Air Accidents Investigation Branch

AAIB Bulletin 11/2024

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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.

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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-28-181, G-BVNS	
No & Type of Engines:	1 Lycoming O-360-A4M piston engine	
Year of Manufacture:	1976 (Serial no: 28-7690358)	
Date & Time (UTC):	23 April 2024 at 1503 hrs	
Location:	1.5 miles from Prestwick Airport	
Type of Flight:	Currency Check flight	
Persons on Board:	Crew - 1	Passengers - 1
Injuries:	Crew - 1 (Serious)	Passengers - 1 (Serious)
Nature of Damage:	Aircraft damaged beyond economic repair	
Commander's Licence:	Light Aircraft Pilot's Licence	
Commander's Age:	75 years	
Commander's Flying Experience:	307 hours (of which 101 were on type) Last 90 days - 0 hours Last 28 days - 0 hours	
Information Source:	AAIB Field Investigation	

Synopsis

While the aircraft was on a right base leg for an approach to Runway 30 at Prestwick Airport, ATC lost visual and radio contact. The aircraft had suffered a power loss and established a glide descent. The aircraft hit a tree during the latter stages of the forced landing, and subsequently struck the ground vertically nose-down. Both of those on board sustained serious injuries.

The report considers carburettor icing and the use of carburettor heat, both of which are the subject of a Civil Aviation Authority (CAA) Safety Sense Leaflet. It also highlights licensing, specifically revalidation, and the CAA's General Aviation Pilot Licensing and Training Simplification work.

History of the flight

The PIC was out of currency according to the flying club's rules which require pilots to fly at least once every 62 days. He therefore scheduled a flight with the club's Chief Flying Instructor (CFI) who, though still in post, did not have a current CAA medical certificate, and could therefore only be aboard the aircraft as a passenger. The plan was to fly for around one hour, conduct some general handling exercises to the south of the airport, including stalling and practice forced landings, and then return for three circuits. Both pilots recalled using carburettor heat during these exercises.

The aircraft had been refuelled to 34 US gal, 17 per side, on 20 April 2024, so the pilot did not refuel before departure on the accident flight. The aircraft taxied out from the club's parking area and departed Runway 30 at 1401 hrs. The aircraft turned left and departed to the south where it conducted the planned general handling exercises without incident. At approximately 1440 hrs the aircraft called Prestwick ATC for rejoin. An Airbus A320 was conducting training in the left-hand circuit, but G-BVNS was cleared via the Dalrymple Visual Reporting Point (VRP) for a left base join to Runway 30 (Figure 1). The aircraft made a normal approach and stopped on the runway for approximately 90 seconds to allow for spacing with other traffic before taking off to join the right hand circuit to the north side of Prestwick Airport.

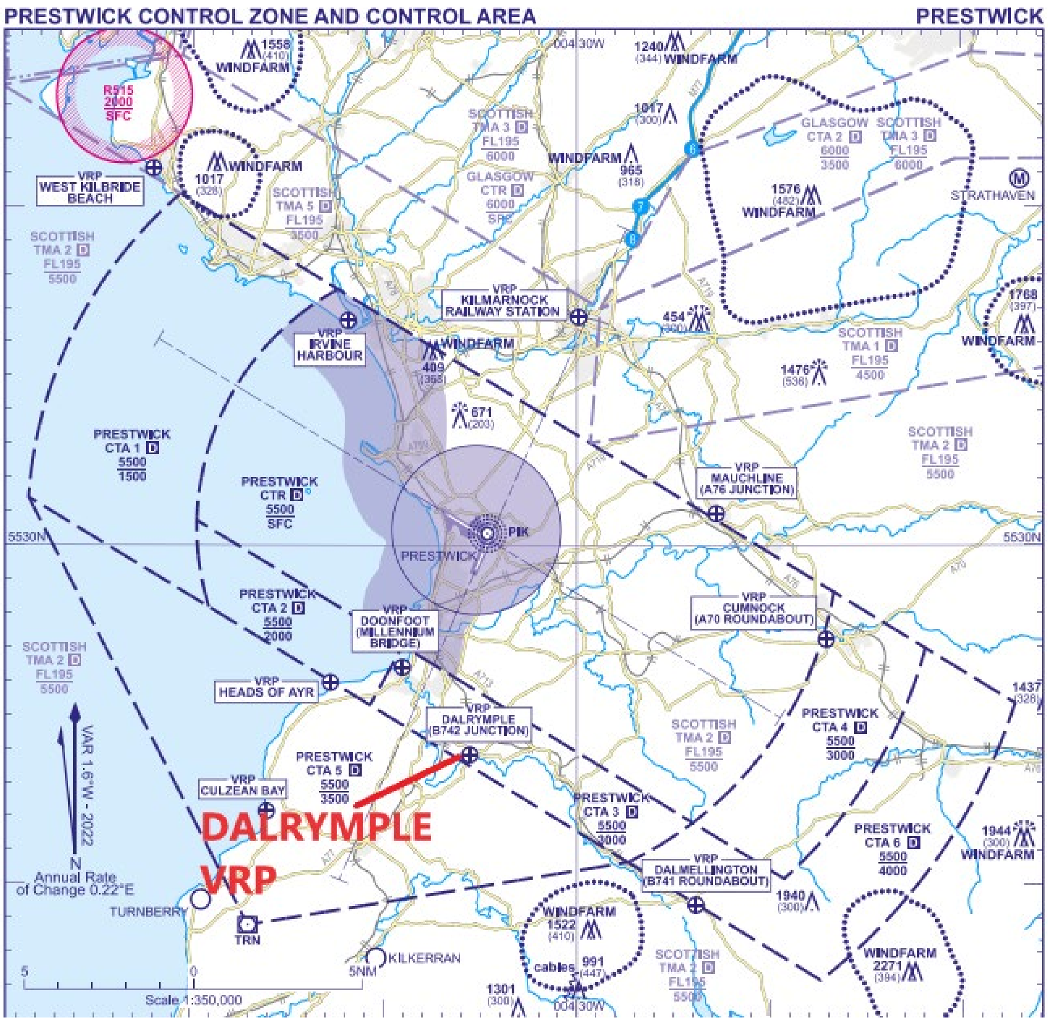

Figure 1

Prestwick Airport and Darlrymple VRP

On the downwind leg ATC asked the aircraft to enter an orbit to allow spacing for the A320 to make an approach to Runway 30; this is a common procedure at Prestwick. After three orbits the aircraft was cleared to right base by ATC and directed to report Final. The call was acknowledged by the pilot and there was no indication of stress in his voice. During the RTF exchange the ATC controller was visual with the aircraft as it rolled out of its final orbit toward a right base track. Following the exchange the tower controller turned around to look at the A320 in the left hand circuit while passing a message to that aircraft. When they turned back the tower controller could no longer see G-BVNS.

Toward the end of the last orbit the PIC had allowed the aircraft to descend to approximately 800 ft amsl. As the aircraft rolled out on a base leg track both those on board recalled that the engine had run down. The CFI believed that the pilot in command had failed to notice the engine issue, called "I have control" and took control. He established the aircraft in the glide and looking ahead could see Runway 21 and the SAR hangar near the threshold of the disused Runway 25 at Prestwick. His initial thought was to attempt glide to that runway. However, in his own words he soon realised that the airfield "was moving up the windscreen" and that it would be out of gliding range. After taking control he directed the PIC to change the fuel tank selection, which he did. Although the CFI was on the right side of the aircraft, he did not feel there were any suitable landing options to the right but "saw a patch of open ground to the left." The CFI considered a Mayday call but decided to concentrate on the forced landing. In the latter stages he initiated a left turn to align with the longest axis of the landing area but saw trees that he considered would obstruct the aircraft's final approach. He described raising the nose to clear the trees. The aircraft reduced speed and, whilst he did not recall hearing the stall warner, he described the aircraft as being in light buffet. The aircraft struck the top of a tree in a left banked attitude, which arrested the forward speed of the aircraft, causing it to roll and yaw left, and pitch down. The aircraft struck the ground vertically nose-down.

The PIC recalled completing the downwind checks, believing he used carburettor heat, and conducting the orbits downwind. As he prepared for a descent towards the airfield, he recalled the engine rpm indication reducing to around 500. He recalled that the CFI said something but could not remember what was said. Ahead he saw trees with an area of green beyond. He recalled that the CFI pumped the throttle, but that the engine did not recover. His last recollection of the flight was the nose being raised with the aircraft in a "right banked" attitude. Then the aircraft was on the ground. He believed that he had been flying the aircraft.

The ATC controller, believing that G-BVNS may have manoeuvred further downwind to position for its approach, made RTF calls to try and establish its position. The call was repeated several times, but no reply was received. The tower controller checked Runway 21 at Prestwick in case the aircraft had landed there. They also asked other personnel in the tower to look out for the missing aircraft; however, no visual contact was made with the aircraft. The tower controller then asked the A320 to move to the right hand circuit to look for the missing aircraft. At 1504 hrs an automated emergency call was received by the emergency services from the mobile phone of the pilot of G-BVNS. The emergency services informed Prestwick ATC of the accident shortly after and at the same time the crew of the A320 reported sighting the aircraft on the ground in a field to the north-east of the airport.

The coastguard SAR helicopter based at Prestwick was launched to attend the scene along with local emergency services. Both pilots had sustained serious injuries and were flown to the major trauma unit of the Queen Elizabeth Hospital in Glasgow.

Airfield information

Prestwick Airport is an international airport serving the west of Scotland, situated one nautical mile (two km) north-east of the town of Prestwick, and 32 miles (51 km) south-west of Glasgow. The airport has two long asphalt surfaced runways; the layout is shown in Figure 2.

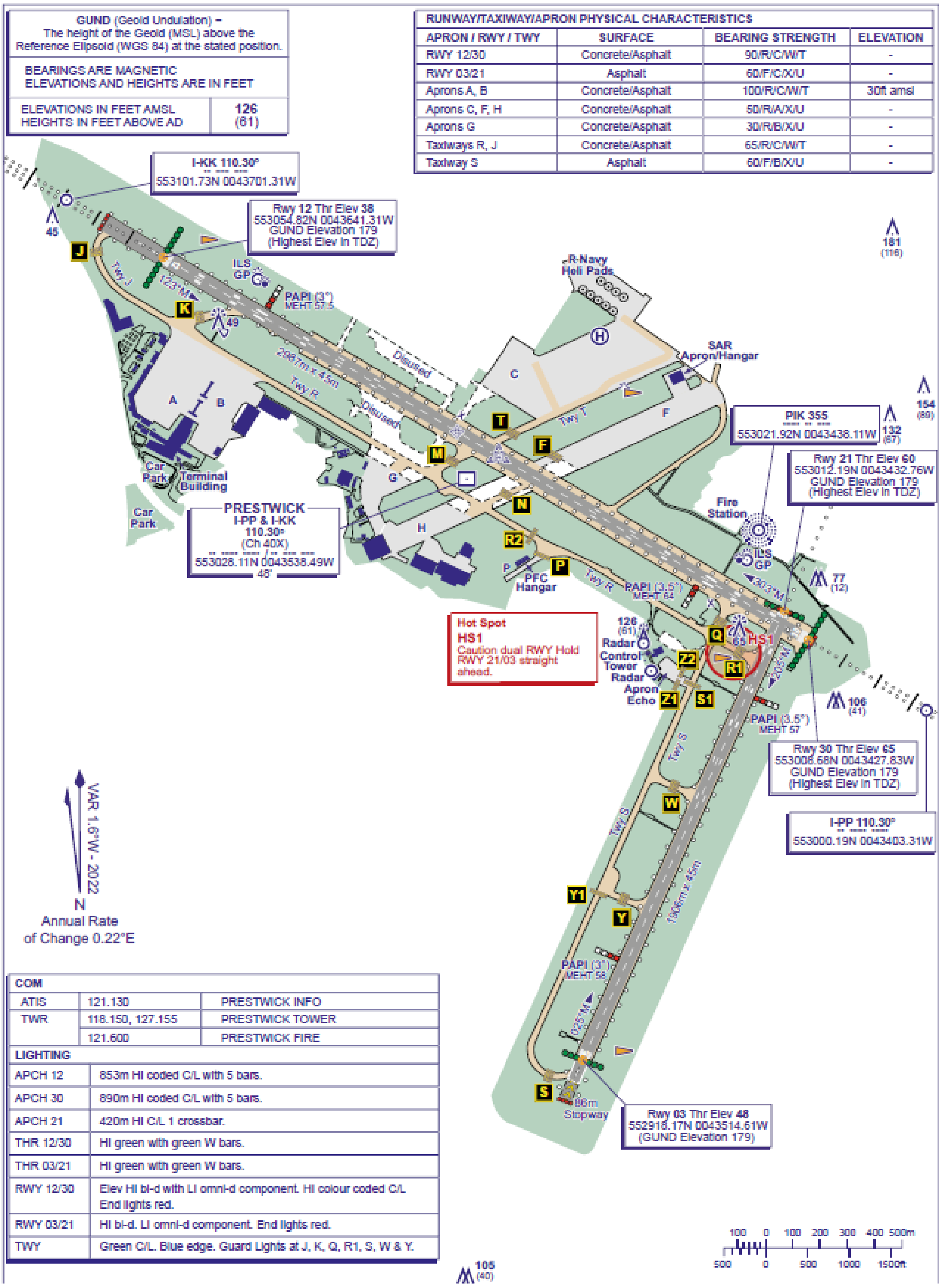

Figure 2

Prestwick Airport chart

Recorded information

The CFI was using a flight-planning and navigation app on his mobile phone which recorded the aircraft's GPS flight path (Figure 3). The figure highlights the three orbits flown at the end of the downwind leg of the circuit and the proximity of the crash site from the airport.

The orbits were flown over a period of 3.5 minutes during which the aircraft climbed and descended about 300 ft. The airspeed varied between about 83 and 110 kt (Figure 4).

