experience:	9,000 hours (of which 5 were on type) Last 90 days - 70 hours Last 28 days - 16 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and additional enquiries by AAIB

Synopsis

During the flight the aircraft developed severe vibration requiring the pilot to return to the airfield where fatigue cracks were found in the propeller and its two mounting blocks. The cracks originated from fretting between the propeller assembly and splines on the engine hub.

The aircraft's Type Responsibility Agreement holder, CAA and LAA are taking combined safety action to promulgate enhanced guidance for continued airworthiness of Fairey Reed propellers. This action is in addition to existing inspection and maintenance requirements to owners of aircraft using this propeller type.

History of the flight

During the initial climb after takeoff, the pilot noticed some subtle airframe vibration. However, due to a lack of recency on type, he could not recollect if the level of vibration was normal for the aircraft and elected to continue the flight.

While manoeuvring, the airframe vibrations increased abruptly and to a level that the pilot had difficulty reading the instruments. The pilot returned to the airfield where during the taxi the vibration caused the low voltage warning light to fall out of the instrument panel.

Aircraft information

General

The de Havilland Canada DHC-1 Chipmunk is a low-wing, single engine aircraft. G-BXHA was manufactured in the UK in 1952 and was equipped with a Gipsy Major 10 Mk 2 piston engine, fitted with a Fairey Reed A66753/X1 fixed-pitch aluminium propeller. This propeller type is fitted on numerous piston engine aircraft operating with either a CAA Certificate of Airworthiness, CAA Permit to Fly or a LAA administered Permit to Fly. There is no Formal Design Authority for Fairey Reed propellers; however, the aircraft's Type Responsibility Agreement holder holds the technical dataset.

Propeller assembly

The propeller is paired with forward and aft boss blocks made from cast aluminium (Figure 1).

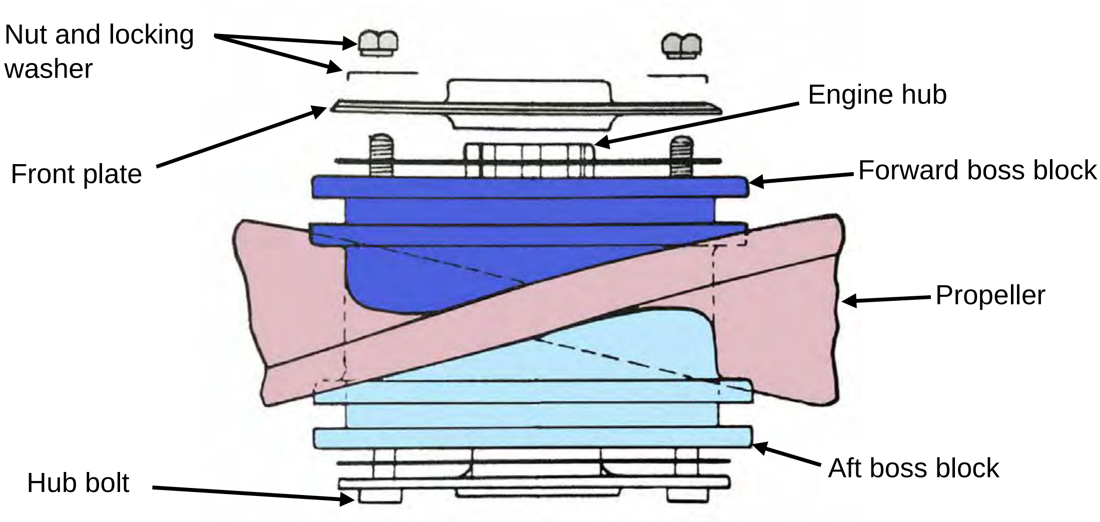


Figure 1
Propeller assembly arrangement

The boss blocks each have one flat surface and one curved surface that is matched to the contour of the propeller face. The propeller assembly's integrity relies upon a close fit between the blocks and propeller surfaces. The assembly is installed on a splined engine hub and held in place by eight propeller hub bolts and nuts.

