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(ALL TIMES IN THIS BULLETIN ARE UTC)

Reminder

IMPORTANT NOTICE

concerning **your** AAIB Bulletin

The AAIB is in the process of reviewing its Distribution List for the monthly Bulletin and plans to reduce the number of copies printed.

In order to help us achieve this - please download the Bulletin from our website:
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If, however, you still wish to continue receiving your Bulletin by post and you have **not** contacted us already, please **either**:

Email us at: publications@aaib.gov.uk - confirming your name, address and postcode
or
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If we do not receive a reply from you we will assume you no longer require a copy of the Bulletin posted to you.

Thank you

INCIDENT

Aircraft Type and Registration:	Boeing 737-800, EI-DHD
No & Type of Engines:	2 CFM 56-7B26 turbofan engines
Year of Manufacture:	2005
Date & Time (UTC):	23 December 2009 at 0847 hrs
Location:	Glasgow Prestwick Airport
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 6 Passengers - 129
Injuries:	Crew - None Passengers - None
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	33 years
Commander's Flying Experience:	5,557 hours (of which 1,832 were on type) Last 90 days - 113 hours Last 28 days - 78 hours
Information Source:	Airfield operator's investigation report and further enquiries by the AAIB

Synopsis

The aircraft made a normal landing on Runway 31 at Prestwick Airport. As the turnoff at the end of the runway approached, the brakes were applied, with no apparent effect, and the aircraft slid off the end of the runway onto the grass. There was no reported damage to the aircraft and there were no injuries to its occupants. The surface at the stop end of the runway was icy.

History of the flight

The United Kingdom had been experiencing snow and ice with sustained sub-zero temperatures for several days preceding the accident.

The aircraft was operating a scheduled service from Dublin, Ireland to Glasgow Prestwick Airport, UK. The commander was the handling pilot for the sector. Weather conditions at Prestwick were clear, with good visibility and no precipitation. A SNOWTAM issued at 0820 hrs described Runway 13 as having frozen ruts or ridges with a mean depth of 6mm in each third. Estimated braking action was listed as medium/good for all three thirds of the runway.

En-route the co-pilot listened to the ATIS information B, issued at 0824 hrs, which broadcast as follows:

> "RUNWAY 13, SURFACE WIND CALM, VISIBILITY 10 KM, FEW AT 3,000, TEMPERATURE -2°C, DEW

POINT -4°C, QNH 985 MB QFE 984 MB. RUNWAY WET, BRAKING ACTION MEDIUM GOOD DECIMAL THREE SEVEN, WET BRAKING ACTION MEDIUM GOOD DECIMAL THREE SIX, WET BRAKING ACTION MEDIUM GOOD DECIMAL THREE SIX. TAXIWAY ROMEO IS CLOSED EASTERLY FROM BRAVO TO WESTERLY HOLDING POINT QUEBEC DUE ICE. TAXIWAYS AND APRONS ARE EXTREMELY ICY, PLEASE USE CAUTION."

He informed the commander of the surface wind and the reported braking action; he added "AND IT'S ICY OBVIOUSLY". There was no further discussion between the crew about the surface conditions.

At 0835 hrs, the crew made contact with Prestwick Radar. They were advised that ATIS information B was current and that they were number two behind a company aircraft positioning to land on Runway 31. ATC asked which runway they would prefer and the crew opted for Runway 31. ATC also advised that Taxiway K was closed and that the aircraft would have to vacate the runway at J. A copy of the aerodrome chart is included at Figure 1.

The preceding company aircraft landed on Runway 31 at 0844 hrs and vacated successfully at the end onto Taxiway J.

At a distance of 4 nm on final approach, the crew noticed a temporary deviation in the localiser signal and had a brief discussion about the reason for it. The approach was continued and at 0846:50 hrs a normal touchdown was made on Runway 31. A closed circuit television camera recording showed that the aircraft touched down on Runway 31 in the touchdown area. ATC instructed the aircraft to vacate at J and proceed to Stand 3. The co-pilot replied and at the same time notified ATC that they had experienced a disturbance in the localiser signal at 4 nm.

The commander recalled cancelling the autobrake at about 100 kt and selecting reverse thrust at 60 kt, before allowing the aircraft to roll to the end of the runway prior to vacating. This was confirmed by the recorded data. Approaching the runway end, the brakes were re-applied but there was no apparent reduction in speed. Realising that the brakes were not decelerating the aircraft sufficiently, the commander increased the pressure to maximum and advised the co-pilot of the problem.

Braking was still ineffective, so, with the end of the runway approaching, the commander attempted to turn the aircraft 90° to the left, onto the taxiway, to avoid a runway excursion. The nose of the aircraft slewed 45° to the left but the wheels continued to track along the runway and the aircraft slid off the paved surface onto the grass at a groundspeed of 24 kt.

Recorded data indicated that the second application of braking started at 0847:24 hrs, at a groundspeed of 42 kt, using gentle pressure at first, increasing to the maximum. The aircraft left the paved surface thirty seconds later at 0847:54 hrs and travelled a further 20 m, before coming to a stop with the wheels having sunk into the grass.

The passengers and crew vacated the aircraft via the forward airstairs onto the grass and moved across to the surface of the taxiway and runway. Several people commented afterwards that the paved area was very slippery to stand on. Photographs of the runway and taxiway, which were taken at the time, appeared to show a glazed reflective surface, suggesting the presence of ice. There was no evidence of any technical problem with the braking systems of the aircraft.

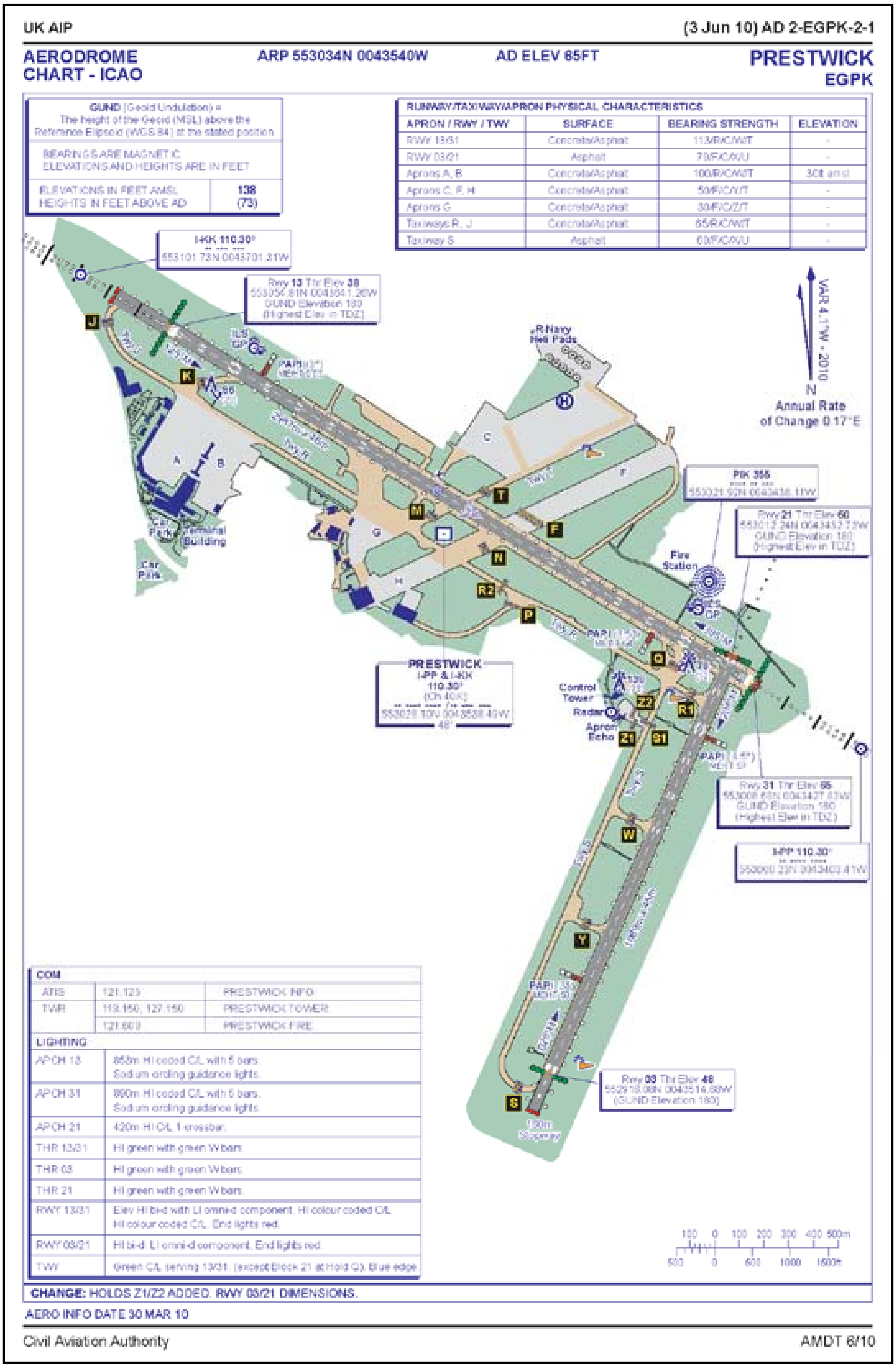

UK AIP
(3 Jun 10) AD 2-EGPK-2-1
AERODROME
CHART - ICAO
ARP 553034N 0043540W
AD ELEV 65FT
PRESTWICK
EGPK
GUND (Geoid Undulation) =
The height of the Geoid (MSL) above the
Reference Ellipsoid (WGS 84) at the stated position
BEARINGS ARE MAGNETIC
ELEVATIONS AND HEIGHTS ARE IN FEET
ELEVATIONS IN FEET AMSL
HEIGHTS IN FEET ABOVE AD
138
(73)
RUNWAY/TAXIWAY/APRON PHYSICAL CHARACTERISTICS
APRON / RWY / TWY | SURFACE | BEARING STRENGTH | ELEVATION
RWY 13/31 | Concrete/Asphalt | 113/R/C/W/T | -
RWY 03/21 | Asphalt | 70/F/C/X/U | -
Aprons A, B | Concrete/Asphalt | 100/R/C/W/T | 30ft amsl
Aprons C, F, H | Concrete/Asphalt | 50/F/C/Y/T | -
Aprons G | Concrete/Asphalt | 30/F/C/Z/T | -
Taxiways R, J | Concrete/Asphalt | 65/R/C/W/T | -
Taxiway S | Asphalt | 60/F/C/X/U | -
I-KK 110.30°
553101.73N 0043701.31W
Rwy 13 Thr Elev 38
553054.81N 0043641.26W
GUND Elevation 180
(Highest Elev in TDZ)
R.Navy
Heli Pads
VAR 4.1°W - 2010
Annual Rate
of Change 0.17°E
PIK 355
Rwy 21 Thr Elev 60
Fire
Station
Terminal
Building
Car
Park
PRESTWICK
I-PP & I-KK
110.30°
(Ch 40X)
Control
Tower
Radar
Apron
Echo
Rwy 31 Thr Elev 55
GUND Elevation 180
(Highest Elev in TDZ)
I-PP 110.30°
Rwy 03 Thr Elev 46
(GUND Elevation 180)
COM
ATIS | 121.125 | PRESTWICK INFO
TWR | 118.150, 127.150 | PRESTWICK TOWER
121.600 | PRESTWICK FIRE
LIGHTING
APCH 13 | 853m HI coded C/L with 5 bars. Sodium circling guidance lights.
APCH 31 | 890m HI coded C/L with 5 bars. Sodium circling guidance lights.
APCH 21 | 420m HI C/L 1 crossbar.
THR 13/31 | HI green with green W bars.
THR 03 | HI green with green W bars.
THR 21 | HI green with green W bars.
RWY 13/31 | Elev HI bi-d with LI omni-d component. HI colour coded C/L. HI colour coded C/L. End lights red.
RWY 03/21 | HI bi-d. LI omni-d component. End lights red.
TWY | Green C/L serving 13/31. (except Block 21 at Hold Q). Blue edge.
CHANGE: HOLDS Z1/Z2 ADDED. RWY 03/21 DIMENSIONS.
AERO INFO DATE 30 MAR 10
Civil Aviation Authority
AMDT 6/10

