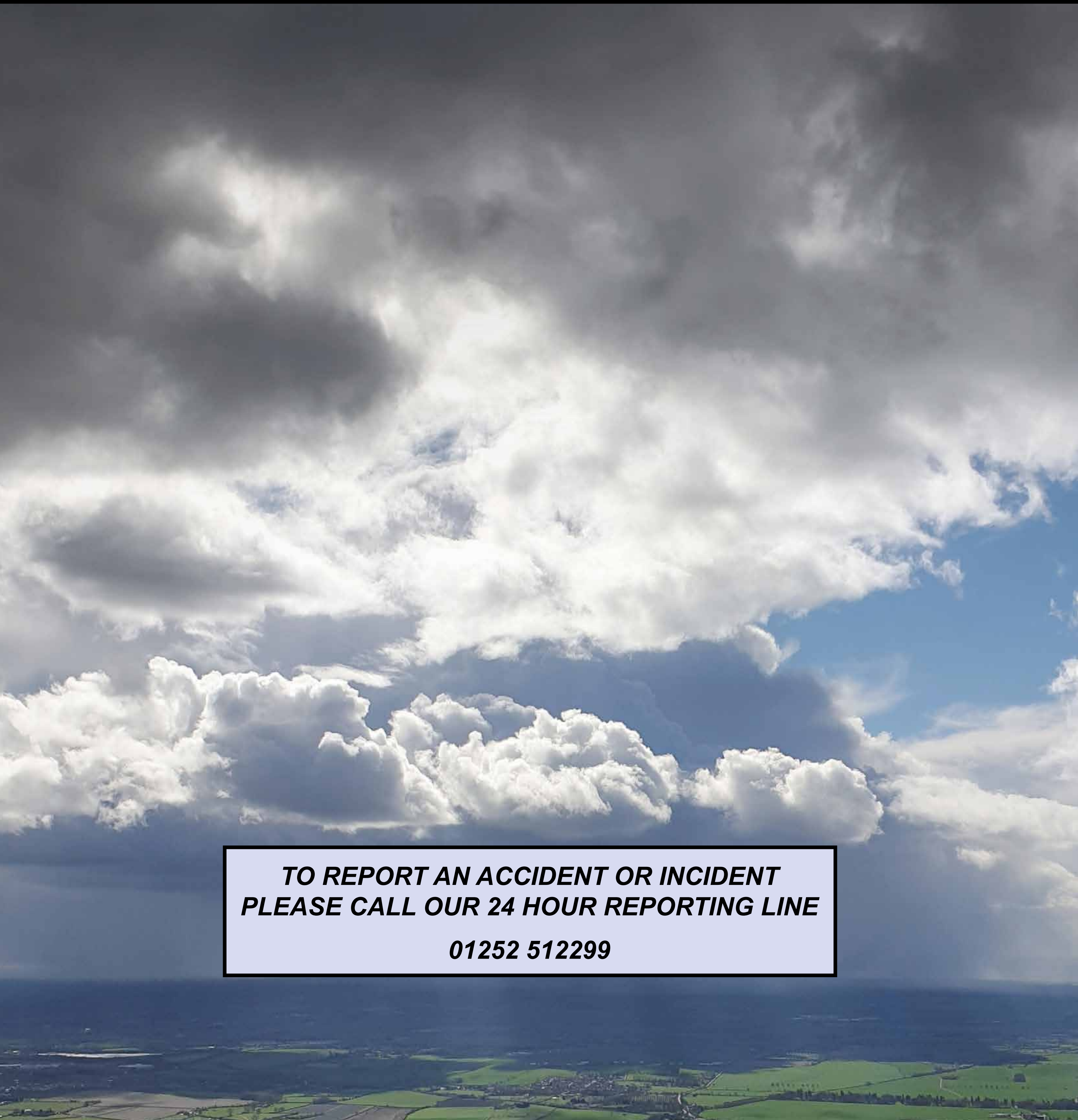
AAIB
Air Accidents Investigation Branch

AAIB Bulletin 5/2021



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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.

SERIOUS INCIDENT

Aircraft Type and Registration:	BAe ATP, SE-MAO
No & Type of Engines:	2 Pratt & Whitney Canada PW126 turboprop engines
Year of Manufacture:	1989 (Serial no: 2011)
Date & Time (UTC):	18 August 2020 at 0825 hrs
Location:	After departure from Jersey Airport, Channel Islands
Type of Flight:	Commercial Air Transport (Cargo)
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	50 years
Commander's Flying Experience:	14,500 hours (of which 100 were on type) Last 90 days - 60 hours Last 28 days - 30 hours
Information Source:	AAIB Field investigation

Synopsis

During a short flight from Jersey Airport to Guernsey Airport, Channel Islands, the flight crew experienced difficult, but manageable, issues with roll control. The aircraft landed safely.

Despite extensive testing, no faults were identified that could have caused the event. The investigation did identify two minor issues with autopilot computer maintenance and testing. These have been addressed through safety action taken by the operator.

History of the flight

The aircraft departed from Jersey's Runway 26 at 0817 hrs for the short flight to Guernsey (the aircraft's track is shown in Figure 1), with the co-pilot as pilot flying (PF). It levelled at 2,000 ft amsl and tracked towards the Guernsey VOR (GUR), with an airspeed of around 200 KIAS. ATC had issued a right turn on to heading 340° when the crew experienced a "jolt" accompanied by a roll to the left, which was corrected by the autopilot. A second "jolt" disengaged the autopilot, generating a continuous 'cavalry charge' audio warning. The co-pilot silenced the warning and took manual control of the aircraft. She intended to continue turning right but found it difficult because the aircraft was "pushing to the left". She said "I'M JUST GIVING EVERYTHING I HAVE TO JUST HOLD IT STEADY"[1]. Her speech appeared

Footnote

[1] CVR data was available for the flight.

calm with no evidence of physical strain, and she was able to comprehend the commander's instructions, with no need for him to repeat anything.

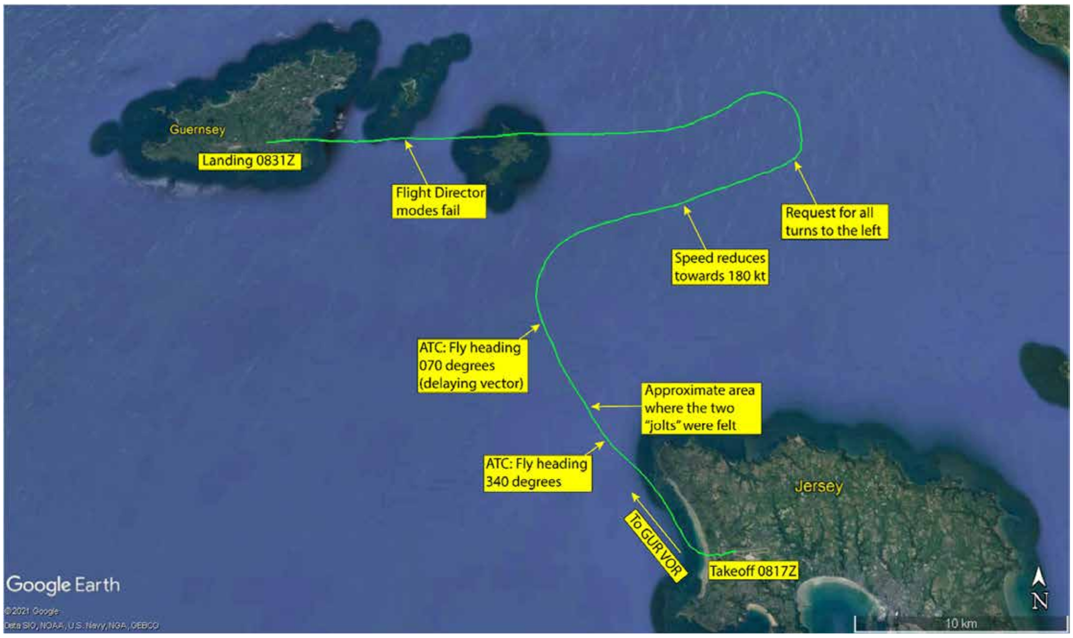

Figure 1

Aircraft's track during the incident flight

The commander transmitted "COULD YOU JUST GIVE US SOME DELAYING VECTORS, JUST FOR A LITTLE BIT, GOT A MINOR ISSUE WE NEED TO SORT OUT" to ATC. They issued a heading of 070°, taking the aircraft through Guernsey's Runway 27 centreline to the north. The crew slowed the aircraft to 180 KIAS which reduced the abnormal control forces.

When the aircraft was flying straight, the commander tried controlling it from his side but experienced the same forces. He subsequently described the aircraft as being "fully controllable but need[ing] a lot of right input". Both crew members agreed that the co-pilot would resume flying the aircraft, enabling the commander to manage the technical issue. The commander recalled that other indications around the flight deck appeared normal, and the flying control trims were indicating neutral positions.

The commander reported a "SLIGHT CONTROL PROBLEM, NOTHING MAJOR, NOTHING SERIOUS" to ATC and, for controllability reasons, requested left turns to establish on the ILS localiser[2]. He prepared the aircraft for a manually-flown ILS using the flight director[3], and advised ATC to expect a normal approach and landing. After operating the aileron trim in an attempt to alleviate the abnormal control forces, the co-pilot commented "I THINK THAT'S BETTER". The commander checked the co-pilot was content to continue as PF and led an approach brief, mentioning the ramifications of abnormal control forces in the event of a go-around.

Footnote

[2] Localiser – the horizontal guidance element of an instrument landing system.
[3] Flight director – a guidance aid presented on the attitude indicator which shows the aircraft attitude required to follow a specified trajectory.

The crew recalled descending out of cloud at around 1,500 ft amsl. After becoming fully established on the ILS, the flight director modes failed and could not be re-selected. The co-pilot continued flying the ILS using raw data[4], with the commander making standard callouts to assist with the flightpath. The aircraft landed at 0831 hrs and taxied to stand normally. The total flight time was 14 minutes.

After the aircraft's engines had been shut down, the co-pilot reported that the flying controls felt normal.

Additional information from the crew

The commander stated that, as a crew, they had spare capacity to perform additional actions. However, he determined that, because aileron control was achievable, it was unnecessary to carry out the *'Aileron control jam'* checklist[5] and, in the absence of any other abnormal indications, no other procedures were relevant. He prioritised making a prompt approach because of overall workload and in case the control difficulties worsened.

The co-pilot recalled that handling the aircraft on final approach "felt ok". She considered that that was because the aircraft was descending in a straight line at a slower airspeed, rather than because the fault had disappeared.

Meteorological information

Guernsey's weather report at 0820 hrs gave a wind of 9 kt from 200°, visibility 10 km or more, broken cloud at 900 ft agl, showers in the vicinity, temperature 18°C, and QNH 1010 hPa.

Recorded information

SE-MAO was fitted with a magnetic tape Flight Data Recorder (FDR), capable of recording 25 hours of flight data, and a solid-state Cockpit Voice Recorder (CVR) of 2 hours duration. Both units were successfully downloaded at the AAIB and covered the whole event. The recording on the tape-based FDR was of a good quality.

Geographic position was not recorded by the FDR but was obtained from radar recordings, an annotated version of this data is shown in Figure 1.

Figure 2 shows the incident flight, produced from the FDR data, with salient points included from the CVR.

Note that the aileron positions, as recorded by the FDR which uses a transducer mounted in each wing, are relative angular measurements and the calibration necessary to show the absolute position of each aileron has not been applied. Also, the FDR only records attitude signals from Attitude Heading and Reference Unit (AHRU) No 1.

Footnote

[4] Raw data – using the basic flight instruments.

[5] From the ATP *'Emergency & abnormal checklist'*, it involves pulling the aileron disconnect handle to isolate a jam present on either the commander or co-pilot's side of the system.

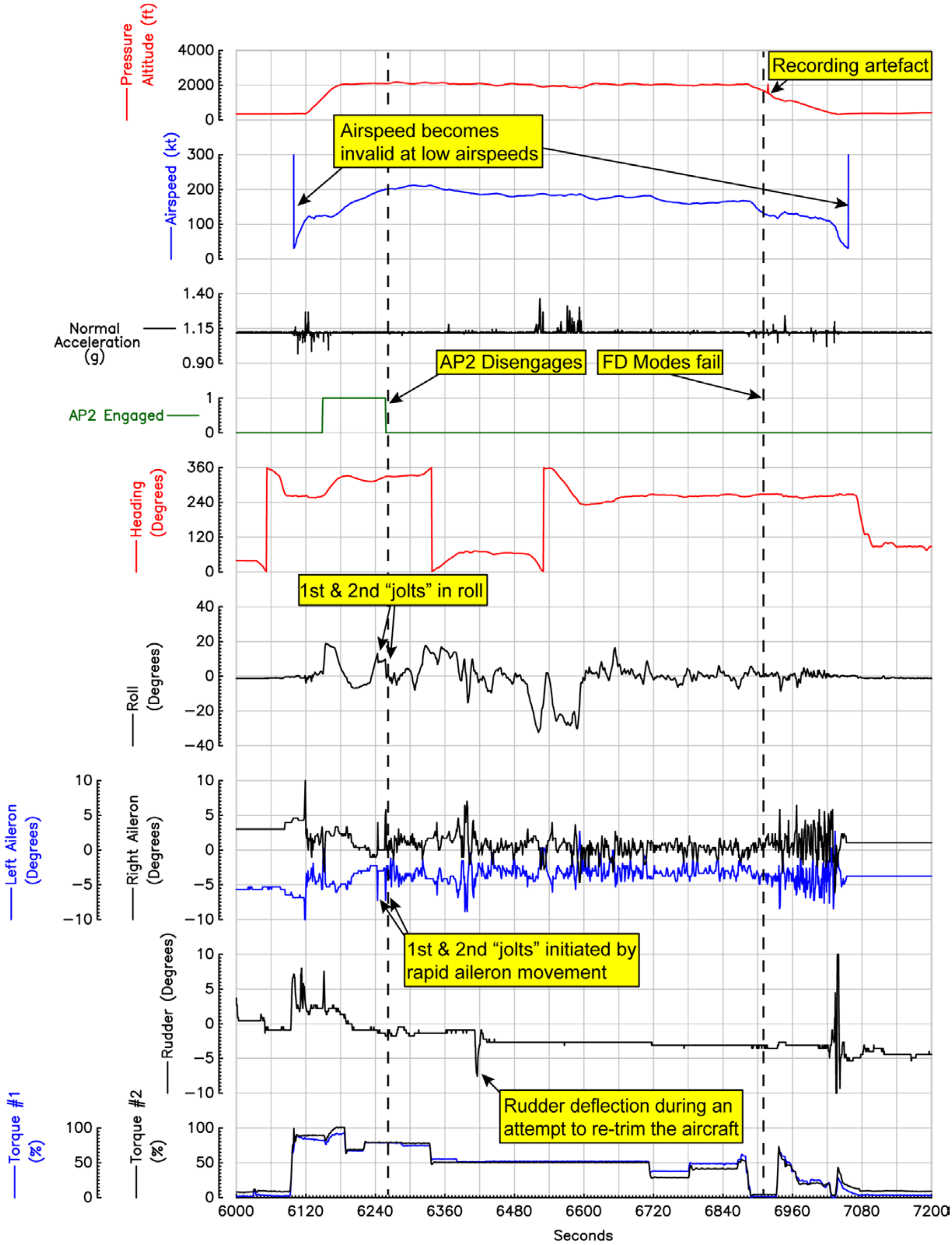

Figure 2

Salient recorded parameters

The recorded data (Figure 2) shows that the aircraft, at approximately 2,000 ft, and 200 KIAS in a right turn passing through a heading of 330°, rolled 5° sharply to the left. Shortly afterwards, the aircraft again rolled sharply to the left, this time by 10°. At that time, the No 2 autopilot, which was engaged, automatically disconnected and a continuous calvary charge was recorded on the CVR. Each sharp roll to the left was preceded by the rapid movement of both ailerons in the correct sense to initiate the observed roll. No fluctuations were observed in the normal acceleration values recorded by the FDR to indicate that the aircraft was experiencing any notable turbulence.

Aircraft information

General

The British Aerospace[6] ATP was derived from the Hawker Siddeley 748. The aircraft is a low-wing turboprop with a conventional tail configuration and two Pratt and Whitney PW126 engines, driving six-bladed variable-pitch propellers. ATPs were manufactured in a passenger configuration and some aircraft were subsequently modified to carry cargo.

SE-MAO

SE-MAO was manufactured in 1989 and had accrued 28,164 cycles and approximately 28,650 flying hours. It was originally configured for passenger transport but started cargo operations in 2007.

According to the operator, the last report of an in-flight fault with the autopilot was raised in June 2019 and this was successfully rectified after troubleshooting.

System descriptions

Autopilot

Automatic flight control is provided by two independent autopilots, only one of which can be engaged at any time. Each autopilot is a two-axis system (pitch and roll) with a yaw damper, and controls the aircraft using electrically-actuated servomotors (servos). A flight (autopilot) controller allows control of the autopilot functions and the selection of system 1 or 2. A simplified schematic of the autopilot interfaces that are discussed in this report is at Figure 3.

There are two autopilot computers that provide the necessary processing and outputs for the autopilot, flight directors and Standby Control System (SCS). The No 1 computer is installed in the forward avionics bay[7] and the No 2 computer is installed in the aft avionics bay. Both bays are beneath the cabin floor and are enclosed, with a hinged panel on the front to allow access to the equipment inside. Cooling air is provided by means of a plenum arrangement and the cooling air is sourced from the passenger (or cargo) cabin.

Footnote

6 BAE Systems (Operations) Ltd is the design Type Certificate holder.
7 The aircraft manuals refer to avionics crates as opposed to bays.

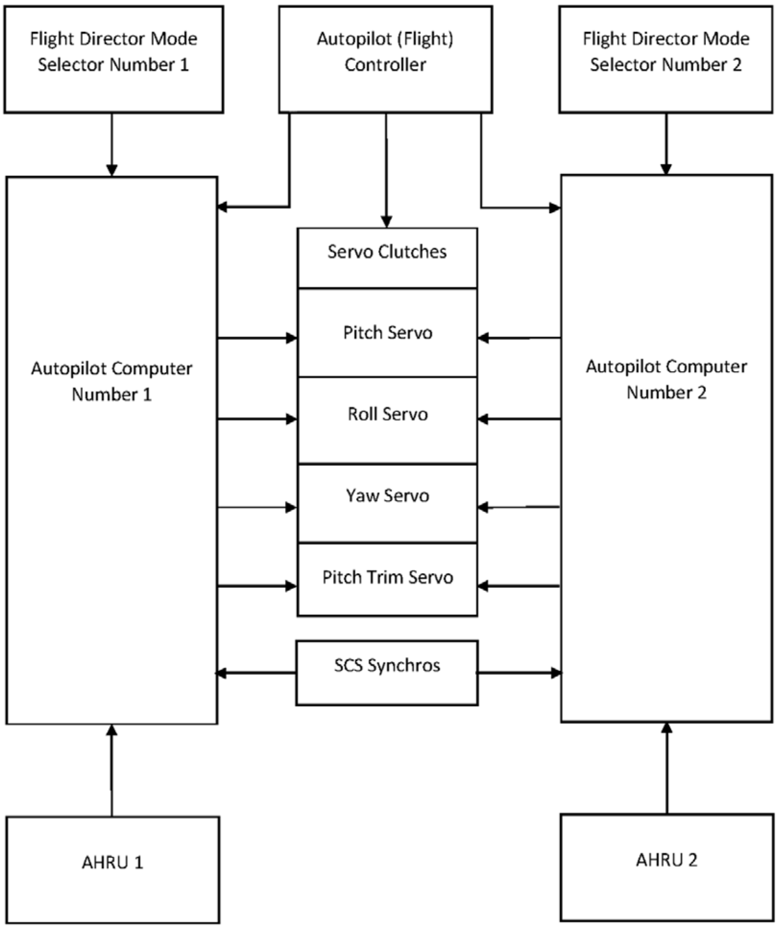

Figure 3

Simplified schematic of the autopilot interfaces

The electrically-actuated servo in each of the elevator, aileron and rudder controls converts the outputs from the autopilot computer into control surface movements. Each servo has a common gearbox driven by two independent motors, one for each autopilot system. An electromagnetic clutch fitted to each servo is energised when the autopilot is engaged. The clutches can be overcome if the autopilot fails to disengage.

When the autopilot is engaged, roll and pitch out-of-trim indicators in the cockpit deflect proportionally to the respective servo load current. If the current exceeds a pre-determined threshold for greater than 2 seconds in pitch or 12 seconds in roll, an amber TRIM light, which is adjacent to the out-of-trim indicators, illuminates (Figure 4). This provides a visible indication to the crew if the aircraft is significantly out-of-trim whilst the autopilot is engaged. When the autopilot is not engaged, electrical power is removed from the servos, so the out-of-trim indicators will remain neutral.

Figure 4

TRIM light and associated pitch and roll out-of-trim indicators (highlighted in the orange box)

Autopilot disengagement

The autopilot can be manually disengaged by pressing the red autopilot disengage switch on either of the pilots' control wheels. This results in a one-second audible 'cavalry charge' warning.

The autopilot will automatically disengage if certain failures are detected, or pre-defined aircraft limits are exceeded. The automatic disengagement criteria include:

- Autopilot computer failure
- Attitude, heading or rate gyro signal invalid
- Servo short circuit
- Pitch attitude exceeds +/- 25°
- Servo clutch insulation breakdown
- ARINC[8] update failure
- Safety circuit operation

The autopilot safety circuit monitors the roll angle and normal acceleration. Automatic disengagement will occur if the roll angle from the active AHRU exceeds 35°, or the difference between the two AHRU roll outputs exceeds 5°. Disengagement will also occur if the normal acceleration is less than 0.4g or greater than 1.6g.

Footnote

8 ARINC refers to the data transfer standard used on the avionics data bus.

Automatic disengagement results in a continuous audible 'cavalry charge' warning, which can be cancelled by pressing either of the autopilot disengage switches.

Primary flying controls

The primary flying controls are operated directly from the control columns through a system of cables, rods and levers. Within the aileron (roll control) system the control wheels on the control columns are connected to each other by chains, sprockets and cable pulleys. The pulleys are connected by a continuous cable loop to quadrants under the left side of the flight deck floor and, from there, the cables are routed down the left side of the fuselage to a tension regulator / quadrant assembly and out to each aileron.

A synchro transmitter is mounted adjacent to each aileron. The right synchro provides a signal corresponding to the position of the right aileron to the SCS and the FDR, whereas the left synchro only provides a signal corresponding to the position of the left aileron to the FDR.