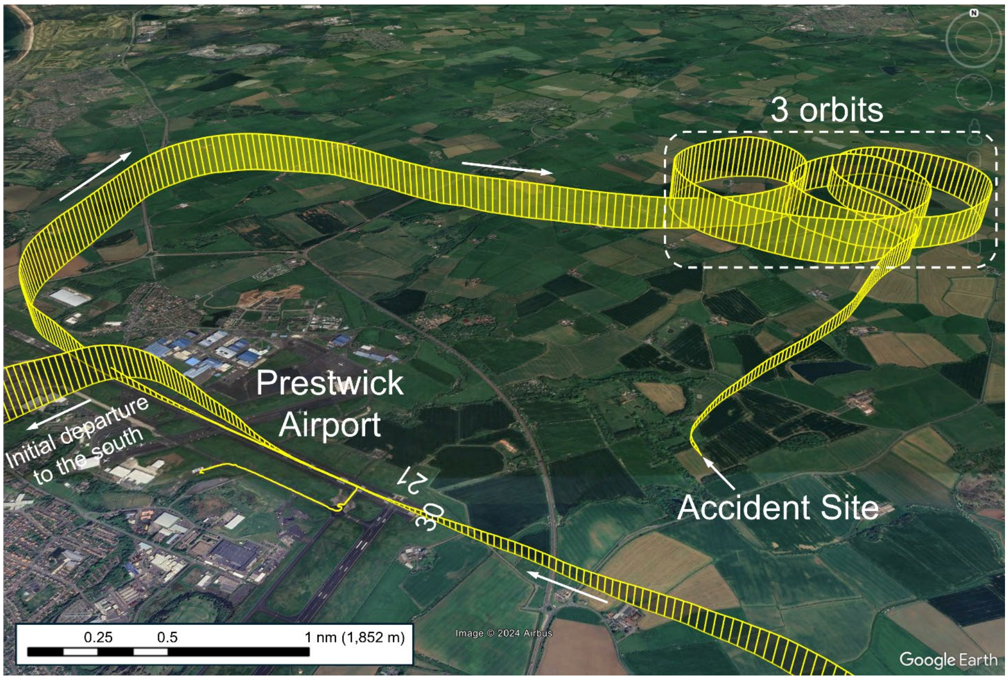

Figure 3

Flight path of right hand circuit with downwind orbits highlighted

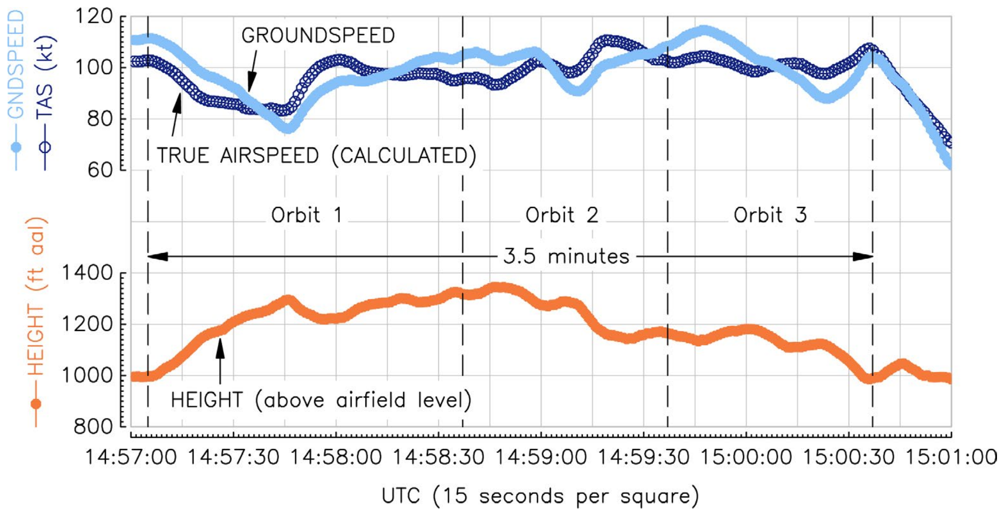

Figure 4

GPS derived data for the three orbits

Figure 5 plots data for the descent starting with the aircraft descending through 1,000 ft amsl (980 ft aal and about 600 ft agl) on base, at about 800 ft/min, just under 2 nm from the threshold of Runways 21 and 30. The descent rate reduced to about 460 ft/min for the remaining 60 seconds of the descent, during which the airspeed reduced from 85 to below 60 kt. The aircraft then struck the tree, after which it descended towards the ground at about 4,250 ft/min (equivalent to 48 mph).

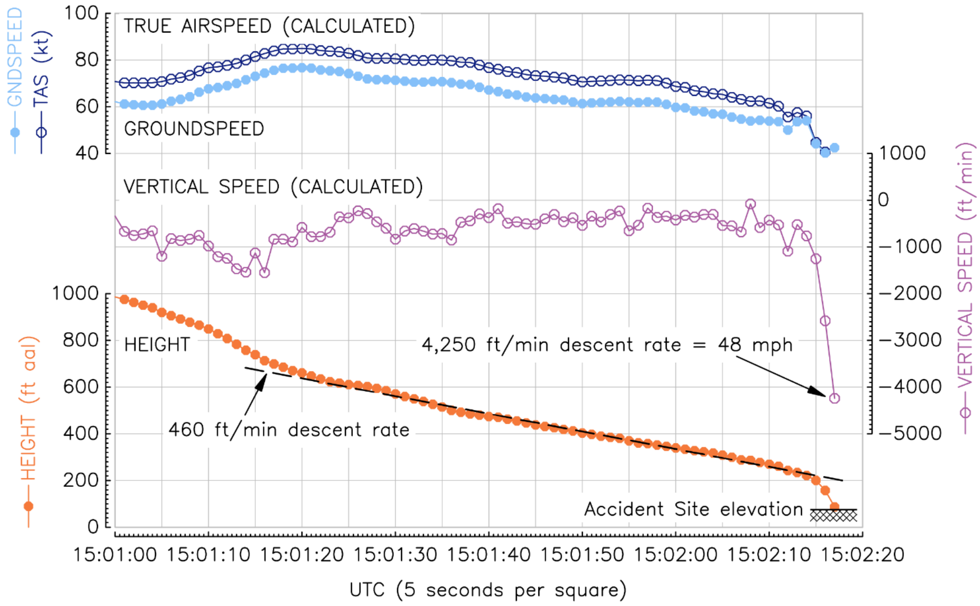

Figure 5

GPS derived data for the descent

Accident site

The accident site was approximately 1.5 miles from Prestwick Airport.

The leading edge of the left wing had struck a tree that was approximately 15 m tall which caused the aircraft to roll and yaw to the left. Indentations in the ground approximately 45 m from the tree indicated that the aircraft had been in a steep nose-down attitude. The right wingtip hit the top of a wooden fence post and the wing separated from the aircraft causing a substantial fuel leak; a small amount of residual fuel was found in the right wing.

The aircraft bounced and fell backwards such that the tail and horizontal tailplane became entangled in a barbed-wire fence that ran along the boundary between two fields. The left wing was still partially attached to the fuselage, but the angle at which the aircraft came to rest meant that the fuel drained out of the wing through a broken pipe.

The propeller sustained minimal damage and there were no propeller slash marks in the ground. This indicates that the engine was either stopped, or not producing any significant power.

Aircraft information

G-BVNS was manufactured in 1976, and the Airworthiness Review Certificate was valid until March 2025. It was equipped with a Lycoming O-360 engine and a two-blade, fixed-pitch, metal propeller. The engine was overhauled in January 2023, and it had accrued approximately 150 operating hours since. There were no reports of any engine related issues in the days preceding the accident.

Fuel uplift

The flying club guidance indicated that at the end of a day's flying, the expectation was that the aircraft would be refuelled to tabs, which is approximately 34 US gal. Fuel bowser records showed that 50 litres (approximately 13.2 US gal) of fuel were uploaded to G-BVNS on 20 April 2024 after the last flight before the accident. The pilots from the accident flight said that they checked the contents of the fuel tanks prior to the flight, and confirmed the aircraft was fuelled to tabs.

Aircraft glide performance

The aircraft POH gives a speed for the best glide range as 76 kt. At this speed with zero flap set, in still air the aircraft should be able to glide approximately 1.6 nm for each 1,000 ft of altitude. This equates to a descent rate of about 800 ft/min.

Aircraft examination

The aircraft was taken to the AAIB facilities at Farnborough for examination.

Flying controls

There was no evidence of a pre-existing flying control failure, and the flaps were retracted.

Fuel

The fuel tank selector valve was found in the LEFT position and the pipework was free of obstruction.

The electric fuel pump switch was found in the ON position and the fuse was undamaged. The pump and its associated fuel pipes contained residual fuel. The pump worked when tested and the filter was free of debris.

The gascolator contained fuel and was free of debris or water.

Engine

The ignition key was found in the BOTH position, which is the normal position for flight. The throttle, mixture, and carburettor heat controls in the cockpit had been disrupted so it was not possible to establish their relative positions at the time of the accident. The air inlet valve in the carburettor airbox was found in the full cold position, and the air intake filter was not blocked. The oil filter was free of debris and the visual appearance of the oil was normal.

The engine showed no signs of a pre-existing fault but sustained relatively minor, localised, impact damage in the accident. This consisted of:

- One broken high-tension lead.
- A broken oil filter casting.
- One dented pushrod tube and a bend in the associated pushrod.

Engine test

Replacement parts were installed, and the engine, magnetos and carburettor were tested as an assembly at an independent repair and overhaul facility with AAIB representatives in attendance. The engine started normally and ran without anomaly for about one hour, at which point the test was terminated. It developed 187 HP at its maximum operating speed of 2,700 rpm – the specification requirement is 180 HP ±10%.

Meteorology

The weather was generally fine at Prestwick on the day of the accident. The airfield weather report at 1550 hrs gave the conditions as follows: wind 250° at 10 kt, visibility greater than 10 km, cloud base 3,000 ft amsl, QHN 1024 hPa, temperature 11°C and dewpoint 5°C.

The temperature and dewpoint combination plotted on a CAA carburettor icing risk chart (Figure 6) from the CAA's Safety Sense Leaflet (SSL) 14 – *Piston Engine Icing* [1] indicates the conditions of the day would have created a serious risk of carburettor icing at any power.

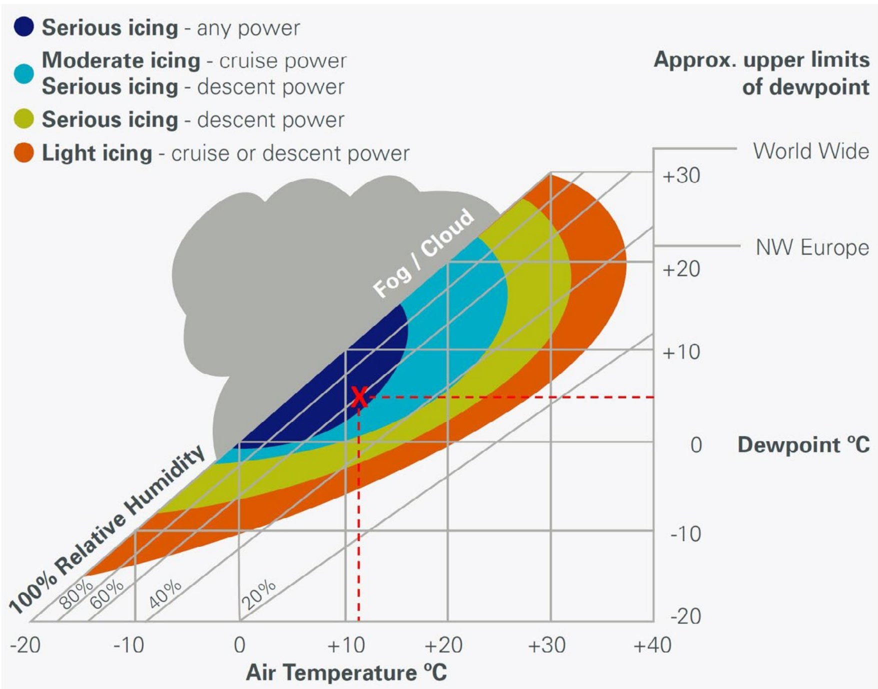

Figure 6

CAA icing risk chart from SSL 14

Footnote

1 CAA Safety Sense Leaflets [accessed September 2024].

Carburettor icing

CAA carburettor icing information

SSL 14 provides extensive information for GA pilots on the risks of icing in piston engine aircraft. The leaflet considers the types of icing, atmospheric conditions which contribute to the risk, prevention, and recommended procedures. With regard to atmospheric conditions for carburettor icing it states:

> *'Piston engine icing is not restricted to cold weather. Particularly carburettor icing may occur on warm days if the humidity is high enough, especially at low power settings. For example, cold and clear winter conditions with low humidity may be less of a hazard than warm and humid days in the summer.*
>
> *Carburettor icing becomes more of a risk in the range between 0°C and 10°C and with high relative humidity. However, tests have produced serious icing at descent power with the outside air temperature above 25°C and with relative humidity as low as 30%. In the United Kingdom and Northern Europe where high humidity is common, you must be constantly on the alert.'*

Pilots Operating Handbook

The manufacturer's Pilots Operating Handbook (POH) for the aircraft contained information on carburettor icing which is shown at Figure 7.

3.29 CARBURETOR ICING

Under certain moist atmospheric conditions at temperatures of -5°C to 20°C, it is possible for ice to form in the induction system, even in summer weather. This is due to the high air velocity through the carburetor venturi and the absorption of heat from this air by vaporization of the fuel.

To avoid this, carburetor preheat is provided to replace the heat lost by vaporization. Carburetor heat should be full on when carburetor ice is encountered. Adjust mixture for maximum smoothness.

Figure 7

Piper PA-28-181 POH extract – Carburettor Icing information

A carburettor ice detector is available as an optional fit for the aircraft, but G-BVNS was not fitted with it. The POH gives further guidance regarding carburettor icing under a section entitled engine roughness and states that such roughness is usually caused by carburettor ice. In this event the crew did not report any symptoms of rough running before the engine failed.

The Engine Power Loss in Flight checklist from the POH is shown at Figure 8. The fourth item in this checklist requires the carburettor heat to be selected on. When the engine lost power and the CFI took control, he directed the PIC to change the fuel tank selection, which he did. The CFI said "I pumped the throttle" in an effort to recover power. While this produced two or three short bursts of apparent power it did not restore the engine. The fuel pump had already been selected on in the downwind checks and the mixture had been left fully rich for the whole flight.

SECTION 3 PIPER AIRCRAFT CORPORATION
EMERGENCY PROCEDURES PA-28-181, ARCHER II

ENGINE POWER LOSS IN FLIGHT

Fuel selector.......................................switch to tank containing fuel
Electric fuel pump ....ON
Mixture ....RICH
Carburetor heat ....ON
Engine gauges ....check for indication of cause of power loss
Primer ....check locked
If no fuel pressure is indicated, check tank selector position to be sure it is on a tank containing fuel.

When power is restored:
Carburetor heat ....OFF
Electric fuel pump.......................................OFF
If power is not restored prepare for power off landing.
Trim for 76 KIAS.