Aircraft maintenance history

In November 2000, the aircraft's propeller and boss blocks were removed and replaced with an overhauled propeller assembly. An invoice showed that in April 2015 the propeller assembly was removed and subjected to an eddy current inspection; however, there was no record in the aircraft logbook to explain why this was carried out. There is also no evidence that the propeller assembly had been subject to damage or repair.

In April 2017, the propeller assembly was removed and Service Bulletin (SB) FRP.001.[1] was carried out. This SB requires a visual inspection for cracks of the propeller and boss blocks; if there is any doubt as to the condition of the propeller, the SB recommends that a dye penetrant technique should be used. However, the SB does not specify the inspection of the inner diameter of the boss blocks for wear or corrosion. The dye penetrant inspection was not carried out and there is no record of any damage having been found on the propeller assembly.

At the time of this event, the propeller had flown 97 hours since the SB was last carried out.

Examination of propeller assembly

General

Two cracks were found in the propeller, four cracks in the forward boss block and three in the aft boss block (Figure 2).

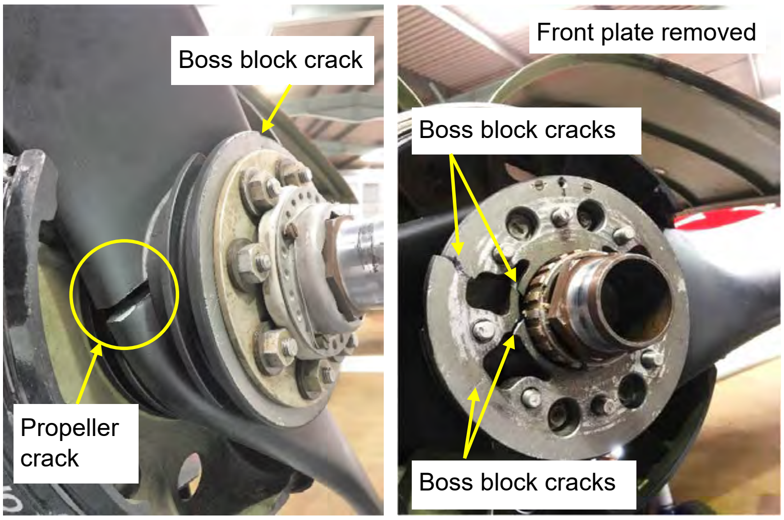


Figure 2

Propeller assembly with spinner removed showing cracks in forward boss block and propeller

Alignment of propeller assembly

The propeller and boss blocks are considered as one unit, and the boss blocks are not interchangeable between other propellers. SB FRP.001.1 states that before dismantling, a white alignment mark should be painted down one side of the boss blocks. No such mark was present on the propeller or boss blocks to verify their correct alignment during the last reassembly. Following this event, the fit of the blocks to the propeller was found to be satisfactory and the serial numbers for the three propeller assembly components were correct.

Footnote

1 SB FRP.001.1 requires the servicing and inspection of all Fairey Reed fixed pitch metal propellers and boss blocks at 300 hour intervals.

Propeller

The propeller had a crack that extended through a hub bolt hole, completely through the material's thickness. A second crack was evident at a second propeller hub bolt hole (Figure 3).

The surface finish of the bolt hole radii[2] and propeller face were not *'smooth and highly polished'* as specified in the Fairey Reed Repair Specification[3].