Both ailerons have a balance tab and the right aileron has a trim tab that is manually operated by the pilot using a trim wheel.

Aileron disconnection

The left control wheel is connected directly to its drive shaft and sprocket. The right control wheel comprises an automatic Aileron Control Disconnect Mechanism (ACDM), drive shaft and sprocket. The ACDM consists of a spring housing, 'C' spring and a synchro position transmitter. By applying sufficient force, it is possible for the right control wheel to rotate about its drive shaft, against the 'C' spring, and move independently of the left control wheel.

In the event of a restriction in the aileron primary controls, partial control can be retained by operation of the aileron disconnect unit, which isolates the left and right side of the aileron controls. The release unit is manually activated by pulling the aileron disconnect handle located on the centre console. This operates an electrical switch that energises a solenoid in the aileron release unit. The system cannot be reset in the air. Operation of the aileron disconnect handle also energises the synchro in the right control wheel, and movement of the control wheel against the 'C' spring sends continuous signals corresponding to the control wheel angle to the SCS. A force of 1.5 lb per degree of aileron movement is required to operate the aileron and movement of the control wheel is limited to 30 lbf, which equates to 20° of aileron movement. When operating in this mode, the position of the control wheel is not an indication of the displacement of the aileron.

Standby Control System (SCS)

The SCS is an emergency system that provides a means of operating the flying controls via the autopilot servos if the primary mechanical flying control circuits are jammed or severed. The SCS logic is controlled by a circuit board in the autopilot computer, so there are two independent systems. It is armed when electrical power is applied to the autopilot circuits, but it is inhibited whilst the autopilot is engaged.

Each SCS has independent channels to control the ailerons, elevator and the rudder. Each channel has a position input sensor (synchro) at the pilot's controls, which is continuously compared with a position feedback sensor (synchro) at the control surface. If the difference between the sensors exceeds a threshold value, and the autopilot is not engaged, the SCS will operate and the relevant servo will be driven to follow the pilot's control demands.

The SCS logic in the selected autopilot system continuously monitors the control inputs and feedback sensors. If the SCS operates, an ENGAGED light that corresponds to the active channel illuminates on the cockpit overhead panel. In addition, the amber STANDBY CONTROLS light illuminates on the central warning panel, the amber 'attention getters'[9] will flash, and an audible warning horn will sound.

Attitude Heading and Reference System (AHRS)

The AHRS provides aircraft attitude information using two independent AHRUs. When the autopilot is engaged, attitude information is sourced from the respective AHRU, which is installed alongside the autopilot computer in the avionics bay.

Aircraft examination

Initial examination and system testing was carried out under the supervision of the AAIB. There was no evidence of anything untoward when the aircraft was checked externally and, with electrical power switched off, the control wheels were free to operate throughout their entire range of movement without any restrictions. The ailerons, balance tabs, and aileron trim were all observed to operate normally.

The rear avionics compartment, where the No 2 autopilot is located, was checked and found to be dry. All the equipment in the compartment was found to be secure.

The aileron control system mechanical runs were visually checked and operated throughout their range of movement. No anomalies were identified, and the control cable tensions were confirmed to be correct.

The autopilot, SCS and AHRS were functionally tested and no faults were apparent, although the right aileron synchro required a small adjustment to bring it into the limits defined in the Aircraft Maintenance Manual.

The operator decided to remove the following components as a precautionary measure before the aircraft was returned to flight:

- Aileron servo (serial number 391)
- Autopilot computer No 1 (serial number 311)
- Autopilot computer No 2 (serial number 218)

Footnote

[9] The 'attention getters' are flashing lights on the instrument panel glareshield. They provide a visual stimulus to the crew that they need to check the central warning panel.

- Autopilot controller (serial number 158)
- Accelerometer (serial number 152)

After reviewing the FDR data and the CVR audio recording, AHRU 1 (serial number 1124) and AHRU 2 (serial number 1281) were also removed. In the meantime, the aircraft had been returned to service and flown without further incident.

Equipment testing

Having reviewed the recorded data, and in consultation with the aircraft manufacturer and operator, the AAIB tested the following components as these would have been operational when the incident occurred:

- Aileron servo
- Autopilot computer No 2
- AHRU 2

Aileron servo

The maintenance policy requires autopilot servos to be overhauled every 4,500 flying hours. The aileron servo that was removed from SE-MAO was found to have exceeded this requirement by approximately 180 hours because the component operating hours had been erroneously reset to zero after a previous repair. The operator reviewed their fleet records and concluded this was an isolated occurrence. They amended their processes to ensure that component operating hours are only set to zero if an item is accompanied by a release certificate that states that the item has been overhauled.

The servo was tested and dismantled by the operator under the supervision of the Swedish Accident Investigation Authority; no anomalies were identified that could have caused or contributed to the incident.

Autopilot computer maintenance policy and test capability

There is no requirement for autopilot computers to undergo periodic testing or servicing, and there is no finite equipment life. If required, computers can be tested using an automated test set that is available at one overhaul agency in the UK. The AAIB established that the test set was no longer undergoing periodic calibration and the operator last returned a computer for testing in 2018. There was no way to recertify an autopilot computer as airworthy, so the operator has implemented a maintenance programme where four computers will be returned for testing on an annual basis.

For the purposes of this investigation, the uncalibrated test set was checked using an autopilot computer that was retained by the overhaul agency as a reference (control) unit. This computer was tested with no faults, and the results were compared with those that were previously obtained when the test set calibration was still valid. The results showed minimal change, indicating that the test set would be adequate for basic fault diagnosis.

Autopilot computer No 2

A label on the computer indicated that it was last tested in 2001 when, according to the operator's records, it had been sent for test / repair because of a problem relating to overshooting selected headings. On return to service it was stored for three years before being installed on SE-LGV. In March 2010, it was removed and stored for another six months. It was fitted to SE-MAO in September 2010 and the operator's maintenance history showed that it had been transposed with the No 1 computer several times whilst troubleshooting various autopilot anomalies.

The overhaul agency advised that the automated test is conducted at ambient (room) temperature and, if the test is passed, a computer could be certified as airworthy. The computer from SE-MAO was tested under the supervision of the AAIB and no faults were recorded.

The printed circuit boards (PCBs) were removed and visual examination found localised corrosion, white translucent staining, and an accumulation of detritus on three of them. The affected PCBs were associated with the SCS logic and autopilot servo operation (Figure 5).

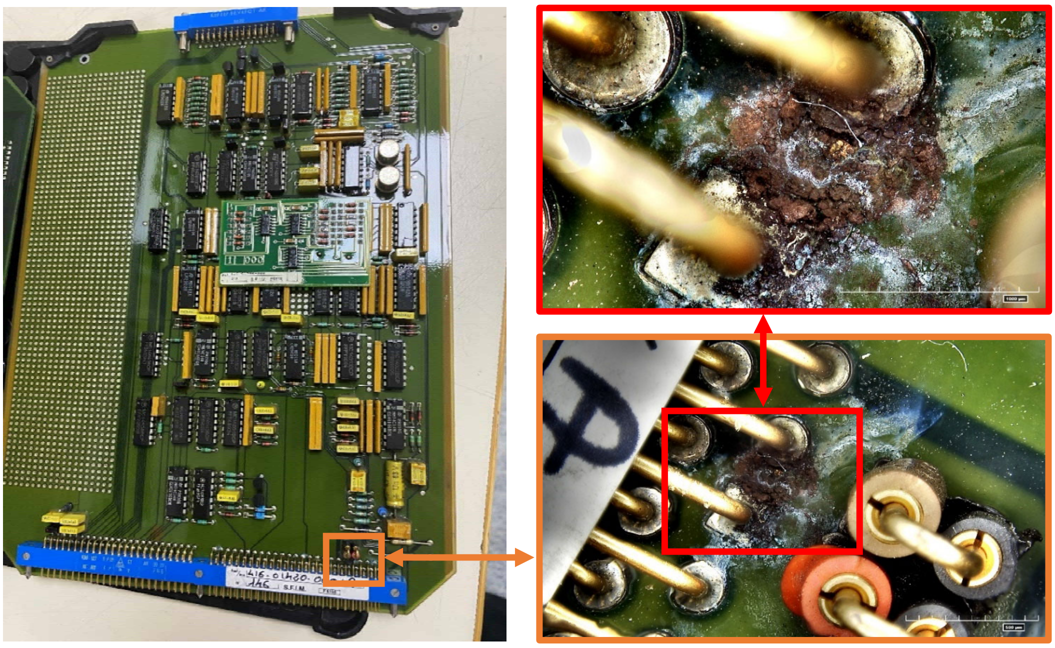

Figure 5

Corrosion, white staining and debris on one of the PCBs

The manufacturer responsible for the autopilot design reviewed photographs of the PCBs and stated that, in their opinion, the corrosion was probably caused by trapped flux, possibly left after a previous repair. They noted an area adjacent to one corrosion site where there was a visible difference in the conformal coating, Figure 6. The repair records from 2001 were no longer available so the detail of the work carried out is unknown.

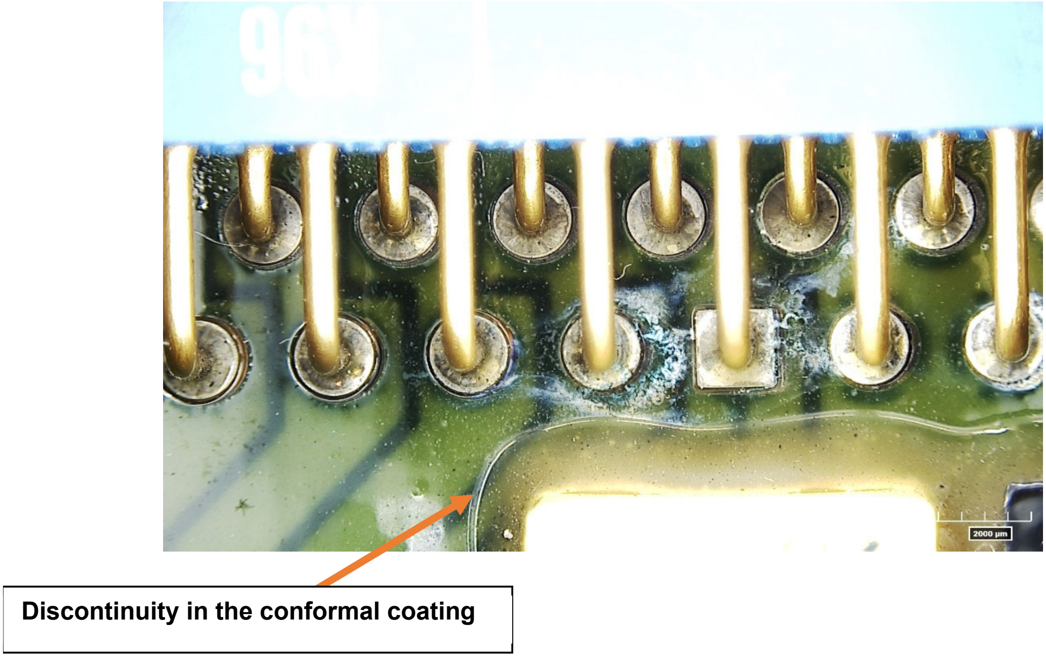

Figure 6
Discontinuity in the conformal coating

There was no requirement to check the internal condition of a computer returned for test or repair, so, under the normal test regime, the computer from SE-MAO would have been recertified as airworthy because it passed the requirements of the automated test.

Autopilot computer 1

The No 1 autopilot computer from SE-MAO was examined and there was no visible evidence of corrosion or debris on the PCBs.

AHRU

The No 2 AHRU was tested by an approved agency in the USA under the supervision of the National Transportation Safety Board (NTSB). The roll output was found to be slightly out of calibration (less than 0.2°), but this would not have caused or contributed to the incident with SE-MAO. The unit was disassembled and there was no evidence of Foreign Object Debris, visible corrosion or debris on the PCBs.

Type Certificate holder's assessment

The Type Certificate holder reviewed the flight data, test results, and the discovery of corrosion in the autopilot computer. They convened an internal design review, which concluded that the Type Design was satisfactory and continues to meet the required safety objectives. Consequently, no fleet action was deemed necessary.

Analysis

Initial "jolts" and autopilot disengagement

The FDR data showed that the two unexpected left rolls occurred whilst the No 2 autopilot was engaged. Both rolls were preceded by the ailerons deflecting and the aircraft manufacturer determined that the rate of aileron deflection matched the performance capability of the aileron servo. When the second roll occurred, the autopilot disengaged with an audible continuous cavalry charge. This indicates that the autopilot logic detected a condition that met the requirements for the autopilot to disengage automatically. It was not possible to determine the reason for the automatic disengagement because no faults were identified during the investigation and the autopilot computer does not record a 'fault log'.

Increased force when turning the control wheel to the right

The crew reported that it was harder to turn the control wheels to the right than to the left after the autopilot disengaged. They perceived that this force decreased as the aircraft slowed down, which might indicate an aerodynamic influence, but no anomalies were found in the aileron control system and the ailerons, balance tabs, and trim worked normally.

The flight data showed that the autopilot disengaged when the continuous 'cavalry charge' started, so the aileron servo clutch should have de-energised at that point. If the clutch failed to de-energise, the aileron servo would have remained connected to the control system, but any increased resistance caused by this should have been apparent in both directions of control wheel movement. The crew reported that the aileron out-of-trim indicator remained neutral after the autopilot disengaged, indicating that electrical power had probably been removed from the autopilot servo as designed.

When the servo was tested and dismantled, there was no evidence of any fault that could have caused or contributed to the incident, and the reason for the increased force to turn the control wheel could not be established.

Loss of the flight director

Flight director status and autopilot modes are not recorded on the FDR. No anomalies were identified during functional testing after the incident and the No 2 autopilot computer passed the automated test in accordance with the recertification requirements. The reason for the loss of the flight director modes during the approach to land at Guernsey could not be established. The operator reported that there have '*not been any significant autopilot issues*' since the aircraft was returned into service after the incident.

No 2 autopilot computer and corrosion

The No 2 autopilot computer was active when the incident occurred and would have been responsible for automatic flight control, the SCS, and the flight director functions. The computer passed the requirements of the recertification test which was conducted at ambient temperature.

When the PCBs were removed there was evidence of localised corrosion on the boards that control the autopilot servo and SCS logic. The overhaul agency and aircraft manufacturer advised that corrosion was not a known issue, and the manufacturer responsible for the design advised that it was probably caused by residual flux under the conformal coating, possibly from a previous repair. There is no requirement to check the internal condition of a computer that passes the automated test, so under the normal maintenance regime, the computer from SE-MAO would have been categorised as no fault found and recertified as airworthy.

Whilst the corrosion in the computer was worthy of note, there was no evidence to link it to this serious incident. The Type Certificate holder concluded that, with respect to the autopilot computer, the existing maintenance programme was appropriate to maintain continued airworthiness of the ATP fleet.

Crew workload management

The abnormal control forces experienced by the crew were significant and there was no checklist directly applicable. Therefore, the commander prioritised a prompt approach and landing, but did not declare an emergency to ATC.

The commander managed the increased workload effectively by providing support to the co-pilot as she flew the aircraft, whilst he led the decision making and communications. He described them having some "spare capacity", and the co-pilot reported the abnormal control forces improving as the aircraft slowed down. However, had the failure occurred in different circumstances, for example, at a higher airspeed, in less favourable weather conditions, and/or further away from a suitable landing airport, or had a go-around been required, then the resulting workload could have been considerably higher.

Conclusion

As the aircraft levelled-off at 2,000 ft and 200 KIAS, there were two uncommanded left rolls and the autopilot automatically disengaged. The crew found it harder to turn the control wheels to the right, but they maintained control of the aircraft and, although the flight director failed during the approach, they made an uneventful landing in Guernsey.

Extensive testing on the aircraft did not identify the cause, but the operator replaced several components as a precautionary measure. Subsequent component testing found no anomalies that could be definitively associated with the incident, although it did identify issues relating to equipment maintenance and testing. The operator has addressed these through appropriate safety action, and they reported that there been no recurrences since the aircraft returned to service.

Safety action

Since this event, the following safety action has been taken:

> The operator has amended their processes to ensure that component operating hours are only set to zero if an item is accompanied by a release certificate that states that the item has been overhauled.
>
> The operator has implemented a maintenance contract for its autopilot computers.

Published: 19 April 2021.

SERIOUS INCIDENT

Aircraft Type and Registration:	Boeing 787-9, G-ZBKF
No & Type of Engines:	2 Rolls-Royce Trent 1000-J2 turbofan engines
Year of Manufacture:	2016 (Serial no: 38622)
Date & Time (UTC):	1 October 2020 at 0800 hrs
Location:	En route to London Heathrow Airport
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 10 Passengers - 53
Injuries:	Crew - None Passengers - None
Nature of Damage:	No aircraft damage
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	49 years
Commander's Flying Experience:	21,200 hours (of which 2,092 were on type) Last 90 days - 111 hours Last 28 days - 35 hours
Information Source:	AAIB Field Investigation

Synopsis

The aircraft was approaching the top of descent when the cabin crew saw smoke emanating from a passenger seat. It was discovered that a mobile phone had fallen down the side of the seat and had been crushed in the seat mechanism. The cabin crew extinguished the fire and the aircraft continued to its destination. There was no damage to the aircraft.

There have been several reports of similar events occurring leading to smoke in the cabin. There are currently no seat design requirements to prevent electronic devices from becoming trapped in seats. Manufacturers and regulators are aware of this issue but it has proven challenging to find a workable solution. The EASA and the SAE International Seat Committee have taken safety action to develop new design standards and recommended practices. A Safety Recommendation is made to the CAA to improve seat design regulations.

History of the flight

The aircraft was flying from Miami International Airport, USA to London Heathrow Airport. Approximately 40 minutes before landing the flight crew made an announcement that woke a passenger. The passenger moved her seat from the flat-bed position to a more upright position then left her seat to use the washroom. One of the cabin crew asked the passenger if she could stow the bedding whilst the passenger was away from her seat. As she removed the bedding, she smelt a strong odour and noticed a charging cable which was plugged in to the seat socket with the other end down the side of the seat. The smell, which she described as “sulphur”, was getting stronger so she attracted the attention of the Senior Cabin Crew Member (SCCM). At this point they heard a “hissing” sound and a large plume of grey smoke emitted from the seat in a “tornado” motion. They remembered seeing an orange glow in the seat area amongst the smoke.

The crew member retrieved a BCF[1] fire extinguisher and fire gloves for the SCCM and asked a third crew member to switch the seat power off. The SCCM pulled back the seat padding exposing a device trapped in the seat mechanism. She discharged several bursts of BCF into the device. The crew member then collected a water extinguisher and filled an ice bucket with water. The third crew member contacted the flight crew.

Shortly before receiving the call from the cabin crew the flight crew smelt an acrid odour on the flight deck. The cabin crew informed the commander that thick smoke was emanating from a seat in the forward cabin and that they had initiated their firefighting drill. The flight crew started the SMOKE, FIRE OR FUMES checklist and evaluated their diversion options. The third pilot went back to the cabin to assist.

After the SCCM had discharged the BCF, the smoke quickly dissipated and the crew were able to clearly see a red mobile phone trapped in the seat mechanism. The crew attempted to remove the device but it was jammed. There was very little heat coming from the device. They checked for secondary heat sources but did not find any. The cabin crew updated the commander.

As the source of the smoke had been identified and extinguished and the aircraft was now only 20 minutes from landing at Heathrow the commander decided to continue to Heathrow. He made a PAN call to alert ATC and ensure the fire service met the aircraft on landing. He also made an alert call[2] to the cabin crew and gave a NITS briefing[3]. He then made a further announcement to the passengers. One cabin crew member remained in the vicinity of the seat with an extinguisher to hand for the remainder of the flight. The aircraft landed normally at Heathrow.

After landing the fire service boarded the aircraft and removed the device from the seat (Figure 1). There was no damage to the aircraft.

Footnote

1 Bromochlorodifluoromethane
2 An ‘Alert call’ is a call made to the cabin crew to alert them all to an abnormal situation.
3 NITS is an acronym used for briefing the cabin crew about an abnormal situation, it stands for Nature, Intentions, Time and Special instructions.

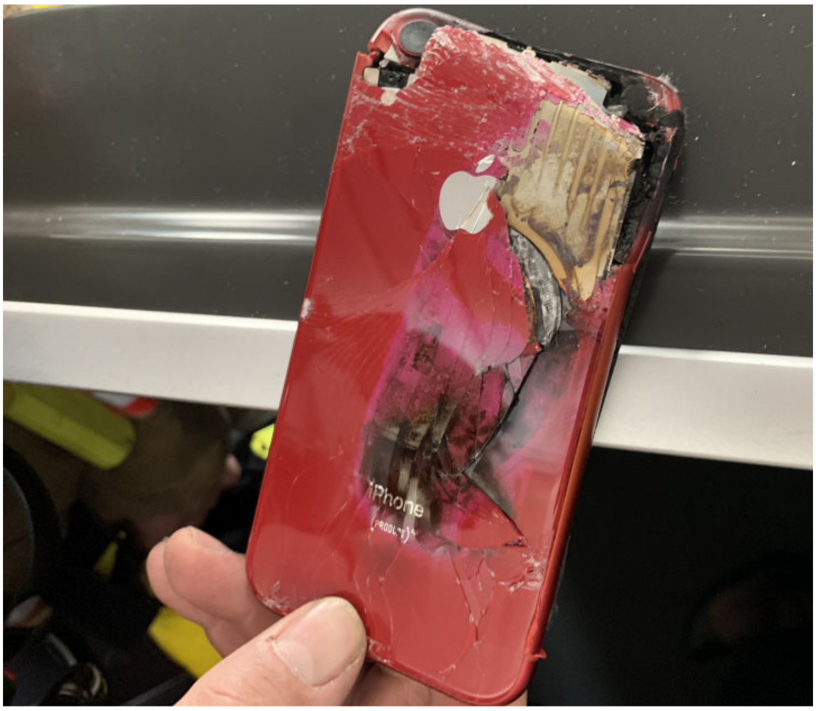

Figure 1
Mobile phone retrieved by the fire service after landing

Operator's procedures

The operator's operations manual contained the following information regarding Portable Electronic Devices (PEDs) and lithium battery hazard:

> *'The potential hazard from these batteries occurs as a result of over-charging or rapid energy release (short circuit). Fumes and gases will be emitted prior to the battery igniting. The resultant over heating of the cells can result in a cell 'thermal runaway'. This is where the cells within the battery ignite in a chain reaction.*

Incidents have occurred as a result of:

- *Structural deformation caused by crushed, physically or electrically abused lithium batteries; in extreme cases PEDs have been known to ignite. Damage could be caused by seat mechanisms crushing misplaced PEDs.*
- *Overheating lithium batteries due to overcharging.*

> *CAUTION: A lithium battery has a higher likelihood of catching fire during or following charging.'*

The manual specifies that passengers may use PEDs throughout the flight but that:

> *'When not being used PEDs must be switched off and disconnected from the seat power.*

PEDs must not be charged while sleeping.