Figure 1

Airport information

Runway 31 at Prestwick has a LDA of 2,987 m and a width of 46 m. At 0430 hrs, Prestwick Airport Winter Operations team carried out a de-icing run on Runway 13/31 and links J, K and Q. The run encompassed an area 15 m either side of the centreline over the full length of main runway and 7.5 m either side of the taxiway centreline on the links. The de-icing rig was automatically limited to an application rate of 20 gram per square metre (g/m2), the rate appropriate for anti-icing. For de-icing, a rate of 30-70 g/m2, dependant upon temperature, is required.

At 0620 hrs ATC issued the following SNOWTAM:

> *'Runway 13 with frozen ruts or ridges with mean depth 6 mm each third. Additional comments – Runway 21/03 closed and taxiways & aprons useable with caution.'*

At 0747 hrs a Boeing 737 aircraft landed on Runway 13. Whilst back tracking, the pilot commented to ATC that there was no adverse effect on landing or braking. At 0758 hrs, a Mu-meter friction test was carried out on Runway 13 by Airfield Operations. The dual average readings taken were 0.37, 0.36 and 0.36. The runway condition at the time was wet full length, with ice patches full length and frozen slush along the full runway. At 0800 hrs, Airfield Operations personnel discussed the surface conditions on the airfield and an agreement was reached that at that time no further de-icing fluid was required.

After the incident the runway was temporarily closed. Re-declared distances were calculated for departures from Runway 13 and arrivals on Runway 31. At 1109 hrs, Mu meter readings of 0.42, 0.42 and 0.38 were obtained and the runway was re-opened.

Recorded information

The two flight recorders were recovered from the aircraft and replayed at the AAIB. Both contained a complete recording of the incident and the preceding events.

Following the incident, the crew pulled the circuit breakers to preserve the Flight Data Recorder (FDR) and the Cockpit Voice Recorder (CVR). This was in accordance with the data retention policy contained in the approved company Operations Manual.

EU OPS. 1.160 *'Preservation, Production and use of Flight Recorder Recordings'* requires that:

> *'(a) Preservation of recordings:*
>
> *1. Following an accident, the operator of an aeroplane on which a flight recorder is carried shall, to the extent possible, preserve the original recorded data pertaining to that accident, as retained by the recorder for a period of 60 days unless otherwise directed by the investigating authority.'*

In previous AAIB investigations, where CVRs have not been turned off and vital information has been lost as a consequence, the AAIB has made a number of Safety Recommendations[1] to both operators and regulators to review procedures and training with a view to enhancing the probability that vital recorded information is not lost following an incident or accident. The crew involved in this incident, acting in accordance with their operating procedures, ensured that FDR and CVR information would be available to the investigation.

Footnote

[1] Safety Recommendations 2010-012, 2010-011, 2008-064, 2006-063, 2006-062, 2005-054, 2005-053, 2005-052.

Discussion

The flight crew were both familiar with Prestwick Airport. After landing, they would normally have expected to vacate the runaway via the rapid exit onto Taxiway K. On this occasion, ATC advised the crew prior to landing that K was not available and that they would have to vacate at the end of the runway.

The co-pilot listened to the ATIS but did not pass on the exact detail of the 'EXTREMELY ICY' taxiways and apron. Perhaps because of this, there was no apparent discussion between the crew about the surface conditions and the potential problems with operating on a slippery surface.

A de-icing run was carried out on the runway but at an application rate only suitable for anti-icing. Therefore, it is likely to have been of limited effectiveness.

It was not possible to tell from the recorded data whether the aircraft maintained the centreline of the runway throughout the landing roll but it seems unlikely that it was outside the 30 m treated strip. The loss of braking effectiveness appears to have started at the onset of the second application of the brakes and, despite the commander having applied up to maximum brake pressure, continued until the aircraft left the paved surface. There was, therefore, a period of 30 seconds where the brakes were applied but were not appreciably slowing the aircraft. This suggests that the runway surface was slippery between K and J, at least in some areas, as the result of ice. There was no attempt to re-deploy reverse thrust, probably because it is an unusual action once cancelled. It could, however, have had some beneficial effect, although it does take a few seconds for engines at idle power to spool up.

The crew of the preceding aircraft did not report any difficulty with the braking action on the same runway four minutes earlier. Why there was a difference was not established.

The deviation in the localiser signal observed by the crew was co-incident with the preceding aircraft vacating the runway and probably occurred as a result.

Safety action

The airport operator identified a number of areas in their winter operations where their procedures could be improved and made appropriate safety recommendations, with a particular focus on anti-icing and de-icing operations. The airline operator has included a training module on operations to or from slippery runways in its recurrent training programme. Therefore, it is not considered necessary to make any further Safety Recommendations.

SERIOUS INCIDENT

Aircraft Type and Registration:	ERJ 190-200 LR Embraer 195, G-FBEE
No & Type of Engines:	2 General Electric CF34-10E7 turbofan engines
Year of Manufacture:	2007
Date & Time (UTC):	23 February 2010 at 1915 hrs
Location:	Jersey Airport, Channel Islands
Type of Flight:	Commercial Air Transport (Non-Revenue)
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	No 2 engine cowling detached and leading edge slat on right wing damaged
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	54 years
Commander's Flying Experience:	9,000 hours (of which 700 were on type) Last 90 days - 57 hours Last 28 days - 15 hours
Information Source:	AAIB Field Investigation

Synopsis

A post-flight inspection, by the crew, after a ferry flight from Jersey to Birmingham International Airport, revealed that both fan cowl doors on the No 2 engine were missing. The doors were later recovered from the runway at Jersey. Engineering rectification on the No 2 hydraulic system had been carried out prior to departure and latches on the fan cowl doors had not been fastened securely.

History of the flight

The aircraft had landed at Jersey with a complete loss of fluid from the No 2 hydraulic system, due to an in-flight leak from a pipe in the right engine pylon. Following rectification work, the commander and co-pilot were tasked with ferrying the aircraft to Birmingham International Airport; this was to be a non-revenue flight so no passengers were being carried.

It was dark and there were no engineering personnel present when the crew arrived at the aircraft to prepare for their flight. They telephoned maintenance control and were told that all work had been completed and the aircraft was "ready to go". The commander carried out the walk-round checks and found nothing amiss. The engine cowl latches are underneath the engine (Figure 1) and were not explicitly included in the walk-round checklist. Having checked the technical log and noting that the rectification work and a daily check had been accomplished, the crew departed Jersey without apparent incident. The flight to Birmingham was uneventful, although the commander felt that the aircraft was "a little noisy". The co-pilot was not concerned as he felt that the engine vibration was not unusual and was reading within limits, so the flight continued through to a normal landing.

After landing, another aircraft radioed the crew of G-FBEE advising them to check their right engine when they parked on stand. The commander did so and discovered that most of both engine fan cowl doors were missing. He advised Birmingham airfield operations to check their runway and forwarded a similar request to Jersey. As a result, the missing fragments of the fan cowl doors were located in the middle of Runway 27/09 at Jersey Airport.

Figure 1

Examination of the aircraft

The fan cowls of the Embraer 195 aircraft comprise two 'clamshell' doors of composite material, hinged at their top edge. When closed and fastened, three over-centre clamps on the outboard cowl engage with hooks on the inboard cowl and, when locked, the clamps are flush with the surface. When unlocked, the clamp levers protrude and their edges are painted 'dayglo' red to make them more conspicuous (Figure 1).

Upon inspection, it was found that the fan cowls of the right engine had torn away from their hinges, leaving only a small portion of the upper structure still attached. Examination of the debris recovered from the runway showed that it comprised a substantial piece of each cowl door and numerous smaller pieces. The lack of any damage to the clamps and hooks indicated that they had not been engaged and that this was the most likely reason for the detachment of the cowls. Damage to the airframe was limited to scuffing and denting of the leading edge slats and two punctures of the slat skin.

Pre-incident maintenance activity

The aircraft had arrived in Jersey on the evening of 22 February 2010. Since the loss of hydraulic fluid meant that the No 2 Engine Driven Pump (EDP) had run without fluid, there was a requirement to check it and the hydraulic filters. There was also a requirement to carry out an inspection of the landing gear, which had been deployed by free-fall. Additional inspection work was also required because the aircraft had landed at higher than normal speed due to the inability to select the appropriate landing flap setting. The EDP check entailed opening the engine cowlings, but the filter check required access behind the wing/fuselage fairing aft of the wing trailing edge. However, these two inspections were detailed as a single *'EDP/Filter check'* task in the maintenance manual.

Work was initiated by Technician 'A' on the late shift on 22 February 2010. He completed the EDP inspection but, having closed the engine cowlings, he was interrupted by a telephone call before he could latch them shut. When he finished the call he stated that "his mind was on the remaining structural inspections to be completed elsewhere on the aircraft" and "he forgot to lock the cowlings" before handing over to Technician 'B' on a different shift at 0530 hrs on 23 February 2010. The verbal handover was to the effect that Technician 'A' had completed the EDP inspection but had not checked the filters.