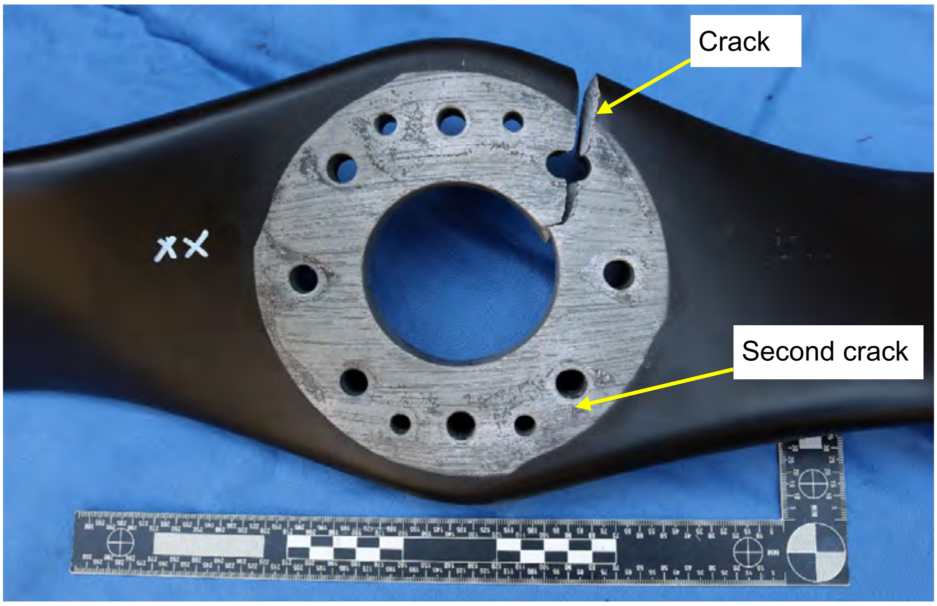


Figure 3
Cracks in propeller

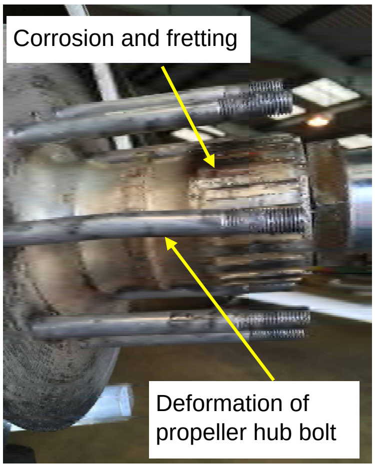
Splined engine hub

There was evidence of fretting and corrosion on the splines of the engine hub with corresponding marks on the inner surfaces of the boss blocks and the propeller (Figure 4). Some marking of the forward boss block inner diameter is considered typical for the propeller's age and type.

One of the propeller mounting bolts was bent. Torque values of the propeller mounting nuts were assessed by the maintenance organisation to be normal.

Footnote

[2] The outer edge of a hole, typically rounded off where it meets the material's upper and lower surfaces.
[3] Repair of Fairey Metal Propellers General Specification F.A.C.1, (Issue 3, April 1950)



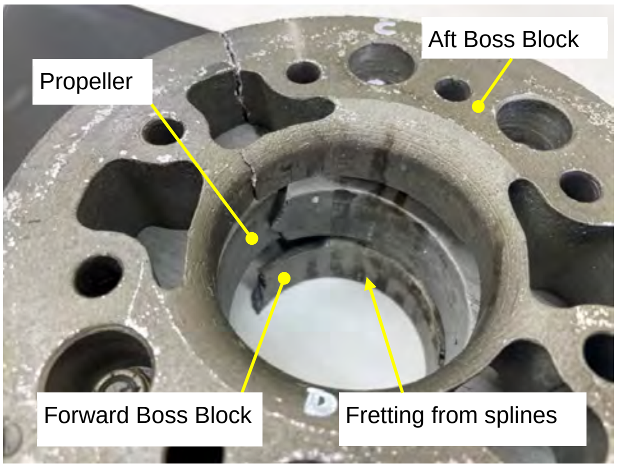


Figure 4

Engine hub corrosion and fretting, and fretting of inner surfaces of blocks and propeller

Analysis of fracture surfaces

The propeller and boss blocks were examined by a metallurgist.

Failure of boss blocks

Of the four cracks in the forward boss block, one was assessed as the primary fatigue fracture and the remaining three were assessed as secondary overload failures. The primary fracture originated from a worn area on the inner diameter, caused by fretting from the splines of the removable propeller hub. Thumbnail shaped deposits of oxide and rust at the edge of the fracture surface (Figure 5) indicated that the crack initially grew slowly and then accelerated when it was a few millimetres deep. The crack had grown to approximately 20 mm in length when final failure occurred.

The aft boss block had fractured in three places, resulting from overload failure.