Cabin crew are not required to check that all devices are switched-off or in 'flight safe' mode, however they are expected to inform passengers of the appropriate requirements.'

The following PAs are made to inform passengers about the use of PEDs:

Prior to departure – 'DURING THE FLIGHT, ALL ELECTRONIC DEVICES MUST BE DISCONNECTED FROM THE SEAT POWER WHEN NOT IN USE.'

During the safety demonstration – 'TAKE CARE YOUR DEVICE DOES NOT GET LOST WITHIN YOUR SEAT. IF IT DOES PLEASE DON'T MOVE IT BUT LET ONE OF YOUR CABIN CREW KNOW. DEVICES MUST BE SWITCHED OFF AND DISCONNECTED FROM THE SEAT POWER SOCKET WHEN NOT BEING USED IN FLIGHT.'

During the initial climb and again 40 minutes before landing - 'IF YOU ARE SEATED IN OUR FIRST OR CLUB WORLD CABIN, PLEASE TAKE CARE THAT YOUR PERSONAL ELECTRONIC DEVICE DOES NOT OBSTRUCT THE ADJUSTMENT OF YOUR SEAT. IF IT DOES GET LOST WITHIN YOUR SEAT, PLEASE DO NOT MOVE THE SEAT AND LET ONE OF US KNOW.'

The manual contains the following instructions for lost PEDs:

'Report all PEDs lost in seat mechanisms in the AML. This ensures engineering will remove the item prior to the next flight. Clarify with the passenger: Identity of the item, Exact location where item may have dropped or slipped, Has the seat been moved since misplacing the item

CAUTION: Electrically operated seats with trapped PEDs should NEVER be moved electrically or manually.'

In addition to the operator's standard firefighting procedure the manual contains the following advice relating to PEDs fires:

'Use a BCF extinguisher to extinguish and prevent flames spreading to additional flammable materials.

Take a suitable container or empty metal toilet bin to the location. Don fire gloves. When considered safe to do so place the device inside the container and immerse the PED in water or other non-flammable liquid.'

CAUTION: Water should not be used on, or in the immediate vicinity of, any other piece of electrical equipment.'

Operator's investigation

The operator considered that the incident had been managed appropriately by the crew. However, it identified the following aspects which it will review to determine if any change is required to its procedures or training:

- The SCCM becoming directly involved in fighting the fire instead of allowing the crewmember that found the fire to fight the fire.

- The crewmember did not dowse the device with water because they believed this would damage the seat electrics or impact on the spill hazard zone.

Operator's seat design

The seat type involved was designed approximately ten years ago. They were designed to limit the chance of a PED becoming trapped, but it was found to be challenging to remove the risk completely. Additionally, since they were designed, PEDs have become smaller, batteries have become more powerful and the number of devices passengers carry has increased. Since they were first designed the operator has made further improvements to the seat to further reduce the likelihood of devices becoming trapped in the mechanism.

EASA safety information bulletin

In December 2015 the EASA published a safety information bulletin[4] regarding passenger awareness of the risks of lithium batteries. It recommends that:

> *'Aircraft and aerodrome operators make passengers aware of the risks caused by PED as a result of the battery being potentially short-circuited or damaged if caught in the movable part of seats, and that they should call a staff member when such situation occurs and/or whenever any abnormal situation is suspected, either on board the aircraft, or at the aerodrome.'*

Other events

The CAA reviewed its Mandatory Occurrence Report database and found 166 previous reports of PED's becoming trapped in passenger seats in the last five years. Of these events 42 resulted in a fire or smoke in the cabin.

Boeing reviewed its safety reporting database and, among the reports of PED failures, was able to confirm three specific events where PEDs were trapped in a seat. Much of what had been reported did not detail trapping within a seat or was vague in the event description but, in these three instances, the events were managed with existing crew procedures.

Footnote

[4] Available at https://ad.easa.europa.eu/ad/2015-28 (accessed 15 December 2020)

Seat design requirements

Neither the CAA, the EASA nor the FAA currently require seats to be designed to prevent PEDs from becoming trapped or crushed. The EASA reported that this is a known issue and seat manufacturers have tried to design seats to minimise the risk. However, it has been challenging to design moving seats that eliminates the chance that a device can fall into its mechanism.

Following this investigation, the EASA requested the SAE International[5] Seat Committee to develop design standards and/or recommended practices to address the issue. It reported that the committee intends to update the Aircraft Seat Design Guidance and Clarifications document (SAE ARP 5526) and incorporate this in the initial release of the Performance Standard for Seat Furnishings in Transport Aircraft document (SAE AS6960). The publication of these documents is planned for late 2021.

Analysis

A passenger's mobile phone became trapped in the seat mechanism and was crushed when the seat was adjusted. This damaged the battery, generating flames, smoke and fumes. The cabin crew were able to extinguish the fire using their existing procedures.

The operator makes announcements to passengers on all flights with electrically powered seats to try to prevent PEDs becoming lost in seats, as recommended by the EASA. They have also tried to design the seats to limit the chance of PEDs being crushed in the mechanism. However, these events continue to occur. The CAA has received 166 reports of PEDs lost in passenger seats in the last five years. A quarter of these events resulted in fire or smoke in the cabin, demonstrating that this is a significant hazard to the safety of the aircraft.

There are currently no CAA or EASA requirements to design seats to prevent damage to PEDs which become accidentally trapped, despite this being a known issue. The SAE international seat committee is taking safety action to develop design standards and/or recommended practices to address the issue. The AAIB makes the following Safety Recommendation to ensure these design standards and/or recommended practices are developed and adopted:

Safety Recommendation 2021-017:

It is recommended that the Civil Aviation Authority require that passenger seats in commercial air transport aircraft are designed to minimise the chance of portable electronic devices becoming crushed in mechanisms.

Footnote

5 SAE International is a global association of engineers and related technical experts in the aerospace, automotive and commercial-vehicle industries. One of their purposes is the development of voluntary consensus standards.

Safety Action

The EASA has requested that the SAE International Seat Committee develop design standards and/or recommended practices for the design of seats on commercial air transport aircraft to minimise the chance of portable electronic devices becoming crushed in mechanisms

Published: 19 April 2021.

SERIOUS INCIDENT

Aircraft Type and Registration:	Cessna C208B Super Cargomaster, N967FE
No & Type of Engines:	1 Pratt & Witney PT6A-114A turboprop engine
Year of Manufacture:	1988
Date & Time (UTC):	23 September 2020 at 1716 hrs
Location:	Terrance B Lettsome International Airport, Tortola, British Virgin Islands
Type of Flight:	Commercial Air Transport (Cargo)
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to both main wheels and to the right landing gear leg fairing and baggage pod
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	55 years
Commander's Flying Experience:	1,878 hours (of which 174 were on type) Last 90 days - 143 hours Last 28 days - 44 hours
Information Source:	AAIB Field Investigation

Synopsis

The pilot was operating a cargo flight from San Juan, Puerto Rico to Tortola, British Virgin Islands. He discontinued the first approach due to poor weather. Following the second approach the aircraft made a hard landing that was 795 m beyond the threshold of the 1,206 m runway. During the landing roll the aircraft veered off the runway damaging the wheels, landing gear and baggage pod.

Data from the aircraft showed that the approach did not meet the operator's stable approach criteria. It also showed that the engine was running below the normal flight idle speed during the last few moments of the flight. Examination and testing found no evidence of anomalies with the engine. It was not possible to determine why the engine was operating below the normal idle speed whilst in flight.

It is likely that the pilot was experiencing high workload due to the unstable approach and poor weather and this may have limited his ability to deal with the situation. The operator intends to update its operations manual to state explicitly the altitude by which stable approach criteria must be achieved for all types of approach.

History of the flight

The pilot was operating a cargo flight from San Juan International Airport in Puerto Rico to Terrance B. Lettsome International Airport on Beef Island (Beef Island Airport) in the British Virgin Islands. He was scheduled to fly back later the same day. This was his only duty on the day and he reported that he was well rested. He checked the weather prior to the flights and believed the weather was good enough to make a visual approach at Beef Island.

The aircraft took off from San Juan at 1619 hrs (1219 hrs local time) and routed to the north-east climbing to 7,000 ft. Figure 1 shows the route flown.

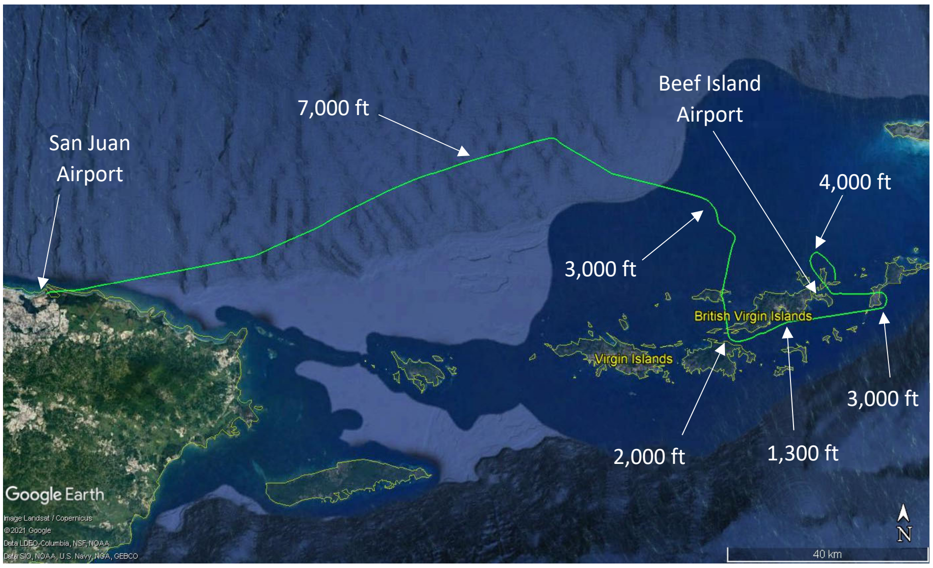

Figure 1

Route flown from San Juan to Tortola Airport

(Note: the aircraft's final position is north-east of the airport as the aircraft could not be tracked at low altitude)

At 1642 hrs the pilot started a descent and flew towards the western edge of Tortola. He contacted Beef Island Air Traffic Control and reported he was making a visual approach to Runway 25. ATC advised that the surface wind was from 180° at 12 kt and there were "SOME SHOWERS APPROACHING THE FIELD FROM THE SOUTH-SOUTHWEST AND LIGHT RAIN AT THE FIELD". The pilot initially reported that he would join "RIGHT DOWNWIND" which led ATC to believe the aircraft was approaching from the north and would be clear of the weather. At 1659 hrs the pilot advised ATC he was "TEN MILES FROM THE NORTH", but the aircraft was actually 10 nm west-southwest of the airport. When the aircraft was 5 nm to the south-west of the airport the pilot reported he was unable to see the airport and that he was going to divert back to San Juan. He requested a heading from ATC, but they were unable to give one as they do not have radar. They instructed the pilot to climb to 3,000 ft and contact San Juan ATC.

The pilot contacted San Juan ATC and was instructed to route directly to San Juan on passing 3,000 ft. Once routing to the north-west the pilot saw dark cumulus cloud ahead so asked ATC for a right turn to avoid the weather. This routing took the aircraft overhead Beef Island Airport. As the aircraft passed over the airport at approximately 5,000 ft the pilot saw the runway and decided he could now attempt a visual approach. He informed ATC and was cleared for a visual approach to Runway 25.

The aircraft descended on a wide right base for Runway 25. The pilot described that as he turned onto the final approach, he could see there was a shower ahead, but he believed it was only light rain. However, as he entered the shower, he lost visual contact with the runway and elected to go-around. He stated that he applied full power and pitched up, but the aircraft did not climb. He was aware there were buildings on his left and hills on his right so he tried to climb straight ahead but the aircraft would not climb. The pilot described that "it felt like strong windshear" and he was unable to prevent the aircraft descending.

Two witnesses saw the aircraft approaching the airport, they described that when they first noticed the aircraft it was at approximately 200 ft but it was too high and travelling too fast to attempt a landing. They described seeing the aircraft continue at this height along the length of the runway and that as it passed Taxiway D it was "swaying side to side" before "the nose turned down" and it started to descend.

Both air traffic controllers recalled seeing the aircraft approaching the airport and then flying along the runway before making a sudden descent.

The aircraft landed on the centreline 795 m past the threshold (total landing distance available - 1,206 m). The right tyre burst on landing and the under-fuselage baggage pod contacted the runway. The aircraft travelled along the runway but as the speed reduced the pilot was unable to keep it on the centreline. The aircraft veered to the right onto the grass, coming to rest approximately 18 m to the north of the runway.

The pilot was not injured and was able to exit the aircraft normally.

Figure 2

N967FE after the incident

Figure 3
N967FE after the incident

Accident site

Figure 2 and 3 show the aircraft after the incident. Figure 4 shows the damage to the right wheel assembly and the aft fuselage. Figure 5 shows the location of the initial touchdown and the marks left on the runway.

Figure 4
Damage to right wheel assembly and under-fuselage baggage pod

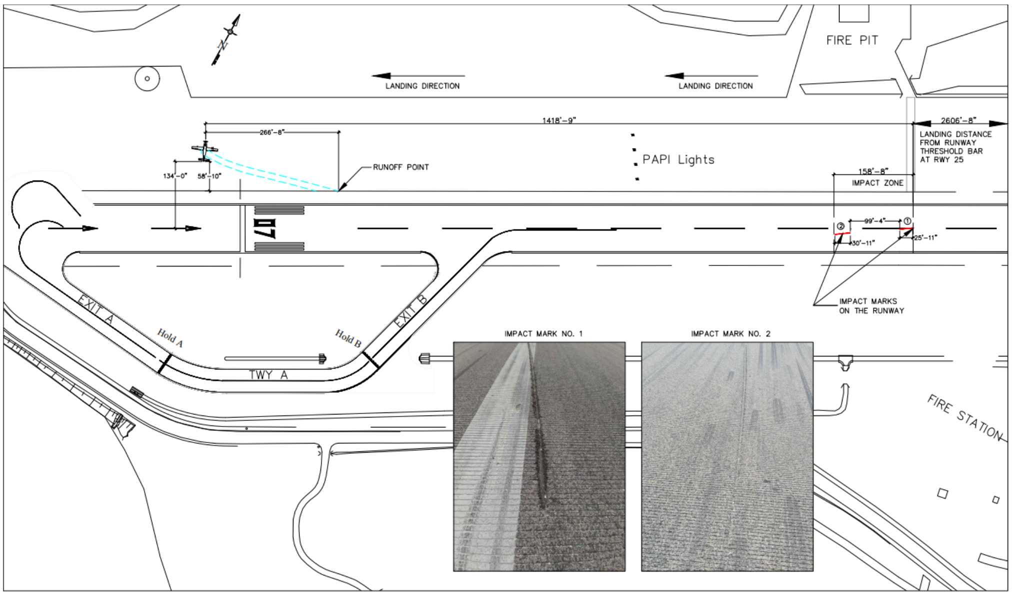

Figure 5

Aerodrome map showing initial impact marks and final position

Recorded information

Data recorders

N967FE was not fitted with a Flight Data Recorder or a Cockpit Voice Recorder, nor were these required to be fitted to this aircraft. However, the engine was fitted with a data recorder manufactured by the engine's manufacturer Pratt and Whitney Canada (PWC). This system, called an ADAS+[1] engine monitoring system, recorded several engine performance parameters including gas generator and propeller speed, inter-turbine temperature (ITT), fuel flow, and engine torque. It also recorded altitude, airspeed, whether any bleed air was being extracted from the engine core, setting of the Emergency Power Lever and outside air temperature. The ADAS+ system was installed when the aircraft was manufactured to assist with the diagnosis of engine related issues during the life of the aircraft and to collect engine trend data to allow the ongoing health of the engine to be monitored. The unit was downloaded by PWC as part of this investigation and used to produce the following plots.

Figure 6 shows a selection of the data for the whole of the incident flight, including the engine start and shutdown, that has been annotated to show the cruise, discontinued approach, visual approach and landing portions of the flight. Of note, the idle speed of the engine in the Cessna 208B Super Cargomaster can be selected by the pilot using the Fuel Condition Lever to either LOW IDLE or HIGH IDLE. LOW IDLE is used for ground operations, such as taxiing, whilst HIGH IDLE is used during flight. HIGH IDLE should be selected by the pilot prior to takeoff and LOW IDLE re-selected after landing. The position of the Fuel Condition Lever was not recorded but the data shows that the engine accelerated normally to LOW IDLE after start and that HIGH IDLE was achieved before taxi.

Footnote

[1] The ADAS+ system is an improved version of PWC's original Airborne Data Acquisition System.

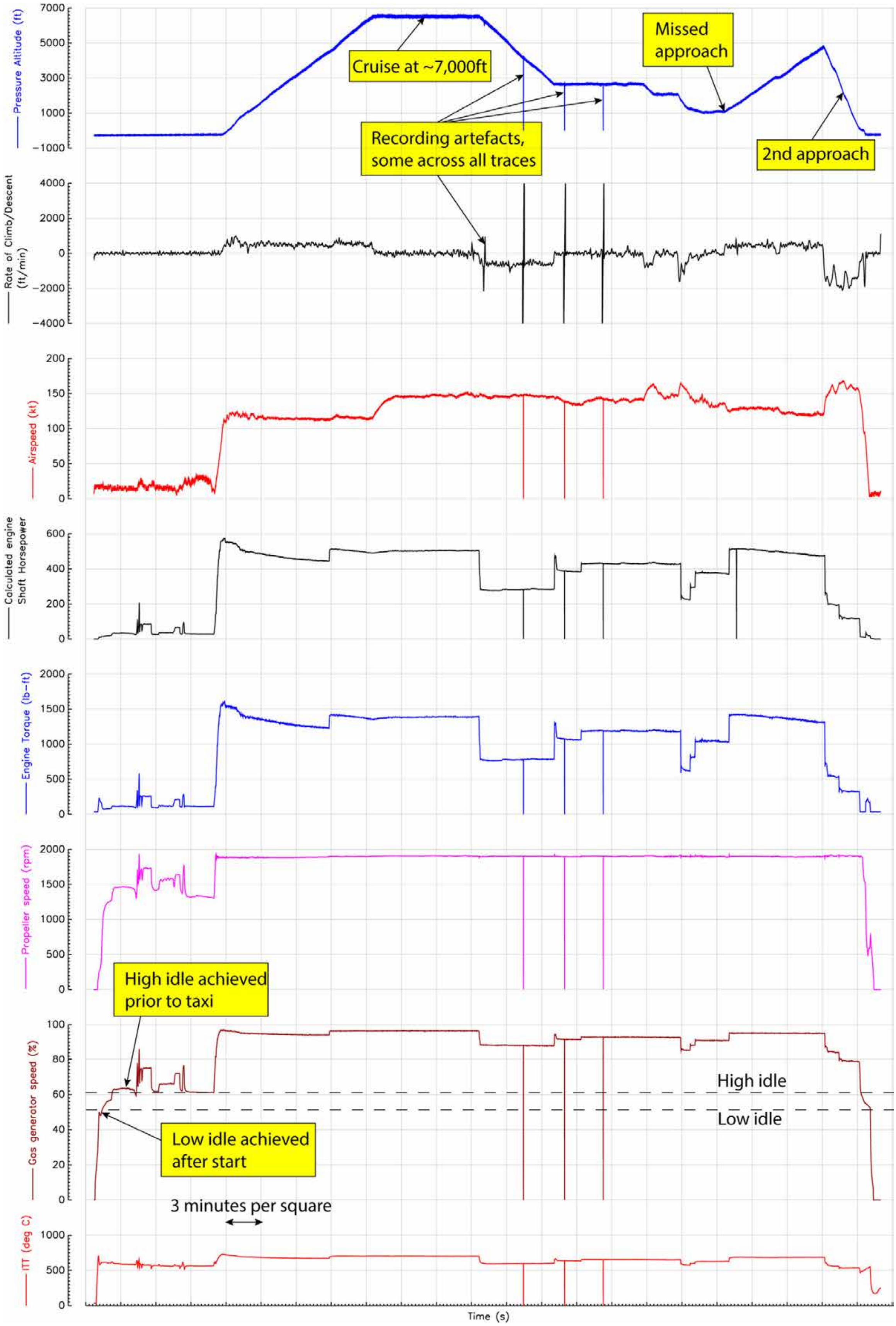

Figure 6

ADAS+ data for the whole of the incident flight

After the discontinued approach, N967FE climbed to approximately 5,000 ft before a second approach was commenced. An expanded view of data for this approach, from 1,000 ft aal, and the subsequent landing at Beef Island Airport is shown in Figure 7. The data shows that N967FE descended at 155 - 160 kt, 15 – 20 kt less than the aircraft's V_{NE} of 175 kt[2], with an average rate of descent of 1,400 ft/min until 350 ft aal. Approximately 30 seconds from landing, the power output from the engine substantially reduced, indicated by a reduction in gas generator speed and engine torque. The airspeed decreased and stabilised at approximately 95 kt and the aircraft flew level at 250 ft aal for a period of 10 seconds. However, the gas generator speed continued to decrease below the HIGH IDLE value expected in flight (62%) and propeller rpm also began to decay. Shortly afterwards, a high rate of descent, approaching 2,000 ft/min, developed as the aircraft passed through 150 ft aal. The gas generator speed, although not fully stabilised, was by this point decreasing towards LOW IDLE.

The position of the Emergency Power Lever, which would have allowed the pilot to directly modulate the fuel flow to the engine if deceleration of the engine was caused by a fuel control unit (FCU) malfunction, was recorded. This data shows that the Emergency Power Lever was not used to restore engine power.

The data also shows that on final approach there were no significant short-term changes in airspeed to indicate windshear.

Flightradar24 data

N967FE's flightpath was tracked by Flightradar24, a commercial flight tracking website. Figure 1 shows the aircraft's route from San Juan to Beef Island Airport.