Technician 'B' concentrated on completing the pipe repair before handing over to Technician 'C' at 1330 hrs, with another verbal instruction to complete the filter checks as well as performing the landing gear inspection. Technician 'B' recalled seeing the unlatched cowlings, but assumed that further access in this area was required for the filter check. As stated previously, the filters are situated behind the wing/fuselage fairing aft of the trailing edge.

The filter check was completed by Technician 'C' who, having worked closely with Technician 'A' for many years, was content to certify both the previous EDP work and his own. He did not realise that throughout this period the engine cowl latches remained unfastened.

Discussion

The in-flight loss of one or both engine cowlings from a modern turbofan can cause additional damage and could jeopardise the safety of the aircraft or even people on the ground. In the case of G-FBEE, the consequential damage was relatively minor, albeit costly. AAIB Bulletin 7/2000 reported an incident to an Airbus A320 aircraft, registered G-VCED, in which both unlatched fan cowl doors on the left engine detached on rotation, causing damage to the flaps, slats, fuselage and fin as well as the engine and the destruction of the cowls themselves. The particular arrangement of the IAE V2500 engines on the A320 was similar to G-FBEE inasmuch as the fan cowls hang under gravity in an apparently closed position without an obvious gap with the adjacent structure. IAE had produced a modification to incorporate a spring-loaded plunger which would prevent the doors closing fully unless the plunger was manually pushed clear. The reason for this and other measures to improve conspicuity of open latches themselves was that, "several instances have been reported of Fan Cowl Doors not being latched prior to flight".

The primary factor in the events which led to G-FBEE taking off with the right engine cowlings unlatched was the distraction of Technician 'A' by a telephone call before he had completed the task. However, there were three further opportunities to address the situation which were also missed:

- Technician 'B' had seen the unlatched cowls but had assumed that further access to the area was required and that Technician 'C' would attend to this task as part of the filter check.
- Technician 'C' completed the filter check and assumed that Technician 'A' had latched the cowls upon completion of the EDP check, being content to sign for work he had not accomplished himself.
- The commander conducted a walk-round inspection but did not notice the unfastened cowling; it should be noted that although the walk-round checklist does state to *'check access panels are secured'*; this did not explicitly include the security of the engine cowls.

Safety actions taken to prevent recurrence

The operator has taken several actions as a result of the findings from this incident:

- An immediate message was sent to all engineers to ensure that, whenever Embraer 195 engine cowlings are opened, an entry in the technical log is raised which must be signed-for upon completion to certify that they are secure.
- All three technicians involved in the incident were given procedural training to reinforce the necessity to raise continuation sheets in the technical log or to use task cards to ensure that certification is carried out correctly.
- The Jersey station Engineering manager was reminded of the need for formal handovers and utilising technical log continuation sheets to break down long or complex tasks.
- The event was incorporated into the company's continuation training programme as an example of distraction and promoting awareness of using task breakdown sheets.
- A poster campaign was launched to highlight the issue of distraction and to remind technicians to check that all panels and doors are closed before despatch.
- A Notice to Aircrews was issued instructing them to include a check for security of the engine cowl fasteners during their pre-flight walk-round checks.

SERIOUS INCIDENT

Aircraft Type and Registration:	AgustaWestland AW139, G-CHCV
No & Type of Engines:	2 Pratt & Whitney Canada PT6C-67C turboshaft engines
Year of Manufacture:	2007
Date & Time (UTC):	23 December 2008 at 1405 hrs
Location:	The North Sea, 65 nm north-east of North Denes Heliport
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 2 Passengers - 8
Injuries:	Crew - None Passengers - None
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilots Licence (Helicopters)
Commander's Age:	45 years
Commander's Flying Experience:	7,311 hours (of which 833 hours were on type) Last 90 days - 113 hours Last 28 days - 43 hours
Information Source:	AAIB Field Investigation

Synopsis

Whilst on a flight from North Denes Heliport to a North Sea drilling platform, the aircraft's crew alerting system displayed a VNE MISCOMPARE message. This was followed by the loss of No 2 engine indications and other aircraft system parameters. The No 1 engine parameters indicated normal operation and the crew elected to return to North Denes Heliport. Whilst still in cloud, the crew received indications that there was a fire in the baggage compartment at the rear of the aircraft. The commander then lost all altitude, airspeed and vertical speed information from his Primary Flight Display. Once below cloud, another company helicopter flew alongside G-CHCV and confirmed that there was no evidence of fire and a safe landing ensued.

The spurious warnings and the loss of indications were found to be due to corrosion in an avionic module. The corrosion had occurred due to the module cabinet being cooled by unfiltered, non-conditioned air drawn from intakes on the fuselage underside. The situation was exacerbated by the helicopter being operated in a maritime environment.

One Safety Recommendation is made.

History of the flight

The crew of G-CHCV were on their first flight of the day and were tasked to carry eight passengers from North Denes Heliport to the Noble Julie Robertson drilling platform 88 nm to the north north-east. The en route and destination weather was forecast to be wind from 240° at 8 kt, visibility 6 km, overcast cloud at 1,200 ft and temperature 9°C.

G-CHCV took off at 1332 hrs and climbed to 2,000 ft on the regional QNH of 1030 mb where it was in IMC. The aircraft commander was PF in the right seat and the crew were in contact with Anglia Radar. The flight was uneventful until about 23 nm from the destination, when the crew recalled receiving a Crew Alert System (CAS) amber VNE MISCOMPARE message. This message is displayed when there is a difference in V_{NE}[1], as calculated by each of the two Modular Avionics Units (MAUs).

Immediately afterwards, the CAS displayed an ENG ANALOG FAILURE caution message, indicating the failure of an analogue engine parameter sensor. At the same time, information relating to No 2 engine systems was lost on the power plant page of the multi-function display (MFD). The crew reported losing indications of No 2 engine power index (a single scale composite display that provides the pilot with an indication of engine performance), inter-turbine temperature (ITT), oil temperatures and pressures and free turbine rotor rpm. In addition, they lost indications of the No 2 hydraulic system, the No 2 fuel quantity and the No 2 radio altimeter. There was also a caution message indicating failure of the No 2 pitot system.

There was no indication of a failure of the No 2 DC generator and the torque indication on the No 1 engine was indicating 50%. The crew assessed that these indications were consistent with both engines operating normally. They also concluded that the warnings and cautions displayed on the CAS were consistent with failure of the No 2 MAU except there was no 2 MAU message displayed on either Primary Flight Display (PFD).

At 1401 hrs, the crew decided to return to North Denes and, after coordination with Anglia Radar, they turned right on track for the heliport and began a descent to 1,500 ft. During the descent, the CAS generated a BAG FIRE warning, with its associated aural warning, indicating a fire in the baggage compartment. There was no red light on the fire control panel, no smell of burning and no smoke visible inside the cabin. The crew were unable to check for smoke outside as they were flying in cloud and the PNF declared a Mayday. During the transmission, information from the No 2 Air Data System (ADS) disappeared from the aircraft commander's PFD and he lost indications of barometric altitude, vertical speed and airspeed. The PNF switched No 1 ADS information to the right PFD, which restored these parameters to the commander's display but meant that both PFDs were using the same source for information.

The crew decided to descend to VMC below cloud, expecting to have to descend to about 1,200 ft amsl. In the event, they descended to below 200 ft amsl, to be in sight of the surface, and found the visibility to be 2,000 m. They assessed that the sea state was suitable for ditching and briefed for such an event, in case it proved necessary. During the transit back to North Denes the crew were unable to couple the flight director to the autopilot. About 10 nm before reaching the heliport, indications of the No1 free power turbine rpm (N_f1) and main rotor rpm (N_r) disappeared momentarily from both PFDs but there was no associated loss of power.

Just before reaching North Denes, a company helicopter flew alongside and confirmed that there was no smoke coming from G-CHCV's baggage compartment. At

Footnote

[1] V_{NE} the calculated helicopter never exceed speed.

1448 hrs, the aircraft landed without further incident. After landing, the passengers were evacuated, the aircraft was shut down and the emergency services inspected the baggage compartment to confirm that there was no fire.

Helicopter description

There are two basic variants of the AW 139: the 'short nose', which includes G-CHCV, and the later 'long nose', which include SAR aircraft. Approximately 170 short nose and 30 long nose aircraft are in service (as at February 2009), with the latter being the current production version.

The helicopter is equipped with the Honeywell Primus EPIC integrated avionic system, which was developed for fixed wing aircraft and currently equips types that include the Gulfstream IV and V, the Dassault Falcon X and Embraer 170/190 series aircraft. The AW139 is the first helicopter application for the system, with the type entering service during 2003. The EPIC system comprises two MAUs, each consisting of a cabinet that contains the functional modules, and each MAU has a main and auxiliary power supply. Should a MAU fail, multiple CAS cautions will be generated that could degrade the operational capability of the helicopter.

Description of the avionic system

1. Basic architecture

The Primus EPIC system architecture is the same for both the long and short nose airframes. However, in the long nose aircraft the MAU cabinets are located in the nose compartment, whereas in the short nose version they are installed either side of the baggage compartment aft of the cabin. Unlike all but one of the fixed wing installations, non-conditioned air is used for cooling the MAU cabinets. The MAU's function is to integrate the systems and sub-systems that supply the aircraft with navigation, communication, autoflight, indicating, recording and maintenance capabilities. Operation is via cockpit controls, sensors, displays and integrated computers.

At the heart of the system are the two MAUs; a generic block diagram of the system is shown in Figure 1. Each MAU consists of a cabinet equipped with Line Replaceable Modules (LRMs) which, for the AW139, may be different for each MAU, although most are duplicated. The module content can also vary between individual airframes: for example, MAU 1 contains a video module on Search and Rescue (SAR) aircraft, which are also flown by G-CHCV's operator. This processes the output from airframe-mounted video cameras. Communication and data processing within each MAU is managed by the Network Interface Controller/Processor (NIC/PROC), which also transmits and receives data from other systems on the aircraft on Aircraft Standard Communication Buses (ASCB) and Local Area Networks (LAN). A software function within the NIC/PROC monitors the aircraft systems and provides warnings, cautions and advisories through the CAS display.

Data from all airframe sensors are not wired directly to each MAU but wired separately to ensure segregation and to allow the MAUs to compare between duplicate sensors. Each MAU has visibility of data acquired by the other as, once acquired by the respective MAU, it is digitised and transmitted on the databuses. A majority of these parameters is acquired in the MAU Custom Input/Output module (CSIO).