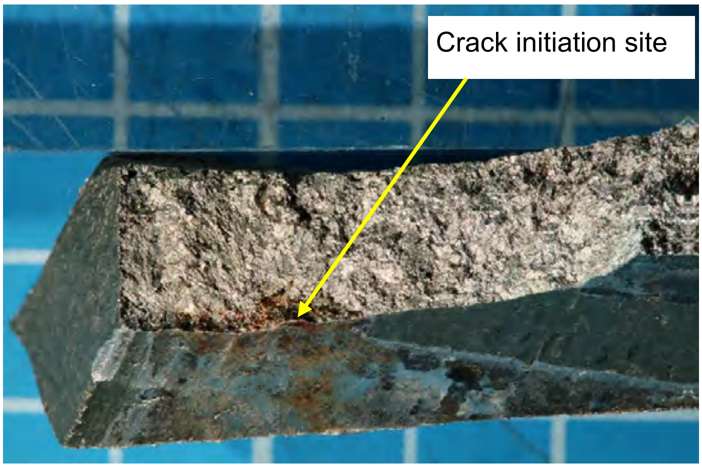


Figure 5

Primary fracture surface of forward boss block

Failure of the propeller

The primary fatigue crack of the propeller initiated on opposite sides of a propeller hub bolt hole (Figure 6). There is no evidence of damage associated with crack initiation on one side of the hole. On the other side of the hole, the crack initiated from a small gouge; however, this damage was not considered to be large enough to have initiated the fatigue failure.

The secondary fatigue crack in the propeller also initiated from the radius of a bolt hole; there was no evidence of pre-existing damage around this hole.

The surface finish of the radii on the bolt holes and the propeller face were not in accordance with the manufacturer's specification. However, this was not considered to be the primary origin of the fatigue failures in these areas.

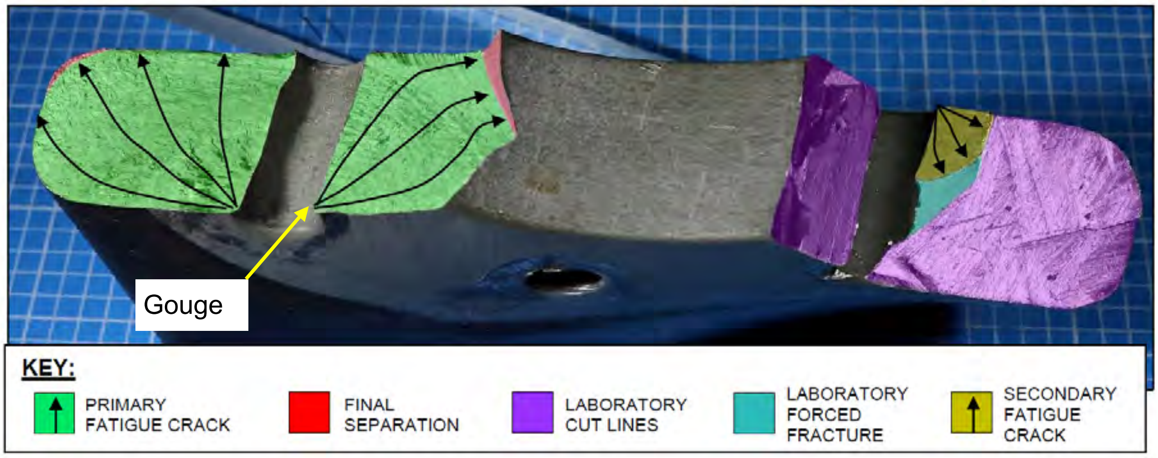


Figure 6
Propeller fracture surfaces

Sequence of failure

The fretting and cracking on the forward boss block and propeller developed at the same time, probably as a result of abnormal loading on the propeller assembly. It was not possible to determine how long the primary crack on the propeller had been present, nor was it possible to identify a source of the abnormal loading.

It is assessed that when the primary crack in the forward boss block reached approximately 20 mm in length, the propeller's primary crack separated. This was followed by separation of the forward boss block primary crack and finally both boss blocks in overload.

Conclusion

The initiating failure of the propeller assembly was caused by fatigue cracking of the forward boss block and propeller, resulting from fretting and corrosion. The existing SB to inspect the propeller assembly does not specify inspection of the inner diameter of the boss blocks for wear or corrosion.