Figure 8

PA-28-181POH extract – Engine Power Loss in Flight checklist

Personnel

Club CFI

The flying club is a Declared Training Organisation (DTO). The CFI, who was also the Head of Training for the DTO, had first noticed symptoms of a medical condition in September 2022. He consulted a doctor but was told the symptoms could be sunstroke and he chose not to discuss the issue with an Aeromedical Examiner (AME). In December 2022 he had another episode and decided to stop flying solo or with anyone who had not gone solo. In early 2023, he consulted a different doctor but was not given any diagnosis. In June 2023 he did not renew his Class 1 medical certificate believing he would have another year's validity with a Class 2 Medical. However, his medical certificate had only been endorsed at Class 2, so from June 2023 only his LAPL (Light Aircraft Pilot's Licence) was valid. In October 2023 he was contacted by the CAA and told that his medical was suspended.

After further exploration his condition was correctly diagnosed and he began a course of treatment. Since beginning the treatment, he has had no further episodes of the condition. An episode of the condition in flight would not have left him in a situation where he would be liable to collapse and impede the controls of an aircraft. He stated that the Pilot in Command was aware of his medical situation before the flight.

Pilot in Command (PIC)

The PIC presented to the investigation a UK Part Flight Crew Licensing (FCL) Private Pilot's Licence (Aeroplanes) (PPL(A)), with a Single Engine Piston (SEP) rating which lapsed in July 2023 and a UK Part FCL LAPL(A). His intention was to operate under the privileges of his LAPL. The LAPL does not require a rating to be endorsed upon it but does require that the pilot fulfils the requirements below on each day that they fly.

The requirements are[2]:

> *'(a) Holders of a LAPL(A) shall exercise the privileges of their licence only if in the last 2 years they have met any of the following conditions as pilots of aeroplanes or TMGs:*
>
> *(1) they have completed at least 12 hours of flight time as PIC or flying dual or solo under the supervision of an instructor, including:*
>
> *— 12 take-offs and landings;*
>
> *— refresher training of at least 1 hour of total flight time with an instructor;*
>
> *(2) they have passed a LAPL(A) proficiency check with an examiner. The proficiency check programme shall be based on the skill test for the LAPL(A).'*

The PIC had not flown since November 2023 and believed that he was taking appropriate action to recover his currency by flying with the CFI, and that the CFI was acting as an instructor during the accident flight. The CFI stated that he took notes of the PIC's performance to facilitate a post-flight debrief.

The PIC did not recall the CFI taking control when the engine failed and considered that he was trying to fly the forced landing. His recollection of events was, however, incomplete.

CAA General Aviation Pilot Licensing and Training Simplification Project

The regulations for revalidation of ratings are complex and there are a number of licence categories. The CAA is engaged in a General Aviation Pilot Licensing and Simplification Project[3]. In October 2022 the CAA published CAP2335 (General Aviation Pilot Licensing & Training Simplification – Phase 1: Strategic Direction) as part of a 3-phase program to simplify training and licensing for the UK's General Aviation (GA) Sector. The subsequent GA community response (CAP2532) showed strong support in several key areas for updating the current legislation with regards to licensing and training.

The Phase 2 consultation, which closed on 22 May 2024 explored these key areas in more detail, to ensure that the CAA works towards the goals of the community whilst maintaining legislative compliance within these areas. Phase 3 will be the rulemaking phase.

Footnote

2 UK Aircrew Regulation | UK Regulation (EU) No. 1178/2011 | FCL.140.A LAPL(A) – Recency requirements [accessed July 2024].

3 Licensing & Training Simplification | Civil Aviation Authority (caa.co.uk) [accessed July 2024].

Recency requirements

CAA 90-day currency rule

For the carriage of passengers, UK Part FCL[4] states:

> *'A pilot shall not operate an aircraft in commercial air transport or to carry passengers:*
>
> *(1) as PIC or co-pilot unless he/she has carried out, in the preceding 90 days, at least 3 take-offs, approaches and landings…'*

To accompany a pilot who is outside the 90-day rule, the accompanying pilot must be in a position to exercise the privileges of their licence. As the CFI's medical was suspended at the time of the accident he was not able to do so and so it is likely the flight did not comply with the 90-day rule.

Flying Club

The syndicate which owned the aircraft had agreed to abide by the published operating principles of the Flying Club and all syndicate members were also flying club members. In its operating principles document the club published the information regarding pilot flying currency (Figure 9).

Currency

- Club currency is 3 landings in 62 days for nosewheel, 31 days for tailwheel
- Cross wind (actual and forecast) meets aircraft and personal capability
- Type flown in previous 90 days
- Student authorised by an instructor.
- PPL members are self authorising
- Aerobatics and formation flying shall be individually approved by club instructors
  - Formation aerobatics is not covered by PFC club governance – pilots own risk.

Figure 9

Flying club currency requirements

The CFI had signed the operating principles document. While the currency periods were clearly defined, due to the wide range of experience amongst club members it was club policy to not specify the requirements for regaining currency.

Footnote

[4] UK Aircrew Regulation | UK Regulation (EU) No. 1178/2011 | FCL.060 Recent experience [accessed July 2024].

Aircraft Syndicate

The syndicate's Standard Operating Procedures (SOPs) contained a slightly amplified set of currency rules (Figure 10).

ADHERENCE TO '62-DAY' & '90-DAY' RULES

The 90 day rule is a requirement under the Air Navigation Order for the carriage of passengers - 3 take offs / landings required within preceding 90 days - includes other pilots non-flying as 'passengers' if single pilot aircraft / operations. This a LEGAL REQUIREMENT and failure to comply would render our insurance cover invalid, leaving YOU liable for any costs / damages should an accident occur. DO NOT BREACH THE 90-DAY RULE!

Prestwick Flying Club operates a '62-day currency' rule - this is not an insurance requirement but SAF has agreed to abide by it. Basically, if you haven't flown within the preceding 62 days, you should contact the CFI (or another instructor) before flying. If you're only out by a couple of days, they might be happy to authorise your flight. If it's a couple of weeks / months, you will most likely be required to undergo a currency check with one of the instructors. It's a common sense approach - based on your flying experience, confidence and skill level - with safety being the primary concern.

If your 62 day currency is on another type of aircraft you must either fly the group aircraft or similar model within a 90 day period of your last flight on that type. If outwith this period then the above procedure re currency must be applied.

Figure 10

Syndicate SOP extract

The SOPs suggest that if a pilot has not flown for a protracted period, it is likely that a check with an instructor would be required and that pilots should contact the CFI or another instructor before flying.

Analysis

Engine and fuel system

There was no evidence of pre-existing faults with the engine and fuel system which would have caused the engine to stop in flight. The engine, carburettor and magnetos were tested as an assembly and found to operate normally. Evidence of leaked fuel at the accident site indicated that there was fuel on board the aircraft. Each fuel tank was selected during the descent, and this had no effect on engine performance.

Carburettor heating and its use during the flight

The weather conditions at the time of the flight were such that there was a serious risk of carburettor icing at any power. The carburettor air inlet valve was found in the full cold position, indicating that carburettor heat was not selected. The valve installation is such that the valve could not have changed position when the aircraft struck the ground.

The general handling portion of the flight was carried out without incident and neither pilot recalled any precursor symptoms that would have suggested any issues with the engine. During this phase of the flight they conducted several PFLs that involved sustained descents at idle power. The use of carburettor heat in these descents would have been appropriate and is suggested in the aircraft check list. Both pilots were sure it was used during these exercises.

On returning to the right hand circuit the aircraft made a successful stop and go. Subsequently, both pilots believed that the downwind checks had been completed and that a carburettor heat check was carried out as a part of those. Neither was absolutely certain about the carburettor heat setting during the orbits made from downwind. At this point the aircraft would have been at a power setting where the risk for carburettor icing was severe. While orbits on the downwind leg are relatively common at Prestwick it is possible that the presence of the A320 was a distraction and disrupted the checks. Approximately four minutes elapsed from the downwind leg till the aircraft was cleared to base leg.

Events after the engine power was lost

The CFI took control of the aircraft from the PIC, believing that the PIC was not aware of the engine losing power. He established the aircraft in the glide and asked the PIC to change the fuel tank selection. The aircraft was less than 2 nm from the Prestwick runways and below 1,000 ft aal. Viable areas for a field landing were available to the right, but ahead, Runway 21 was in view and may have captured the CFIs attention initially. He did not consider a right turn into wind in the period immediately following the power loss. As the aircraft descended in the direction of Runway 21 the CFI realised that there was insufficient height to glide to the airfield and that a field landing was inevitable.

Now lower, the choices were reduced and he felt that all options to the right were impeded by trees. He saw a field ahead to the left and decided to attempt a landing there. As the aircraft approached the chosen field the CFI recognised that the trees were moving up in his sightline and that in his estimation the aircraft was going to hit the trees. He raised the nose in an attempt to get the aircraft over the trees, reducing the airspeed below the aircraft's ideal glide speed. Raising the nose created an illusion that the aircraft would clear the trees.

Licensing

The PIC was aware that he was out of currency to fly at the club and had contacted the CFI to arrange for a currency check. His understanding was the role of the CFI was to "check him out" and to act as an instructor providing appropriate guidance. He was unclear about the 90-day rule but considered that as he was flying with an instructor it was not relevant to this flight. As the CFI's medical was suspended he was not in a position to exercise the privileges of his licence and, therefore, could not act as an instructor or as accompanying pilot in accordance with the 90-day rule. The existence of an LAPL and a PPL confused the situation with regards to the validity of ratings.

Whist the statuses of the pilots' licences are unlikely to have contributed to the accident, this event highlights the potential for pilots to be confused regarding current licensing regulations. The CAA's General Aviation Pilot Licensing and Training Simplification project seeks to address these issues.

Conclusion

The engine most likely stopped because of carburettor icing and a forced landing ensued. The aircraft struck trees during the latter stages of the approach to the forced landing and control was lost. Both occupants survived but sustained severe injuries.

Published: 3 October 2024.

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:	Boeing 737-4K5, G-JMCZ
No & Type of Engines:	2 CFM56-3C1 turbofan engines
Year of Manufacture:	1989 (Serial no: 24126)
Date & Time (UTC):	26 April 2024 at 0030 hrs
Location:	En-route to Edinburgh Airport
Type of Flight:	Commercial Air Transport (Cargo)
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to liner tape and paint on forward bulkhead
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	58 years
Commander's Flying Experience:	9,045 hours (of which 2,365 were on type) Last 90 days - 70 hours Last 28 days - 33 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

At the start of the descent for Edinburgh Airport the cargo shifted in the main deck and came into contact with the forward bulkhead. The aircraft landed safely at Edinburgh without further incident. The crew were notified of the movement after the cargo had already been unloaded so it was not possible to ascertain whether the locks had not been engaged or had malfunctioned in some way. The operator took a number of safety actions to address the risks of unsecured cargo moving during flight.

History of the flight

When the crew began their descent on the flight from London Stansted Airport to Edinburgh Airport, they heard what they described as a "dull double bang." All the engine indications were normal except a momentary higher vibration indication on the right engine. There had been previous reports of sporadic indications on this engine and the crew considered the possibility that the engine had surged but there were no further indications. The crew also considered that there may have been a cargo shift on the main deck. Having completed their decision-making process, they elected to continue to Edinburgh where the aircraft landed safely without further incident.

Once the aircraft was parked on the stand, the main cargo door was opened and cargo unloading began immediately. The crew were informed by the ground crew that a unit load device (ULD) that had been loaded in Bay B in the aircraft was found in Bay A.

Aircraft information

G-JMCZ is a Boeing 737-400 built in 1989 as a passenger aircraft. It was converted into a cargo aircraft in 2010 with the addition of a large side cargo door and a cargo handling system inside the cabin. The aircraft is fitted with a bulkhead at the front of the cargo cabin between the large cargo door and the forward aircraft door. This bulkhead has a small sliding door to allow the crew to enter the main cargo deck when not blocked by any loaded cargo. There is a small porthole window in the door. The aircraft can be loaded with both 108 inch and 125 inch pallets or ULDs that can be placed in one of 11 (named A to L) bays within the main deck. Bay A is at the front of the aircraft. The aircraft holds are also available for cargo.

All cargo carried in the aircraft must be secured to prevent movement during aircraft operations such as takeoff, turbulence, landing or during an emergency. For the main deck, ULDs are secured using the aircraft palletisation side rails and floor locks, whilst pallets are secured using floor locks and by straps or cargo nets.

Aircraft examination

Examination of the forward bulkhead revealed some minor damage to the liner tape and paint. There was no damage to the main door bulkhead, door, or the cargo handling system.

Aircraft cargo load

The aircraft was loaded with items in Bays B to L, leaving Bay A empty. This is described as a void bay. The weight of the item in Bay B was 695 kg and the total weight of the cargo on the main deck was 8,944 kg.

Weight and balance

One of the many risks for a cargo shift in flight is a change in the aircraft centre of gravity that can lead to issues with controlling the aircraft. During the flight the crew experienced no control or handling difficulties. Calculations by the operator after the incident demonstrated that even with the cargo shift, the aircraft centre of gravity remained well inside the manufacturer's limits and the change was insignificant.

Organisational information

Cargo loading and security

Prior to loading the commander will receive a load instruction form (LIR). This will either be for the crew to plan the load positions or they will already have been planned using a computer based tool. In either case, the crew must check that the loading plan is correct and meets regulatory requirements. The loading can then be completed by the ground crew.

The operator's Operations Manual Part B (OMB) states that:

> *'The aircraft commander is responsible for all loading and off-loading of cargo although he may defer this responsibility to other suitably qualified company personnel. The loading and off-loading of the aircraft by handling agents and/or ground crew will be supervised at all times by the aircraft crew or other suitably qualified company personnel.'*

Once loading is complete the cargo handling person responsible for loading must sign the LIR. In doing so they are signing to say that the cargo is loaded in accordance with the load instruction and secured in accordance with the current company regulations. As a result of a review into a number of incidents, the operator developed and launched a new LIR, which makes clearer what the load supervisor and commander are signing for.

Visual inspection of cargo security by the crew

As each pallet or ULD is loaded onto the main deck, the volume of the cabin is obstructed and it is not possible to move past or look at the locks of either the new load or any previously loaded item beyond the locks visible from in front of the load. A crew member cannot inspect the load for security beyond what they can see from the front of the load. Whilst they can attempt to move the foremost pallet or ULD to give them some indication of its security, such items can weigh a significant amount and may not move easily even if they are unlocked.

Once in flight, the crew can look through the small window in the bulkhead door but what they can see is limited both by the lack of lighting and the lack of space around the cargo load.