Engine parameters are acquired by the MAUs from the Electronic Engine Controllers (EECs). Each EEC collects data from sensors installed on its respective engine and digitises it. This data is then transmitted to both MAUs so that in the event of a MAU failure

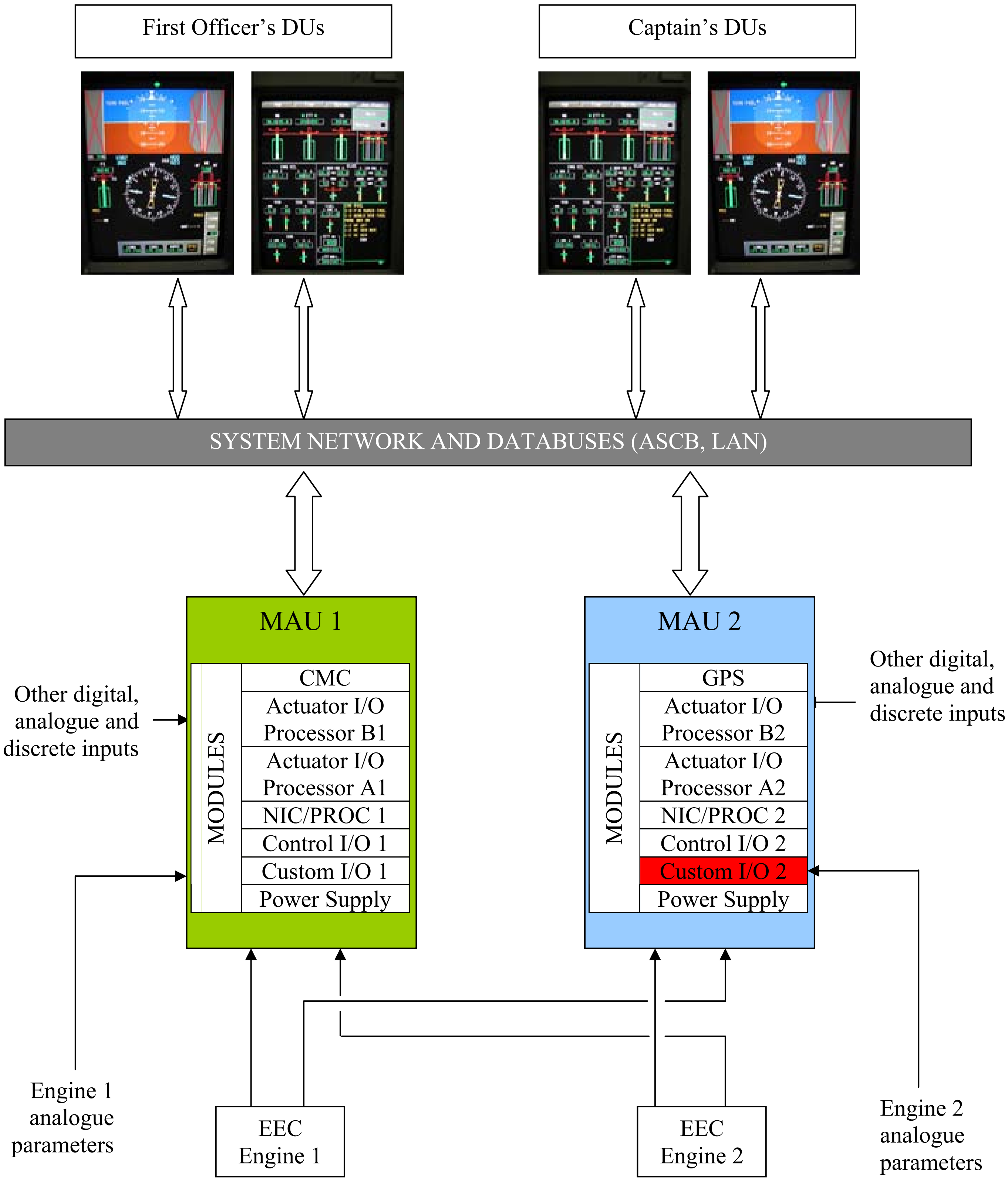


Figure 1

AW139 MAU installation

(caused, for example, by a power supply problem or a self-diagnosed shut-down), the data from both engines remains available. Data received from the EECs is referred to as 'digital' engine data. For redundancy purposes, some sensors are wired directly from the engine sensors to each MAU, bypassing the EECs. These parameters are referred to as 'analogue' engine parameters as they are acquired by the MAUs directly from the sensor. No 1 engine analogue parameters are only connected to MAU 1 and No 2 engine to MAU 2. The MAUs digitise the analogue parameters and transmit them on the ASCB. In the event of loss of any analogue engine parameters, an ENG ANALOGUE FAILURE message is displayed on the CAS.

Engine parameters are usually displayed on the MFD, with the system always defaulting (on power up) to the digital source. Logic within the Display Units (DUs) will always attempt to select valid engine parameters from the ASCBs. In the event of a fault with the digital data, the display can be 'forced' into analogue mode by using the cursor control device (CCD) on the cockpit pedestal to select a drop-down menu from the Powerplant system and selecting 'analog' from the options.

2. Module description

The modular design of the MAU provides flexibility in installation of the Primus EPIC system. Customisation of each airframe specific application is made possible by adding or removing the appropriate modules. In addition to the NIC/PROC, the MAU cabinets in G-CHCV also contained the following modules which were of relevance to the investigation:

- Central Maintenance Computer (CMC) Module. This contains the CMC function and the data loading function. It collects active faults from member systems, conducts Built in Test (BIT) routines and compiles a Fault History Database (FHDB).
- Control Input/Output (CIO) module. This supplies an interface for external input/output data on the ASCB and other data buses. It also supplies an interface for the system display controllers, the multifunction cockpit display units and CCD devices and additionally contains audio warning circuitry for the crew alerting system.
- Custom Input/Output (CSIO) modules (one in each MAU cabinet). This module performs a similar function to the CIO, with more databus transmitter/receivers. There are also a number of additional aircraft-specific inputs, including analogue discretes and 28V dc. An example would be the bag fire sensor, which is processed in each CSIO module in MAU 1 and MAU 2, CSIO1 and CSIO2, respectively.

MAU installation

In order to meet the MAU installation requirements for the short nose aircraft, the helicopter manufacturer provided ducting that directed cooling air from two scoops on the underside of the rear fuselage. The ducts were asymmetrically disposed, such that the outlet of one of them was immediately underneath the MAU 2 cabinet. No outside air is used for cooling in the long nose MAU installation.

Honeywell specified the MAU installation requirements in an Installation Bulletin which details items such as dimensional, cooling and environmental requirements. Part of this bulletin highlights that, when installed in the airframe, the MAU must be protected against exposure to water.

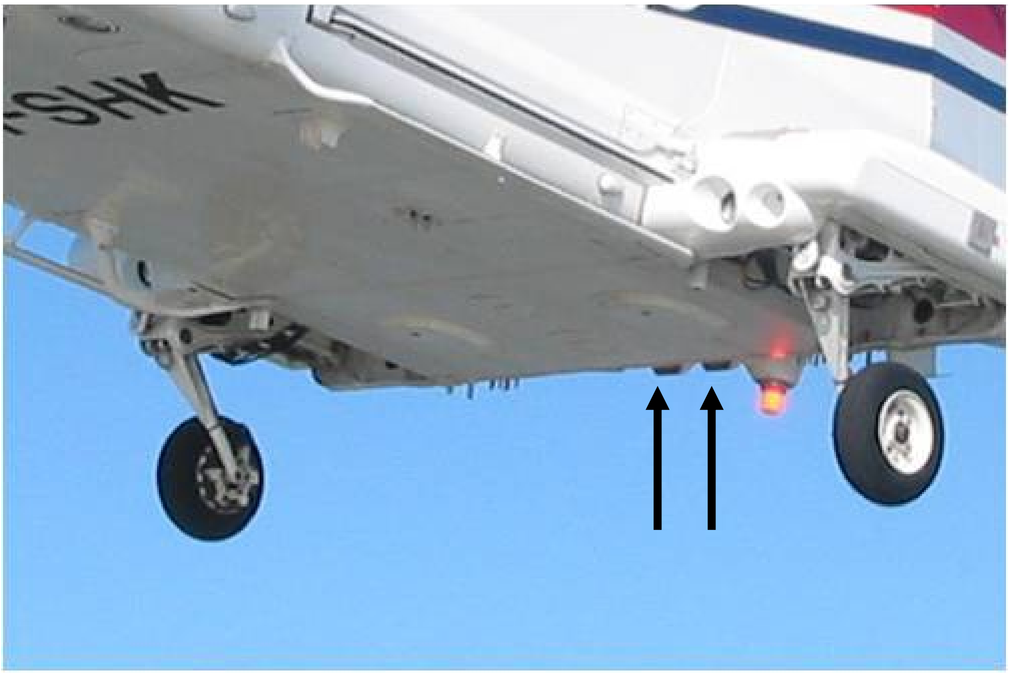


Figure 2

AW139 MAU Cooling Duct Intake Scoops

MAU hardware qualification

The environmental requirements for the MAU were agreed between Honeywell, AgustaWestland and the certification authorities during system development. These environmental requirements reference an RTCA document DO160D, '*Environmental Conditions and Test Procedures for Airborne Equipment'*, which defines a series of minimum standard environmental test conditions and applicable test procedures. Standards within DO160D are commonly adopted by airframe manufacturers and recognised by airworthiness authorities.

Amongst the tests agreed were those for *'humidity and water proofness'* (sic), for which the MAU was found to be compliant. DO160D calls for the humidity test to be performed in a controlled test chamber but without requirements for the equipment under test to be operational. Compliance is achieved by removing the equipment from the test chamber after exposure and applying power within one hour. A further 15 minutes is then allowed to warm up the equipment before determining whether or not susceptibility exists. For the water proofness tests, the manufacturer confirmed that the MAU was powered and suffered no failures when the environmental testing was performed.

The individual modules that are installed in each MAU were not required to be tested separately. Honeywell applied a spray-on conformal coating during manufacture which conferred a degree of water resistance. Whilst it is possible to provide a higher level of protection, for example by dipping the circuit boards into a container of the same liquid, it results in them being more difficult to repair during service.

Honeywell noted that no contamination-induced incidents had been reported in other Primus EPIC installations.

Baggage compartment fire detection

The baggage area is monitored by a smoke detector which is connected to both MAUs and the fire warning panel. If a baggage fire warning is detected, the crew should be alerted by a red light on the fire warning panel, a BAG FIRE CAS message and audio warning. The CAS warning will be displayed if either MAU detects a trigger from the smoke detector, but all audio warnings are generated by MAU 2. Figure 3 shows the system schematic diagram.

Recorded information

The aircraft was fitted with a Multi Purpose Flight Recorder (MPFR) which combined the functions of both flight data and cockpit voice recording. The MPFR was downloaded by the operator and provided to the AAIB for analysis. The MAU also contained a Fault History Database (FHDB) which logged detected failures for maintenance purposes. Due to late notification of the event, the voice recording was overwritten.