Closed-circuit television (CCTV)

CCTV at the airfield captured N967FE approaching the airfield and the subsequent landing. Figure 8 shows the aircraft approaching from the east. Figures 9 and 10 shows the aircraft descending towards the western end of the runway. Figure 11 shows the touchdown with the aircraft banked to the right.

Radio communications

Communications between Beef Island Airport ATC and N967FE were recorded. A transcript of the communication assisted in determining the history of the flight.

Footnote

[2] V_{NE} is the aircraft maximum (never exceed) speed limitation

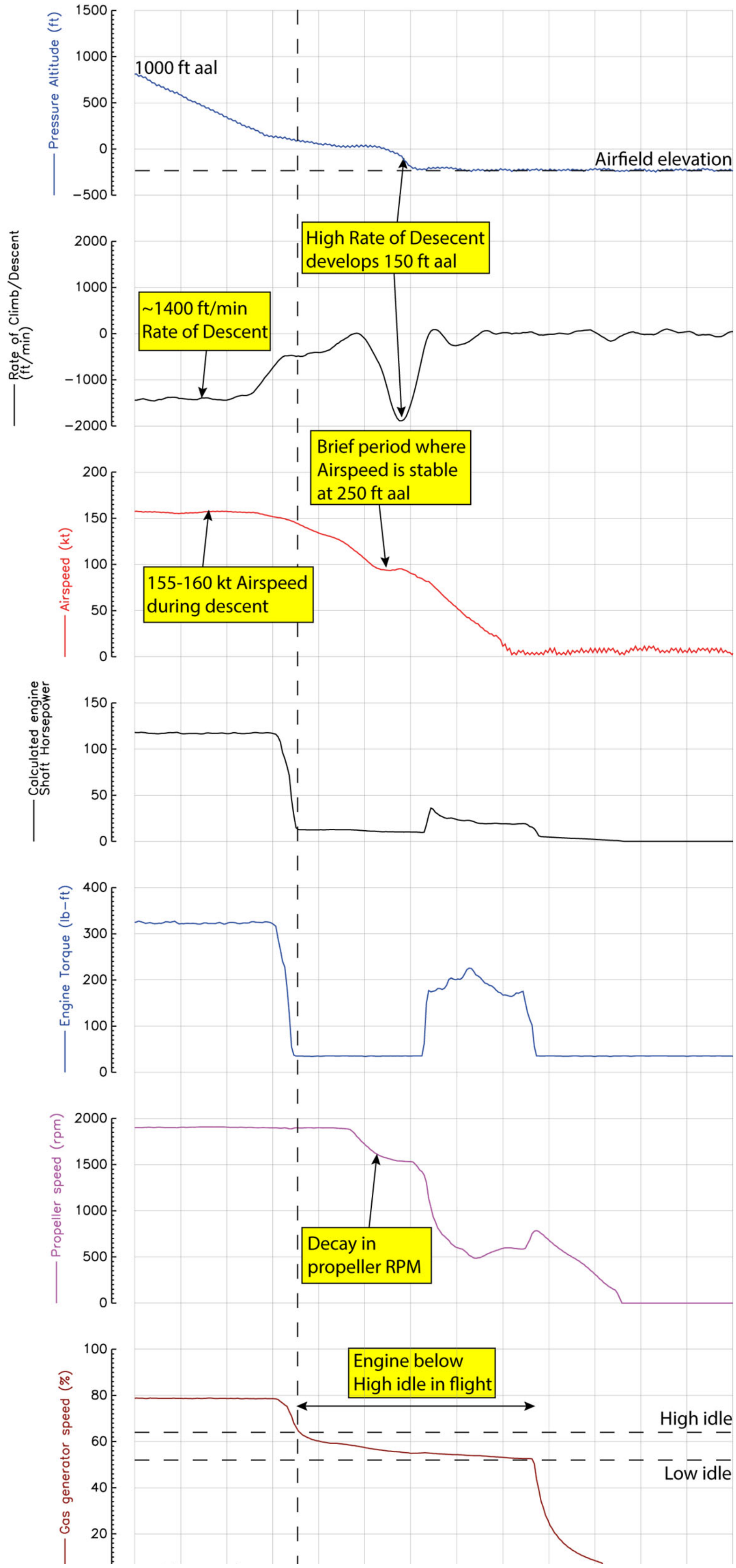

Figure 7

ADAS+ data from 1,000 ft aal for the incident flight

Figure 8
CCTV looking East at time 1715:29 hrs

Figure 9
CCTV looking West at time 1715:45 hrs

Figure 10
CCTV looking West at time 1715:48 hrs

Figure 11
CCTV looking West at time 1715:49 hrs

Aircraft information

The Cessna C208B Super Cargomaster is a single engine high-wing cargo aircraft with a maximum takeoff weight of 3,977 kg. It is powered by a Pratt & Whitney PT6A-114A turboprop engine and has fixed tricycle landing gear. The pilot has three main engine controls: a power lever used to control the engine power output, a propeller lever which is used to control the propeller rpm and a Fuel Condition Lever that is used to control the engine idle speed and to shut the engine down by cutting off the fuel flow. The Fuel Condition Lever has three positions: CUT-OFF, LOW IDLE and HIGH IDLE. In addition, there is an Emergency Power Lever which can be used to control the engine power if the normal controls become ineffective.

Aircraft examination

The aircraft was examined by the operator. Damage was found to the left and right main wheel assemblies, the right landing gear fairing, the right axle cover, the nosewheel steering bungee and the DME[3] antenna. A scrape mark was found on the aft of the cargo pod where it had contacted the runway but this was found to have only damaged the paint. A Hard Landing inspection was carried out, no structural damage was found.

Once the airframe damage was repaired, a subsequent engine run, on 7 October 2020, identified a lack of engine response to throttle movement. As part of fault finding, in accordance with the maintenance manual, the P3[4] line and P3 filter were replaced and the Py[4] line was blanked at the FCU[5] to eliminate it from the fault finding. This had no effect on the engine operation and as a result the FCU and the engine fuel pump assembly were replaced. These units had been fitted approximately six flying hours before the occurrence on 23 September 2020. Once the replacement components had been installed and tested the aircraft was returned to service.

Meteorological information

The air traffic controller on duty when the incident occurred reported that at the time of the incident visibility from the northwest clockwise to the east was in excess of 10 km and the cloud ceiling was scattered at 1,800 ft. There was light rain on the field but it did not obscure visibility on the final approach to Runway 25 as Virgin Gorda (7 nm away) was still visible. However, there was reduced visibility to the south. He recalled that when he saw the aircraft start to sink, he immediately looked at the wind for Runway 25 and Runway 07. One was showing 170° at 3 kt and the other was variable at 2 kt.

The meteorological actual report issued by the airport at 1700 hrs reported the surface wind was from 150° at 14 kt, visibility was 2 statute miles, there was a rain shower over the field, the cloud was scattered at 1,700 ft, temperature was 28°C, dew point was 24°C and the pressure was 29.95 inches of mercury. The report at 1800 hrs recorded the surface wind

Footnote

[3] Distance Measuring Equipment
[4] P3 and Py are designations of internal engine pressures that are used to assist it in controlling the engine.
[5] The FCU is the normal device used to control the engine in response to pilot inputs, ambient conditions and relevant engine parameters, by metering the appropriate amount of fuel to the engine.

was variable at 2 kt, visibility was 10 statute miles, there was a thunderstorm over the field, the cloud was few at 1,000 ft, temperature was 29°C, dew point was 26°C and the pressure was 29.93 inches of mercury.

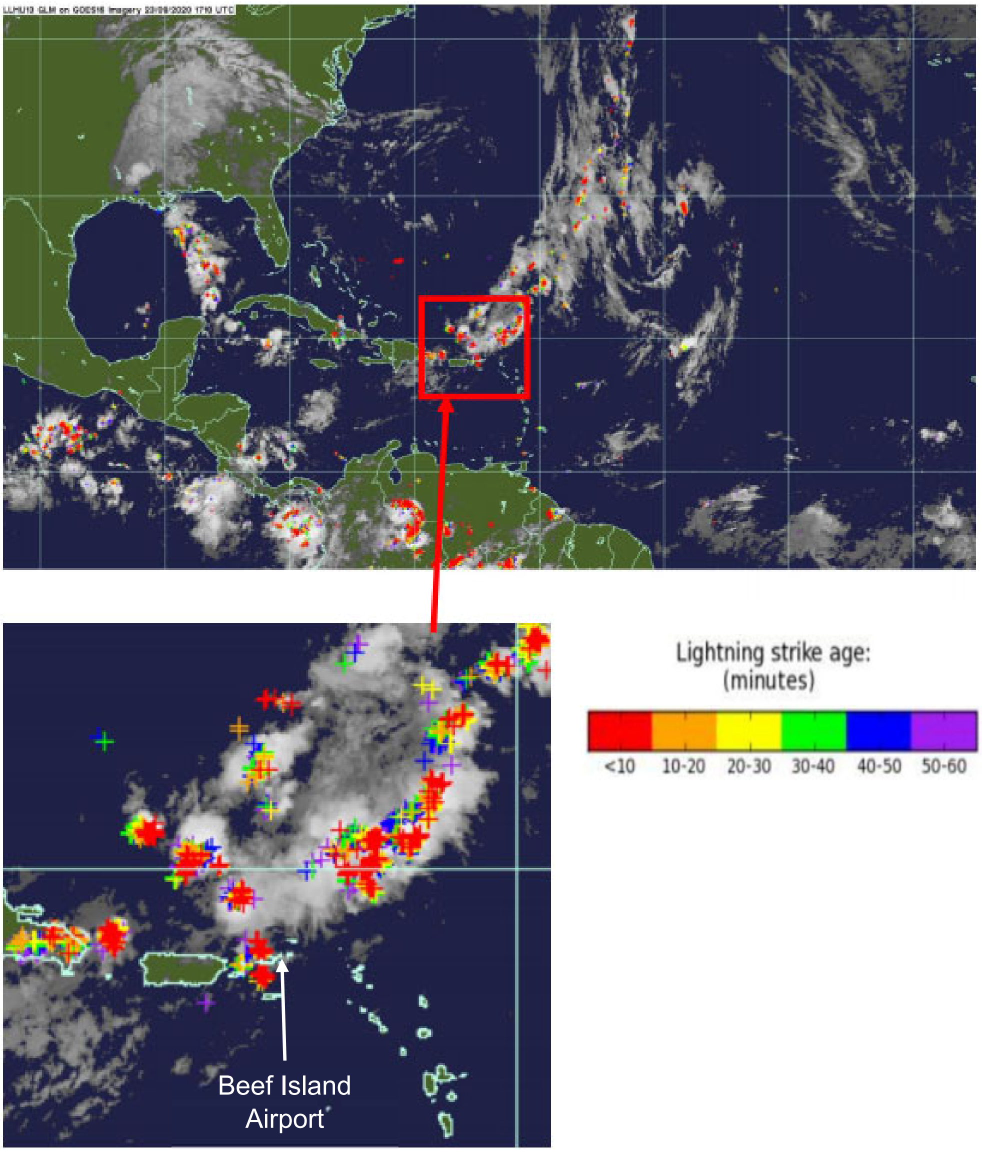

Figure 12

Satellite image of the Caribbean with Lightening activity overlaid valid at 1710 hrs

Figure 12 shows a satellite image displaying a band of cloud with embedded thunderstorm activity extending from the mid-Atlantic towards the Caribbean, the majority of the activity remained to the north of the British Virgin Islands, but there were several active thunderstorms surrounding the territory at 1710 hrs. Figure 13 shows a radar image valid at 1710 hrs, obtained from the US weather radar situated in San Juan (140 km to the west of the accident site). The bright echoes on the radar picture indicates heavy showers over both the British and US Virgin Islands. These showers correlate well with the areas of thunderstorm and lightning activity in Figure 12.

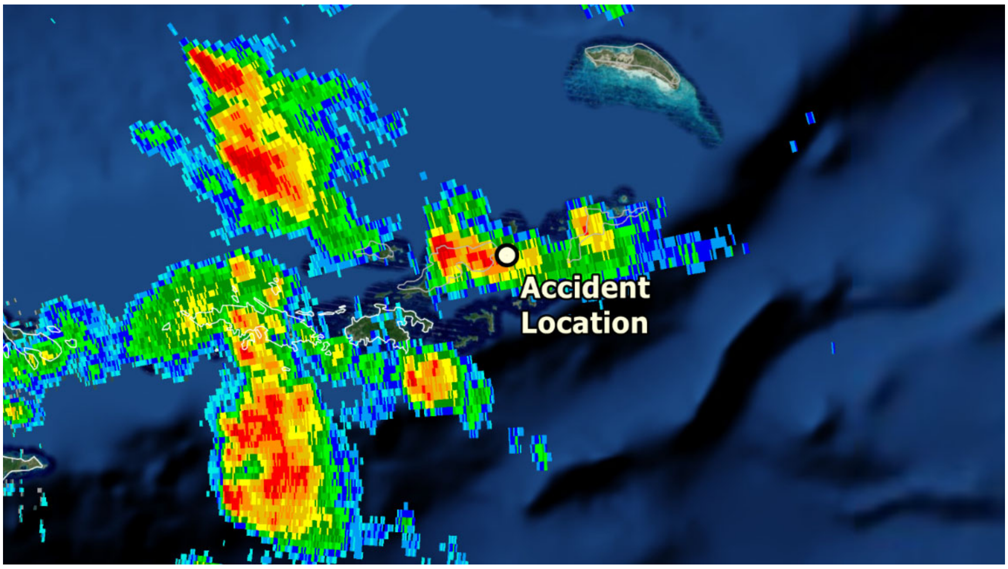

Figure 13

Radar image valid at 1710 hrs

Aerodrome information

Terrance B Lettsome International Airport is situated on a small island (Beef Island) on the eastern end of Tortola. It has a single asphalt runway orientated 07/25 which is 1,416 m long and 30 m wide. Terrain effects the approach to both ends of the runway. Runway 07 is the predominate runway used due to the prevailing wind. Runway 25 has a landing distance available of 1,206 m.

Runway 25 has PAPI[6] on the south side of the runway set to indicate a 3.5° approach slope. RNAV(GNSS)[7] instrument approaches are published for both runways. The RNAV approach to Runway 25 is a straight-in approach constructed with a 3.3° approach slope.

Pilot information

The pilot held an FAA Commercial Pilot's Licence with valid multi engine and single engine ratings. He held a valid Class 1 medical. He had a total flight time of 1,878 hours of which 174 hours were on the Cessna C208B. He joined the operator 8 months before the incident in February 2020.

He had flown to Beef Island Airport many times before and had flown the same route two days before the incident. The pilot commented that most of his approaches to Beef Island had been to Runway 07.

Footnote

6 Precision Approach Path Indicators.
7 RNAV – Area Navigation, GNSS – Global Navigation Satellite System.

Organisational information

The operator's operations manual stated that all approaches shall be flown using a stable approach configuration. The criteria are shown in Figure 14.

STABILIZED APPROACHES

All approaches shall be flown using a stabilized approach configuration. The approach can be considered stabilized when the following criteria is met.

(1) The aircraft is on the correct flight path.

(2) Only small changes in heading and pitch are required to maintain that path.

(3) The aircraft speed is stabilized at selected approach speed.

(4) The aircraft is in the landing configuration.

(5) The rate descent is no more than 1000 fpm.

(6) The power setting is appropriate for the configuration and not below the minimum power setting for the approach.

(7) All briefings and checklist items have been performed before crossing the FAF.

(8) ILS approaches must be flown within one dot of localizer and glide slope and must be stabilized by 1000 ft. height above touch-down (HAT)

(9) During visual approaches, wings must be level when the aircraft reaches 500 ft. HAT.

Figure 14
Operator's stable approach criteria extracted from their operations manual

Other than for an ILS approach, the manual does not specify the altitude at which the criteria must be achieved. However, the operator advised that they would expect an aircraft on a visual approach to be stable from 'pattern altitude'. The manual states that '*normal traffic pattern altitudes for all company flights shall be 1500 ft agl for turbine powered aircraft*'. Following the incident, the operator intends to update its operations manual to explicitly state the altitude by which the criteria must be achieved for all approaches.

The operator was in the process of installing the Appareo Vision 1000 flight data monitoring system on all its aircraft which comprises a forward looking camera, GPS, attitude and rate sensors. However, the system had not been installed on N967FE when the incident occurred. The system would allow the operator to monitor approach stability, manage trends and, where necessary, enhance training. The operator reported it intends to have the system installed on all aircraft by February 2021.

Technical examination

FCU and fuel pump examination

The FCU, fuel pump assembly and P3/Py lines removed from the aircraft were sent to the engine manufacturer for examination and test. When the FCU was unpacked on arrival, it was found that blanking caps, normally fitted when the component is removed, were not fitted to the P3 line adaptor. The examination and testing did not identify any anomalies that would have contributed to the reported event.

Other engine related information

The FCU and fuel pump assembly that were previously installed on the aircraft had been in operation for approximately 345 flight hours. They were removed from the aircraft on 15 September 2020 (a week before the incident flight) because the engine would not initially respond to power demands, although it did after several attempts. These components were also sent to the engine manufacturer for inspection and test.

Testing of the previously installed FCU found that the setting of the cut-off valve was interfering with the HIGH IDLE fuel flow. Depending on how the aircraft Fuel Condition Lever was rigged this could have resulted in unstable fuel flow at HIGH IDLE which could cause the reported engine behaviour event. It is not known when the adjustments to these settings were made. Examination of the fuel pump assembly did not identify any anomalies. After replacement of this FCU and fuel pump assembly, ground engine run tests were completed satisfactorily, and the aircraft returned to service, operating without reported incident until the occurrence on 23 September 2020.

Analysis

The aircraft was making a visual approach to Beef Island Airport when the pilot reported that the aircraft entered a rain shower and he decided to go-around. However, he reported that the aircraft did not climb. The aircraft was seen on CCTV and by several witnesses flying level, at approximately 300 ft and high speed, along the runway before descending steeply to the ground. It landed firmly, two thirds of the way along the runway, leaving scrape marks on the runway surface, and then left the paved surface during the landing roll.

Data from the aircraft showed that the approach did not meet the operator's stable approach criteria. At 1,000 ft aal the aircraft's airspeed was between 150 and 160 kt and remained above 150 kt until the aircraft was at 350 ft aal. This was significantly above the target approach speed of 110 kt with the flaps retracted reducing to 85 kt with flaps extended. From 1,000 ft aal the average rate of descent was 1,400 ft/min; much greater than the 1,000 ft/min criteria in the operator's operations manual.

The investigation considered three factors which could have contributed to the incident: an aircraft anomaly which prevented the aircraft from climbing, windshear on the approach or the unstable approach leading to high pilot workload.

Aircraft anomaly

The aircraft was not examined by the AAIB or any other safety investigation authority. The pilot did not report any technical fault with the aircraft after the incident.

Two weeks after the incident and following repairs to the aircraft, the operator reported that during ground runs the engine did not respond to throttle movements. The FCU, fuel pump and pressure sensing lines were replaced, and the aircraft returned to service. The engine has been operating normally since it was returned to service.

Examination and testing of this FCU, fuel pump and sense lines did not identify any anomalies that could have contributed to the event or the lack of engine response during the subsequent ground tests following the airframe repairs.

A different FCU and fuel pump, that were removed from the aircraft six flying hours prior to the incident, were found to have adjustment settings that could have caused the lack of response seen in a previous event on 15 September 2020. There was no record of the rigging settings of the aircraft's engine controls so it was not possible to draw any conclusions about what effect the rigging of these controls may have had on the engine operation.

The actual position of the engine control levers during the accident flight could not be confirmed as they are not recorded.

Analysis of the data recovered from the aircraft showed that the engine was operating at a typical HIGH IDLE speed prior to takeoff and that the engine operated normally during the flight. However, during the approach the engine decelerated below HIGH IDLE. Being below HIGH IDLE in isolation would not have prevented the engine from accelerating if the pilot advanced the power lever. The possible causes for the engine to decelerate below HIGH IDLE include pilot selection of low idle, an FCU malfunction or a blockage of the pressure sensing lines.

The operator trained its pilots to select HIGH IDLE during the before takeoff checklist and return it to LOW IDLE when clearing the runway after landing; and that it should remain at HIGH IDLE throughout the flight. It considered it unlikely that the pilot would have inadvertently or intentionally moved the lever back from HIGH IDLE in flight. The operator reported that it was not aware of any instances of pilots doing this during their pilot checking programme.

No fault was found with the FCU or the pressure sensing lines that were replaced but, it is possible there was a temporary blockage or debris upstream of the P3 filter that was dislodged during the remedial work. It is also possible that there was a temporary blockage where the P3 line enters the FCU; this debris could have been dislodged during removal or transport to the engine manufacturer as blanking caps were not fitted to the P3 line adaptor. If there was a blockage this could have caused the engine to not respond to the power lever. In this case, the only way to increase power would have been to use the Emergency Power Lever.

Windshear

Satellite and radar images showed active thunderstorms to the west of the airfield at the time of the incident with multiple lightning strikes recorded in the previous ten minutes. It is therefore possible that windshear was present. However, ATC reported that they checked the wind when they saw the aircraft descending rapidly and did not see anything which suggested windshear. They reported that there was light rain at the airfield and the visibility in the direction the aircraft was approaching from was greater than 7 km.

The data from the aircraft did not show any rapid airspeed changes or turbulence which might indicate windshear.

Unstable approach and workload

The pilot was experienced flying this aircraft and familiar with Beef Island Airport. However, it was notable that he incorrectly reported his position and intentions to ATC. He reported that he was north of the island and would join "right downwind" when in fact he was south-west of the island and joining from the south (left downwind). This might suggest the pilot's workload was quite high and he was prioritising flying the aircraft and navigating probably due to the challenging weather conditions.

The second approach commenced from overhead the airfield at 5,000 ft. Recorded data showed the aircraft was above the normal profile with a high rate of descent and high speed throughout the approach. The aircraft did not meet the stable approach criteria specified by the operator. When the aircraft was 30 seconds from touchdown the airspeed was still over 150 kt. It is likely that the high energy approach would further increase the pilot's workload.

ATC reported that the visibility in the direction the aircraft was approaching from was greater than 10 km and the cloud was scattered at 1,800 ft. However, the pilot reported that he decided to go-around because he lost sight of the runway when he entered a rain shower that was heavier than he anticipated. Although, prior to the point where the aircraft started to fly level, where the pilot reported he tried to go-around due to entering a rain shower, the aircraft was already in a position from which it would have been challenging to land safely.