As a result of this investigation, the aircraft Type Responsibility Agreement holder, the CAA and LAA are taking the following Safety Action:

Aircraft Type Responsibility Agreement holder

Will promulgate a Technical News Sheet to its subscribers which will include enhanced guidance for continued airworthiness of Fairey Reed propellers. This will include the use of Non-Destructive Testing, and inspections for corrosion, fretting and correct surface finish.

CAA and LAA

Will work together to promulgate the content of the Technical News Sheet to owners of this propeller type operating under a UK CAA Certificate of Airworthiness, UK CAA Permit to Fly, or LAA administered Permit to Fly.

ACCIDENT

Aircraft Type and Registration:	Piper PA-32-300, G-WINS
No & Type of Engines:	1 Lycoming IO-540-K1A5 piston engine
Year of Manufacture:	1976 (Serial no: 32-7640065)
Date & Time (UTC):	3 November 2022 at 1350 hrs
Location:	Approximately 7 nm SE of Jersey Airport
Type of Flight:	Training
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Aircraft sank after ditching
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	46 years
Commander's Flying Experience:	6,973 hours (of which 1,073 were on type) Last 90 days - 133 hours Last 28 days - 64 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and additional enquiries made by the AAIB

Synopsis

The aircraft ditched south-east of Jersey after the engine lost power. Both pilots were uninjured and were rescued from their life raft by the Royal National Lifeboat Institution (RNLI). The aircraft sank and was not recovered so the cause of the loss of power is unknown.

History of the flight

G-WINS departed Jersey on an instrument training flight for a PPL holder who was a member of the syndicate that owned the aircraft. No anomalies were found during the pre-flight checks and it was reported that a visual assessment of the fuel tanks indicated that there was approximately 64 USG of fuel onboard[1]. The pilots estimated that this was adequate for 3.5 to 4 hours duration, which was sufficient for the planned flight of 1 hour 15 minutes.

ATC cleared the aircraft to operate in the training area to the south and south-east of Jersey between an altitude of 2,000 and 5,000 ft. The final part of an instrument scanning exercise was a descent from 4,000 ft to 2,000 ft for a Required Navigation Performance (RNP) approach to Runway 26 at Jersey. The pilot-in-command said that the descent was conducted with the power slightly above idle with an airspeed of approximately 120 kt and

Footnote

[1] G-WINS was equipped with additional long-range fuel tanks. The aircraft had a maximum fuel capacity of 84 USG (approximately 318 litres)

a rate of descent of 700 ft/min. Everything seemed normal as they levelled off at 2,000 ft with 23” manifold pressure and 2,300 rpm, but after about 30 seconds the engine lost power and the manifold pressure reduced to less than 10”. They described the engine sound to be abnormal, but not rough-running.

They tried to rectify the problem by switching the electric fuel pump on, selecting alternative fuel tanks, selecting alternate air, and cycling the magneto switches. None of these actions had any effect so the pilot-in-command took control in a descent to maintain 75 kt. They tried adjusting the mixture (which had been fully rich) and different rpm selections but this had no effect. When the power lever was brought back towards the idle stop there was a slight increase in power and the manifold pressure increased to approximately 13”, but when the power lever was advanced the power reduced again, and the manifold pressure dropped to 10”. Unable to maintain altitude it was apparent that they would have to ditch.

As the aircraft descended, ATC reminded the pilot of his clearance, and he asked the controller to standby because they had an engine problem. Almost immediately after this the pilot declared a PAN and ATC confirmed the nature of the problem and the number of people on board. They said that the approximate position of the aircraft was known, and they were alerting the emergency services.

The PF asked the syndicate member to check that the life raft and his ‘grab’ bag, which contained a personal locator beacon (PLB), were readily accessible on the rear seats; these had been pre-positioned behind the forward seats prior to the flight. Both pilots were already wearing life jackets and three-point harnesses. The PF turned the aircraft into wind to reduce the groundspeed and he selected two stages of flap. The syndicate pilot transmitted that they were ditching, and ATC confirmed receipt of this transmission and said that the emergency services had been notified.