Data recorded by the MPFR is supplied by MAU 2, which transmits the same data as shown on the commander's displays. It indicated that G-CHCV was in cruise at a radio height of 2,100 ft, on a magnetic heading of 022°M and an indicated airspeed (IAS) of 145 kt. At 1358:48 hrs, the outside air temperature (OAT) parameter began increasing from 7°C and, over a 30-second period, reached 26°C, before failing (characterised by a drop to 0°C (see Figure 4). No 2 engine oil temperature, the tail rotor gearbox (TGB) and intermediate gearbox (IGB) oil temperatures and No 2 hydraulic system temperature also exhibited this characteristic rise, followed by failure. For clarity, Figure 4 only shows the OAT and No 2 engine oil temperature.

At the same time as the loss of these temperature parameters, data was lost from one of the two radio altimeters, No 2 engine ITT and, 20 seconds later, the No 2 engine power index. The loss of No 2 ITT caused the ENG ANALOGUE FAILURE warning and, five seconds later, the VNE MISCOMPARE warning was recorded.

V_{NE} is calculated as a function of pressure altitude and temperature. When there is a failure in the OAT probe, the V_{NE} computation is based on the current pressure altitude and the largest temperature value in a V_{NE} 'lookup' table. A VNE MISCOMPARE CAS warning is

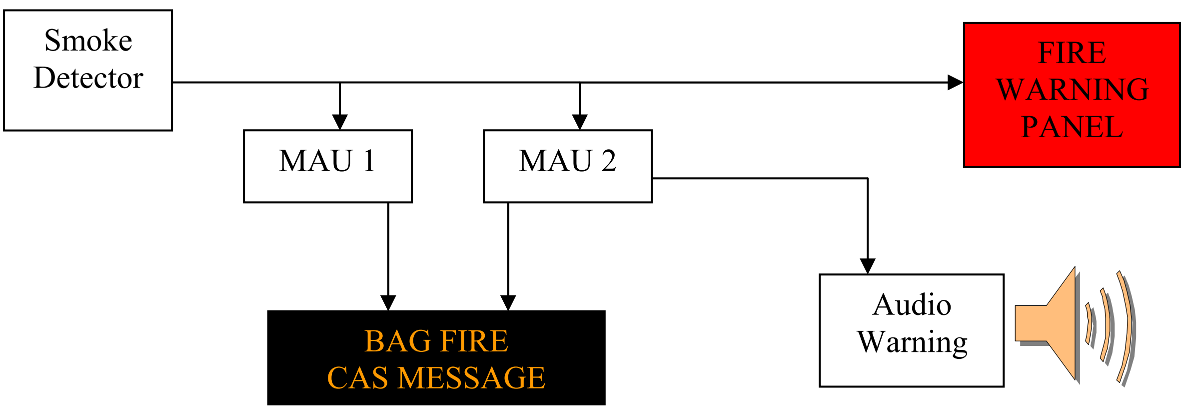


Figure 3

The baggage compartment fire detection system schematic

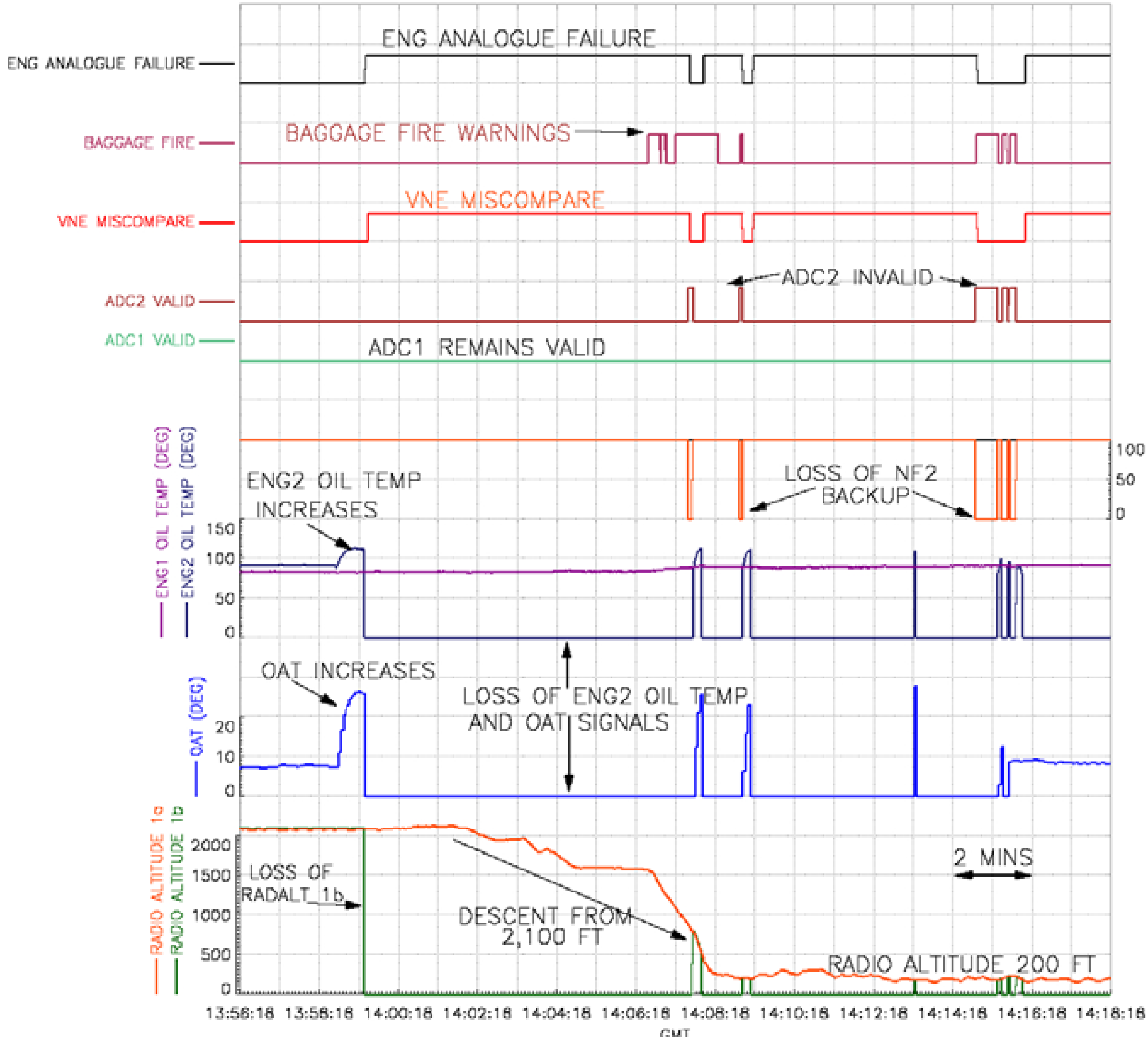


Figure 4

G-CHCV MPFR recorded parameters

generated when the V_{NE} calculated by MAU 1 differs from that calculated by MAU 2.

At 1401 hrs, G-CHCV turned back towards North Denes and began a descent from 2,100 ft to 1,600 ft. Just over five minutes later, the first baggage fire warning was recorded. The descent then continued, with G-CHCV levelling off at a radio altitude of approximately 200 ft and an IAS of 110 kt. During this descent, the recorded data shows loss of further engine analogue parameters and the failure of No 2 ADC (Air Data Computer No 2). This loss of data appeared to be reversible, with some data apparently recovering but then failing again (Figure 4).

Also recorded were more ENG ANALOGUE FAILURE and VNE MISCOMPARE messages and a total of 25 separate baggage fire warnings. No loss of digital engine parameters was recorded and it was not possible to ascertain whether the digital or analogue engine parameters had been selected for display on the MFD. There is a flight recorder parameter which should indicate this but, after investigation it was found not to be working. The manufacturer has confirmed that this will be rectified in the next MAU software standard.

An analysis of the CSIO2 module FHDB from 14 December 2008 up to the incident flight did not reveal any other VNE MISCOMPARE, ENG ANALOGUE FAILURE or baggage fire warnings. Recorded analogue data from MAU1 revealed that at 1433:32 hrs, there was a momentary loss of No 1 engine N_g and N_f and the analogue N_r calculated by MAU 1. This loss of data lasted for between one and seven seconds and could not be explained by the manufacturer. All other failed parameters and spurious warnings were attributed to data generated by the MAU 2 CSIO card.

Similar incidents to AgustaWestland AW139 helicopters

During the investigation of the incident to G-CHCV, the AAIB became aware of three similar incidents:

1. An aircraft was transiting at 3,000 ft in IMC when a BAG FIRE message appeared on the CAS. There was no red light on the fire control panel. About 10 to 15 seconds later a list of cautions appeared, including an amber 2 MAU indication on the PFD. The crew began a descent during which the baggage fire indication disappeared. The crew declared a PAN and carried out the actions in the emergency checklist, following which the aircraft landed without further incident. No evidence of fire was found during the subsequent inspection.

2. An aircraft had been left out overnight during which there had been torrential rain. During the flight, whilst in IMC, the FDR FAIL and CVR FAIL CAS messages appeared followed shortly afterwards by ENG ANALOGUE FAIL and VNE MISCOMPARE. The warnings disappeared after a short time but later the BAG FIRE message appeared for approximately 10 seconds although there were no signs of fire or smoke. Later in the flight, the SERVO 2 message illuminated and, later still, a number of messages appeared including: NOSE DOOR; ENG ANALOGUE FAIL; VNE MISCOMPARE; 1 FUEL LOW; HOOK ARM; FLOAT ARM. While dealing with these indications, the crew noticed that the aircraft had descended from 8,000 to 4,700 ft. The autopilot was engaged but none of the flight director modes that had been selected were annunciated on the PFD. While climbing, following this uncommanded descent, the CAS displayed 1 ENG OUT followed by 2 ENG OUT. Other indications confirmed the engines were still functioning. The crew saw the ground through some breaks in the cloud and were able to descend and make a visual approach to a nearby airport. A number of CAS messages remained on the MFD until after landing.

3. An aircraft had made an approach to a hospital in poor weather and was climbing in IMC during a go-around from a missed approach. The pilot saw multiple CAS messages and noticed that the airspeed, altitude and radio altitude had disappeared from his PFD. He switched No 1 ADS information to his PFD, which restored the

lost parameters, declared a PAN and decided to fly another approach. While climbing to 2,500 ft, he switched guidance controllers and re-engaged the heading and altitude acquire modes, confirming that the correct annunciations appeared on the PFD. He began to programme the flight management system for a further approach when he was told by the crewman that the aircraft was approaching 3,000 ft. The pilot re-selected 2,500 ft and noticed that a rate of descent of 750 ft/min was being shown on the PFD. He began to review the CAS messages with the crewman and saw that failures were indicated in the following systems: electrical, fuel and hydraulic; flight management; weather radar; flight control unit and autopilot; GPS and other avionics and aid data. When he looked back at the PFD, the pilot saw that the aircraft was approaching 3,300 ft. He regained control and flew the approach but, once again, was unable to land due to the weather. He then undertook a manually flown diversion to a nearby airport where he landed successfully.