The aircraft is fitted with an Emergency Power Lever which can be used to supply fuel to the engine if the FCU malfunctions. If the engine does not respond to power lever movement and the pilot suspects a malfunction of the FCU the Pilot Operating Handbook directs the pilot to use the Emergency Power Lever. However, on the accident flight the pilot reported that he did not have time to consider using the Emergency Power Lever. If the engine did not respond it is likely that any increase in workload caused by the weather conditions and the high energy approach would have reduced the pilot's capacity to diagnose the problem and respond appropriately.

The operator intends to update its operations manual to state explicitly the altitude by which stable approach criteria must be achieved for all types of approach.

Prior to the incident the operator was installing a flight data recording system on all its aircraft. However, it had not been installed on the incident aircraft at the time of the incident. The system allows the operator to monitor approach stability and hence manage trends and enhance training. The operator reported that it expected to have all its aircraft fitted with the system by February 2021.

Conclusion

The aircraft made a hard landing two thirds of the way along the runway and left the paved surface during the landing roll.

Recorded data showed the engine speed reduced below HIGH IDLE shortly before landing but this would not have prevented the engine accelerating. No evidence was found of a technical anomaly with the aircraft or its engine that would have contributed to the event. Although the FCU was removed due to a later issue, no attributable faults were found. However, a temporarily blocked sense line could cause these symptoms. No blockage was found, but the possiblility of a temporary blockage could not be excluded.

Weather conditions for windshear were present in the area but the evidence suggested the aircraft was not affected by windshear. The approach was unstable, and it is possible that this increased the pilot's workload making it more challenging for him to deal with the situation in which he found himself.

Safety action

The operator intends to update its operations manual to state explicitly the altitude by which stable approach criteria must be achieved for all types of approach.

Published: 22 April 2021.

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:	Antonov 26B, UR-CQD
No & Type of Engines:	2 AI-24VT Turboprop engines
Year of Manufacture:	1980 (Serial no: 10101)
Date & Time (UTC):	16 July 2020 at 0219 hrs
Location:	Birmingham Airport
Type of Flight:	Commercial Air Transport (Cargo)
Persons on Board:	Crew - 6 Passengers - 3
Injuries:	Crew - None Passengers - None
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	44 years
Commander's Flying Experience:	2,512 hours (of which 624 were on type) Last 90 days - 71 hours Last 28 days - 44 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and additional information from the operator and ATC

Synopsis

The aircraft made two non-precision approaches to Runway 33 at Birmingham Airport, remaining too high on the first and too low on the second. In both cases ATC instructed the aircraft to go around. The aircraft then made a successful third approach to Runway 15 using the ILS. The absence of a precision approach for Runway 33, the pressure of undergoing a line check with a senior manager, a new flight instrument layout and missed opportunities to provide correcting action to the operating pilot are likely contributory factors to the aircraft being too low on the second approach.

History of the flight

After an uneventful flight, the aircraft was cleared to carry out a LOC/DME approach to Runway 33 at Birmingham Airport. The commander had only recently been promoted and was undergoing a line check by a senior manager within the company. The visibility at the time was good with a broken cloud base at 1,900 ft.

The aircraft was cleared to descend to 2,000 ft and when 12 nm from touchdown was established on the localiser with clearance to descend further with the procedure (Figure 1).

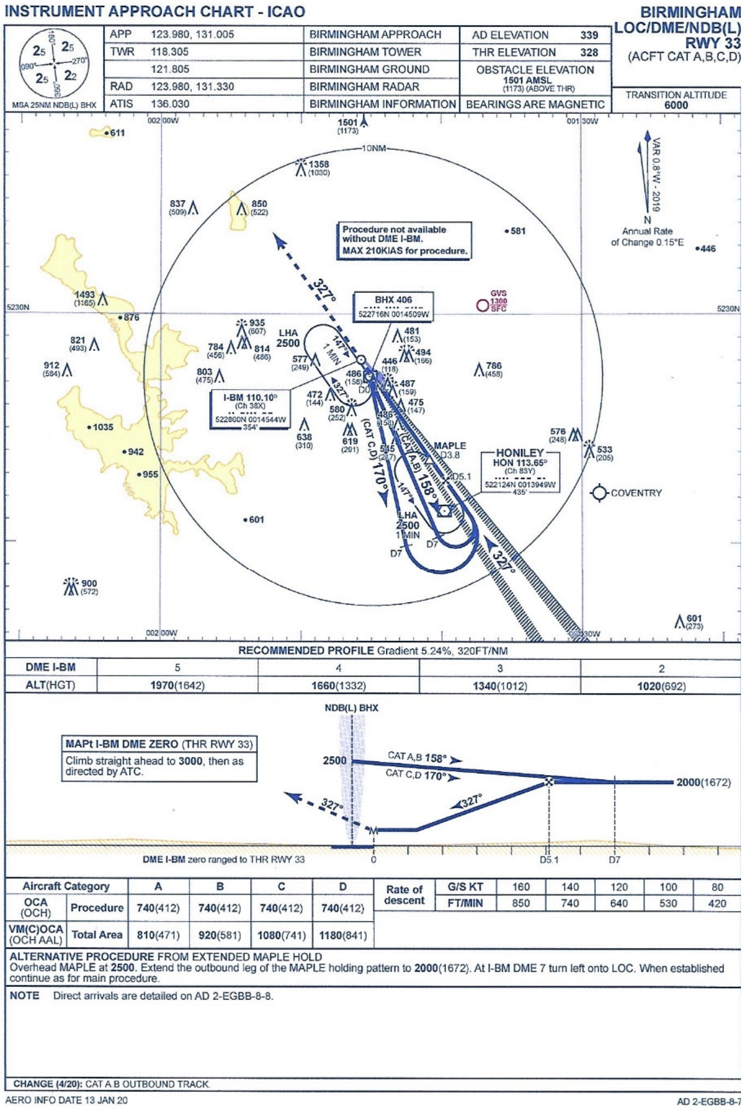

Figure 1

LOC/DME Approach Chart for Runway 33

At 5.5 nm from touchdown the aircraft was at 2,500 ft, 500 ft above the platform altitude for the approach. The aircraft continued to descend but then maintained an altitude of about 2,000 ft, remaining at this altitude beyond the start of the approach descent point, situated 5.1 nm from touchdown. At 3 nm from touchdown the aircraft was still maintaining 2,000 ft, 660 ft above the correct profile altitude. ATC instructed the pilots they were above the correct descent profile and the aircraft began a descent, but a few seconds later ATC instructed the pilots to go around and to climb straight ahead to 3,000 ft, in accordance with the published missed approach procedure. The aircraft then made a left turn before once again maintaining the runway heading. It was re-cleared to climb to 4,000 ft and given radar vectors for a further LOC/DME approach to Runway 33.

ATC provided further radar vectors to establish the aircraft on the localiser for a 10 nm final approach to Runway 33, reminding the pilots that there was no glideslope available.

The aircraft was cleared to descend with the procedure but started its descent below the 2,000 ft platform altitude when 8 nm from touchdown, 2.9 nm before the correct procedural descent point. At 7 nm the aircraft was descending through 1,600 ft, 400 ft below the correct altitude. ATC passed altitude and range information to the pilots but did not warn the pilots that they were below the correct altitude. The aircraft continued its descent and at 6 nm was at 1,500 ft, 500 ft below the correct altitude. ATC then gave the pilots a terrain warning and instructed them to go around. There was no immediate reply so ATC repeated the instruction with the aircraft now passing 1,400 ft, 600 ft below the correct altitude. The pilots responded that they had the runway in sight and were "*approaching the glideslope*". ATC informed them there was no glideslope and again instructed the aircraft to go around, which the pilots then acknowledged.

ATC offered the crew an ILS approach to Runway 15 which, under the prevailing wind conditions, the pilots were able to accept and the aircraft landed without further event.

Airfield information

Early in 2014 work was completed to extend the threshold of Runway 33, including the installation of a new ILS system. Problems were then identified with ground water affecting the glide slope aerial, causing the glide slope to be removed from service in 2016. Drainage works were then undertaken and the glide slope re-established, but further problems due to ground water resulted in the glide slope once again having to be taken out of service.

Additional drainage works were undertaken in July 2020 with the glide slope being finally re-commissioned in September 2020.

Other information

The operator reported that the commander had previously flown non-precision approaches without difficulty. It also commented that earlier in the year the aircraft's instrument panels had been modified, with some instruments changing position.

In his report the commander commented that he had reduced the descent rate excessively during the first approach, resulting in the aircraft remaining above the correct profile. He further commented that during the second approach the runway had been in sight and that he had intended to reduce the descent rate when ATC instructed the aircraft to go around.

Previous Incidents

The AAIB has previously investigated incidents involving non-precision approaches to Runway 33 at Birmingham Airport.[1]

Footnote

[1] AAIB reference AAIB-26144. Aircraft Registration EC-KLT. https://assets.publishing.service.gov.uk/media/5f3b7e6fd3bf7f1b164fe178/Airbus_A320-216_EC-KLT_10-20.pdf (Accessed March 2021)

Analysis

Based on the profile of the first approach it appears that the pilots had either misinterpreted the approach or had been mistakenly expecting to intercept a glide slope. This was followed by advice from ATC that there was no glide slope available. On the second approach the crew appear to have mis-interpreted the approach profile, commencing their descent too early, or had commenced an early visual approach without notifying ATC. The apparently routine nature of ATC height and distance checks may have given the pilots the impression the aircraft was descending in accordance with the correct profile for landing. The manager carrying out the line check was in a position to intervene had he believed the pilot's deviation from the correct profile was inappropriate or unsafe, but did not do so.

Non-precision approaches are becoming less common and pilots may be less current in flying them. The commander also cited the new instrument layout and the pressure of undergoing a line check with a senior manager as additional factors affecting his performance.

Early and unequivocal intervention from those able to see the aircraft was not on the correct profile would have been appropriate. The return of the ILS to this runway after a protracted absence may enhance the safety of future approaches.

SERIOUS INCIDENT

Aircraft Type and Registration:	1) ATR 72-212 A, G-OATR 2) ATR 72-212 A, G-ORAI
No & Type of Engines:	2 Pratt & Whitney Canada PW127M turboprop engines
Year of Manufacture:	1) 2019 (Serial no: 1580) 2) 2019 (Serial no: 1599)
Date & Time (UTC):	1) 29 June 2020 at 1320 hrs 2) 22 July 2020 at 1110 hrs
Location:	Guernsey Airport, Guernsey
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	1) Crew - 6 Passengers - 50 2) Crew - 4 Passengers - 42
Injuries:	1) Crew - None Passengers - None 2) Crew - None Passengers - None
Nature of Damage:	None
Commander's Licence:	1) Airline Transport Pilot's Licence 2) Airline Transport Pilot's Licence
Commander's Age:	1) 51 years 2) 61 years
Commander's Flying Experience:	1) 10,009 hours (of which 3,460 were on type) Last 90 days - 17 hours Last 28 days - 0 hours 2) 5,500 hours (of which 4,500 were on type) Last 90 days - 34 hours Last 28 days - 7 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and further enquiries by the AAIB

Synopsis

Two separate cabin smoke events were reported while starting the engines on different aircraft in the operator's fleet. The operator concluded that low utilisation of the aircraft and a high amount of airborne salinity resulted in corrosion forming on the P2.5/P3 engine air switching valve, sufficient to prevent it from fully closing. With the valve partially open, contaminated air from the engine was able to enter the cabin.

Safety action has been taken by the operator to help prevent corrosion forming on the valve and to amend the engine start procedure to reduce the risk of contaminated air entering the environmental control system.

History of the flight

G-OATR

As a result of the coronavirus pandemic, the utilisation of the operator's fleet had reduced significantly. In line with the engine manufacturer's recommended practice for running the engines, the operator scheduled their aircraft to fly at least every 14 days. G-OATR had last flown 10 days prior to the event.

G-OATR was scheduled to fly from Guernsey Airport to Southampton Airport. The crew started both engines and the aircraft was pushed back from the stand. As the tug was being detached from the aircraft, the flight crew received a call from the Senior Cabin Crew Member (SCCM) who stated that there was a "faint haze or smoke" in the cabin. Shortly afterwards the SCCM reported that its intensity was increasing. There was no smoke or haze visible in the cockpit.

The commander turned off the cabin air recirculation fans when he was first alerted of smoke in the cabin and when he was informed that the intensity was increasing, he shut down both engines. The co-pilot reviewed the QRH for an applicable checklist, however, there was no procedure for 'smoke on ground'. The flight crew and the SCCM agreed to rapidly disembark the passengers through the rear cabin door and a PAN call was made to ATC informing them of this decision. Once all the passengers had disembarked, the crew departed via the cabin door and liaised with the AFRS who were on scene.

G-ORAI

Following the G-OATR event, the operator suspected that the low utilisation was affecting the performance of the Environmental Control System (ECS). In response, the operator decreased the maximum interval between flights from 14 to 7 days.

G-ORAI had last flown five days prior to the event. As in the previous event on G-OATR, the SCCM reported a slight haze or smoke in the cabin after both engines had been started and the aircraft had been pushed back. The commander informed ATC that there would be a rapid disembarkation of the passengers, which took place after the engines had been shut down and the propellers stopped rotating.

Aircraft information

The ATR 72-600[1] is a twin-engine, short-haul regional aircraft fitted with Pratt & Whitney Canada PW127M turboprop engines. Pressurised air from the engine compressor is used for sealing bearing cavities, assisting in engine oil scavenging, providing internal engine cooling and cabin pressurisation.

Footnote

[1] Marketing name for the ATR 72-212A with a specific equipment fit including PW127M engines.

Air pressurisation system

During normal operation, pressurised air is taken from an intermediate stage of the compressor, known as P2.5 air. During engine start there is insufficient P2.5 air pressure available, therefore a spring-loaded air switching valve allows air from a different compressor stage (P3 air) to pressurise the system. Once the engine high-speed rotor speed (NH) reaches 40-45%, P2.5 air pressure is high enough to overcome the spring force and close the valve. If P3 air continues to be used above 45% NH (ie the valve remains open) then high oil consumption and temperature can result, as well as an oil smell in the cabin and smoke in the exhaust.

The P2.5/P3 air switching valve consists of a piston which slides inside a sleeve and reacts against the large spring (Figure 1). A piston ring seals the gap between the piston and the sleeve. When P2.5 air pressure is lower than the spring force, the valve opens allowing P3 air to flow into the rear inlet case. Once P2.5 air pressure overcomes the spring force, the valve closes, isolating P3 air and allowing P2.5 air to enter the rear inlet case. The air switching valve components are manufactured from various alloys of corrosion resistant steel.

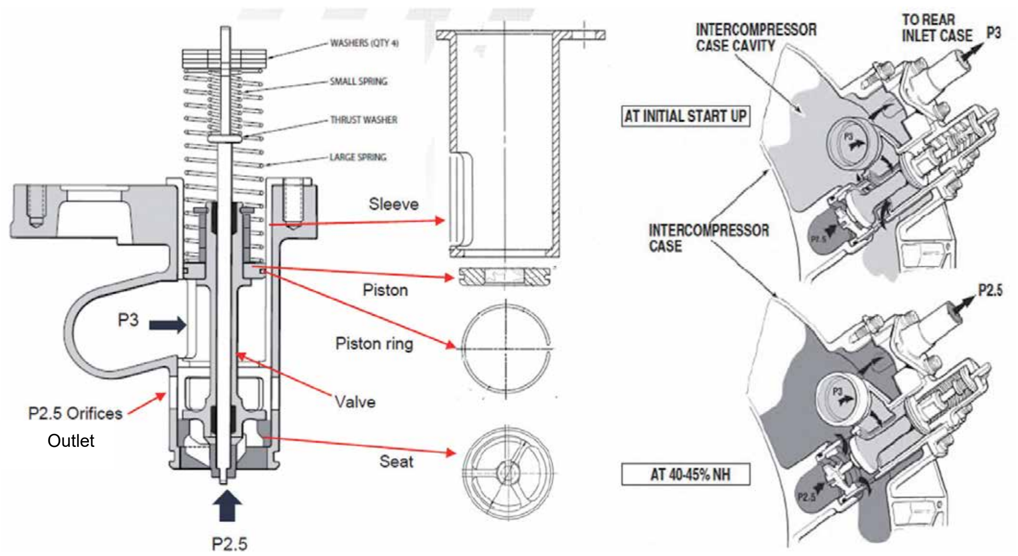

Figure 1

P2.5/P3 air switching valve
(Image used with permission of Pratt & Whitney Canada)

Aircraft examination

After each event the engines were run at 80% power with the bleed air system and ECS selected ON; smoke and haze were observed in the cabins on both occasions. The P2.5/P3 air switching valves on all four engines were examined and found to be either stiff to move or seized. The valves were disassembled, and corrosion was found on the pistons and sleeves (Figure 2).

The corroded components were replaced, and the valves operated normally during the subsequent ground runs with no oil smells or haze in the cabin.

Figure 2

Corrosion found on piston and sleeve inner bore
(Images used with permission of the operator)

Operator's actions

Frequency of operating the engines

As G-ORAI had not flown for five days prior to its event and still experienced a problem, the operator further reduced the interval between flights to three days. If an aircraft did not fly within three days, then engine ground runs would be required to ensure the correct function of the air valves and the ECS. The operator also introduced a new inspection of the P2.5/P3 air switching valve every 42 days and a replacement of the piston ring every 100 days.

In addition, the engine manufacturer has amended the Engine Maintenance Manual (EMM) to include an inspection of the valve following any period of storage (irrespective of duration and environment) and to replace the valve during overhaul. They have also initiated a redesign of the P2.5/P3 air switching valve, which will consider the materials used in the valve assembly.

Engine start procedure

The procedure for a normal engine start requires the bleed air system and ECS to be selected ON. The engine manufacturer provided a "No Technical Objection" to a request from the operator for the engines to be started with the bleed air system and ECS selected OFF. This will allow time for the engines to come up to speed and stabilise before demanding air for the ECS. The operator has introduced this procedural change, which is applicable to all engine starts, either for flight or maintenance.

Conclusion

The operator determined that the smoke and haze in the cabin was due to the partial seizing of the P2.5/P3 air switching valves, which allowed oil vapour to enter the ECS. Corrosion was found in all the valves, which probably resulted from the reduced utilisation of the aircraft due to the corona virus pandemic, and the aircraft being parked and operated from an airfield close to the sea where there was a relatively high level of airborne salinity.

Safety actions

Following the events on G-OATR and G-ORAI, the following safety actions were taken:

The operator:

- Introduced a requirement for engine ground runs to be carried out on aircraft that have not flown for three days to ensure the correct operation of the bleed air system and ECS.
- Introduced an inspection of the P2.5/P3 air switching valves every 42 days and replacement of the piston ring every 100 days.
- Issued a 'Notice to Crew' to require flight crews and maintenance personnel to start the engines with the bleed air system and ECS selected OFF.

The engine manufacturer:

- Updated the EMM to include an inspection of the P2.5/P3 air switching valves following a period of storage, irrespective of duration and environment.
- Issued a requirement to replace the P2.5/P3 air switching valves during engine overhaul.
- Initiated a redesign of the P2.5/P3 air switching valve, which will consider the materials used in the valve assembly.

SERIOUS INCIDENT

Aircraft Type and Registration:	Beech B200, G-YVIP
No & Type of Engines:	2 Pratt & Whitney Canada PT6A-42 turboprop engines
Year of Manufacture:	1988 (Serial no: BB-1306)
Date & Time (UTC):	23 October 2020 at 0920 hrs
Location:	Bournemouth Airport, Dorset
Type of Flight:	Private
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Circuit breaker panel damaged
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	40 years
Commander's Flying Experience:	7,200 hours (of which 900 were on type) Last 90 days - 45 hours Last 28 days - 20 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and operator's safety investigation report

Synopsis

The aircraft landed safely after an electrical fire and smoke in the cockpit during the final approach. The operator's investigation found that the commander's circuit breaker (CB) panel showed evidence of moisture ingress and the back-lighting circuit board was burned. They concluded that the most likely scenario is that rainwater entered the cockpit through the storm window, which is above the CB panel. Following this event, the operator took action to ensure that all their King Air aircraft have an improved storm window seal and that their aircraft are parked inside a hangar when they are not in use.

History of the flight

The aircraft was on final approach to Bournemouth Airport in clear weather, at a height of approximately 1,200 ft. Very shortly after selecting approach flap, they noticed a yellow glow and smoke coming from behind the commander's CB panel. They attempted to isolate the problem by operating the MASTER SWITCH gang bar, which switches off the battery and electrical generators, but this had no effect, so they declared a MAYDAY. The first officer tried to reach the fire extinguisher under his seat but found this to be difficult because of his shoulder straps. After landing the crew evacuated the aircraft on the runway and the airport fire service attended but the smoke stopped without intervention when the aircraft was shut down.

Operator's investigation

The operator found evidence of moisture ingress in the commander's CB panel and there was overheat and burning damage on the back-lighting circuit board (Figure 1).

Figure 1

CB panel showing evidence of moisture ingress and overheating

The commander's CB panel is under the left storm window, which can be opened. The window has a seal to minimise the risk of moisture leaking into the cockpit, and the operator assessed this to be serviceable after the incident. They reported that there is a '*reasonable body of evidence that they are prone to water ingress, particularly when the aircraft is parked outside in the rain*', and that water, which tends to collect on the outside of the window, can enter the cockpit when it is opened. They said that an improved seal is available as an optional modification, but this had not been fitted to G-YVIP.

The operator reported that they normally keep their aircraft in a hangar when they are not in use, but G-YVIP was a recent addition to their fleet and anecdotal evidence indicated that it previously spent most of its time outside. Another possible contributory factor was that the operator's crews had been routinely opening the storm window recently to clear the cockpit of a 'fogging' agent that was used for sterilisation in response to the global coronavirus pandemic. They considered that this might have increased the likelihood of water ingress.

Conclusion

The operator's investigation found evidence of moisture ingress, overheat and burning damage in the commander's CB panel, which is under the left storm window. They concluded that the most likely scenario is that moisture entered the cockpit through the window, eventually resulting in electrical breakdown of the CB panel back-lighting circuit board.

Safety actions

> The operator has installed the improved window seal across their fleet of King Air aircraft, and whenever possible, their aircraft will be parked inside the hangar and only towed outside when required.