The PF flared the aircraft for the landing and both pilots said that the stall warner was sounding when the aircraft ditched. One described that water splashed over the windscreen but the other believed that the nose of the aircraft might have submerged before resurfacing. Neither were injured and the aircraft remained upright with the cockpit water-tight whilst they switched off the electrical power. They exited onto the starboard wing and inflated their life jackets before deploying and entering their life raft as the aircraft started to sink. They activated the PLB when they were in the life raft and observed that the aircraft looked intact. The only item of debris seen in the water was probably one of the wheel spats and the pilot-in-command estimated that the aircraft was submerged about three minutes after they ditched.

The syndicate pilot tried to send a text message using his mobile phone (which was wet), but there was no network coverage. The pilots were rescued by the Jersey Lifeboat about an hour after the aircraft ditched.

Cause of the power loss

The aircraft was not recovered and there were no photographs or recordings from onboard the flight. Records indicated that this was the second flight since the aircraft was refuelled on 15 October 2022, when 176 litres of fuel were uploaded. The aircraft logbook showed that the flight that was conducted immediately after refuelling was approximately one hour and on the day the accident occurred, the aircraft had been airborne for approximately 30 minutes. The possibility of contaminated fuel is considered unlikely, but the cause of the power loss was not established.

AAIB comment

This accident highlights the importance of prior planning, continuing to 'fly the aircraft', and carrying appropriate safety equipment when flying over water. CAA Safety Sense Leaflet 21[2] provides guidance to GA pilots regarding ditching light aircraft on water.

Footnote

[2] CAA Safety Sense Leaflet 21 – *Ditching Light Aircraft on Water* SafetySense_21-Ditching.pdf (caa.co.uk) (last accessed 4 January 2023)

ACCIDENT

Aircraft Type and Registration:	BB85Z hot air balloon, G-ELMR
No & Type of Engines:	No Engines
Year of Manufacture:	2022 (Serial no: 1936)
Date & Time (UTC):	13 September 2022 at 1730 hrs
Location:	Deighton, North Yorkshire
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 1 Passengers - 14
Injuries:	Crew - None Passengers - 1 (Serious) 1 (Minor)
Nature of Damage:	No reported damage
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	58 years
Commander's Flying Experience:	2,821 hours (of which 3 were on type) Last 90 days - 38 hours Last 28 days - 4 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

Having completed a flight over the city of York the pilot of G-ELMR began a descent ready for landing. Having decided on a field the pilot began to slow his rate of descent. Despite an extended burn, the balloon landed more heavily than the pilot would have liked before bouncing back into the air. It finally came to rest in a wide ditch between fields. During the landing sequence two of the passengers were injured.

History of the flight

Having been airborne for around 50 minutes, the pilot of G-ELMR decided to descend to find a landing spot for the balloon. With a light wind from the north, the pilot positioned the balloon to allow for a downwind landing. Having chosen a cut field near a main road, the pilot began to slow his descent.

With the wind varying in direction, the pilot then realised that the burns he had done to reduce the descent rate were not going to be sufficient to stop the balloon touching down short of his target field. He instructed his passengers to adopt their briefed and rehearsed landing positions. He committed to landing in a field of short stubble under the balloon. G-ELMR touched down harder than the pilot would have liked, and the balloon bounced 20 to 30 ft into the air before coming to rest in a wide ditch. One of the passengers sustained an injury to their neck and another reported similar injuries later.

Organisational information

Before flight, passengers are given a safety brief in which the position they must adopt on landing is shown to them, and they must then demonstrate the position to the pilot. This position is to have their heads and back against the padding of the basket and to hold on with two hands until the balloon comes to a complete stop. They are also briefed that the balloon may experience one or two bounces on landing and that it is vital they remain in the landing position if this should occur.

When a burn is in progress it can be difficult for the passengers to hear the instructions of the pilot. This can sometimes mean that the instructions to adopt the landing position can be later than ideal if a long burn is used to reduce the descent rate, as was the case with G-ELMR. The pilot of G-ELMR had been using the burners for a significant time to slow the descent rate and, after realising that his burn would not prevent the touchdown, was only able to give the passengers the instruction shortly before touchdown, as the balloon passed treetop level.