Risks of a void bay

Void bays are acknowledged as a risk for load security within the operator's OMB. For multiple void bays the operator requires that all floor locks are raised to the locked position to minimize movement in the event of a load shift. The operator originally preferred that any void bays should be at the front of the aircraft so that the floor locks could be inspected, if possible, by the crew through the bulkhead door or the main cargo door as required. The requirement for a single void bay to be Bay A for the B737-400 was changed by the operator after this incident by a notice to crew to state:

> *'A single void planned in B is considered the lowest risk despite being unable to inspect visually from the forward vestibule, because the human error exposure from the ground teams forgetting to raise floor locks on a single in A is higher than if in B due to load procedures. If a void is in B, a crew could push on the ULD in A via the bulkhead door which may give an indication of the security of that ULD.'*

The new version of the LIR also contained a section where parties sign for the status of the floor locks in any void bays.

Unloading procedures

When the aircraft arrives on stand at the destination and has been shut down, one of the crew must open the main cargo door so that unloading can begin. The operator had no specific procedures for the ground crew to check the load and to notify the crew or the operator if the cargo had moved from its loaded position.

Other information

The Civil Aviation Authority (CAA) manages a number of forums to capture industry-wide issues and to share best practice between operators, and these forums include the Flight Operations Liaison Groups. They established a liaison group for larger cargo operators which includes the operator of G-JMCZ. The operator took the lead within this group on managing the threat of void bays.

Analysis

During the start of the descent into Edinburgh, the ULD loaded in Bay B moved forward into Bay A and struck the forward bulkhead. Although the crew initially considered that the noise might have been associated with an engine after they noted an abnormal vibration indication, they concluded that they may have had a cargo shift. Due to the cargo being unloaded before the crew had completed their post-flight actions, it was not possible to establish which locks, if any, had been secured on the ULD before the flight departed from Stansted or if the locks malfunctioned in some way. There was some minor damage to the bulkhead and no damage to the cargo loading system. The aircraft centre of gravity remained within limits and the crew experienced no limitations in control or handling. The aircraft landed at Edinburgh without further incident.

The cargo was loaded at Stansted leaving Bay A as a void. Given the lack of space within the main deck, it is not possible for anyone to check the security of the load or the position of the locks once the cargo is loaded. It is only possible to check the front locks of the forward most ULD and any void space in front of that. The check of the locks therefore must be done for each ULD or pallet as it is loaded. It is likely that during the loading of the ULD in Bay B, either some or all of the locks were not secured, and this allowed the ULD to move forward into Bay A when the aircraft pitched down for the descent.

The operator's procedures place the ultimate responsibility on the commander (or a delegated crew member) to ensure the security of the load, but it is difficult to see how this can be complied with unless each individual ULD or pallet is checked as it is loaded. The operator's procedures also require the cargo handling person responsible for the loading to sign to confirm that the load is secure. All these procedures were to be reviewed by the operator as part of the safety action group review. A new version of the LIR was already in use at the time of publication to make clear the responsibilities of all parties in ensuring the load is secure. It also required all the parties to acknowledge and sign for the security of void bays in that all floor locks have been raised.

The operator took action to address the risks posed by cargo shifts and particularly void bays within its operation. It was also leading an initiative within an industry-wide group established by the CAA on the specific threat of void bays.

Conclusion

During the start of the descent for landing at Edinburgh, the ULD loaded in Bay B shifted forwards, hitting the forward bulkhead wall. The ULD was found in Bay A when the cargo was unloaded on arrival. It is likely that the locks on the ULD loaded in Bay B were not secured as required, allowing the ULD to move during flight. The operator made a number of changes to address the risks of cargo shifts and of void bays in particular.

Safety actions/Recommendations

The operator took the following safety actions:

- Issued a notice to crew aimed at crew awareness and mitigation of load shift during flight, specifically relating to void bay awareness and management.
- Issued guidance to move a single void bay in the B737-400 from Bay A to Bay B as it was assessed to be lower risk and gave the crew some opportunity to check the security of Bay A from the bulkhead door.
- Convened a Safety Action Group to specifically look at the risk exposure and assess barrier strengths in cargo loading and security.
- Issued a new LIR which made the obligations of each party clear for load security and included a box requiring the signature of all parties for the locks in void bays should there be any on the flight.
- Engaged with the CAA safety forum, leading on the risks of void bays

The CAA also took action as a result of a number of cargo shift events in the industry:

- Established a medium-size-operator Flight Operations Liaison Group which captures the larger cargo operators to share events, risks and best practice

Serious Incident

Aircraft Type and Registration:	Boeing 737-8K5, G-TAWD	
No & Type of Engines:	2 CFM56-7B27E turbofan engines	
Year of Manufacture:	2011 (Serial no: 37265)	
Date & Time (UTC):	17 October 2023 at 0615 hrs	
Location:	East coast of UK, North Lincolnshire	
Type of Flight:	Commercial Air Transport (Passenger)	
Persons on Board:	Crew - 6	Passengers - 187
Injuries:	Crew - None	Passengers - None
Nature of Damage:	None reported	
Commander's Licence:	Airline Transport Pilot's Licence	
Commander's Age:	53 years	
Commander's Flying Experience:	18,000 hours (of which 1,600 were on type) Last 90 days - 291 hours Last 28 days - 86 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

Synopsis

A CABIN ALTITUDE warning was activated as the aircraft passed FL130. Both engine bleed air systems had been inadvertently left off for the departure, so the aircraft failed to pressurise. The crew selected both systems on and continued the climb. The aircraft then generated a PACK caution, so the crew stopped the climb at FL200. After discussion with the operator's maintenance control the commander decided to return to the departure airfield. Recorded data indicated that the CABIN ALTITUDE warning remained on for 43 minutes. The crew did not don oxygen masks.

History of the flight

The aircraft was operating a sector from Manchester Airport (MAN) to Kos Airport, Greece. Neither of the pilots were originally scheduled to operate the service and both were rostered for a standby duty commencing at 0300 hrs. The commander was awoken by a notification on his smartphone roster app at 0100 hrs indicating he had been assigned the Manchester to Kos duty. The co-pilot was notified by a phone call from crewing at 0230 hrs. Both pilots were given a report time of 0430 hrs.

On a previous flight the aircraft's air conditioning packs had not been operating correctly and a maintenance work order had been generated to investigate the issue. Immediately prior to the incident flight, maintenance work had been carried out on the air conditioning packs and noted in the aircraft technical log.

The co-pilot downloaded the Operational Flight Plan while at home and reviewed the weather and the aircraft status. They noted that there were no open defects in the technical log. The commander reported to the crew room on time and was then contacted by the co-pilot whose journey had been affected by the closure of a motorway. As the co-pilot was going to be late reaching the airport it was agreed that the commander would assume the PF role and that the co-pilot would meet the crew at the aircraft.

At the aircraft the commander conducted the walk round checks, then boarded and began the commander and PF pre-flight duties. During these he noted that there were no open defects in the technical log but that work had been carried out on the right air conditioning pack after the aircraft's last flight. The co-pilot arrived as the passengers were boarding at approximately 0500 hrs. The pilots knew each other from previous flights and the commander said that although an on-time departure was desirable, preparing the aircraft correctly would be paramount. The co-pilot recalled that they did not feel under pressure but did try to conduct their pre-flight duties in an expedited manner.

The taxi out and the departure from Manchester were uneventful. The commander was PF and recalled he manually flew the aircraft until the after-takeoff checks were completed. The after-takeoff checklist, carried out by the PM on a challenge and response basis, includes a check that the bleed air switches are selected ON. Both pilots recall completing this checklist and were sure that the bleed switch positions were visually verified as being ON. The commander recalled that, with the aircraft passing approximately 15,000 ft amsl, the CABIN ALTITUDE warning light illuminated accompanied by the associated warning horn. In his report the commander stated that '*It was quickly noticed that both engine bleeds were off, these were placed straight back on and the problem was resolved.*' The commander then stated '*The aircraft was levelled off and the QRH*[1] *was actioned. Once this was completed, shortly afterwards the right pack failed.*' Neither pilot actioned the QRH Cabin Altitude Checklist which contains memory items, including the immediate use of oxygen masks. The commander recalled noticing that both engine bleed switches were selected to OFF and that he directed the co-pilot to switch them ON. Both pilots recalled that the bleed switches were selected ON before they requested a level off at FL150 from ATC. Once the aircraft was level the commander recalled that memory items from the checklist for cabin altitude warning should have been completed. However, as the bleed systems were now on and believing the situation to be under control, he decided that the memory items, including the use of oxygen masks, were disproportionate to the situation.

Once level the commander checked the cabin altitude indication on the overhead panel and recalled it was approximately 2,000 ft and believed this was achieved "within a couple of minutes" of the engine bleed switches being selected ON. He then decided that the crew should read through the checklist to ensure there were no actions he felt should be done or any other information they should be aware of. Satisfied that the situation was under control and that the cabin altitude was below 3,000 ft, the crew felt safe to continue the flight and a further climb was requested from ATC.

Footnote

[1] Quick Reaction Handbook (QRH). Contains normal and non-normal checklists for the aircraft.

During the climb the MASTER CAUTION illuminated and drew the attention of the crew to a PACK caution on the overhead panel indicating a fault in the right air conditioning pack. The crew requested a level off at FL200 from ATC and actioned the QRH checklist for a right PACK caution. They were not able to recover the right air conditioning pack and, aware this would impose some limitations on the return flight, the commander decided to discuss the situation with the operator's maintenance control (Maintrol). After consulting Maintrol it was agreed that the aircraft should return to Manchester. As the aircraft was above maximum landing weight the crew planned to enter a hold with the landing gear extended to burn fuel and reduce weight. The senior cabin crew member was brought to the flight deck for a briefing and the situation was explained to the passengers over the public address system. Once the aircraft weight had been satisfactorily reduced the aircraft made a normal approach to Runway 05 at Manchester.

Recorded information

The FDR information was downloaded by the AAIB and a copy sent to the aircraft manufacturer for analysis. CVR data was not recovered. A digest of the information analysed by the operator from the Quick Access Recorder Data is as follows:

06:06:35 Airborne from Runway 05 Flap 5 departure.

06:07:09 Thrust reduction to climb thrust.

06:07:12 Autopilot(AP) A engaged.

06:07:51 Acceleration and flap retraction phase commenced.

06:08:29 All flaps indicate 'up'.

06:08:32 Selected altitude increased to FL190.

06:10:08 Selected altitude increased to FL280.

06:11:50 CABIN ALTITUDE recorded above 10,000 ft. Passing FL130. At this point the CABIN ALTITUDE warning activated.

06:12:11 Selected altitude reduced to FL150, aircraft passing FL139.

06:12:26 AP Pitch mode changes to altitude acquire with aircraft passing FL145.

06:12:47 AP altitude hold captured at FL150.

06:13:03 ENG BLEED 1 switched ON, then ENG BLEED 2 switched ON.

06:16:46 Selected altitude raised to FL280.

06:18:37 Selected altitude reduced to FL200.

06:19:26 AP altitude hold captured at FL200.

06:23:10 R pack switched OFF – L pack transitions to HIGH flow.

06:34:53 180° turn to return to MAN.

06:35:09 CABIN ALTITUDE recorded descending below 10,000 ft.

06:49:41 Descent commenced from FL200.

06:58:54 FL090 acquired.

07:11:19 Aircraft enters hold at FL90, north-east of MAN 07:51:28 Hold exit.

08:10:16 Touchdown at a weight of 64,360 kg.

The recorded data shows the autopilot was engaged at 1,980 ft and that the flaps indicated fully retracted at 4,000 ft, though the commander's recollection was that he flew the aircraft manually until the after-takeoff checklist was complete. Checking that the flaps are fully retracted and that the bleed switches are ON are part of the after-takeoff checklist which is shown at Figure 1.

AFTER TAKEOFF

Engine bleeds . . . . ON

Packs . . . . AUTO

Landing gear . . . . UP and OFF

Flaps . . . . UP, No lights

Figure 1
After-takeoff checklist

Both pilots recalled that the bleed switches were selected ON within a few seconds of the cabin altitude warning. The QAR data shows a delay of approximately 73 seconds between the cabin altitude warning and the bleed switches being selected ON. During that time the aircraft levelled at FL150.

An analysis of the FDR data by the AAIB indicated that the CABIN ALTITUDE warning remained active for 43 minutes, until 06:53:47.

It was not possible to recover data from non-volatile memory within the cabin pressurisation controllers aboard the aircraft and therefore the actual cabin altitude during the period that the cabin altitude warning was triggered was not ascertained. However, the FDR data showed that the passenger oxygen masks in the cabin were not deployed. As they deploy automatically if the cabin altitude exceeds 14,000 ft, the maximum was below that limit.

Engineering Information

The operator carried out an internal investigation into the maintenance work carried out during the night before the incident flight on a fault related to the right air conditioning pack (there had been two entries in the aircraft technical log in the days before, but no fault had been found). The Fault Isolation Manual task required the Bleed 1, Bleed 2 and Bleed APU switches to be selected OFF, and the left and right Pack switches to be selected to AUTO ahead of a test of the system. After the test, the Pack switches were to be left in the OFF position and all other switches returned to their original position.

The packs were operated for two hours without fault after which they were shut down. The engineer followed the post-test procedure and placed the Pack switches in the OFF position, and believed all other switches had been returned to their original configuration. A separate engineer, allocated to the departure, did not detect that the bleed switches were, in fact, in a 'non-normal' configuration ie OFF.

Aircraft information

Cabin altitude warning

The aircraft cabin altitude warning consists of an aural warning horn and a red CABIN ALTITUDE warning light on each pilot's forward panel. The light illuminates simultaneously with the aural warning when the cabin altitude is greater than 10,000 ft and remains illuminated until the cabin altitude pressure switch deactivates. The cabin altitude pressure switch can deactivate between 500 and 1,500 ft below the activation altitude. Neither pilot could recall if the CABIN ALTITUDE warning light remained illuminated after the engine bleed switches were selected ON.

Bleed air system

Air for the bleed air system can be supplied by the engines, APU, or an external air cart/source. The APU or external cart supplies air to the bleed air duct prior to engine start. After engine start, air for the bleed air system is normally supplied by the engines. The following systems rely on the bleed air system for operation:

- Air conditioning/pressurisation.
- Wing and engine thermal anti-icing.
- Engine starting.
- Hydraulic reservoirs pressurisation.
- Water tank pressurisation.

The engine bleed air controls and indicators on a B737-800 are on the right side of the overhead panel (OHP). The air conditioning panel is shown in Figure 2.