ACCIDENT

Aircraft Type and Registration:	Grob G115A, G-GPSX
No & Type of Engines:	1 Lycoming O-235-H2C piston engine
Year of Manufacture:	1988 (Serial no: 8040)
Date & Time (UTC):	7 December 2020 at 1420 hrs
Location:	Nottingham City Airport, Nottinghamshire
Type of Flight:	Training
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Collapsed nosewheel, bent propeller
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	41 years
Commander's Flying Experience:	410 hours (of which 360 were on type) Last 90 days - 130 hours Last 28 days - 5 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and additional AAIB enquiries

Synopsis

The nose landing gear gas strut piston rod failed under overload during a touch-and-go landing. Three previous occurrences of similar failures on the Grob G115 were due to the incorrect fitment of the sliding tube during maintenance of the nose landing gear. The failure in these cases occurred within days following the maintenance. However, for G-GPSX, the last maintenance that required the dismantling of the nose landing gear was in August 2017. Since then, the aircraft had accumulated about 1,000 hours flying time.

History of the flight

The event occurred on a training flight during which the student was practising exercises 12 and 13 (takeoff and climb to downwind position / circuit, approach and landing). Following the first few touch-and-go landings everything appeared normal, then, during a subsequent circuit, both the instructor and student heard a "cracking" noise. They continued with the exercises and the next touch-and-go landing was uneventful. However, during the following landing the same, but this time louder, "cracking" noise was heard as the student applied full power for the takeoff.

The instructor contacted the Air/Ground radio operator to ask for someone to visually inspect the aircraft on the next approach. The pilot of another aircraft in the circuit then reported that the nosewheel appeared to be "swaying backwards and forwards". On hearing this information, the instructor took control of the aircraft and transmitted a MAYDAY call.

For the landing, the instructor prolonged the flare as much as possible to minimise the nose landing gear contact with the paved runway surface. During the landing rollout, the aircraft derotated onto the upper half of the nose landing gear, with the nosewheel assembly dragging behind, still attached by the scissor torque link (Figure 1), allowing the propeller blades to contact the ground.

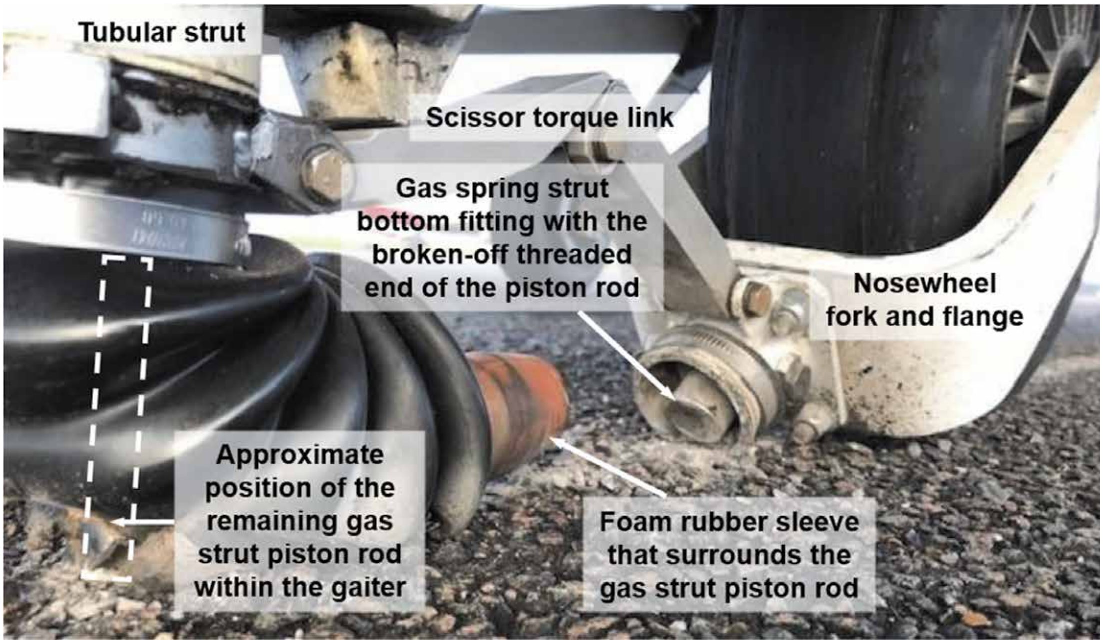

Figure 1
Nose landing gear assembly after landing

Nose landing gear assembly and failure

The nose landing gear assembly consists of a steel housing secured to the airframe, into which fits a tubular strut that is connected to the steering yoke at the top and, via a scissor torque link, to a flange on top of the nosewheel fork assembly. The steel housing is raked forward relative to the fuselage. Inside the tubular strut is a gas spring strut shock absorber. The cylinder end of the gas strut is also connected to the steering yoke, and the piston rod end to the flange on top of the nosewheel fork assembly. A number of these components can be seen in Figure 1.

The piston rod is surrounded by a foam rubber sleeve, with a loose spacer washer at either end of the sleeve, which is housed inside a sliding tube (that slides within the tubular strut). The end of the piston rod is threaded into a bottom fitting. Figure 2 shows these components (from another aircraft) with the sliding tube slid part way up the foam rubber sleeve to expose the piston rod bottom fitting. The bottom fitting and sliding tube both sit inside the flange attached to the nosewheel fork assembly, held in place by a nut and bolt. A black rubber gaiter covering the sliding tube is attached by jubilee clips to the tubular strut and nosewheel fork flange.

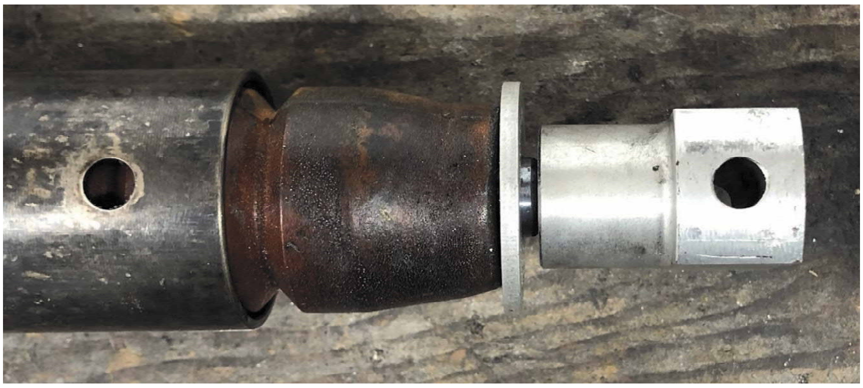

Figure 2

Example sliding tube, gas strut piston rod sleeve and bottom fitting with piston rod just visible as it enters the bottom fitting

The gas strut piston rod is chamfered to the diameter of the thread root at the start of the threaded section (Figure 3).

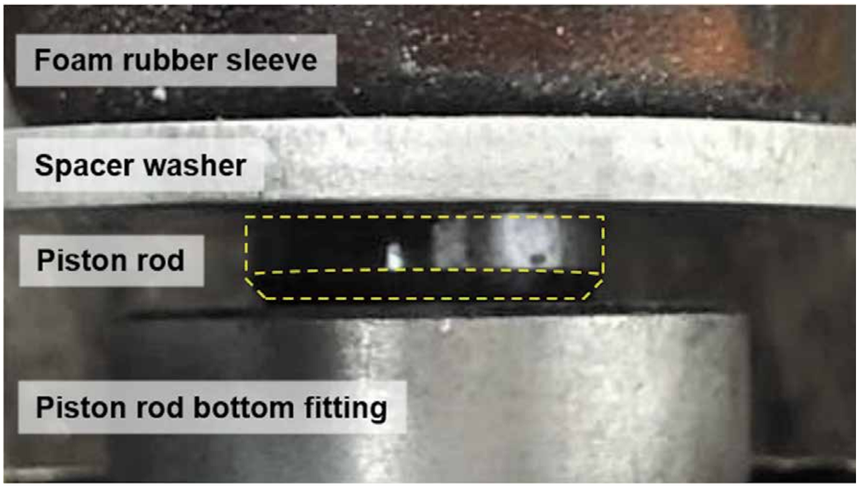

Figure 3

Close-up showing piston rod chamfer at start of threaded portion of the piston rod inside the bottom fitting (the visible part of the piston rod is highlighted)

The bottom fitting from G-GPSX can be seen in Figure 1 which shows that the gas strut piston rod fractured at the start of the threaded section. The sliding tube fell from the aircraft at some point during the last circuit, when the nosewheel assembly would have been swaying from the scissor torque link. The sliding tube was not recovered nor were any fragments of it found trapped between the bottom fitting and bolt in the flange.

Maintenance history

The last maintenance carried out on the aircraft, that required the dismantling of the nose landing gear, was in August 2017 during which the gas spring strut was replaced. Since then, the aircraft had accumulated about 1,000 hours flying time.

All times are UTC

Previous occurrences

The AAIB has investigated three previous occurrences of similar nose landing gear leg failures on the Grob G115. In each case, the sliding tube had not been installed properly following maintenance. The first was in February 2003 (G-BVHG - AAIB Bulletin 9/2003) where, following this accident, the maintenance organisation added additional steps and warnings in their procedures about the correct installation of the sliding tube. The second accident occurred in November 2006 (G-BYVZ - AAIB Bulletin 2/2006), which resulted in the maintenance organisation introducing a duplicate inspection requirement to ensure that the flange and sliding tube are correctly assembled. The third accident happened in May 2007 (G-BYWE - AAIB Bulletin 9/2007) after maintenance work to replace the gaiter, during which the maintenance procedure, put in place to check for the correct installation of the sliding tube, was not carried out.

In all three accidents, the failure of the piston rod occurred within days of the incorrect installation of the sliding tube.

Discussion

The sliding tube protects the gas spring strut from any bending loads induced on the nose landing gear during taxiing, takeoff and landing. If the sliding tube migrates upwards out of the flange, the protection is lost, and the bending forces are absorbed by the gas spring strut instead. For the three previous occurrences, the failure of the gas strut happened within days of maintenance work during which the sliding tube had not been secured in place. For this accident, the failure happened after about 1,000 hours flying time after the last time the nose landing gear had been dismantled. It is unlikely, therefore, the sliding tube could have remained in the flange unsecured for so long, had it not been fitted correctly during the maintenance work. Equally, it is not possible to establish how the sliding tube could have failed without leaving any fragments trapped in the flange.

Conclusion

The nose landing gear gas strut piston rod failed under overload during a touch-and-go landing. Previous similar occurrences on other aircraft occurred within days following maintenance on the nose landing gear. However, this aircraft had accumulated about 1,000 flight hours since the last maintenance on the nose landing gear, which would indicate that the maintenance carried out was not a factor in this event. It was not possible to establish the cause of the piston rod failure.

SERIOUS INCIDENT

Aircraft Type and Registration:	Pioneer 300, G-CGTL
No & Type of Engines:	1 Rotax 912ULS engine
Year of Manufacture:	2012 (Serial no: LAA 330-15038)
Date & Time (UTC):	25 May 2020 at 1400 hrs
Location:	Near Abergavenny Airfield, Gwent
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to propeller and lower fuselage
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	53 years
Commander's Flying Experience:	1,306 hours (of which 4 were on type) Last 90 days - 10 hours Last 28 days - 0 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and additional enquiries by the AAIB

Synopsis

The aircraft was on its first flight after maintenance when an electrical current audio warning was announced during the climb, followed shortly thereafter by a loss of engine power. The electrically-operated landing gear did not extend when selected and there was insufficient time for the pilot to extend the landing gear manually. He performed a successful wheels-up forced landing in a field.

The aircraft was not examined by the AAIB. Given the weather conditions on the day and the use of Mogas fuel, the investigation considered vapour lock in the fuel system as a potential cause of the loss of engine power.

The electrical current problem may have been exacerbated by the loss of engine power. This, in isolation or in combination with landing gear system adjustment issues, could account for the failure of the landing gear to extend when selected.

History of the flight

Background

The aircraft had recently undergone modification, reassembly and maintenance, much of which was done under the supervision of a Light Aircraft Association (LAA) inspector at his premises at Abergavenny Airfield. The maintenance had included an annual inspection for renewal of the aircraft's Permit to Fly, which had expired during the period when the work was being undertaken.

Following completion of the maintenance, the pilot, who was a friend of the aircraft owner, was to undertake a post-maintenance check flight. Subject to that being satisfactory, the plan was to then carry out a test flight for renewal of the Permit to Fly after which he would fly the aircraft back to its home base.

The flight

The pilot arrived at the airfield at around 1130 hrs to find G-CGTL parked on the apron, fuelled and ready to fly. He met with the LAA inspector who briefed him on the work that had been performed on the aircraft. Although the aircraft had not flown since being reassembled, the engine had been run for approximately 15 minutes with no issues apparent.

The pilot carried out the pre-flight checks and checked the weather and NOTAMS for Cardiff Airport. He reported that at around 1330 hrs he ran the engine on the apron for approximately 12 minutes and was happy with the engine temperature and pressure readings. The exact duration of the ground run was not determined. After completing control checks, he taxied to the threshold of Runway 15 where he carried out a final full power check, a magneto drop check and a carburettor heat check, all of which were normal. He took off and climbed to the south. He reported that when the aircraft was at 600 ft agl an Electrical Flight Instrument System (EFIS) *'electrical power'* warning was announced through his headset. As he commenced a right turn through 180° to return to the airfield, the engine started to vibrate violently and run erratically before losing thrust and stopping. He checked that the electric fuel boost pump was ON, changed the selected fuel tank and attempted to restart the engine. The engine fired and operated for several seconds before once again losing thrust, although it continued to operate with the propeller windmilling.

Realising he would not make it back to the airfield, the pilot turned the aircraft into wind, lowered the landing gear selector switch and chose a field in which to land. However, the three landing gear indication lights did not illuminate and he noted that the landing gear circuit breaker had tripped. He reset the circuit breaker and reselected the landing gear DOWN but the circuit breaker tripped again. The aircraft was at approximately 300 ft agl and there was insufficient time to lower the landing gear manually. At 75 ft agl he switched the engine off and conducted a successful wheels-up landing in a field approximately 1.6 miles south of the airfield (Figure 1). The pilot was uninjured and exited the aircraft without assistance.

Following the forced landing the LAA inspector recovered the aircraft. After lifting the aircraft, he reported that the landing gear extended normally and the engine started and appeared to run normally, including at full power. The aircraft was then taxied to the edge of a track, where the wings were de-rigged for recovery.

The pilot later commented that he had previously experienced the '*electrical power*' warning on G-CGTL, but only on the ground with the engine at idle or taxi power and all electrical loads running. The owner subsequently advised the pilot that he had also previously experienced this warning twice on climb out and extending and raising the landing gear had appeared to resolve it.

Figure 1
G-CGTL after landing

Meteorology

Cardiff Airport, approximately 31 miles south-west of Abergavenny Airfield, was reporting good weather conditions at the time of the flight with no cloud, visibility in excess of 10 km and a wind of between 6 and 8 kt from the south-west. The temperature was 21°C with a dewpoint of 8°C. When plotted on the Civil Aviation Authority (CAA) carburettor icing chart (Figure 2) they indicate that there was a likelihood of moderate icing at cruise power and serious icing at descent power.

The pilot reported that the actual wind at Abergavenny prior to takeoff was predominantly southerly at 7 kt and the temperature was 19°C with a dewpoint of 8°C.

Aircraft information

The Pioneer 300 is a home-built, two-seat light aircraft of conventional layout and predominantly wooden construction which is sold in kit form. The landing gear retraction/extension system uses a single electric motor which drives three screw jacks, one for each landing gear. The right main landing gear is the master leg and movement of the left and nose landing gear legs are slaved to it. DOWN stop and UP stop microswitches on the right main landing gear provide stop limits for the electric motor. The current drawn by the motor is directly proportional to the torque being produced. A circuit breaker rated at 7.5 Amps, is incorporated in the system. In addition to protecting the wiring, the circuit breaker ensures the motor cannot exert undue loads on the wooden airframe and mechanical aspects of the landing gear system, if the motor stop limits are exceeded.

When the landing gear legs are fully extended, the screw jacks operate overcentre mechanisms to lock them in position. Indication of the landing gear position is provided by microswitches on each landing gear and three landing gear indication lights, illuminate green when the landing gear are down and locked. If the electric motor fails, or the landing gear does not lock down for any reason, a hand crank can be used to drive the mechanism manually; approximately 40 turns are required to fully extend the landing gear.

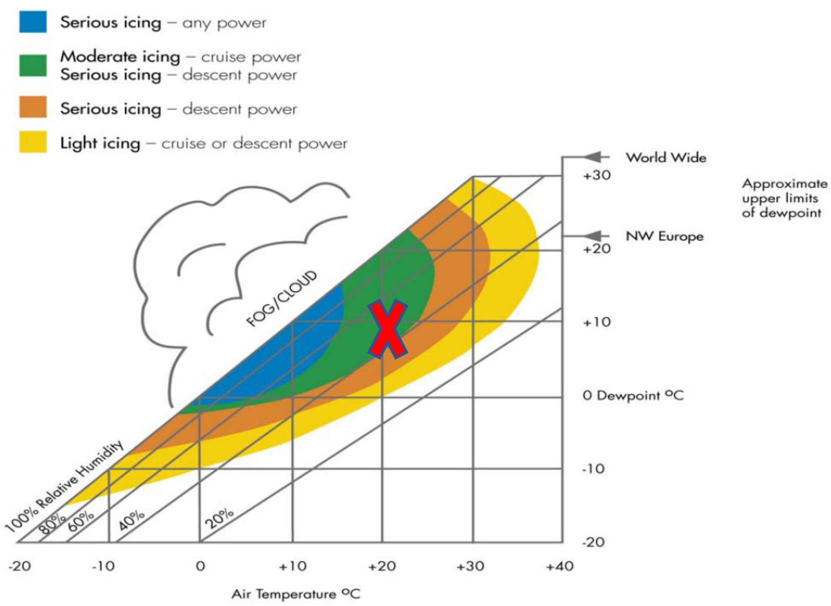

Figure 2

Carburettor icing chart

In the March 2017 edition of its monthly magazine, the LAA wrote an article about landing gear issues on Pioneer 300 and 400 aircraft, including the importance of correct adjustment of the landing gear extension/retraction system and its microswitches. It points out that the Pioneer landing gear system requires regular inspections including retraction checks, to ensure that it remains correctly adjusted.

G-CGTL was fitted with a Rotax 912ULS four-cylinder, horizontally opposed, four-stroke, piston engine and a two-blade variable-pitch propeller. The engine has two carburettors, one at the rear of each pair of cylinders. G-CGTL was also equipped with a dual screen Dynon Avionics Skyview EFIS system which incorporates an engine monitoring function. Selected engine parameters are monitored and relevant warnings appear in a dedicated message window on the Skyview display and associated audio alerts are announced via the audio panel or intercom. Warnings relevant to the electrical system include 'ELECTRICAL CURRENT' and 'VOLTAGE' warnings.

Fuel

G-CGTL was approved by the LAA to use Mogas (unleaded motor gasoline) with an ethanol content not exceeding 5% volume, designated as E5 Mogas. LAA Technical Leaflet (TL) 2.26 *'Procedures for use of E5 unleaded Mogas to EN228'* dated December 2017, contains guidance relating to the use of Mogas in LAA aircraft and the associated operational limitations.

Mogas has a wider boiling point range and contains more volatile components than Avgas, which means it can form a vapour more easily. Therefore, an increase in temperature or a drop in pressure can cause it to vapourise. The reduction in pressure with altitude, as an aircraft climbs causes vapours to form more easily, even at moderate temperatures. Furthermore, Mogas can become heat-soaked in hot weather.

When fuel turns to vapour in a fuel system, it can form a bubble creating a 'vapour lock' which can restrict or prevent the fuel flow to the engine. This can cause lean running of the engine or loss of engine power. This situation can be further exacerbated if the fuel system design is such that a fuel delivery line passes close to a hot part of the engine, further increasing the likelihood of vapourisation. Due to its greater tendency to vapour lock, the LAA restricts Mogas to operation with a fuel tank temperature not exceeding 20°C and an altitude not exceeding 6,000 ft.

As Mogas contains a larger proportion of low boiling point hydrocarbons than Avgas, it evaporates earlier when it enters the carburettor. This, in addition to ethanol's tendency to absorb water, means carburettor icing is more likely to occur when using Mogas.

Mogas has a shorter shelf life compared with the more chemically stable Avgas and TL 2.26 cautions against storing it in large quantities or using old fuel. The composition of Mogas varies by season, with winter grade Mogas containing more volatile components and having a higher vapour pressure than summer grade, to assist engine starting in cold weather. This reduces the temperature at which vapourisation occurs. TL 2.26 advises that using winter fuel in spring, summer or autumn can increase the likelihood of vapour problems.

Aircraft maintenance

G-CGTL, in common with other Pioneer aircraft, was required by the LAA to undergo a modification to the flight control hinge bolts. Its fuselage had also suffered damage due to moisture ingress while hangered at its home base. The owner arranged to have the wings and elevators removed by a local maintenance organisation and these were transported to Abergavenny Airfield, where the modification to the flight controls was carried out under the supervision of an LAA inspector. The fuselage was sent to a separate facility for repair and repainting, after which it was transported to Abergavenny where the aircraft was reassembled and independent post-rigging inspections were carried out. This included landing gear retraction checks.

The LAA inspector carried out some additional maintenance at the owner's request. This included replacing the nosewheel and checking and adjusting the landing gear. He subsequently reported that he had encountered some difficulty when adjusting the landing gear system. The maintenance also included tightening the nuts on the choke and throttle quadrant, changing the engine oil, replacing the oil filter, visually inspecting the oil and fuel lines, undertaking an engine compression check and performing the annual inspection for renewal of its Permit to Fly, which had expired on 16 May 2020. The accompanying worksheets indicated that much of this work was done by an assistant and inspected/ signed off by the LAA inspector. A Permit Flight Release Certificate was issued by the LAA inspector to enable test flying.

When refuelling the aircraft following completion of the maintenance, a piece of electrical insulation tape, approximately eight inches long, was found floating in the left wing fuel tank. No work had been carried out in the fuel tank during the recent maintenance. The left wing was removed and the tank was removed, drained, inspected and flushed; no other contamination was noted. The LAA inspector advised that the aircraft had been fuelled from his personal supply, which had recently been replenished with fresh fuel from a local garage forecourt. The wings and control connections were re-rigged once again and independent post-rigging inspections carried out.

Prior to the incident flight, the LAA inspector briefed the pilot on some of the work which had been undertaken on the aircraft, including the actions taken as a result of finding the debris in the left fuel tank. The LAA inspector reported that he advised the pilot to remain in the vicinity of the airfield and to be aware that the landing gear had been adjusted, therefore manual operation may be necessary. He was therefore surprised to see the aircraft depart the airfield after takeoff. The pilot did not recall being made aware that the landing gear had been adjusted.