Analysis

Having adopted a high rate of descent rate ready for the end of the flight, the pilot then required a long burn to reduce this descent rate for landing. During this burn it was difficult for the pilot to instruct the passengers to adopt their landing positions due to the noise. Having realised that ground contact short of his planned field was unavoidable, the pilot gave the landing instructions to the passengers. The balloon touched down heavily, before bouncing and coming to rest in a ditch. Two of the passengers were injured, possibly due to not being in the correct landing position throughout the sequence.

Conclusion

As G-ELMR came into land at the end of the flight, it touched down heavily before bouncing back into the air and coming to rest in a ditch. Two passengers on the flight were injured during the landing sequence, possibly because they did not maintain their briefed and demonstrated landing position.

AAIB Record-Only Investigations

This section provides details of accidents and incidents which were not subject to a Field or full Correspondence Investigation.

They are wholly, or largely, based on information provided by the aircraft commander at the time of reporting and in some cases additional information from other sources.

The accuracy of the information provided cannot be assured.

Record-only investigations reviewed: November - December 2022

8 May 2022 **Mainair Blade** **G-CCZW** Headon Airfield, Nottinghamshire

A student pilot was attempting to land at Headon Airfield following a short solo flight. The pilot reported that she rejected the first landing, as she considered she was too high during the approach. On the second attempt to land, as the microlight touched down, it was caught by gusting wind, resulting in a heavy landing and loss of directional control. The aircraft then bounced and departed the runway at 90°, coming to rest in a hedgerow.

23 Jul 2022 **Cessna P210N** **N6398W** Providenciales International Airport, Turks and Caicos Islands

During the landing roll the aircraft drifted off the side of the runway and the nose landing gear leg collapsed.

13 Aug 2022 **Rans S6-ES** **G-BYZO** Old Warden Aerodrome, Bedfordshire

During the landing flare the aircraft's main wheels hit an unexpected hump on the runway, jolting the pilot's hand from the control column. Before he could apply power to go around the aircraft bounced again and landed on the nose wheel. The pilot reported that he had been distracted by initially misidentifying the landing runway, and that his approach speed may have been too high.

6 Sep 2022 **DH82A Tiger Moth** **G-ADPC** Derby Airfield

G-ALNA was taxiing behind G-ADPC in preparation for departure. The pilot of G-ALNA was carrying out pre-takeoff checks and became distracted from maintaining a good lookout. G-ADPC stopped, and the pilot of G-ALNA was unable to stop in time to prevent a collision causing damaged to the wings of both aircraft.

14 Sep 2022 **Sherwood Scout** **G-CLWT** Kingsmuir Airfield, Fife

The aircraft became low on the final approach to a farm strip and the left wheel struck a wire fence short of the runway threshold. The aircraft touched down sideways and span round as it stopped, damaging the left landing gear and propeller. The pilot may have been distracted by vehicles moving towards the runway undershoot on an adjacent farm track.

8 Oct 2022 **Piper PA-28RT-201** **G-BOJI** Blackbushe Airport, Surrey

Approximately 30 seconds after takeoff, the right side of the engine cowling top panel became detached and the panel lifted up 45°, partially obscuring the pilot's forward view. A PAN call was made and the pilot flew one circuit to land on the departure runway. Due to the drag of the panel the pilot made the approach with increased power and airspeed. The aircraft landed safely.

Record-only investigations reviewed: November - December 2022 cont

11 Oct 2022 **DA 40 NG** **G-LDGB** Mid Wales Airport, Welshpool, Powys

At a height of 20 ft, as the student pilot reduced power to land, the aircraft "rocked" slightly to the left. The pilot applied full power to go around but the aircraft continued to sink, and its left wheel touched the ground, pulling the aircraft to the left. The pilot reduced the power to idle and, as it slowed, the aircraft hit a fence and stopped in an adjacent field, damaging the left wingtip and the propeller.

12 Oct 2022 **Piper PA-28-161** **G-WARB** Wolverhampton Halfpenny Green Airport

With a passenger in the left seat, the pilot was flying from the right and had just levelled the aircraft at 1,500 ft when a "brownish coloured band" appeared on the windshield. He assumed it was from an engine oil leak and immediately turned back to the airfield. Soon, the oil completely obscured the pilot's forward visibility. He flew a crabbed approach, approximately 30° left of the runway track, and opened the cabin door so that he could see forward through the door aperture to line up with the runway. The aircraft landed safely. The oil leak was caused by a failed crank case seal plug.