Initial investigation of the G-CHCV modules

As noted earlier, no evidence of a fire was found after the aircraft had landed. The aircraft was subsequently powered up electrically and the systems functioned normally, with no repeat of the multiple failure indications.

MAU 2 was removed from the aircraft, which allowed the associated wiring and connectors to be inspected for damage; no defects were found. The MAU 2 modules were then removed and visually inspected for water damage, overheating, or any other defect. The fault history database (FHDB) generated by the Central Maintenance Computer (CMC) was downloaded and was found to contain a number of continuous failure entries. This, together with data from the MPFR, was reviewed by Honeywell, who advised removal of the NIC/PROC, power supply module and the CSIO card from MAU 2 and these were despatched to the manufacturer's facility. There, an examination, together with some initial tests, was conducted under the auspices of a local FAA official, who was appointed to look after the AAIB's interests.

The power supply module was found to be clean and functioned correctly on test. Similarly, no problems were found with the NIC/PROC module. However, inspection of the CSIO2 card revealed that it was contaminated with dirt and debris. In addition there was evidence of corrosion with what appeared to be copper oxide on the pins of some of the circuit card components. Figures 5a and 5b show photographs of the module and an example of the corrosion, the latter being from one of the Australian incident helicopters. It was then decided to conduct a series of tests on this module on Honeywell's MAU system test bench.

Tests on the CSIO2 circuit board

The presence of contamination and corrosion on the CSIO2 card strongly suggested that moisture had been present on the board during service and, thus, may have been responsible for the incident to G-CHCV, although no indications of water were apparent on the MAU modules after the event. However, during the investigations of the Australian incidents, water was found to be present in and around the MAU cabinets. Accordingly, it was decided to examine the behaviour of the CSIO2 card under damp conditions by subjecting it to a water spray during operation.

(Photo: Honeywell)

Figure 5a

A CSIO2 module

(Photo: Honeywell)

Figure 5b

Example of corrosion on another CSIO2 processor

Honeywell examined the CSIO2 module components with a view to establishing the input/output functions that were implicated in generating the invalid data that was responsible for the multiple CAS messages. Table 1 lists the signal inputs that were investigated.

The tests were conducted at a Honeywell facility in the presence of the AAIB and the helicopter manufacturer. The MAU system test bench was linked to an AW139 flight deck, which effectively functioned as a fixed base simulator. The system was loaded with the same application software standard which was installed on G-CHCV and the CSIO2 card was mounted on an extender board, which allowed it to be visible and accessible during test. The bench was then powered up so that any cockpit effects could be monitored. All the ASCB data generated during the tests was recorded and later analysed by Honeywell. This data represented everything that was available to the software responsible for such functions as the autopilot and cockpit displays.

The CSIO2 card operated normally, with no CAS messages. Thus it was considered that the contamination and corrosion had little or no effect when dry. The system was allowed to reach its working temperature, following which a short water spray, using deionised water, was applied to the area of the board that included, amongst other components, the central processing unit (CPU), which had the most corrosion. This resulted in a number of amber CAS messages, including VNE MISCOMPARE, although this subsequently disappeared. The OAT indication disappeared, followed by an ADS 2 failure message. This was accompanied by the loss of altitude, airspeed and vertical speed indications from the right hand cockpit display. These were replaced with

Signal Name	Signal Type
Analog ITT	Analog
No. 2 fuel pressure	Analog
Analog NG	Analog
Analog NF	Analog
Analog torque	Analog
Main Bus Voltage	Analog
Analog NR	Analog
Engine 2 oil pressure	Analog
Pitot 2 Fail	28V/Open Discrete In
Fuel quantity 1b	ARINC 429 Rx
No. 2 Hydraulic Oil Temp	Analog
Engine 2 oil temp	Analog
Fuel quantity 2b	ARINC 429 Rx
IGB temperature	Analog
Outside Air Temperature	Analog
Bag Fire Warning	28V/Open Discrete In
DC generator 2 amps	Analog
TGB temperature	Analog
Air Data Module	ARINC 429 Rx
Radar Altimeter	Analog

Table 1

red Xs, as occurred on the incident flight. In addition, some engine analogue indications failed, although the digital parameters remained.

After a few minutes the cockpit display indicated a slow decrease in altitude; there was no autopilot audio warning, although there was a chime. The observed effect was assumed to be the result of the loss of the No 2 ADS and appeared to mirror closely one of the Australian events. The problem was rectified by coupling the Flight Director to No 1 ADS.

A second water spray was then applied to the CSIO2 card, this time slightly away from the CPU, in the area of a bank of multiplexers. This produced no additional effects. A heat gun was used to dry the module, but none of the displayed faults unlatched. However, after MAU 2 was powered down and then restarted, all indications returned to normal.

Next, the spray was applied to the lower half of the CPU, with the remainder of the board masked off with a piece of card. This produced no cockpit effects, so the test was repeated with the complete CPU exposed, again with no effects. Two more sprays were applied close to the CPU, the second of which provoked three amber CAS messages and one red warning, MGB OIL TEMP. This represented the main gearbox over-temperature discrete, which was processed by the CSIO2 module. It was noted that the MGB temperature indication had remained within the green, ie normal, area of the indicating scale.

A reset operation was carried out in order to clear the CAS captions, followed by two additional spray applications. This produced the same captions as in the previous test, plus a drifting OAT 2 indication and the loss of some analogue indications. By this time the card was wet from the repeated spray applications, with the effects most probably becoming increasingly meaningless. However, it was decided to direct the final spray application in between the two circuit card assemblies that comprised the CSIO2 module. This resulted in three amber CAS captions, two of which subsequently disappeared. Then ENG 1 OUT, ENG 2 OUT messages appeared, together with the associated audio warning. There was also a momentary BAG FIRE warning. The module was then dried out but failed to reset, which suggested that permanent damage had occurred as a result of the repeated water applications. This was confirmed on a subsequent attempt to subject the module to an automated test, when the associated software failed to load.

An 'as new' CSI02 card was installed in the test bench MAU and a water spray applied to the general area of the CPU. After a few minutes the engine analogue data failed and an ADS2 message appeared, although all indications subsequently recovered to normal.

It was considered that the recovery of the replacement card, as it dried out, reflected the fact that the deionised water was of low conductivity, whereas, the contaminated components on the card from G-CHCV became conductive when wet, and remained so for considerably longer than with deionised water alone.

Finally, a fire detector sensor, which comprised a photoelectric device that operated on the light-scattering principle, was tested by spraying a water mist at it. This produced the appropriate warning when connected to a serviceable CSIO module.

Analysis of tests

After the tests, Honeywell conducted a detailed analysis of the extensive ACSB data, which was compared with the FHDB data from G-CHCV and the other incidents. The key findings are summarised as follows:

1. The tests reproduced the loss of engine analogue parameters, together with instances where digital engine parameter group data was recorded as *'invalid and stale'*. However, there was no effect on displays, as valid data continued to be supplied via MAU1. It was noteworthy that no similarly invalid digital engine parameter data was observed on the G-CHCV recording, although there was the loss of engine analogue parameters.

2. The data indicated that the CSIO2 module triggered the CAS BAG FIRE caption after water was sprayed between the two circuit boards of the module. Additional messages were generated simply as a result of water shorting out the 'Bag Fire 28V/Open Discrete' signal. However, it should be noted that the warning light on the Fire Control Panel is not connected to CSIO2 (or any other MAU module) and is only illuminated following activation of the bag fire sensor (see Figure 3).

3. The slow increase of the OAT 2 parameter seen in the G-CHCV MPFR data was also reflected in the ASCB data from the tests. One possible scenario was that failures in the analogue processors resulted in a loss of calibration, causing large changes in the calculated value. The software imposes a heavy filter on this value in order to damp out small fluctuations. Thus it would, in Honeywell's estimation, take around 30 seconds for the parameter to ramp up to a value where it became invalid, when the OAT display consists of a series of dashes. This represented a similar time period to the G-CHCV event, following which the signal was lost.

4. The OAT is used by the ADS, which in turn is used by the AFCS. If it determines that any differences between the ADS1 and ADS2 signals exceed monitoring thresholds, the AFCS declares that the ADS data is invalid. This results in the cancellation of Flight Director modes and the removal of the associated mode annunciations and guidance cues from the PFD. Other ADS signals monitored by the AFCS include Pressure Altitude, Altitude Rate and Calibrated Airspeed.

Finally, the investigation did not provide an explanation for the apparent loss of digital engine data reported by the crew of G-CHCV. During the tests, digital data remained available at all times, although the analogue failures were reproduced. Honeywell speculated that a graphical generation function software fault within the cockpit display units may have displayed the digital data as failed, when in fact it was valid. Alternatively, a similar software fault, either within the display units or the NIC/PROC, may have displayed analogue data despite digital data having been selected. However, Honeywell considered these scenarios to be unlikely in the light of a lack of other indications of hardware or software failures.

Examination of other MAU modules

In addition to the three incidents referred to earlier, other similar incidents came to light during the course of the investigation. Honeywell was also aware of a number of CSIO modules that their service centres had reported as displaying evidence of corrosion, although without associated incidents. Many of the modules were examined in Honeywell laboratories, which included energy dispersive X-ray analysis of the corrosion products. A high proportion was found to contain elements such as sodium and chlorine, which was indicative of operation in maritime environments. Other contaminants were consistent with dust and dirt being blown into the MAU cabinet.

The investigation additionally found that CIO and power supply modules had been affected by corrosion, although there had been no resulting incidents. All the affected modules were located in MAU 2, with their location close to a cabinet vent which was, in turn, near to the cooling duct outlet.

Safety action

In April 2009 AgustaWestland issued a Service Bulletin, Bollettino Tecnico BT AW139-166, which applied to short nose configuration helicopters. The purpose of the BT was twofold. Firstly, the power supply, CIO and CSIO modules of *both* MAUs were to be inspected for evidence of corrosion. The BT contained guidance material on accept/reject criteria, in order to assist in this process. Secondly, the cooling air duct was modified so that the outlet was moved away from the lower surface of the MAU 2 cabinet.

This BT was applicable to 168 short nose AW139 helicopters and, at March 2010, had been completed on 137, not applied on one, with no information available on the remaining 30. Embodiment of this BT is not mandatory.