Aircraft examination

The aircraft was examined by a representative from the LAA Engineering department, who noted minor damage to lower fuselage panels, floor support and the tip of one propeller blade. Low and high-power engine runs were conducted and the variable-pitch propeller was operated; all systems appeared to be working normally. Inspection of the fuel system included checking the fuel filters, carburettor float bowls and gascolator; no anomalies were noted. A fuel pipe to the right carburettor was found to be loose, although no leakage was observed when a fuel system pressure test was conducted. The fuel pipe had not been disturbed during the recent maintenance. Fuel samples were collected from the aircraft fuel system and the inspector's fuel supply.

The wings were rigged and the aircraft jacked to carry out landing gear extension and retraction tests. The LAA Engineering representative reported that the landing gear appeared to operate normally mechanically and electrically but noted that although the nose landing gear locked down correctly, when retracted, it did not retract sufficiently into its housing for the wheel to come in to contact with the wheel brake. The examination did not establish the reason for the landing gear circuit breaker tripping.

The aircraft was not examined by the AAIB.

Post-incident repair

During a subsequent repair assessment at a separate maintenance facility, the incident damage was discovered to be more extensive than initially estimated. Additionally, several issues relating to the initial aircraft assembly were identified and are under review by LAA Engineering. One issue which may have potential relevance to this incident is that the left fuel tank vent was positioned in such a way that it could have generated a lower than normal fuel tank pressure; staining was noted on the underside of the wing in the vicinity of the vent which indicated that there had been fuel flow from this vent. In isolation, the LAA did not consider that this finding would have prevented fuel from entering the fuel pump, however the reduced fuel system pressure could have contributed to a fuel vapourisation issue.

The maintenance facility had the carburettors overhauled as a precaution and no anomalies were noted. It also intends to replace all fuel hoses. At the time of publication of this report, the aircraft was still undergoing repair and the maintenance facility had not yet undertaken further examination of the aircraft fuel system.

Information from the aircraft manufacturer

The aircraft manufacturer stated that if the landing gear system is correctly set up, a landing gear buzzer will sound in the air if the flaps are down and the landing gear is in the UP position or not fully extended.

It indicated that incorrect setup of the landing gear microswitches could cause the landing gear circuit breaker to trip. Correct adjustment of the microswitches is required for the landing gear electrical motor to stop in the correct position. The manufacturer stated that the post-incident observation, that the nosewheel was neither fully retracted or braked in its housing, would not have had an adverse effect on the aircraft. Nor should it have prevented successful extension of the landing gear.

Tests and research

The fuel samples taken from the aircraft fuel system and the fuel supply during the LAA aircraft examination were analysed using gas chromatography with a mass spectroscopy detector to investigate the presence of ethanol. A trace level of ethanol was detected in each sample, well within the 5% allowable.

The samples were also tested for vapour pressure and the results obtained fell in the correct range for spring, summer, and autumn volatility grades of Mogas. The results were not consistent with winter grade fuel. However, the laboratory could not be definitive on this matter as it noted that the containers in which the samples were collected and stored were not ideal and may have allowed a loss of vapours, which could have contributed to the low result.

Operational procedure for engine failure

Section 4 'Emergency procedures' of the Pioneer 300 flight manual states:

> *'The engine installed in the Pioneer 300 is not certified and can fail at any time. Never fly over areas on the which a safe landing cannot be made in the event of an engine failure.'*
>
> It also states:
>
> *'Due to the airframe structure and retractable gear emergency forced landings should be performed with gear and flaps up. This configuration has been demonstrated to minimise damage.'*

Analysis

Operational aspects

The pilot indicated that he had intended to remain within gliding distance of the airfield but considers that he was distracted by the electrical warning and continued to climb while trying to establish its cause. Had he remained within the immediate vicinity, he considers that he could have made it back to the airfield following the loss of engine power.

Loss of engine power

The engine operated normally on the ground following the forced landing and during subsequent examination several days later. No obvious cause for the loss of engine power was identified.

Debris of unknown origin was found and removed from the left wing tank prior to the flight. A post-incident examination by the LAA did not identify any debris or contamination in the fuel system or carburettor float bowls, and this was ruled out as a potential cause of the loss of engine power. No anomalies were noted during subsequent overhaul of the carburettors.

The issues associated with the use of Mogas are well documented in LAA TL 2.26. The ambient temperature on the day was between 19 and 21°C. The aircraft was sitting in the sun when the pilot arrived at the airfield and remained so for another two hours, which could have created potential for heat soaking of the fuel tanks. An extended engine ground running period would have caused high engine temperatures. Given the combination of these factors, it is possible that the temperature in the fuel tanks, or elsewhere in the fuel system, exceeded the 20°C operational limit for Mogas. This could have led to fuel vapourisation and vapour lock within the fuel system, interrupting the fuel flow to the carburettors, which in turn could account for the engine vibration and loss of power. The positioning of the left fuel tank vent may also have generated a lower than normal fuel tank pressure and could have contributed to any fuel vapourisation problems.

Laboratory testing of the fuel samples indicated that the ethanol content was well within the 5% allowable and the samples appeared to be consistent with the appropriate grade of Mogas for the time of year.

The weather conditions on the day created a likelihood of moderate carburettor icing at cruise power. The pilot recalled that he maintained the initial climb power setting while attempting to establish the reason for the electrical warning, reducing the likelihood that carburettor icing could have contributed to the loss of engine power.

Landing gear and electrical issues

Post-incident examination identified that the nose landing gear did not retract fully into its housing. It was not established whether this was related to landing gear adjustment issues or misalignment which may have occurred during the forced landing. The subsequent repair facility noted heat damage in the nosewheel housing which it considered was due to wheel friction.

While the aircraft manufacturer indicated that this would not necessarily prevent successful extension of the landing gear, correct adjustment of the landing gear system and its microswitches is crucial to ensure the landing gear electrical motor stops in the correct position. Improper adjustment can cause the motor to require greater than normal torque to actuate the gear and could cause the landing gear circuit breaker to trip to protect the mechanical aspects of the system. There was no indication of a problem with the landing gear system until the pilot attempted to lower the landing gear for the forced landing and he did not report the landing gear buzzer sounding. The importance of correct adjustment of the landing gear system and its microswitches has previously been promulgated by the LAA.

The pilot reported an aural '*electrical power*' warning during the climb. Based on the range of available engine parameter warnings it is likely that more specifically this was an ELECTRICAL CURRENT warning generated by the EFIS engine monitoring function. The extended engine running period on the ground may have depleted the aircraft's battery. There are many electrical loads in the aircraft, including two EFIS displays and all systems were likely to have been operating during the short flight. It is therefore possible that the additional and potentially increased electrical demand caused by raising the landing gear after takeoff, may have come close to, or exceeded the alternator output, leading to the ELECTRICAL CURRENT warning. This situation could have been further exacerbated by the loss of engine power and the alternator output would likely have remained insufficient to support operation of the landing gear motor, despite the pilot's attempts to reset the landing gear circuit breaker.

The aircraft owner reported that previous occurrences of the ELECTRICAL CURRENT warning were cleared by extending and raising the landing gear. While these actions may have temporarily resolved the problem on those occasions, this option was not available to the pilot during the incident flight. The previous warnings may have indicated that something was amiss with the set up of the landing gear system and/or its interaction with the electrical system.

The Pioneer 300 flight manual advises that in the event of an emergency forced landing, the landing gear should be retracted. While in different circumstances the problems with the landing gear could have resulted in an unsafe condition, in this instance it was perhaps fortuitous that the landing gear remained retracted. That the pilot attempted to lower the landing gear prior to the forced landing, may indicate that he was not fully conversant with the emergency procedures for the Pioneer 300.

Conclusion

The aircraft was not examined by the AAIB and the investigation did not conclusively identify the cause of the engine power loss or the landing gear problems. But given the weather conditions on the day and the use of Mogas, vapour lock in the fuel system was considered as a potential cause of the loss of engine power. The electrical current problem, either in isolation or in combination landing system adjustment issues, could account for the failure of the landing gear to extend when selected.

Faced with several warnings and system failures, the pilot prioritised flying the aircraft and completed a successful forced landing because his training and practice enabled him to identify a suitable landing site within the gliding capability of the aircraft.

INCIDENT

Aircraft Type and Registration:	Piper PA-28-161, G-BZDA
No & Type of Engines:	1 Lycoming O-320-D3G piston engine
Year of Manufacture:	2000 (Serial no: 2842087)
Date & Time (UTC):	13 September 2020 at 1742 hrs
Location:	White Waltham, Berkshire
Type of Flight:	Training
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Landing gear collapsed. Bent propeller blade and left wing root skin creased
Commander's Licence:	Private Pilot's Licence with Flying Instructor rating
Commander's Age:	60 years
Commander's Flying Experience:	1,008 hours (of which 574 were on type) Last 90 days - 71 hours Last 28 days - 35 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and enquiries by the AAIB

Synopsis

Climbing through 100 ft after takeoff from Runway 29R at White Waltham Airfield, G-BZDA's engine abruptly ran down. The instructor took control from the student, lowered the aircraft's nose and looked for a suitable landing area ahead. As the nose was lowered, the engine recovered to full power, so the instructor raised the nose to climb away again but the engine ran down a second time and stopped. The instructor turned the aircraft left towards open ground and carried out a forced landing. The student and instructor were unhurt and vacated the aircraft without assistance.

The loss of power resulted from the gascolator drain being inadvertently locked open leading to partial fuel starvation. Following this accident, the CAA released a Safety Notice reminding owners and operators of this potential hazard for aircraft fitted with lockable gascolator drains and recommending replacement with '*suitable, non-locking alternatives.*' The CAA also undertook to review the risk associated with lockable gascolator drains against current Airworthiness Directive criteria.

History of the flight

The accident flight was the fourth instructional flight of the day in G-BZDA for the instructor who was also the PIC. While his student undertook cockpit preparation, the instructor carried out a Transit Check in accordance with the PA-28 checklist. In addition to the Transit Check, he sampled fuel from both wing tank fuel drains and from the gascolator.

During the after-start checks it was noted that fuel pressure dropped when the fuel pump was turned off but stayed within the green range on the gauge, indicating to the instructor that the system was functioning satisfactorily.

The engine parameters were in the normal range during the before takeoff power check. On the takeoff roll the aircraft accelerated as expected but as G-BZDA climbed through 100 ft its engine abruptly ran down. The instructor took control, lowered the nose and looked for a suitable landing area while simultaneously transmitting a brief MAYDAY call. The engine then recovered to full power, so the instructor gently raised the nose to climb away. He had just started cancelling the MAYDAY when the engine ran down for a second time and stopped. With a railway line ahead, the instructor turned the aircraft hard left towards open ground and executed a forced landing. Although the nosewheel collapsed during the landing, the student and instructor were unhurt and able to vacate the aircraft without assistance.

The airfield fire service were the first responders on scene and observed fuel leaking from the aircraft's gascolator drain.

Gascolator drain valves

Background

The gascolator is a combined fuel filter and sump located upstream of the engine fuel inlet, normally at the lowest point of an aircraft's fuel supply system. It is designed to trap water and debris present in the fuel to prevent it from entering the engine fuel system. Gascolators are typically fitted with drain valves so that fuel can be drawn off to check for the presence of contaminants. These drains have an internal plunger which, when pushed inwards using a cross bar (Figure 1a), opens a valve allowing fuel to be drawn off through the body of the drain. On lockable variants the plunger mechanism can be held in the open position by rotating the cross bar into a locking detent (Figure 1b).

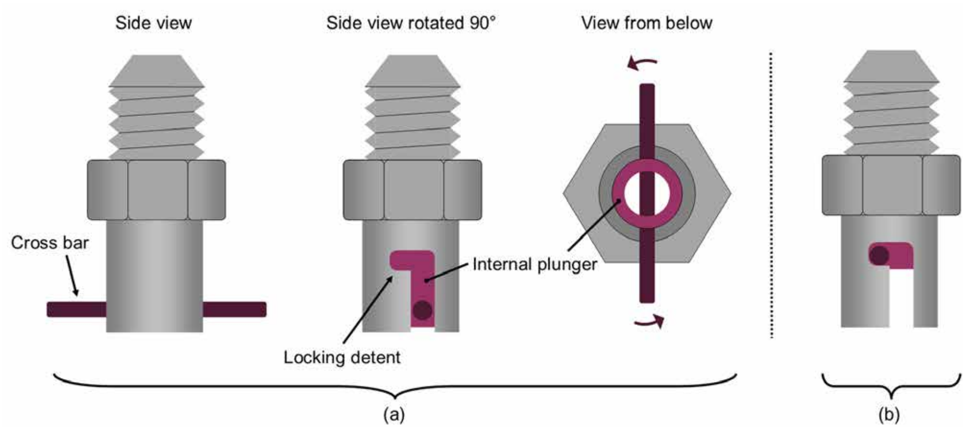

Figure 1

Lockable drain valve (a) closed (b) locked open (schematic)

With the drain valve in the open position fuel can leak from, and air can be drawn into, the gascolator leading to the risk of engine fuel starvation at high power settings, especially in climb attitudes.

Previous accidents

The AAIB investigated a gascolator drain-related accident involving a PA-28, G-BPBM, in December 1988[1]. The accident report referenced a service bulletin[2] issued in 1975 by the CAA's Chief Service Engineer (CSE) recommending removal of the locking feature on drain valves fitted to gascolators. This was to be achieved by filing away a portion of the valve body, thereby removing the detent, so that it could remain open only if actively held in that position (Figure 2).

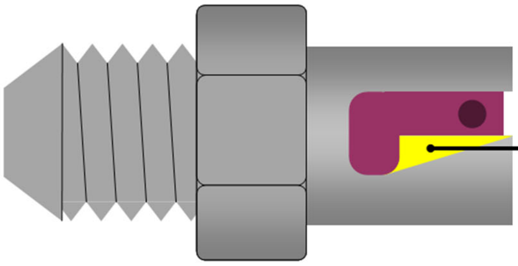

Figure 2
Drain valve with material to be removed indicated in yellow

The CAA publication, *General Aviation Safety Information Leaflet 12/88* (GASIL 12/88), also commented on the drain valve hazard and reiterated the recommendation that the CSE service bulletin be implemented. Following the G-BPBM accident, the AAIB recommended that the CAA require the deletion of the valve locking feature on any aircraft on the British register that could be affected adversely by this type of drain being left open.

A subsequent accident, involving G-BHFL in November 1989[3], appeared to have been caused by the same lockable gascolator drain problem. Since the drain locking feature was still present on G-BHFL, the AAIB reiterated its previous recommendation to modify such valves. In 1990 the CAA issued Emergency Airworthiness Directive (EAD) 001-02-90 which required affected aircraft to be placarded, alerting pilots to check the fuel drain was closed after use (Figure 3). G-BZDA was placarded in accordance with the EAD.

Footnote

[1] Piper PA28-161 Warrior, G-BPBM, 11 December 1988. Available at https://www.gov.uk/aaib-reports/piper-pa28-161-warrior-g-bpbm-11-december-1988 [accessed 17 December 2020].
[2] Chief Service Engineer Service Bulletin 6/75.
[3] https://assets.publishing.service.gov.uk/media/5422ebd140f0b613460000b3/Piper_PA-28-180__G-BHFL_02-90.pdf [accessed March 2021].

Figure 3

Placard wording introduced by EAD 001-02-90

In a 1993 Progress Report on their response to AAIB Safety Recommendations,[4] the CAA declared the following intention:

> *'In the absence of a manufacturer's Service Bulletin the CAA is preparing an Additional Airworthiness Directive, intended to replace EAD001-02-90, that will require the replacement of the existing 'Curtis' gascolator drain valves with alternative, non-lockable Curtis units on PA28 variants with fuel systems similar to those on the accident aircraft.'*

Documents pertaining to the 1993 Airworthiness Directive (AD) proposal were no longer in the CAA archive, so it could not be determined why the proposed additional AD was not published. Following this accident, the CAA undertook to re-assess the issue of lockable gascolator drain valves against the current AD criteria[5] to determine if issuing one would be appropriate.

Manufacturer action

The PA-28-Warrior III design, as documented in the aircraft manufacturer's Illustrated Parts Catalogues (IPC) dated October 1987, shows a non-locking valve[6] for the gascolator drain and a locking valve[7] for the wing tank drains. Prior to this, the manufacturer's IPC called for the same lockable drain in all three locations.

Footnote

[4] CAP 625 Progress Report 1993: CAA Responses to Air Accidents Investigation Branch (AAIB) Safety Recommendations. Available at https://publicapps.caa.co.uk/modalapplication.aspx?catid=1&pagetype=65&appid=11&mode=detail&id=132 [accessed February 2021].

[5] Aircraft Regulatory Framework Part 21 for aircraft previously managed by the EASA.

[6] Manufacturer's part number 492-312.

[7] Manufacturer's part number 492-022.

In 1989 the aircraft manufacturer determined that non-locking gascolator drain valves provided a '*higher level of safety*' and initiated a change to their technical drawings to replace the original valve with a non-locking variant. At that time the manufacturer determined no service action was required and that product improvement would be implemented using their IPCs and service replacement parts.

Remote from the engine fuel system, an open wing fuel tank drain would not lead to fuel starvation in the same way as an open gascolator drain, hence lockable variants are a permitted specification. Anecdotal evidence is that leaks from open wing tank drains are more obvious than those from gascolators.

G-BZDA's gascolator

G-BZDA would have been equipped with a non-lockable gascolator drain as standard when built, but when inspected after the accident it was found to have a lockable version (Figure 4). The investigation was not able to identify how, when or why the original drain had been replaced with the wrong variant.

Figure 4

Gascolator and drain removed from G-BZDA after the accident

Regulatory action

When the EASA was established in 2003, EAD 001-02-90 was cancelled and there was no replacement publication. The cancellation of the EAD was '*in the interests of harmonisation*' rather than an indication that the issue was fully resolved.

Two similar accidents involving New Zealand-registered aircraft in 2010 and 2011 prompted the CAA of New Zealand to issue ADs requiring the replacement of lockable gascolator drains with non-locking variants on PA-28[8] and PA-38[9] aircraft. While the aircraft manufacturer's technical support department knew of the accidents in New Zealand, they only became aware of the ADs following correspondence with the UK AAIB in relation to this investigation.

As a result of this accident, and after consultation with the AAIB, the UK CAA released Safety Notice SN-2021/005[10] reminding owners and operators of this potential hazard for aircraft fitted with lockable gascolator drains and recommending replacement with '*suitable, non-locking alternatives.*' The Safety Notice was later amended to further recommend that aircraft are checked at the next scheduled maintenance point, and where a non-lockable gascolator drain valve is fitted, any associated placard is removed to minimise the potential for confusion.

Discussion

This accident resulted from the aircraft's gascolator drain valve being inadvertently locked open after a fuel sample had been taken. The open drain caused partial fuel starvation leading to a loss of power when the aircraft was climbing shortly after takeoff.

The investigation found evidence dating back to 1975 that lockable gascolator drains were an identified hazard. The aircraft manufacturer changed their design standards in the late 1980s to eradicate the risk to new build aircraft and the New Zealand regulator later issued ADs as mitigation for older aircraft. G-BZDA was built to the revised design standard but had been fitted with a lockable drain valve at some point during its service life. The investigation was not able to determine how, why or when this maintenance error had occurred. The commonality of wing and gascolator drain fittings was considered one possible error pathway for which maintenance procedures were the primary barrier.

The investigation did not establish how many aircraft in the UK might remain at similar risk, but the CAA undertook to review the risk against current AD criteria. A CAA Safety Notice was published to raise awareness of the issue among owners and operators.

Footnote

8 Airworthiness Directive Schedule Aeroplanes Piper PA-28 Series (Cherokee, Cruiser, Warrior, Archer, Pathfinder, Dakota and Arrow), dated 28 January 2021. Available at https://www.aviation.govt.nz/assets/aircraft/airworthiness-directives/aeroplanes/PA28.pdf [accessed 12 February 2021].

9 Airworthiness Directive Schedule Aeroplanes Piper PA-38-112 (Tomahawk), dated 27 October 2011. Available at https://www.aviation.govt.nz/assets/aircraft/airworthiness-directives/aeroplanes/pa38.pdf [accessed 12 February 2021].

10 CAA Safety Notice SN-2021/005: Lockable Gascolator Drain Valves on General Aviation Aircraft, issued 4 February 2021. Available at https://publicapps.caa.co.uk/modalapplication.aspx?catid=1&pagetype=65&appid=11&mode=detail&id=10140 [accessed 12 February 2021].

Safety action

Following this event, the UK CAA undertook the following Safety Action.

Safety Notice SN-2021/005 was released, highlighting to owners, operators and pilots, the risks associated with lockable gascolator drains and recommending replacement with '*suitable, non-locking alternatives.*' This was later amended to include a recommendation that aircraft be checked for appropriate placarding at the next scheduled maintenance event.

Due to the lack of documentary evidence available to them regarding the decision not to replace EAD001-02-90, the CAA undertook to review the issue of lockable gascolator drains against current AD criteria.

ACCIDENT

Aircraft Type and Registration:	Piper PA-28-161 Warrior II, G-BTRY
No & Type of Engines:	1 Lycoming O-320-D3G piston engine
Year of Manufacture:	1981 (Serial no: 28-8116190)
Date & Time (UTC):	13 September 2020 at 1655 hrs
Location:	Enstone Airfield, Oxfordshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to left main landing gear, left wing and tailplane
Commander's Licence:	Private Pilot's Licence
Commander's Age:	73 years
Commander's Flying Experience:	18,400 hours (of which 1,415 were on type) Last 90 days - 112 hours Last 28 days - 38 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

Whilst on final approach to land on Runway 26 at Enstone Airfield the pilot allowed the aircraft to descend too low and the aircraft struck a pile of gravel, causing the left main landing gear to detach from the aircraft. The pilot went around and diverted to Oxford Airport which had better fire and rescue services than Enstone Airfield. The aircraft departed the runway on landing at Oxford Airport, damaging the left wing and tailplane.

History of the flight

The pilot was returning to Enstone Airfield from Ledbury Airfield and, as the wind was light, he positioned the aircraft on a long final for Runway 08 to avoid landing into the setting sun. As the aircraft approached the airfield the pilot announced his intention to land on Runway 08 on the airfield's Air/Ground frequency, and he heard a radio call in response stating that the runway in use was Runway 26. The pilot replied stating that he would join downwind for Runway 26.