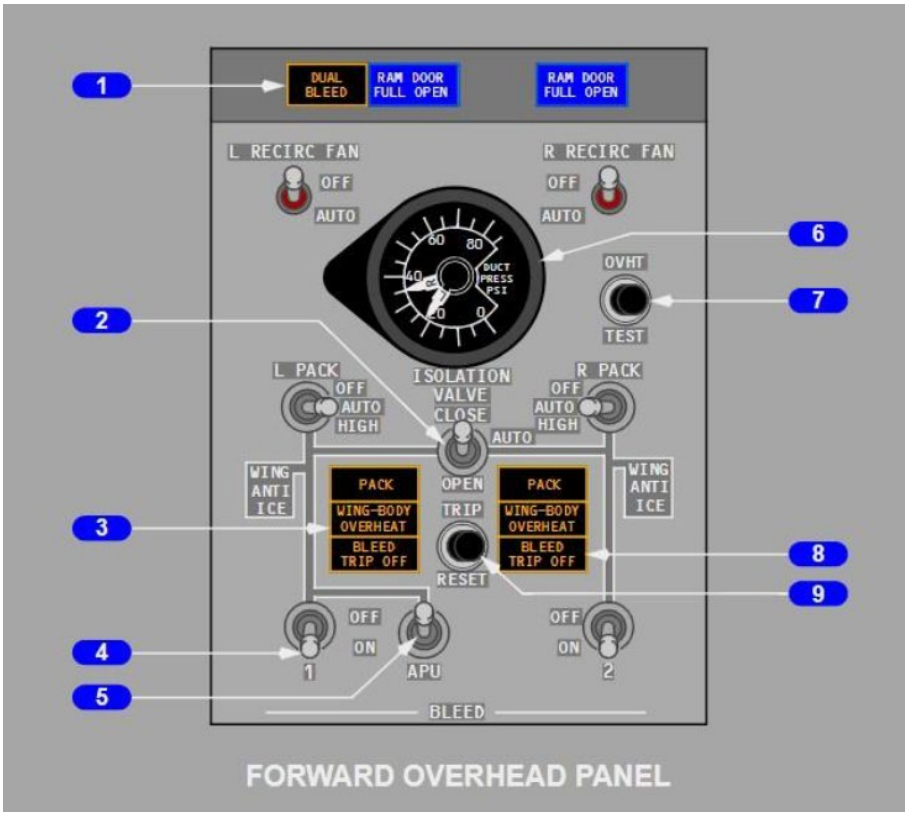

Figure 2

Air conditioning panel
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The engine bleed switches are indicated by the number 4. The commander pointed out the difficulty of seeing these switches from his seat position.

The engine bleed switches should be positioned ON as a part of the co-pilot's pre-flight procedure. If this does not happen, the next procedural opportunity to notice the omission is as part of the after-takeoff checklist. In adverse weather where de-icing is required or if performance limitations require a no engine bleed takeoff, then the engine bleed switches may require manipulation before and after takeoff. In these circumstances there are published procedures for crews to follow. Neither was applicable for this flight.

Cabin altitude indications

The cabin altitude indicators (Figure 3) are also in the OHP adjacent to the bleed air system controls. The cabin altitude gauge at number 1 has two needles. The longer needle indicates the cabin pressure differential to the outside air and the smaller needle indicates the cabin altitude. The gauge at number 2 shows the cabin rate of climb or descent. As these gauges are located close to the bleed switches the commander would have similar difficulty in reading them. The commander recalled the needle being between the one and 2 o'clock position on the dial but was uncertain if it was the large or small needle.

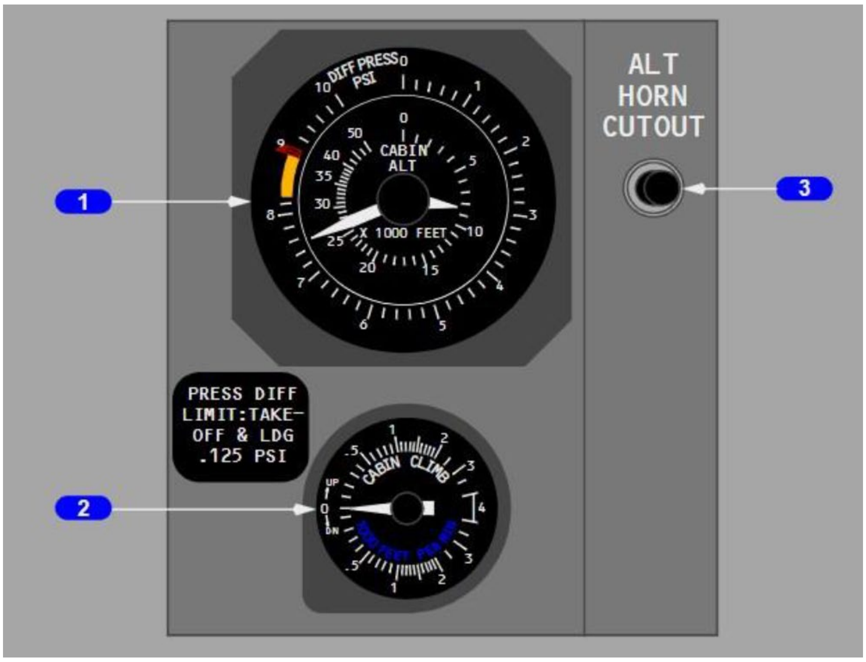

Figure 3

Cabin altitude indicators
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The aircraft manufacturer stated that the pressurisation system would control the cabin rate of descent at a maximum of 750 fpm. Once the bleed switches were selected ON it would have taken over nine minutes for the cabin altitude to reach 3,000 ft.

Air conditioning system

The air conditioning system provides temperature-controlled air by processing bleed air from the engines, APU, or a ground air source in air conditioning packs. Conditioned air from the left pack, upstream of the mix manifold, flows directly to the flight deck. Excess air from the left pack, air from the right pack, and air from the recirculation system is combined in the mix manifold. The mixed air is then distributed through the left and right sidewall risers to the passenger cabin. Electronic controllers command the pack temperature control valve toward open or closed to satisfy pack discharge requirements. If a primary pack control fails, the affected pack is controlled by the standby pack control in the opposite controller. Should both primary and standby controllers fail, the PACK light illuminates immediately. Should either a primary or standby pack controller fail, the PACK, Master Caution and AIR COND system annunciator lights will illuminate when the Master Caution recall button is pressed. The QRH contains a checklist for crew to use in response to a PACK caution illuminating and this is shown at Figure 4. The checklist directs crews to select a warmer temperature on the cabin and flight deck temperature controllers to reduce the load on the affected pack. The crew could not recall what cabin temperatures had been selected on the incident flight. On return to Manchester the right pack was checked by the operator's engineers and no fault was found.

2.14

BOEING

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PACK | **PACK**

Condition: One or more of these occur:
- The primary and standby pack controls are failed
- A pack overheat.

1 Temperature selectors (all) . . . . . . Select warmer temperature

This reduces the workload on the affected air conditioning pack.

2 TRIP RESET switch . . . . Push

If the PACK light illuminated as a result of the pack temperature exceeding limits, the light extinguishes if the pack temperature has cooled below limits.

▼ Continued on next page ▼

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▼PACK continued▼

3 Choose one:

◆**Both** PACK lights are **extinguished**:

Continue normal operation.

■ ■ ■ ■

◆**A single** PACK light **stays illuminated**:

ISOLATION VALVE switch . . . . CLOSE

PACK switch (affected side) . . . . OFF

■ ■ ■ ■

Figure 4

Pack QRH Checklist

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Hypoxia risk

As the aircraft did not pressurise, the crew and passengers were exposed to the risk of hypoxia. At cabin altitudes above 10,000 ft but below 14,000 ft, without the pre-existence of significant medical issues, the likelihood of loss of consciousness is very small. However, in this altitude window the hypoxic exposure can be sufficient to affect cognitive performance and decision making to the point where the decline would be observable in cognitive tests. In this range of altitudes there are many variables that affect the severity and impact of hypoxia, including duration of exposure, rate of hypoxia onset (eg rate of climb if no pressurisation), physical workload, fatigue, individual responses and type of task being performed. In this range of altitudes it is also difficult to separate the relative contribution of hypoxia versus other performance degraders such as fatigue, distraction or other human performance issues.

The aircraft climb was interrupted by the crew attending to the PACK caution. If the aircraft had continued to climb, the aircraft's passenger oxygen system would have deployed automatically when the cabin altitude reached 14,000 ft, and the pressurisation AUTO FAIL master caution would have been triggered at 15,800 ft cabin altitude, according to the Flight Crew Operating Manual. As progressive exposure to hypoxia increased, the likelihood of the crew taking correct recovery actions would have decreased.

Fatigue

The operator's fatigue team had discussions with both pilots and conducted a fatigue analysis. Individual work history showed that both pilots had been working harder than usual. A key metric used to gauge fatigue is the Samn-Perelli Score (SPS)[2] obtained through statistical analysis of rosters and sleep achieved. SAFE[3] analysis of the commander's roster for the previous eight weeks placed him in the top 10% of the operator's B737 commanders, scoring high for fatigue when comparing work/duties completed. For the incident duty the commander scored 4.48 on the SPS scale and so fatigue was not a sufficient explanation on its own for the omissions made in response to the CABIN ALTITUDE warning. For the co-pilot, the percentage of time with a high SPS and the total time with an SPS above five were both low. Sectors flown in the previous eight weeks were low both in comparison to the overall community and to the operator's MAN co-pilots.

Analysis found that in terms of acute fatigue[4], the duty was not in itself particularly fatiguing, but the commander's pre-duty rest was disturbed with just three hours sleep achieved. There were several indicators from the analysis of the previous eight weeks that suggested chronic fatigue was a possible factor for the commander. He had carried out a significant number of overtime duties and, although they were not necessarily individually fatiguing, the cumulative disruption may have been a factor. The SAFE analysis also showed that the commander's exposure to fatiguing duties was amongst highest across the operator's B737 fleet and joint highest amongst its commanders at Manchester.

Though the commander did not believe fatigue was a factor in this event, the analysis of his roster over the eight weeks preceding the event and the rest period immediately before it suggest that fatigue could still have been a contributory factor. It should be noted that fatigue, particularly chronic fatigue, can be insidious such that an individual may not recognise the symptoms in themselves.

Crew training

Experience of cabin altitude/decompression during recurrent training is required every three years as detailed in the operator's training manual. The co-pilot completed a decompression training module in the B737 simulator on 5 January 2023 and the commander carried out a classroom session on 10 March 2022. Neither pilot experienced a realistic, surprising, cabin altitude or decompression event in the simulator during their annual training/checking, although such surprise is difficult to generate in the simulated environment.

Footnote

2 Samn-Perelli 7-Level fatigue scale. | Download Scientific Diagram (researchgate.net) [Accessed August 2024].

3 A biomathematical fatigue model that predicts fatigue hazards experienced by commercial aircraft pilots.

4 Acute fatigue is associated with sleep restriction or extended hours awake within the last 1 or 2 days.

The cabin altitude warning experienced in the aircraft during the event flight occurred at a relatively low level, outside of the more extreme area of the flight envelope where such an event is normally experienced in the simulator.

QRH Information

The aircraft QRH contains Quick Action Index (Figure 5) for situations that require a quick response. Titles shown in upper case are annunciated by a light, alert or other indication.

These checklists can have both memory and reference items. Memory items are immediate actions which must be done before reading the rest of the checklist. It is the operator's policy that memory items shall be carried out without reference to the checklist. Once complete the crew use the QRH to ensure that no memory items have been omitted prior to commencement of the reference items. The end of the memory items is signified by a dashed horizontal line. The QRH checklist for CABIN ALTITUDE is at Figure 6

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Quick Reference Handbook

Quick Action Index

Aborted Engine Start.................................... 7.1
Aborted Engine Start.................................... 7.2
Airspeed Unreliable.................................... 10.1
APU FIRE 8.1
CABIN ALTITUDE WARNING.......... 2.1
Emergency Descent.......................0.1
ENGINE FIRE.. 8.2
Engine Limit or Surge or Stall 7.4
ENGINE OVERHEAT 8.5
Engine Severe Damage or Separation 8.2
Engine Tailpipe Fire 8.6
Evacuation .... Back Cover.2
LANDING CONFIGURATION........................ 15.1
Loss Of Thrust On Both Engines 7.8
Rapid Depressurization 2.1
Runaway Stabilizer 9.1
Smoke, Fire or Fumes 8.8
TAKEOFF CONFIGURATION 15.1
WARNING HORN (INTERMITTENT) 15.2
WARNING LIGHT - CABIN ALTITUDE OR TAKEOFF CONFIGURATION....................... 15.2

Figure 5

QRH Quick Action Index
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CABIN ALTITUDE WARNING
or
Rapid Depressurization

CABIN ALTITUDE **(If installed and operative)**

Condition: One or more of these occur:
- A cabin altitude exceedance
- In flight, the intermittent cabin altitude/configuration warning horn sounds or a CABIN ALTITUDE light (if installed and operative) illuminates.

1 Don oxygen masks and set regulators to 100%.

2 Establish crew communications.

3 Pressurization mode selector . . . . MAN

4 Outflow VALVE switch . . . . Hold in CLOSE until the outflow VALVE indication shows fully closed

5 **If** cabin altitude is **uncontrollable**:

Passenger signs . . . . ON

PASS OXYGEN switch . . . . ON

►►Go to the Emergency Descent ( ) checklist on page 0.1

■ ■ ■ ■

6 **If** cabin altitude is **controllable**:

Continue manual operation to maintain correct cabin altitude.

When the cabin altitude is at or below 10,000 feet:

Oxygen masks may be removed.

7 **Checklist Complete Except Deferred Items**

Figure 6

Cabin Altitude Warning Checklist
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Analysis

Maintenance work was carried out during the night before this flight during which the engine bleed air switches were selected OFF. The engineer carrying out the maintenance believed that the switches had been returned to the ON position after the work had been completed, but it appears that they were left OFF. The engineer assigned to the aircraft's departure did not detect the incorrect switch position.

During the pre-start procedures by the flight crew, it was not identified that the engine bleed switches were set OFF nor was this oversight detected in the after-takeoff checks. The crew did not use the prescribed memory items in response to a cabin altitude warning and may have misinterpreted the cabin altitude gauge readings after the engine bleed switches were selected to ON.