In the case of the BAG FIRE warnings, the absence of the red light on the fire warning panel indicated that it had not been triggered by the smoke detector. The investigation indicated that the warnings were generated by a spurious signal in CSIO2.

Shortly after this incident, the Flight Manual was amended so that the flight crew should only take action if all three indicators are present in the event of a baggage fire warning, ie CAS message, red light on Fire Panel and audio warning.

Finally, as part of a product improvement update, Honeywell upgraded the Primus EPIC software to Phase 5 software in late 2009. This upgrade included correcting the problem of the MPFR not recording which engine parameters, analogue or digital, have been selected for display.

Analysis

1. Incident causes

The incidents involving G-CHCV and other helicopters occurred as a result of corrosion on the CSIO2 module installed in MAU 2. The corrosion had affected numerous pins on the components of the circuit board assemblies, which shorted out when they became conductive under the action of moisture, which in turn resulted in corrupted data being processed. In the case of G-CHCV, the resultant cascade of spurious warnings caused confusion on the flight deck as, in addition to the loss of ADS related information, the crew had difficulty in assessing the operational state of other aircraft systems. The BAG FIRE warning had a particular significance, as it raised the possibility of having to ditch, with the attendant risks to the aircraft and its occupants. Had the aircraft been equipped with the onboard video package, as installed in the SAR variant, the airframe mounted cameras could have been used to inspect for evidence of fire. Other incidents involved uncommanded descents, following disengagement of the autopilot and the potential risk to the aircraft with a busy, possibly distracted crew dealing with other CAS warnings. In all cases, upon reset on ground, the system recovered and the faults could not be reproduced during on-aircraft troubleshooting.

The nature of the occurrences, together with the detailed investigation conducted by Honeywell in support of the investigation, served to underline the complexity and high degree of integration of the Primus EPIC system. In particular, the level of integration resulted in an interdependency of the aircraft systems which rendered them vulnerable to what was, essentially, a common mode failure. This was abundantly illustrated by the fact that information from the engines, drive train, air data, fire detection and other systems is processed by the CSIO2 module; the redundancy conferred by multiple data paths is somewhat negated by this single point module.

The tests did not explain the apparent loss of digital engine data reported by the crew of G-CHCV; digital data remained available during the tests, although many of the analogue parameters had failed. The MPFR data from the incident similarly recorded no loss of digital data, although it was not possible to determine whether the digital or analogue displays had been selected. Honeywell investigated the possibility that a potential software failure could result in the cockpit display units and/or the NIC/PROC not displaying digital data or displaying it as having failed, despite there being valid engine data on the ASCB. However, there were no other indications of such failures, which would have been in addition to, and coincident with, the failures on the CSIO2 module. Despite the fact that the NIC/PROC was changed following the incident, it is considered that a failure of this nature was unlikely.

The cockpit displays would have defaulted to digital data when the helicopter was powered up. Changing to analogue data requires the use of a cursor control device and, hence, is unlikely to have been accomplished accidentally by one of the crew. A potential explanation is that the analogue display had been selected earlier in the flight and subsequently was not reselected to digital. However, the crew did not recall having changed the engine data display during the flight.

2. MAU installation and validation

During the course of the investigation it became apparent that the issue of corrosion was widespread, although in many cases it had not progressed to the stage where it caused an incident. Whilst the corrosion had also affected other modules, the incidents invariably stemmed from the CSIO module in MAU 2. The source of the corrosion was attributed to moisture in unfiltered cooling air, which was drawn from a duct intake on the fuselage underside and discharged directly onto the MAU 2 cabinet, with the affected modules being located close to the cabinet vents.

The corrosion and the ensuing incidents are typical of development problems that can occur on new or, in this case, relatively new, aircraft types. This was the first helicopter application for the Primus EPIC, which differed from its previous, fixed-wing installations in that unfiltered, non-conditioned air was used for cooling. This, in combination with the helicopter's predominant operation at low altitudes in salt-laden air, generated the conditions that resulted in corrosion on the module components. With the benefit of hindsight, it might have been beneficial if the avionic and helicopter manufacturers had been aware of such a possibility and developed a temporary module inspection programme for the early years of service. Honeywell service stations were noting evidence of corrosion on modules returned for repair and had recently initiated an investigation.

As part of the certification process, the MAU had demonstrated compliance with the specified environmental standards; some confidence in the process has been demonstrated in that the incidents discussed here have not occurred on any other Primus EPIC-equipped aircraft. With complex equipment it is difficult to predict, using failure mode/effect analyses, the full range of failure modes and their associated indications. Honeywell had anticipated the common mode failure of moisture ingress in the MAU cabinets and had addressed this by means of the requirements in the Installation Bulletin.

Environmental testing is unlikely to generate corrosion and its associated products. However moisture penetration may well produce the sort of problems likely to occur in service, a fact that was demonstrated during this investigation when a 'new' CSIO module was subjected to water spray tests.

Safety Recommendation

In the event of a common mode failure in part of an integrated avionic system, there can be potentially more serious consequences, relative to earlier generations of equipment, in terms of loss of essential parameter indications and spurious system warnings.

After extensive testing and investigation, it has been concluded that the Primus EPIC system MAU installed on the short nose version AW139 is susceptible to failures in the event of moisture ingress. Although measures have been introduced to remove a likely source of moisture, the modification to the ducted air supply to MAU 2 is not mandatory. As a result, the following Safety Recommendation is made:

Safety Recommendation 2010-077

It is recommended that the European Aviation Safety Agency mandate the embodiment of the AgustaWestland Bollettino Tecnico BT AW139-166 on all short nose versions of the AgustaWestland AW139.

ACCIDENT

Aircraft Type and Registration:	Beechcraft Baron B58, N27MW
No & Type of Engines:	2 Continental IO-520-C piston engines
Year of Manufacture:	1978
Date & Time (UTC):	26 September 2009 at 1304 hrs
Location:	Runway 09, Guernsey Airport, Guernsey
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to landing gear, engines and propellers
Commander's Licence:	Private Pilot's Licence
Commander's Age:	45 years
Commander's Flying Experience:	428 hours (of which 13 were on type) Last 90 days - 50 hours Last 28 days - 11 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Whilst performing a touch-and-go on Runway 09 at Guernsey, the landing gear was inadvertently retracted instead of the flaps.

ACCIDENT

Aircraft Type and Registration:	Cessna 152, G-BWNC	
No & Type of Engines:	1 Lycoming O-235-L2C piston engine	
Year of Manufacture:	1980	
Date & Time (UTC):	30 June 2010 at 1058 hrs	
Location:	Wellesbourne Mountford Aerodrome, Warwickshire	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - None
Injuries:	Crew - None	Passengers - N/A
Nature of Damage:	Damage to nose landing gear, engine mounting frame, propeller and engine bulkhead	
Commander's Licence:	Student Pilot	
Commander's Age:	17 years	
Commander's Flying Experience:	13 hours (of which 13 were on type) Last 90 days - 13 hours Last 28 days - 13 hours	
Information Source:	Aircraft Accident Report Form submitted by the student's flying school and AAIB enquiries	

The student had satisfactorily flown three circuits with her instructor who then authorised her to undertake her first solo flight. The wind was light and variable, and the flight was uneventful until late on the approach when the student felt she was "a little high". In order to reduce height she pushed the control column slightly forward and then flared the aircraft sufficiently for it to land on both main wheels. The aircraft then bounced three times and on the final touchdown the nose leg collapsed. The student, who was unhurt, made the aircraft safe and informed the Flight Information Service Officer (FISO), by radio, of the accident.

ACCIDENT

Aircraft Type and Registration:	Cessna 172M Skyhawk, G-BBKZ
No & Type of Engines:	1 Lycoming O-320-E2D piston engine
Year of Manufacture:	1973
Date & Time (UTC):	25 June 2010 at 1058 hrs
Location:	Land's End Airport, Cornwall
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Propeller, engine shock loaded, ventral antenna, cowling, left wheel cover
Commander's Licence:	Private Pilot's Licence
Commander's Age:	68 years
Commander's Flying Experience:	345 hours (of which 283 were on type) Last 90 days - 5 hours Last 28 days - 5 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The aircraft departed Exeter for a cross country flight to Land's End (St Just) Airport. The weather was good and the transit was uneventful. The weather at St Just was wind calm, visibility in excess of 10 km and cloud FEW at 2,000 ft. The pilot was cleared for a straight-in approach for the left side of Runway 25 but the first approach was abandoned. A go-around was executed, with the aircraft being positioned downwind for Runway 25. Excessive altitude was gained during the go-around and the aircraft was still high when it was established on the final approach to Runway 25. In an attempt to lose height, power was reduced to idle and full flap lowered. The aircraft touched down at about the midpoint of the 695 metre dry, grass runway and, despite maximum braking, overran the end, entered a hedge at low speed and collided with the airport perimeter fence. The occupants were uninjured and vacated the aircraft through the normal exit. The pilot considered that he had landed long and fast in the calm wind conditions, with the down slope at the western end of the runway possibly a contributory factor.

ACCIDENT

Aircraft Type and Registration:	Cessna 177A Cardinal, G-BTSZ
No & Type of Engines:	1 Lycoming O-360-A2F piston engine
Year of Manufacture:	1969
Date & Time (UTC):	26 May 2010 at 1018 hrs
Location:	Tempsford Airfield (disused), Bedfordshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 2
Injuries:	Crew - 1 (Minor) Passengers - 2 (Minor)
Nature of Damage:	Landing gear collapsed and damage to the propeller
Commander's Licence:	Private Pilot's Licence
Commander's Age:	68 years
Commander's Flying Experience:	1,432 hours (of which 118 were on type) Last 90 days - 43 hours Last 28 days - 13 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and information provided by maintenance organisation

Synopsis

Approximately 15 minutes into a local area flight from Cranfield, the aircraft's engine began to misfire. The pilot applied carburettor heat, to no effect, and then observed that both fuel quantity gauges indicated that the fuel tanks were empty. The pilot carried out a forced landing, during which the nose landing gear collapsed. Subsequent investigation showed that the probable cause of the loss of power was the build up of water-contaminated fuel residue in the engine fuel strainer drain mechanism, which prevented the drain from closing fully after the pre-flight checks and resulted in the loss of fuel.

History of the flight

The pilot had arranged to take two passengers for a flight from Cranfield to the local area. On arrival at the aircraft he visually inspected the fuel tank contents and estimated that there was sufficient fuel, approximately 22 gallons, for two hours of flight. The engine fuel strainer (gascolator) drain operating handle was located on the upper right engine cowling and when opened discharged fuel through a pipe extending through the lower left engine cowling. The pilot completed the engine fuel strainer drain check, with the assistance of one of his passengers, and no abnormalities were observed during the pre-flight checks.