He was then observed to fly a circuit to the north of the airfield, to position the aircraft on an approach for Runway 26. The pilot stated that he found the glare of the setting sun distracting as he approached the runway, but that he could see the white frangible airfield boundary fence and runway markings clearly enough to continue the approach. An instructor in an aircraft that was waiting to depart at the Runway 26 holding point stated that G-BTRY was very low on the final approach.

The aircraft's left main landing gear tyre struck the top of a 3.5 m tall light-coloured pile of gravel that was being stored on a disused section of the airfield, outside the airfield boundary fence. The gravel pile was on the runway extended centreline, approximately 120 m from the runway threshold (Figure 1).

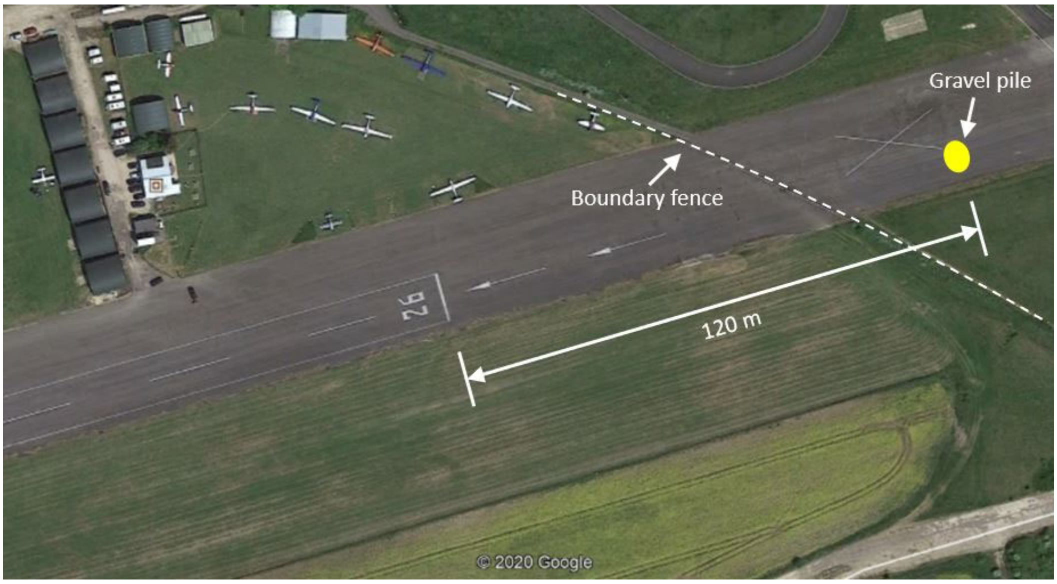

Figure 1

Gravel pile and Runway 26 threshold
(image © 2020 Google, Image © Getmapping plc, Infoterra Ltd & Bluesky, Maxar Technologies)

The impact caused the left landing gear leg to detach from the aircraft (Figure 2). The instructor made a radio call to the pilot, informing him that he had lost his left landing gear leg and that he should go around. The aircraft was observed to briefly touch down on the right main landing gear before the pilot applied power and the aircraft climbed away.

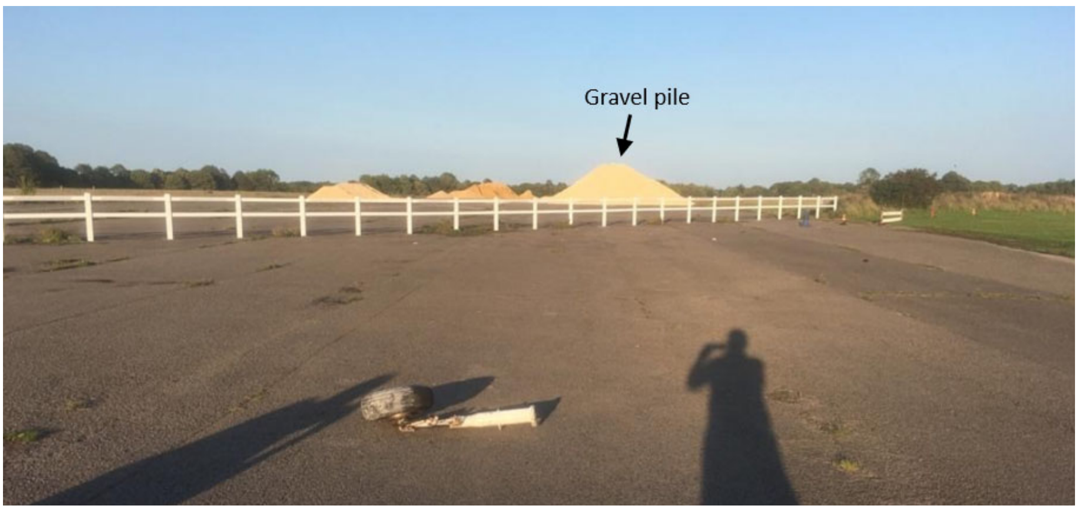

Figure 2

Gravel pile and detached landing gear leg

Having appraised the situation, and discussed his options with the instructor by radio, the pilot decided to divert to Oxford Airport as it had better rescue and firefighting equipment than Enstone. The instructor called Oxford Airport ATC by phone to brief them on the situation and to expect G-BTRY to arrive shortly. The pilot contacted Oxford Airport by radio and landed on Runway 19. Shortly after touchdown the aircraft left the runway's paved surface to the left, coming to rest on the grass (Figure 3). The damage to the aircraft was limited to the left wing and the tailplane, and neither the pilot nor his passenger were injured.

The pilot stated following the accident that he had been aware that the disused portion of the airfield was being used for the storage of sand and gravel.

Figure 3
G-BTRY after landing at Oxford Airport

CAP 793 Safe Operating Practices at Unlicenced Aerodromes

CAP 793 provides guidance on the recommended layout, physical characteristics and visual aids appropriate to safe operating practices at unlicenced aerodromes. Chapter 4, section 5 contains the following guidance in relation to obstacles:

> *Obstacles*
>
> *5.1 Anything that, because of its height or position, could be a hazard to an aircraft landing or taking off should be conspicuously marked if it cannot be practicably removed or minimised.*

Conclusion

The aircraft struck the gravel pile because it was too low on the final approach to Runway 26. The top of the gravel pile formed an angle of 1.7° to the Runway 26 threshold, well below a normal approach path angle of 3°. It is likely that the glare from the sun on the final approach, combined with the pilot's visual focus on identifying the runway threshold contributed to him allowing the aircraft to descend too low on the approach. The lack of a conspicuous marking on the top of the gravel pile, as recommended in CAP 793, probably contributed to the pilot's lack of perception of this obstacle.

Safety action

The airfield operator commented that following the accident the landowner of the disused portion of the airfield had reduced the height of the gravel piles and ensured that subsequent gravel storage occured further away from the airfield boundary, to remove the hazard to aircraft.

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 February - March 2021

31-Aug-20 **DJI Matrice 210 V1** Bath, Somerset
The UA was at about 6 m agl. Without warning it tilted forwards and dropped to the ground damaging the blades and the arms. It was not clear what the cause was, although the operator suspected one of the motors had failed.

09-Dec-20 **DJI Inspire 2** Oswestry, Shropshire
The pilot misjudged the position of the UA and it collided into a hill.

12-Jan-21 **DJI Mavic Pro 2** Dewsbury, West Yorkshire
The UA was being flown over open ground when it struck a bird. The UA fell to the ground damaging the rotor arms.

23-Jan-21 **Bumblebee** Roundway Down, nr Devizes, Wiltshire
The UAS was being flown using First Person View (FPV) goggles with a spotter. Connection with the UA was lost at 50 m range and the UA descended into a misty valley. The UA was found several days later.

01-Feb-21 **Mavic 2 Dual Enterprise** Northwich, Cheshire
UA made an uncommanded response and collided with a bridge. The UA fell to the ground.

02-Feb-21 **DJI Phantom III Professional** Near Ropley, Hampshire
Two minutes after takeoff, and without warning, the aircraft fell to the ground from a height of 25 m. The operator reported that the accident had occurred because one of the propellers had detached in-flight.

12-Feb-21 **Parrot Anafi** Bath, Somerset
Control of the UAS was lost and it flew away for 150 m and dropped to the ground.

16-Feb-21 **DJI Enterprise Mavic Dual** Longford Park, Coventry, West Midlands
While the UA was descending before landing, the operator misjudged the height of some trees and the UAS struck the tree canopy.

05-Mar-21 **DJI Phantom 4 V2.0** Near Sizewell, Suffolk
During a coastal survey, the UA took off and was climbing to a height of 300 ft. At approximately 280 ft, it banked, fell to the ground and was substantially damaged.

cont

Record-only UAS investigations reviewed February - March 2021 cont

09-Mar-21 **DJI Phantom 4** Whatley Quarry, Somerset

The UA lost power and fell approximately 40 m. It suffered extensive damage.

15-Mar-21 **Intel Falcon 8+** Petty Pool Farm, Cheshire

The pilot was flying the UA in preparation for a General Visual Line of Sight Certificate (GVC) practical assessment. During a 45° ascent manoeuvre the UA became lodged within a tree at approximately 20 m above ground level. The UA fell to the ground about 20 minutes after the collision.

17-Mar-21 **DJI Matrice 600 Pro** Silvertown Tunnel, Greenwich

The pilot flew the UA to avoid a bird. The UA struck a light fixture which caused the UA to tip, rotate and strike the ground. It came to rest on the ground within the safety zone.

20-Mar-21 **DJI Phantom** Altrincham, Cheshire

The UA struck a garden hedge and fell to the ground. The outer casing was significantly damaged.

01-Apr-21 **DJI Matrice 300RTK** West End, Surrey

The UA was being operated at approximately 60 m agl at night. There was a loud bang and the UA fell to the ground. The operator believed the UA was struck by a bird.

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).

ACCIDENT

Aircraft Type and Registration:	Europa, G-BXTD
No & Type of Engines:	1 Rotax 912-UL piston engine
Year of Manufacture:	2000 (Serial no: PFA 247-12772)
Date & Time (UTC):	28 July 2020 at 1226 hrs
Location:	Enstone Airfield, Oxfordshire
Type of Flight:	Private
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to right wing, undercarriage strut, flaps and fuselage aft of the wing
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	65 years
Commander's Flying Experience:	20,076 hours (of which 91 were on type) Last 90 days - 37 hours Last 28 days - 21 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and further inquiries made by the AAIB

Note: Prior to publication in the April Bulletin, it was noted that the incorrect version of this report had been sent to the printers. Therefore the version that appeared in the hard copy of the April Bulletin is incorrect. The correct version is printed below. The online version of the report, published on 8 April 2021, was amended at the time of publishing.

Synopsis

During a right turn and climb shortly after takeoff, the engine rapidly reduced speed and stopped. Unable to restart the engine, the instructor carried out a forced landing in a field. The aircraft was badly damaged but both occupants were uninjured.

The cause of the engine stoppage could not be positively determined. It was found that the bend radius of the oil pipe connected to the oil pump had narrowed the cross-section of the pipe, restricting oil flow into the engine. However, there were also possible causal factors of corrosion, due to an extended period in which the aircraft was not flown, and fatigue damage related to a previous incident.

History of the flight

On the morning of the accident, the weather at Enstone airfield was dry, clear and bright with over 10 km visibility. There was a light westerly wind with scattered clouds and the airfield runway surfaces were dry.

The intended flight was to be the first of a series of flights to enable an instructor to familiarise the owner with operating his Europa aircraft. The instructor was an experienced pilot holding an ATPL and Class Rating Instructor (Single Engine). The owner was also an experienced general aviation pilot.

The owner and instructor removed the aircraft from its trailer to prepare it for reassembly. Once satisfied it was rigged and assembled correctly, they prepared the aircraft for flight. Concerned that the engine had only been run for 44 minutes since the Permit to Fly check flight in December 2019, the instructor gave a detailed brief to the owner on the actions to take in the event of an emergency.

With the start-up checks complete, the engine was started and the aircraft taxied by the owner to grass strip Runway 26S. After completing engine power checks, the owner selected full power and commenced the takeoff roll. Both pilots reported that engine rpm, temperatures and pressures all remained normal during the takeoff. Both pilots also reported that it took slightly longer to achieve rotational speed than expected. They later attributed this to rolling resistance from the grass strip, the strip's upwards slope and the aircraft's weight, which had been calculated at just 2.1 kg below its maximum of 589.8 kg.

Once airborne and climbing, the rate of climb was 800 ft/min at 200 ft agl, which the owner and the instructor considered normal. The owner started a right turn to comply with local noise abatement measures when, at 520 ft agl, the engine rpm decreased over a period of approximately 5 seconds and then stopped. There were no indications of engine problems prior to the loss of rpm.

The instructor immediately took control of the aircraft and turned right, away from a large house near a wooded area and towards open fields. Estimating that they could not reach Enstone airfield safely, he promptly selected the most suitable field available for a forced landing. He pitched the nose of the aircraft down aggressively to maintain enough airspeed to reach the field while the owner attempted to restart the engine, but to no avail. The propeller did not move. The instructor called for the owner to switch the master and fuel switches off and touched down in the field of crops. As the landing speed was higher than normal, he realised they were going to run into a nearby hedgerow. He pulled hard on the brake lever, causing the aircraft to turn to face the opposite direction and the aircraft stopped before it reached the hedgerow.

Police, fire and ambulance services attended the scene but both pilots were uninjured and had climbed out of the aircraft before their arrival.

Accident site

Measuring the length of the path through the crops revealed that the aircraft had travelled approximately 50 metres along the ground before stopping. The landing and subsequent turn damaged the aircraft's right undercarriage outrigger, wing, flap and aileron. Cracks were evident in the rear fuselage between the cockpit and tail (Figure 1) and the tail section below the left elevator was also cracked and the skin distorted. There was no damage to the cockpit area.

Figure 1

Aircraft final resting position and cracks evident in the rear fuselage section

Aircraft history

Built in January 2000, the previous owner had reported that the aircraft had suffered a propeller strike and the propeller had been replaced. The engine was shock-load tested but no further repairs or replacement parts were considered necessary. The aircraft had flown less than 580 hours when it was placed in storage in 2013. He reported that he had run the engine monthly to keep it in working condition.

The new owner purchased the aircraft in March 2019 and started work to restore the aircraft to flight capability. He consulted with the aircraft manufacturer and an experienced Europa aircraft engineer to produce a detailed aircraft restoration and maintenance programme. He also completed a number of type conversion flights between March 2019 and February 2020 in a similar Europa aircraft.

The aircraft's LAA inspection and Permit to Fly check flight were completed on 2 December 2019 without incident and with the owner as passenger. Two more flights followed in February 2020 but no further flights were made in the aircraft before the day of the accident.

Engine examination

The exterior surfaces of the aircraft around the engine bay were clean although there was a small trail of oil under the aircraft from the oil breather 'catch-pot' overflow pipe. The oil tank and coolant levels were full.

When the propeller was turned, it rotated by 15° but would not turn any further. Rotax 912 UL engines are fitted with a torsional load absorption mechanism to reduce the effect of instantaneous loads during engine start, shut down and rapid power changes. This mechanism allows the propeller shaft to be rotated 15° before further rotation turns the engine crankshaft.

Before removing the engine, the owner noticed the cross-sectional shape of the pipe from the oil cooler had narrowed where it had been bent by 90° in order to connect it to the oil pump (Figure 2). On checking the Europa engine installation manual, the owner realised that an oil pipe with a pre-formed 90° bend was available, to avoid bending the pipe when connecting it to the pump. However, the owner also commented that later testing on a bench showed that this geometry only created an 'oval' cross-section in the pipe and did not 'kink' it. Further, the aircraft had flown with the pipe in this geometry for its Permit test flight and for a further flight as part of the owner's type conversion, with no indication of oil pressure problems at any stage.

Figure 2

Oil pipe showing narrowing at the bend connecting it to the pump

After removing the pistons from the engine, dents were found on the top surfaces (crown). The shape of the dents matched the edges of the cylinder inlet valves. None of the inlet valve stems were bent and the edges of the valves showed no signs of impact damage. The dents in the piston crowns were also coated with carbon deposits (Figure 3).

Figure 3
Piston crowns showing dents from impact with inlet valves

The No 4 piston had also been in contact with the cylinder head, creating cylinder head shaped dents in the crown (Figure 4).

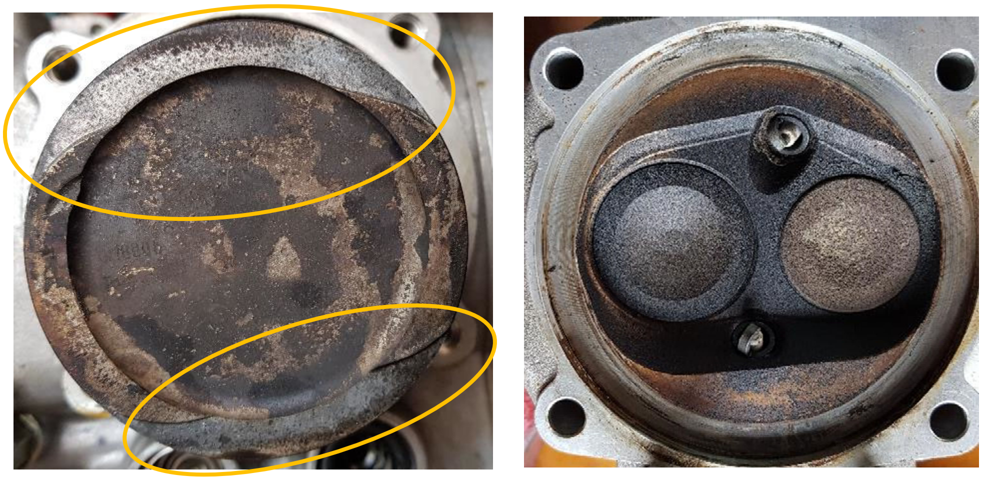

Figure 4
Piston crown (left) showing dents made by the cylinder head (right)

When the engine crankcase was opened, it was evident the No 4 piston connecting rod and bearing had failed at the attachment to the crankshaft (Figure 5). There were impact marks along the lower edges of the adjacent No 3 piston and cylinder.

Figure 5
Failed No 4 piston connecting rod

Surface pitting caused by corrosion was found around the sides of each piston below the piston rings.

Analysis

The inability to rotate the propeller beyond 15° indicated that the engine crankshaft was jammed and unable to rotate following the accident.

The sharp bend radius and distortion of the oil pipe at the connection to the oil pump would have caused oil flow to be restricted to the engine to some degree. However, the presence of oil in the crankcase, and over the working parts, shows that oil was reaching the working parts and the aircraft had flown a number of times in this condition, without adverse indications.

The inlet valve impact marks on the piston crowns indicate that an abnormal event, such as an engine overspeed after a propeller strike, had caused the valves and the pistons to collide at some point before the aircraft's purchase in 2019. The presence of carbon deposits in the dents also showed that the damage had occurred prior to the accident flight. Once the valves were removed and inspected, the owner determined that the valve stems were straight and there were no impact witness marks on the edge of the valve heads; the valves may have been replaced during a previous engine repair. The owner commented that he should have given more weight to the propeller strike information when deciding the depth of inspections necessary to restore the aircraft after the purchase in 2019.

Evidence of surface pitting around the sides of the pistons showed that a corrosive environment had existed within the crankcase and 'regular running' of the engine had probably not been enough to avoid corrosion damage during the extended period in which the aircraft was not flown. Corrosion-initiated fatigue may have weakened the engine's working parts, resulting in failure of the No 4 connecting rod.

Conclusion

The cause of the engine stoppage could not be positively determined. It was found that the bend radius of the oil pipe, connected to the oil pump, narrowed its cross section, restricting oil flow into the engine to some extent. However, bench tests of this geometry, and the fact that the aircraft had flown like this a number of times, indicated that it is unlikely to have been the major factor in the engine failure.

There were also indications of corrosion within the engine, probably due to an extended period in which the aircraft was not flown. There was further evidence of mechanical damage within the engine related to a previous incident, probably of a propeller strike and likely engine overspeed. The combination of these factors, the corrosion and mechanical damage, is more likely to have brought about the engine failure, through a fatigue mechanism in the No 4 connecting rod.

In considering these factors, the owner noted (as above) that after his purchase he should have given more weight to the reported propeller strike when deciding the depth of maintenance necessary to restore the aircraft. He also commented that his 'take-home' is that engines that have not been flown for many years should be treated with great caution.

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

3/2014 Agusta A109E, G-CRST
Near Vauxhall Bridge,
Central London
on 16 January 2013.

Published September 2014.

1/2015 Airbus A319-131, G-EUOE
London Heathrow Airport
on 24 May 2013.

Published July 2015.

2/2015 Boeing B787-8, ET-AOP
London Heathrow Airport
on 12 July 2013.

Published August 2015.

3/2015 Eurocopter (Deutschland) EC135 T2+, G-SPAO
Glasgow City Centre, Scotland
on 29 November 2013.

Published October 2015.

1/2016 AS332 L2 Super Puma, G-WNSB
on approach to Sumburgh Airport
on 23 August 2013.

Published March 2016.

2/2016 Saab 2000, G-LGNO
approximately 7 nm east of
Sumburgh Airport, Shetland
on 15 December 2014.

Published September 2016.

1/2017 Hawker Hunter T7, G-BXFI
near Shoreham Airport
on 22 August 2015.

Published March 2017.

1/2018 Sikorsky S-92A, G-WNSR
West Franklin wellhead platform,
North Sea
on 28 December 2016.

Published March 2018.

2/2018 Boeing 737-86J, C-FWGH
Belfast International Airport
on 21 July 2017.

Published November 2018.

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

Published March 2020.

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
DFDR	Digital Flight Data 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)
FIR	Flight Information Region
FL	Flight Level
ft	feet
ft/min	feet per minute
g	acceleration due to Earth's gravity
GPS	Global Positioning System
GPWS	Ground Proximity Warning System
hrs	hours (clock time as in 1200 hrs)
HP	high pressure
hPa	hectopascal (equivalent unit to mb)
IAS	indicated airspeed
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
IP	Intermediate Pressure
IR	Instrument Rating
ISA	International Standard Atmosphere
kg	kilogram(s)
KCAS	knots calibrated airspeed
KIAS	knots indicated airspeed
KTAS	knots true airspeed
km	kilometre(s)
kt	knot(s)
lb	pound(s)
LP	low pressure
LAA	Light Aircraft Association
LDA	Landing Distance Available
LPC	Licence Proficiency Check
m	metre(s)
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

AAIB
Air Accidents Investigation Branch