The departure was early in the morning and the commander's rest had been disturbed by his mobile phone and as a result he had slept for only three hours in the night preceding the duty. Additionally, his workload over recent weeks had been higher than average for the operator and he had been exposed to a number of potentially disruptive overtime duties. It is possible, therefore, that fatigue was a factor in the commander's decision making. The co-pilot had a lower fatigue risk than the commander but their journey to work had been disrupted and they had arrived late at the aircraft. Although the co-pilot recalled that they did not feel under pressure, they were trying to expedite the departure. It is possible, therefore, that in completing their procedures in an expeditious manner they were more vulnerable to seeing what they expected to see. As both bleed switches were in the same position, OFF, it is possible the co-pilot perceived them to be ON, since that was their expectation.

The engine bleed switches are not mentioned again until the after-takeoff checklist so there was no further procedural opportunity to identify the incorrect switch positions until the aircraft was airborne. After takeoff the PF calls for the after-takeoff checks, which are completed by the PM using challenge and response techniques. It appeared likely that during these checks the co-pilot again saw what they expected to see and so did not notice that the engine bleed switches were still selected OFF. The switches are on the opposite side of the cockpit to the commander, reducing the likelihood that he would notice that they were in the wrong position.

The aircraft continued to climb with the bleed air systems off and so the cabin failed to pressurise. The CABIN ALTITUDE warning was triggered with the aircraft at approximately FL130. The aircraft QRH specifies memory items in response to this warning, the first of which is to don oxygen masks and establish crew communications. The crew did not conduct the memory items but in response to the warning the commander noticed the engine bleed switches were OFF and directed them to be selected ON. The crew recalled that this was done very quickly, though in fact 73 seconds elapsed between the warning and the bleeds being selected ON, during which the aircraft was levelled at FL150. Although the memory items were not carried out, the pilots were perhaps pre-disposed to check the bleed switches due to the entry in the aircraft tech log, related to air systems, which they had noted earlier. The pilots may have suffered a startle effect at the initial warning, but simple memory items are included in checklists to support crew decision making in crisis and support pilots by creating a structure for them to follow.

Crew training is generally focussed on rapid decompression at high altitudes. This event occurred at a much lower level with much less grave symptoms and so may have subconsciously conditioned the degree of urgency attributed to the response by the crew.

With the bleed switches selected ON, the crew assumed that the aircraft systems would correct the cabin altitude and that the rest of the memory items beyond donning oxygen masks would have been disproportionate. However, donning the oxygen masks as an immediate action would have given both pilots immediate protection from any hypoxia risk and allowed them to clarify the situation with the highest risk removed.

The crew's expectation was that selecting bleeds ON would have resolved the problem. The commander's recollection was that the cabin altitude was 2,000 ft within "a couple of minutes". The aircraft was level at FL150 for three minutes and 30 seconds before recommencing the climb to FL280. The commander recalled seeing the needle on the cabin pressure gauge as being between the one and two o'clock positions. If the longer needle on the gauge was in that position it would indicate a cabin pressure differential of between one and two psi, suggesting a cabin altitude that was still high. Confirmation bias may have been a factor for the commander as his expectation was that turning on the bleed air system would have rapidly resolved the problem. However, the aircraft pressurisation system would have required over 10 minutes to achieve a cabin altitude of 2,000 ft.

Certain that the problem had been resolved the crew continued the climb and neither pilot recalled the red CABIN ALTITUDE warning light as being on. During the climb the right PACK caution illuminated. The crew stopped the climb at FL200 and actioned the QRH for the PACK caution, but this did not recover the pack and so the crew sought advice from the operator's Maintrol. Dispatching for the return leg to Manchester with a pack inoperative would have imposed limitations on the altitude to which the aircraft could climb and would have incurred significant performance penalties, so the decision was taken to return to Manchester. No technical cause for the pack fault was subsequently found but a likely cause is that the system was placed under a high load by the crew selecting low temperatures for the air conditioning, although neither pilot could recall what temperatures were set on the aircraft.

The recorded data indicated that the CABIN ALTITUDE warning remained on for 43 minutes. During that time the associated red warning light should have been illuminated, though neither pilot recalls seeing it. As the passenger oxygen masks did not deploy, the cabin altitude did not exceed 14,000 ft but, nevertheless, it was likely that the crew and passengers were exposed to a progressive hypoxia risk. While any loss of consciousness was highly unlikely, a negative impact on the ability of the crew to process information and make decisions was probable.

The climb to cruising altitude was interrupted by the PACK caution. Had the aircraft continued to climb, the passenger oxygen system would have deployed at 14,000 ft cabin attitude, and at 15,800 ft the AUTO FAIL caution on the pressurisation would have triggered a further master caution, and each of these events would have been a further opportunity to re-assess the situation. With one pack operational, the aircraft would have pressurised at a rate of climb below that of the aircraft, leaving a risk of progressive hypoxia that, coupled with fatigue, could have reduced the crew's ability to respond appropriately to these indications.

Conclusion

The aircraft departed with the engine bleed air system off because the switches had been incorrectly left OFF following maintenance activity and had not been turned ON during pre-flight procedures. The after-takeoff checklist is designed to trap the latter omission, but the incorrect switch selection went undetected by the crew. The aircraft failed to pressurise, but the crew did not complete the prescribed QRH drills in response to a CABIN ALTITUDE warning, which remained illuminated for 43 minutes.

Serious Incident

Aircraft Type and Registration:	1) Boeing 787-9, G-VDIA 2) Airbus A350-1041, G-XWBC	
No & Type of Engines:	1) 2 Rolls-Royce Trent 1000-K2 turbofan engines 2) 2 Rolls-Royce Trent XWB-97 turbofan engines	
Year of Manufacture:	1) 2016 (Serial no: 37975) 2) 2019 (Serial no: 362)	
Date & Time (UTC):	6 April 2024 at 1120 hrs	
Location:	London Heathrow Airport	
Type of Flight:	1) N/A 2) Commercial Air Transport (Passenger)	
Persons on Board:	1) Crew - 1 2) Crew - 14	Passengers - None Passengers - 107
Injuries:	1) Crew - None 2) Crew - None	Passengers - N/A Passengers - None
Nature of Damage:	Both aircraft sustained structural damage	
Commander's Licence:	1) N/A 2) N/A	
Commander's Age:	1) N/A 2) N/A	
Commander's Flying Experience:	1) N/A 2) N/A	
Information Source:	Aircraft Accident Report Form submitted by the operator and further enquiries by the AAIB	

Synopsis

During a pushback operation to reposition G-VDIA, the aircraft's left wingtip struck the right horizontal stabiliser of G-XWBC. Both aircraft were damaged but there were no injuries. The operator of G-VDIA found that the pushback tug turned too soon, so the pushback did not follow the correct angle. Contrary to their company airport operating manual, the pushback was conducted without wing walkers; a wing walker on the left side of the aircraft would probably have seen the impending collision and could have stopped the pushback operation.

Safety actions were implemented by the aircraft and airport operators in response to this serious incident.

History of the flight

G-VDIA was parked on Stand 323 at London Heathrow Airport, and G-XWBC was parked alongside, on Stand 325. G-VDIA was scheduled to depart from Stand 211, so the aircraft needed to be pushed back and repositioned. G-XWBC was in the process of boarding passengers for flight.

Three people were involved in the pushback operation: a tug driver, a headset operator and a 'brake-rider[1]' in the cockpit.

As G-VDIA was pushed back, the aircraft was turned in preparation for it entering the taxiway. The left wingtip struck the right horizontal stabiliser of G-XWBC causing damage to both aircraft. Nobody was injured but the collision was reportable to the AAIB because people were onboard G-XWBC with the intention of flight.

Aircraft examination

Both aircraft were structurally damaged but there were no fluid leaks and no requirement for emergency intervention or containment.

Operator's investigation

Under the provisions of their Safety Management System, the operator of G-VDIA carried out their own investigation and shared their findings with the AAIB.

G-VDIA has a wingspan that is approximately 1 m inside the allowable limit for Stand 323, and G-XWBC is 0.25 m and 1.71 m inside the respective limits for wingspan and length[2]. The operator of G-VDIA considers the pushback to have been '*on reduced safety margins*' but within normal operations.

The operator concluded that as the aircraft was pushed away from the stand, the turn to enter the taxiway was initiated too early. This meant that the left wing passed over the cross-hatched area, which should be kept clear of objects, between the two stands. The cross-hatched area was noted to contain several items of ground equipment relating to G-XWBC, so the pushback was paused to allow this equipment to be removed. The possibility of a collision between the two aircraft was not identified at this time and the pushback resumed. None of the people involved in the pushback had a clear view of the left wing and, contrary to the operator's procedures, wing walkers[3] were not being used. The collision occurred shortly after the pushback resumed, and ATC intervened with an instruction to hold position.

The operator reported that they introduced a requirement for wing walkers in 2021 but, in this event, this requirement was not followed by their ground handling agent. As such, the pushback operation did not comply with the operator's procedures.

Safety action

The aircraft operator issued a safety alert highlighting their requirement for wing walkers during aircraft push back operations.

Footnote

[1] The brake-rider sits in the aircraft cockpit and can apply the aircraft brakes if the towbar snaps.
[2] The airport operator advised that these limitations are defined in airfield licensing requirements.
[3] The wing walker watches and monitors the path of an aircraft's wing whilst the aircraft is being manoeuvred to ensure there is sufficient clearance from objects in the vicinity.

Other information

The airport operator does not mandate wing walkers when operating from Stand 323, so the push back operation met those standards.

Safety action

The airport operator issued an Aerodrome Safety Alert highlighting the following safety considerations:

- *'If you are unsure about the safety of the pushback, then stop immediately and re-assess. Contact ATC if required.*
- *The use of wing-walkers should be considered for pushbacks or where the visibility of the tug driver may be obscured due to the nature of the manoeuvre.*
- *Headset operators should be positioned in such a manner that they are able to provide additional observation of any potential risks.*
- *Company processes, policies and training should be followed at all times.*
- *Hatched areas should always be clear of vehicles and equipment so as not to impede safe operations.'*

The airport operator also advised that they were reviewing '*non-standard pushbacks*'[4] and the associated Operations Safety Instruction.

Conclusion

G-VDIA collided with G-XWBC when it was being pushed back to allow it to be repositioned on another stand. The aircraft was being moved in accordance with airport requirements, but the turn was initiated too soon. Contrary to the aircraft operator's processes, the pushback was being carried out without dedicated wing walkers. A wing walker on the left side of the aircraft would probably have seen the impending collision.

Safety actions/Recommendations

- The operator of G-VDIA issued a safety alert to highlight their requirement for wing walkers during aircraft pushbacks and towing operations.
- The airport operator issued an Aerodrome Safety Alert outlining factors that should be considered during aircraft pushback or towing operations.
- The airport operator advised they were reviewing non-standard pushback operations and the associated Operations Safety Instruction.

Footnote

[4] The airport operator described non-standard pushbacks to be '*those that are not pushed at 90 degrees to the taxiway centreline*'.

Accident

Aircraft Type and Registration:	Beechcraft King Air C90GTx, D-IMEP
No & Type of Engines:	2 Pratt & Whitney Canada PT6A-135 turboprop engines
Year of Manufacture:	2010 (Serial no: LJ-2026)
Date & Time (UTC):	1 June 2024 at 1437 hrs
Location:	London Biggin Hill Airport
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to the passenger cabin door assembly
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	57 years
Commander's Flying Experience:	4,825 hours (of which 2,821 were on type) Last 90 days - 9 hours Last 28 days - 4 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and additional enquiries made by the AAIB

Synopsis

The cabin door, although the external door handle appeared to be in the locked position, opened during the climb after takeoff. The aircraft returned for a safe landing.

History of the flight

The pilot reported that he boarded the aircraft and closed the passenger cabin door but shortly after takeoff, whilst passing through 1,700 ft amsl, the red warning annunciator for the cabin door began to flicker. It then illuminated steadily and, simultaneously, he heard a bang that he attributed to the cabin door having come open. He immediately made a PAN call to ATC and returned to the airport for a safe landing.

The airport's apron CCTV was reviewed by the on-duty airport manager, and according to the pilot, showed that the external door handle was in the closed position. Both the pilot checklist and Pilot Operating Handbook detail several visual checks that should be made on the door locking mechanism, as well as a mechanical check to ensure the door handle is in the locked position, that are intended to confirm the cabin door has been properly secured prior to departure.

The aircraft manufacturer advised that there have only been two other events on the King Air 90 series where the passenger cabin door has inadvertently opened during flight.

Accident

Aircraft Type and Registration:	Boeing A75, G-PTBA
No & Type of Engines:	1 Lycoming R-680-17 piston engine
Year of Manufacture:	1937 (Serial no: 75045)
Date & Time (UTC):	4 August 2024 at 1025 hrs
Location:	Lundy Island Airstrip, North Devon
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Left main landing gear leg sheared off and impact damage to the underside of the left lower wing
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	68 years
Commander's Flying Experience:	9,651 hours (of which 301 were on type) Last 90 days - 37 hours Last 28 days - 16 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft struck a runway edge marker during landing, causing the left main landing gear leg to detach, leading to a runway excursion. The pilot commented that reduced peripheral visual references whilst the aircraft was flared in a three-point landing attitude contributed to the aircraft drifting to the left edge of the runway during the landing roll.

History of the flight

The pilot was flying to Lundy Island to attend a fly-in event. After flying a normal circuit to Runway 24, he made a three-point landing on the left side of the runway. The aircraft had drifted to the left and shortly after it touched down, the left main landing gear leg struck a white-painted rock that was placed alongside the runway as one of the edge markers. The impact with the rock caused the left main leg to fail and detach, which then struck the left lower wing. The aircraft slewed to the left, off the runway, before coming to rest (Figure 1). The pilot and his passenger were uninjured and were able to vacate the aircraft normally.

Airfield information

Lundy Island is situated 10 nm from Hartland Point on the north Devon coast. Lundy Island Airstrip is approximately 400 m long, 50 m wide, oriented 060°(M)/240°(M) and has a rough grass surface. The runway edges are marked with white-painted rocks placed approximately every 10 m.

Figure 1
G-PTBA after the accident, with white-painted runway edge marker rocks visible behind

Pilot's comments

The pilot commented that he elected to land on the left side of the runway as it appeared to be smoother than the right side, and that a number of pilots who subsequently arrived after the accident also made the same decision. He noted that once in the three-point landing attitude, there were few forward or peripheral visual cues to ensure that he remained tracking parallel to the runway edge markers during touchdown.

Analysis

The pilot was unable to keep the aircraft tracking straight down the runway due to a loss of visual references after flaring the aircraft in a three-point landing attitude. This prevented him correcting a left drift that was present during touchdown, causing the impact with the runway edge marker.