23 Oct 2022 **Piper PA-28-161** **G-BOPC** Newquay Airport, Cornwall

The pilot inadvertently lined up on the runway edge lights as he was dazzled by the early morning sun on the wet runway. During the subsequent start of the takeoff run, three runway edge lights were damaged together with the propeller and nosewheel tyre of the aircraft. Believing that he had suffered a birdstrike the pilot rejected the takeoff and taxied back to the GA apron.

25 Oct 2022 **Gulfstream AA-5A** **G-BGCM** Near Whitby, North Yorkshire

During flight the pilot noticed that the two carbon monoxide spot detectors in the cockpit had turned black indicating the presence of carbon monoxide, so he elected to make a precautionary landing on his property's landing strip. After touching down, he believed he couldn't stop before reaching the end of the grass strip and decided to go around. The aircraft subsequently struck a wire fence and a dry-stone wall. The pilot escaped with minor injuries, but has since elected to cease flying.

25 Oct 2022 **Bristell NG5 Speed Wing** **G-NGCC** Hawks View Airstrip, Cheshire

The pilot was back tracking along the runway whilst listening to the Manchester area rather than the airfield radio. He noticed an aircraft on base leg and so vacated to the side of the runway and his aircraft subsequently struck a fence causing damage to the propeller and wing.

Record-only investigations reviewed: November - December 2022 cont

4 Nov 2022 **Cessna 182F** **G-WARP** Meppershall Airfield, Bedfordshire

Whilst taking off from a wet, grass runway, the aircraft started to drift to the left and despite attempts to correct its direction, departed off the edge of the runway onto soft ground. The nose wheel of the aircraft sank into the mud and broke off, resulting in the propeller contacting the ground and the aircraft coming to an immediate stop.

9 Nov 2022 **Piper PA-28-140** **G-ZEBY** Carlisle Lake District Airport

The pilot reported that the approach to land was too fast. The aircraft bounced several times before the nose gear collapsed.

25 Nov 2022 **Cessna 150M** **G-BRNC** Leeds East Airport

During the landing by a solo student, the aircraft bounced twice and the nose wheel leg collapsed.

27 Nov 2022 **Guimbal Cabri G2** **G-ETWO** Leicester Airport

The helicopter descended too quickly and landed heavily which resulted in damage to the right skid.

13 Dec 2022 **X'Air Falcon D(1)** **G-TBYD** Felthorpe Airfield, Norfolk

The aircraft was high and fast on approach. It landed heavily and the left gear leg collapsed.

14 Dec 2022 **Cessna 152** **G-CJPN** Cumbernauld Airport, North Lanarkshire

On touchdown during the student pilot's fourth landing of the day, the aircraft skidded, left the runway and the nose gear collapsed.

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).

BULLETIN CORRECTION

Aircraft Type and Registration:	Freefly Systems Inc. Alta X
Date & Time (UTC):	29 June 2022 at 1124 hrs
Location:	Henley-on-Thames, Oxfordshire
Information Source:	Aircraft Accident Report Form submitted by the pilot and further AAIB enquiries

AAIB Bulletin No 1/2023, page 46 refers

Prior to publication it was noted that the aircraft manufacturer was incorrectly stated to be ‘Free Fly’, whereas the correct description is ‘Freefly Systems Inc.’.

The online version of the report was corrected before the report was published on 12 January 2023.

TEN MOST RECENTLY PUBLISHED FORMAL REPORTS ISSUED BY THE AIR ACCIDENTS INVESTIGATION BRANCH

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.

1/2020 Piper PA-46-310P Malibu, N264DB
22 nm north-north-west of Guernsey
on 21 January 2019.

Published March 2020.

1/2021 Airbus A321-211, G-POWN
London Gatwick Airport
on 26 February 2020.

Published May 2021.

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 Union 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
GNSS	Global Navigation Satellite System
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)
mb	millibar(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
TODA	Takeoff Distance Available
UA	Unmanned Aircraft
UAS	Unmanned Aircraft System
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