Conclusion

The aircraft struck a runway edge marker during the landing roll, causing damage to the left main landing gear leg and a subsequent runway excursion.

Accident

Aircraft Type and Registration:	Jodel DR11, G-AWMD
No & Type of Engines:	1 Continental Motors Corp C90-14F piston engine
Year of Manufacture:	1969 (Serial no: PFA 904)
Date & Time (UTC):	3 August 2024 at 0945 hrs
Location:	Rhigos Airfield, Glamorgan
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Serious) Passengers - N/A
Nature of Damage:	Right landing gear detached, damage to wing leading edges, fuselage and instrument panel
Commander's Licence:	Private Pilot's Licence
Commander's Age:	77 years
Commander's Flying Experience:	731 hours (of which 0 were on type) Last 90 days - 1 hour Last 28 days - 1 hour
Information Source:	Aircraft Accident Report Form submitted by the pilot

The pilot was practising approaches to Runway 27R at Rhigos airfield when, on the second approach, he reduced throttle and set the carburettor heat to ON. Shortly afterwards the engine stopped, and he noticed that fuel mixture had been cut instead of the carburettor heat being set to ON. He reset the mixture to RICH and tried restarting the engine, but it only ran for a few seconds, by which time he was slow and low on final approach. The aircraft struck a bank which formed part of the airfield boundary (Figure 1) and the pilot suffered serious facial and spinal injuries.

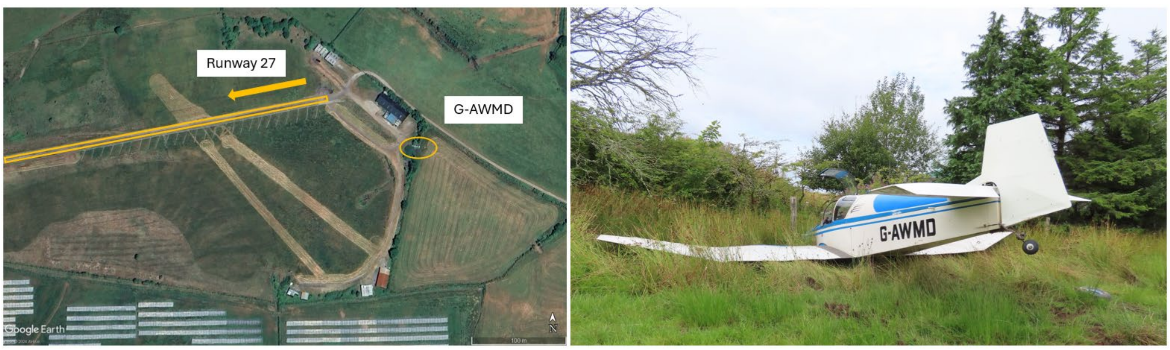


Figure 1

Rhigos Airfield and G-AWMD at the accident site

Accident

Aircraft Type and Registration:	Piper PA-28R-200, G-BCPG	
No & Type of Engines:	1 Lycoming IO-360-C1C piston engine	
Year of Manufacture:	1970 (Serial no: 28R-35705)	
Date & Time (UTC):	21 April 2024 at 1220 hrs	
Location:	Teesside International Airport, Durham	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - None
Injuries:	Crew - None	Passengers - N/A
Nature of Damage:	Damage to gear leg, retraction mechanism, mounting brackets, wing spar and upper wing structure	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	49 years	
Commander's Flying Experience:	400 hours (of which 200 were on type) Last 90 days - 0 hours Last 28 days - 0 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot and further enquiries by the AAIB	

Synopsis

During taxi, the left main landing gear collapsed aft. Inspection of the landing gear installation revealed that the landing gear retainer tube assembly had unscrewed which released one of the gear's two mounting points. The forces encountered by the landing gear leg during the taxi, tore the leg out of the remaining forward mounting point, causing significant damage to the left wheel well, landing gear and wing.

The manufacturer will be updating the aircraft maintenance manual to include a torque setting for the retainer tube bolt in the next revision of the manual.

History of the flight

The pilot had completed a 50 hr check and planned to go for a short local flight. He taxied to hold C of Runway 05 to carry out engine checks, but as he turned left into the wind, he heard a loud thud and the left wing dropped. He shut down the engine, turned off the master switch and, uninjured, vacated the aircraft. External visual inspection confirmed that the left main landing gear had collapsed. Contrary to the pilot's expectation, however, the leg had not folded inwards as it would during a retraction, but instead it was pointing aft (Figure 1).

Figure 1
Left main landing gear collapsed rearwards

Aircraft examination

Main landing gear assembly

The landing gear assembly is attached to the wing spar in the wheel well on the underside of the wing by support fittings and gear support bearings, forward and aft (Figure 2).

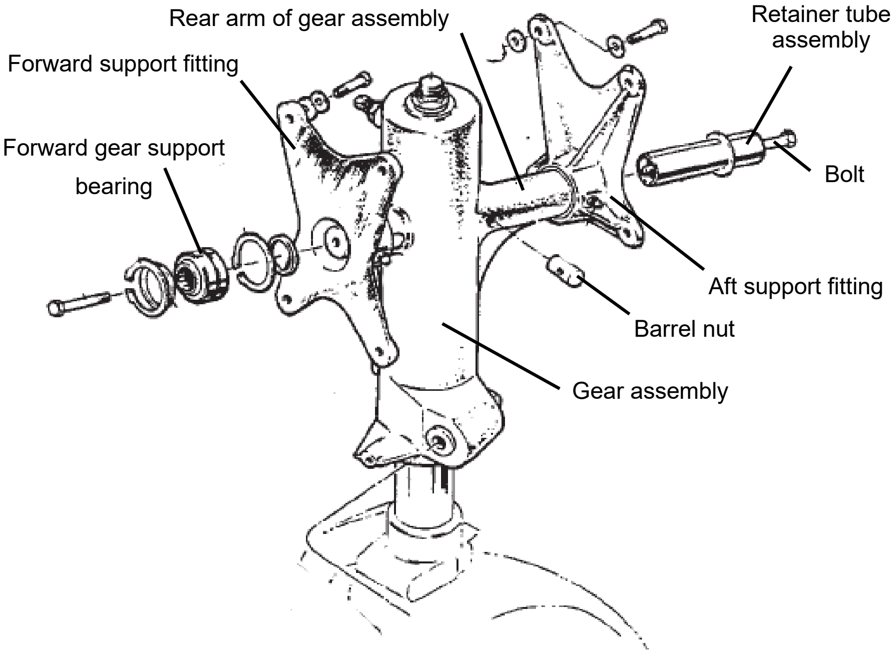


Figure 2
Schematic drawing of upper landing gear assembly

To fit the landing gear, the forward gear support bearing is bolted onto the forward arm of the gear assembly which is then fixed to the forward support fitting using washers and retainer rings[1]. The aft support fitting with the aft gear support bearing installed is then bolted to the rear attachment point in the wheel well under the wing. The retainer tube assembly is inserted into this support fitting via an access hatch on the underside of the wing adjacent to the wheel well. Once the gear is in position, the forward support fitting is bolted in place, attaching the forward arm of the gear assembly to the wing spar. The rear arm of the gear assembly is aligned with the gear support bearing in the aft support fitting, and the retainer tube assembly pushed into rear arm through the access hatch. The tube assembly bolt is then tightened into the barrel nut, fixing the rear arm of the gear assembly in place in the wheel well. Once these actions are complete, the gear assembly can pivot in the wheel well around both arms of the gear assembly, gear support bearings and fittings. The gear side brace assembly (not shown in Figure 2) can then be installed to provide gear retraction.

Examination of damage to the landing gear and wheel well

Inside the left wheel well, the landing gear was found mechanically disconnected from the wing. The forward support fitting was disrupted around the gear support bearing with parts of the bearing missing but some fractured remains still in the bracket (Figure 3). The centre of the forward support fitting was bent away from the wing spar and a hole had been punched through the upper surface of the wing. There were also deep score marks around a circular cut-out in the web of the spar.

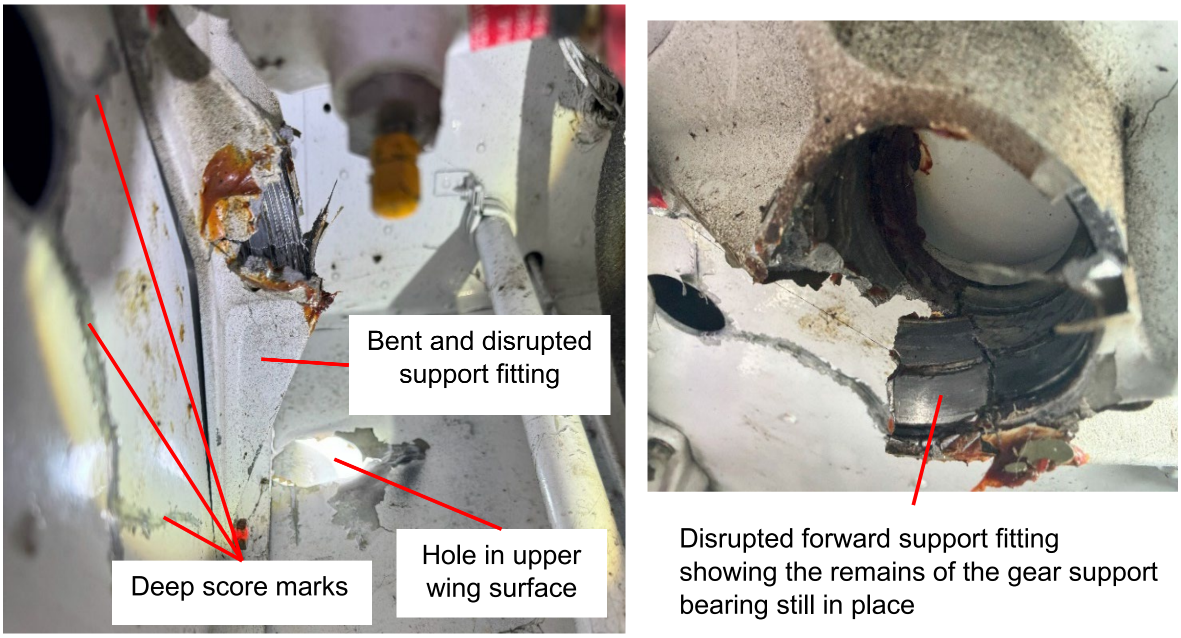


Figure 3

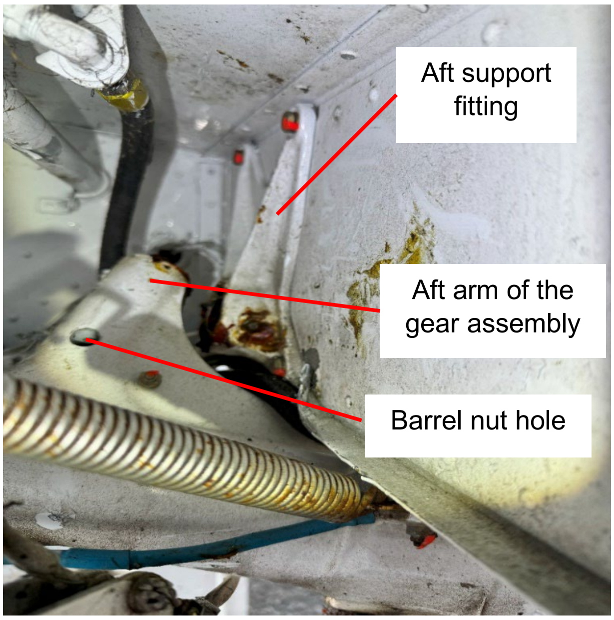
Looking upwards into the wheel bay at the forward support fitting (Left) and the disrupted fitting with the remains of the bearing still in place (Right)

Footnote

1 This paragraph is only a brief overview of the process. The full installation process can be found in the Piper Cherokee Service Manual 753-586 PA-28-28R-180-200 SM_20210918 Section 7A-25.

The aft support fitting was largely undamaged with the aft gear support bearing intact and still installed in the fitting (Figure 4). The aft arm of the gear assembly was located close to the support fitting but not connected by the retainer tube assembly that would have been fitted during the installation of the landing gear leg. Once the access panel in the lower surface of the wing adjacent to the wheel well was opened, the retainer tube assembly was found loose in the access space. The barrel nut for the tube assembly bolt was still in place in the hole forward of the aft arm of the gear assembly (Figures 2 and 4).

Although the tube assembly showed some signs of wear, the bolt was intact (Figure 5). The thread of the bolt and the barrel nut were also undamaged but with some signs of wear. The barrel nut and tube assembly bolt were screwed back together successfully with no play evident.



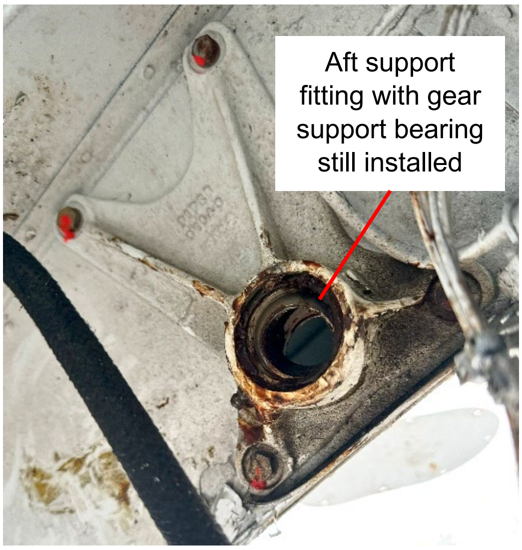


Figure 4

Looking upwards into the wheel bay at the aft support fitting (Left) and the undamaged fitting showing the intact gear support bearing still installed (Right)

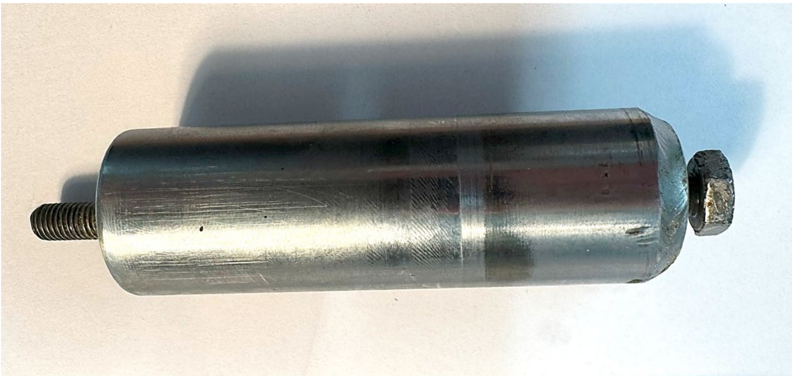


Figure 5

Retainer tube assembly and bolt

Main landing gear maintenance

The left main landing gear had been removed, serviced and re-installed in 2019. Since then, the landing gear had been inspected annually and the work had been carried out by three different maintenance organisations. The inspection instructions stated in the Piper Cherokee Maintenance Manual[2] are shown in Figure 6.

PIPER CHEROKEE SERVICE MANUAL

TABLE III-II
INSPECTION REPORT - PA-28R-180/200

NATURE OF INSPECTION	Inspection Interval (Hrs) 50	100
F. LANDING GEAR GROUP		
1. Check oleo struts for proper extension and evidence of fluid leakage. See Landing Gear, Section II	O	O
2. Inspect nose gear steering control and travel		O
3. Inspect wheel alignment		O
4. Put airplane on jacks. (Refer to Section II.)		O
5. Inspect tires for cuts, uneven or excessive wear, and slippage		O
6. Remove wheels; clean, inspect, and repack bearings		O
7. Inspect wheels for cracks, corrosion, and broken bolts		O
8. Check tire pressure	O	O
9. Inspect brake linings and discs for condition and wear		O
10. Inspect brake backing plates for condition and wear		O
11. Inspect brake and hydraulic lines for condition and security		O
12. Inspect shimmy dampener operation		O
13. Inspect gear forks for damage		O
14. Inspect oleo struts for fluid leaks and scoring		O
15. Inspect gear struts, attachments, torque links, retraction links, and bolts for condition and security. (See Note 26.)		O
16. Inspect downlock for operation and adjustment		O
17. Inspect torque link bolts and bushings. Rebush as required		O
18. Inspect drag and side brace link bolts. Replace as required		O
19. Inspect gear doors and attachments		O
20. Inspect warning horn and light for operation		O
21. Retract gear, check operation		O
22. Retract gear, check doors for clearance and operation		O
23. Inspect anti-retraction system squat switch		O
24. Inspect actuating cylinders for leaks and security		O
25. Inspect hydraulic lines, electrical leads, and attaching parts for condition and security (i.e., routing, chafing, damage, wear, etc.)		O
26. Inspect position indicator switch and electrical leads for security		O
27. Lubricate per Lubrication Chart in Section II	O	O
28. Remove airplane from jacks. (Refer to Section II.)		O

G. SPECIAL INSPECTIONS

Review inspections in Special Inspections, "Requirements" on page III-37. Perform all special inspections applicable to your aircraft and currently due per the given inspection interval.

III - INSPECTION 11/30/19

III-32

Figure 6

Piper Cherokee PA-28R-180/200 - 100-hour Inspection Requirements

Footnote

2 Piper Cherokee Service Manual 753-586 PA-28-28R-180-200 SM_20210918.

The LAA generic maintenance schedule for the Permit to Fly[3], states the following inspection for the landing gear (Figure 7):

Landing Gear		
Inspect landing gear assemblies, shock-absorber struts/units for leaks and correct extension, brake system, brake linings, drums/discs, wheels and tyres.		
Service tyre pressures, hydraulic brake system fluid level.		
Inspect structural members, attachment fittings, pivot points, shock absorbing devices, bungee rubbers, torque links, shimmy dampers, main wheels, nose/tail wheels, bearings, skids, hoses and lines, hydraulic and electric actuators, jacks, struts, wheel fairing. Note: Carry out with weight off the landing gear.		
Operational check of main and parking brake systems.		
Operational check of normal/emergency retraction and extension, locking devices, doors and operating linkages, indicators, warning devices.		
Check hydraulic/pneumatic operating system.		

Figure 7

LAA 12 Month/150-hour generic inspection schedule for landing gear

Analysis

As there was no damage to the thread of the retainer tube assembly bolt, and it screwed back into the barrel nut with no sign of play or damage, it is highly likely the bolt gradually unscrewed due to vibration since re-installation of the landing gear in 2019. Since installation, the landing gear had been inspected annually and by three different organisations. There is no specific check that the tube assembly bolt is secure, therefore, it is possible that the bolt tightness was not checked and gradually became unscrewed over 5 years since installation. This enabled the aft arm of the landing gear to disconnect from the bearing. The landing gear would then only have been held in place by the forward arm, bearing and fitting. The forces applied to the landing gear as the aircraft taxied were sufficient to tear the forward arm of the gear from the fitting and bearing resulting in the landing gear collapse experienced by the pilot and the damage seen in the gear well.

Data searches for accident reports which detail PA-28R landing gear collapses where the retainer tube assembly was causal found no arisings both in the UK and the USA. Following consultation with the aircraft manufacturer, the PA-28R-201 aircraft (which has a similar landing gear arrangement) maintenance manual specifies a torque of 40 – 50 inches lb for the retainer tube bolt. This specification will be incorporated into the PA-28R-180/200 maintenance manual at the next revision.

Footnote

[3] LAA Permit to Fly Generic Maintenance Schedule Form LAA/GMS/12/150 Issue 2 April 2022.

Conclusion

The landing gear collapse that occurred whilst the aircraft was taxiing was likely to have been caused by the left main landing gear retainer tube bolt releasing the aft landing gear arm which allowed the gear to collapse and cause significant damage to the wing. The manufacturer will be issuing an update to include a torque setting for the retainer tube bolt during the next revision of the maintenance manual for this aircraft type.

Serious Incident

Aircraft Type and Registration:	Spitfire IXT, G-BMSB
No & Type of Engines:	1 Rolls-Royce Merlin 266 piston engine
Year of Manufacture:	1943 (Serial no: CBAF 7722)
Date & Time (UTC):	25 June 2024 at 1355 hrs
Location:	London Biggin Hill Airport
Type of Flight:	Safety Standards and Consent
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Cockpit canopy detatched
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	46 years
Commander's Flying Experience:	1,940 hours (of which 12 were on type) Last 90 days - 135 hours Last 28 days - 56 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The front cockpit canopy detached from the aircraft during the climb, shortly after takeoff from London Biggin Hill Airport. The aircraft returned to the airport and landed safely. Neither occupant was injured and the aircraft did not sustain any additional damage, but the canopy was not recovered.

The pilot commented that low time on type and distraction during pre-flight preparations contributed to not closing the cockpit side door prior to takeoff. This meant that when the canopy was closed prior to departure it did not latch properly.

History of the flight

The aircraft, a two-seat Spitfire IXT, was being operated on a passenger experience flight from London Biggin Hill Airport. As the aircraft accelerated during the takeoff run on Runway 03, the canopy on the forward cockpit began to slide backwards. The pilot continued the takeoff and during the climb out, while the aircraft was in a left turn, the canopy slid back further before detaching from the aircraft.

The pilot advised air traffic control of the situation and requested immediate clearance to land. A full airport emergency was declared and the airport RFFS were in attendance for the landing. The aircraft's return to the airport, approach and landing were uneventful and the aircraft was taxied back to the hangar, where it was met by the airport RFFS. The pilot and passenger were uninjured and disembarked the aircraft normally, without assistance.

The aircraft was undamaged but at the time of reporting, the canopy which fell into fields adjacent to the airport, had not been recovered. The canopy of the rear cockpit, in which the passenger was sat, remained securely latched through the flight.

Figure 1

G-BMSB after landing showing absent front canopy and open cockpit side door

Pilot's comments

The pilot commented that being relatively new to the aircraft type and being somewhat distracted by a talkative passenger, meant that they omitted to close the cockpit side door and did not notice this before departure. Therefore, when the canopy was pulled forward as the final action before departure, it did not latch properly and as the aircraft accelerated, the canopy slid back. The pilot added that they may have reverted to common practice on other aircraft types, without a cockpit side door, where the final action before takeoff is simply to slide the canopy closed.

On the Spitfire IXT, the forward part of the left side canopy rail is on the top edge of the cockpit side door. With the door open, the canopy was not engaged in the rail and the air flow was able to get underneath the canopy causing it to detach.

The pilot considered that the safety lesson learned is to close the door before engine start and have the ground crew confirm that it is properly latched. The operator issued a crew notice instructing its pilots that the cockpit door must be closed prior to engine start. On subsequent passenger flights, the pilot has requested passengers to observe a sterile cockpit approach until the aircraft is airborne and clear of the Aerodrome Traffic Zone.

Conclusion

The front cockpit canopy detached in flight as the cockpit side door had not been closed prior to departure. Contributory factors included the pilot's level of familiarity with the aircraft, being relatively new to the type and distractions due the pre-departure phase of flight.

Serious Incident

Aircraft Type and Registration:	Tecnam P2008-JC, G-PFTE
No & Type of Engines:	1 Rotax Gmbh 912 S2-01 piston engine
Year of Manufacture:	2022 (Serial no: 1243)
Date & Time (UTC):	1 July 2024 at 1158 hrs
Location:	Oxford Airport
Type of Flight:	Training
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	No visible damage to aircraft
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	32 years
Commander's Flying Experience:	2,073 hours (of which 43 were on type) Last 90 days - 98 hours Last 28 days - 43 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

History of the flight

The aircraft was being flown by a student with an instructor to practice circuits and touch-and-go techniques. This activity had been in progress for approximately 1 hour without incident. As the aircraft was being flown by the student and was climbing from a touch-and-go, the instructor became aware of a reduction in power. The aircraft was at about 300 ft agl and started to sink. The instructor took control and verified full power was set and the choke was off. He noted the carburettor heat was also off. At this point the engine was at 2,000 rpm and was audibly at a lower pitch than normal but appeared to be running smoothly.

The instructor took an immediate decision to carry out a forced landing and configured the aircraft accordingly. He landed in a field about 10° left of the runway centre line. There were no injuries and the aircraft was undamaged.

Cause

Examination of the aircraft found the left carburettor throttle butterfly valve spring was missing. This led to an imbalance between the two carburettors and resulted in the power loss. The cable operated throttle system relies on the butterfly valve spring tension to open the throttle as power demands are made when the hand control is pushed forwards in the cockpit. To close the throttle, the hand control is pulled rearwards against spring pressure. Without the spring there can be a tendency for the throttle cable to 'buckle' rather than move the butterfly valve lever which is what happened in this case. Figure 1 shows the system with the spring present.

Figure 1
Cable, throttle and spring system (picture courtesy of the pilot)

An engine ground run was carried out with the spring missing, which replicated the power loss symptoms experienced during the incident. The pilot suspects the spring broke and detached during the flight.

Accident

Aircraft Type and Registration:	Exodus Deltajet 500 Stingray, G-CMMW
No & Type of Engines:	1 BMW R1200 two-cylinder piston engine
Year of Manufacture:	2023 (Serial no: EA 006)
Date & Time (UTC):	1 May 2024 at 1635 hrs
Location:	St Michael's Airfield, Lancashire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Serious) Passengers - N/A
Nature of Damage:	Significant damage possibly beyond economic repair
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	70 years
Commander's Flying Experience:	1,143 hours (of which 69 were on type) Last 90 days - 2 hours Last 28 days - 2 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and further enquiries by the AAIB

Shortly after takeoff, the engine foot throttle jammed with the engine at high rpm, so the pilot shut the engine down and prepared to return to the airfield. He believed he had sufficient height and speed to land safely. To reduce height, he carried out a turn which positioned him further away from the airfield than he intended. As he reached the boundary fence, the aircraft encountered a wind gradient, stalled and subsequently struck the ground. An image of the aircraft after the accident is shown in Figure 1. The pilot suffered serious leg injuries but commented that his injuries would have been much worse had he not been wearing his upper torso restraint and helmet. The cause of the throttle restriction could not be positively determined.

Figure 1

Image showing substantial damage to the fuselage and base bar

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 UAS investigations reviewed: August - September 2024

15 Jul 2024 **DJI Mavic II Enterprise** Near Tilbury, Essex

Whilst carrying out a photographic survey of a site, communication with the UA was lost. The UA descended and was damaged as it came to rest in a field. The battery had come loose and fallen out of the UA leading to the loss of power and control. It is likely the battery had started to swell during the flight which led to it loosening and then disconnecting.

29 Jul 2024 **XAGP100 Pro** Near Tern Hill, Shropshire

The remote pilot re-programmed the UAS following an earlier error message related to route uploading, but missed a step that would have ensured the UA remained clear of power lines. Towards the end of its route, the UA flew under a power line with approximately 1 m separation. It was hit by a spark from the cable and dropped to the ground.

9 Aug 2024 **DJI M3T** Wynyard, County Durham

During a training flight, the Remote Pilot engaged 'Sport' mode which disabled the collision avoidance safety feature. The UA subsequently collided with a tree and suffered substantial damage.

17 Aug 2024 **MA scale Duo Discus** Near Petersfield, Hampshire

Following a control failure, the model aircraft dived into a standing crop. The resultant small fire was quickly extinguished.

4 Sep 2024 **DJI M300** Near Loch Rannoch, Perth and Kinross

The UA was flying towards an electricity tower which was about to be inspected when the UA 'folded up' in flight and fell to the ground. It was subsequently found that the rear right arm had not been connected correctly.

13 Sep 2024 **Albatross** Llanbedr airfield, Gwynedd

The UA was approaching the runway off centre so the Remote Pilot initiated a go-around. The Remote Pilot deselected half flaps which caused the UA to pitch forward, but was not able to respond in time, and the UA struck the ground nose first at 35 kt to the side of the runway.

13 Sep 2024 **MA semi-scale Cessna 190** Deeside Model Aircraft Club, Flintshire

Following a failure of the communication link, the model aircraft flew in circles. The remote pilot followed it until he lost sight of it.

Record-only UAS investigations reviewed: August - September 2024 cont

15 Sep 2024 **MA Arrows Hobby Bigfoot Electric** Near Newbuildings, Londonderry

The model aircraft was in auto assist mode when the remote pilot was blinded by the sun and lost sight of it. The pilot cut the throttles immediately and believes the aircraft could have landed somewhere in a rural wooded area.

Miscellaneous

This section contains Addenda, Corrections and a list of the ten most recent Aircraft Accident ('Formal') Reports published by the AAIB.

The complete reports can be downloaded from the AAIB website (www.aaib.gov.uk).

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

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.

1/2023 Leonardo AW169, G-VSKP
King Power Stadium, Leicester
on 27 October 2018.

Published September 2023.

2/2023 Sikorsky S-92A, G-MCGY
Derriford Hospital, Plymouth, Devon
on 4 March 2022.

Published November 2023.

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