After engine start, the aircraft was held on the ground for 15 minutes due to other movements in the circuit. Approximately 15 minutes after takeoff the engine began to misfire, so the pilot selected the carburettor heat to ON, which had no effect. The pilot then checked the two fuel quantity gauges which showed both fuel tanks to be empty. After establishing the aircraft in a glide, the pilot informed ATC of the problem and his intention to carry out a forced landing at a disused airfield in the vicinity. During the approach, he realised that the aircraft would not reach the remaining section of runway, so he carried out a landing on an area of ploughed ground to the north of the site. The nose landing gear failed during the ground roll and the occupants suffered minor injuries but were able to leave the aircraft unassisted.

Investigation

The pilot confirmed that his estimation of the fuel quantity prior to the flight was made by visual assessment of the depth of fuel observed through the fuel tank filler necks. The tank necks were not fitted with 'tabs' to assist with this estimation. The pilot also commented that approximately 18 months ago he had experienced a problem with the engine fuel strainer (gascolator) drain being difficult to operate and close fully, but this had been rectified. He also stated that he placed covers over the wing fuel filler caps when the aircraft was parked to help prevent water contamination of the fuel system. The maintenance organisation who later examined the aircraft confirmed that it was fitted with an early standard of fuel filler caps, which are more prone to water ingress than the 'raised umbrella' type of fuel filler cap.

Inspection of the aircraft's fuel tanks confirmed that they were empty and there was evidence of an in-flight fuel leak from the engine fuel strainer drain. In view of the previous problems with the fuel strainer, tests were carried out which confirmed that, after operation, the drain valve could stick in a partially open position producing a leak rate of between 18 and 24 gallons per hour. When the filter drain mechanism was disassembled it was found contaminated by a large deposit of waxy material, similar to that produced when fuel is contaminated with water. After cleaning and reassembly, the fuel filter drain operated normally. It is possible that the deposits in the fuel drain mechanism prevented the closure of the fuel strainer drain, which then resulted in an unobserved fuel leak.

On 30 July 2010 the Federal Aviation Administration published Special Airworthiness Information Bulletin SAIB CE-10-40R1 advising owners and operators of Cessna 100, 200 and 300 series aircraft of the hazards of water contamination of the fuel system and methods of minimising water ingress, including the use of a new 'raised umbrella' type of fuel filler cap.

ACCIDENT

Aircraft Type and Registration:	Cirrus SR22, N404RW
No & Type of Engines:	1 Continental Motors IO-550-N piston engine
Year of Manufacture:	2009
Date & Time (UTC):	5 April 2010 at 1253 hrs
Location:	White Waltham Airfield, Berkshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Private Pilot's Licence
Commander's Age:	51 years
Commander's Flying Experience:	400 hours (of which 15 were on type) Last 90 days - 45 hours Last 28 days - 10 hours
Information Source:	AAIB Field Investigation

Synopsis

During takeoff on the undulating grass runway, the aircraft became airborne at a low speed, rolled rapidly, and cartwheeled. The runway profile and the pilot's lack of training and experience on the aircraft type were possible contributory factors.

History of the flight

The pilot planned to fly the aircraft to a nearby airport to practise instrument approaches. He was accompanied by the aircraft owner, who was also a pilot, and who sat in the right hand seat. The two discussed the flight before departure and agreed that the owner would act as co-pilot, operating the radio; this was their normal arrangement when they flew together. Both understood clearly that the pilot, not the owner, would be in command of the flight. The pilot had not received any formal training on the Cirrus aircraft.

They boarded the aircraft, started the engine, and taxied for departure. The wind was approximately 220/15 kt and the grass Runway 21 was in use. The flaps were set to 50% for takeoff and the trim was set slightly towards the aft end of the takeoff range. Having completed a normal power check, the pilot lined the aircraft up for takeoff and applied full power. He reported that he kept the control column approximately neutral in pitch during the takeoff roll.

The pilot stated that the aircraft became airborne quite early and that he intended to let the aircraft accelerate in ground effect before climbing away. However, without any warning, the left wing dropped and contacted the ground, and the aircraft cartwheeled. Eyewitnesses recalled that the accident sequence began approximately at the intersection of Runway 21 with Runway 25. The aircraft fuselage came to rest on the runway, erect but substantially damaged. Parts of the aircraft structure had separated from the fuselage during the cartwheel. Both occupants evacuated the aircraft without injury before fire engulfed the cabin.

The aircraft owner, who was more experienced on the type, reported that he had not been paying sufficient attention to the progress of the takeoff to enable him to intervene to prevent the accident.

The runway

AAIB investigators who inspected the runway found that the surface was somewhat rough in places and had a notable undulation at its intersection with Runway 25. Civil Aviation Publication (CAP) 168 – *'Licensing of Aerodromes'* gives guidance on the subject. The section relating to unpaved surfaces (including grass runways) states, in part:

> *'A simple method of assessing the evenness of a natural surface is to drive over it in a suitable vehicle. The surface should not display undue signs (e.g. wheel ruts) of the vehicle's passage and, if the surface is acceptably even, this test should be accomplished without discomfort to the vehicle occupants.'*

Takeoff technique

The aircraft's Flight Manual recommends that a smooth rotation should begin at 70 kt, but adds:

> *'Soft or rough field takeoffs are performed with 50% flaps by lifting the airplane off the ground as soon as practical in a tail-low attitude. If no obstacles are ahead, the airplane should be levelled off immediately to accelerate to a higher climb speed.'*

Wreckage examination

The wreckage was examined after its removal from the accident site. There was no evidence of malfunction or failure to account for the accident. Trim settings were approximately mid-range. Neither the seatbelt mounted air bags, nor the ballistic parachute, had deployed.

Recorded data

The displays fitted to the aircraft contained three SD data cards on which various parameters were recorded, each parameter being sampled once per second. The cards were retrieved from the wreckage and downloaded. The aircraft was also fitted with a Recoverable Data Module (RDM), which records a wider range of parameters. However, the additional parameters were not considered necessary for the investigation and the RDM was not downloaded.

The display data showed that following a small pitch oscillation at about 52 kt, the aircraft's pitch attitude began increasing at 57 kt, reaching 11° nose-up before the aircraft rolled right and then rapidly left (see Figure 1).

Analysis

There was no evidence of a technical cause for the accident. It is probable that the undulating runway contributed to the aircraft becoming airborne at a low speed, and the pilot lacked training and experience on the aircraft type that might have assisted him in controlling the situation.

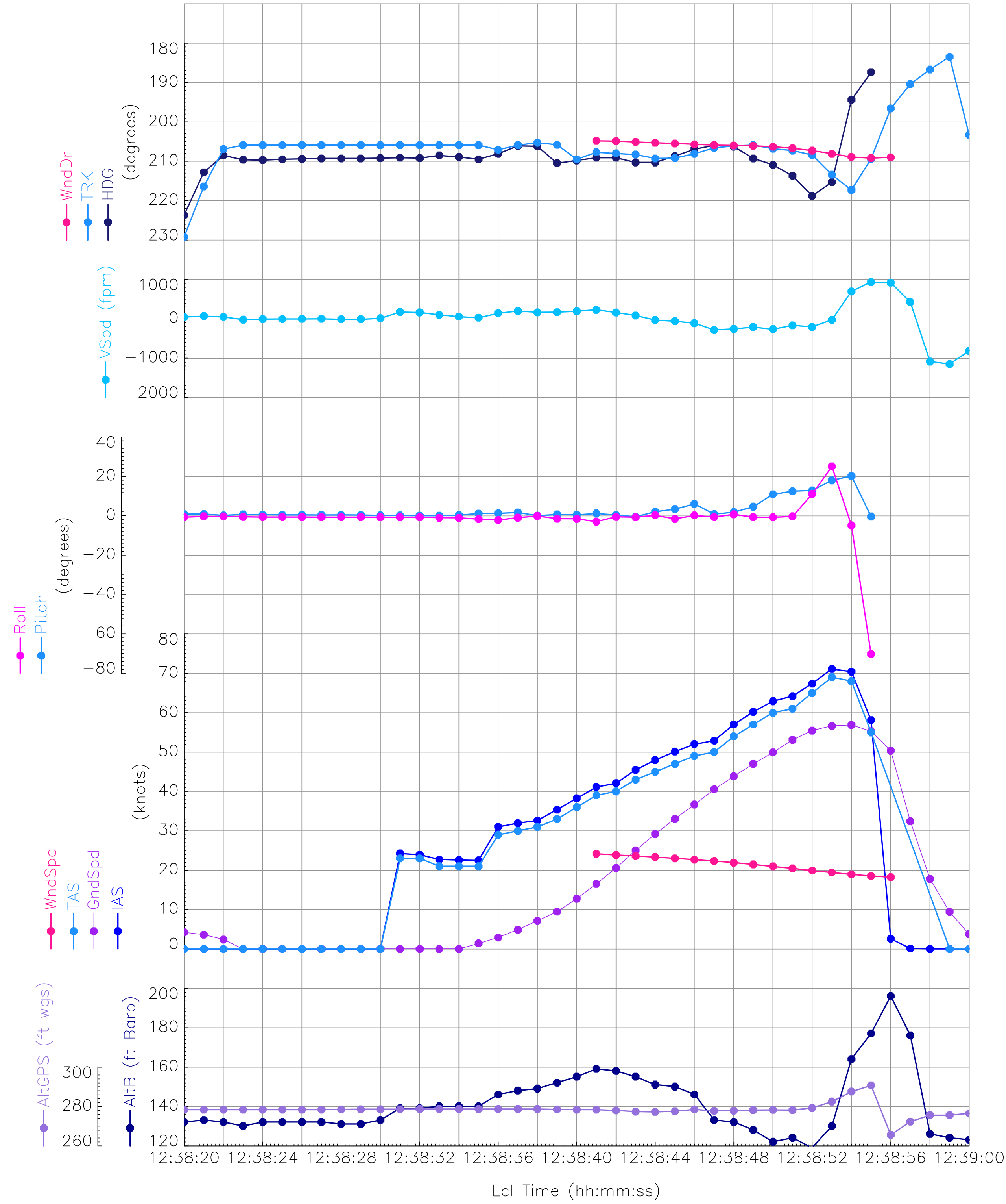


Figure 1

Display data

ACCIDENT

Aircraft Type and Registration:	Extra EA 300, G-SIII
No & Type of Engines:	1 Lycoming AEIO-540-L1B5 piston engine
Year of Manufacture:	1994
Date & Time (UTC):	7 April 2010 at 1825 hrs
Location:	White Waltham Airfield, Berkshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Right landing gear, propeller blades and right aileron damaged
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	56 years
Commander's Flying Experience:	1,983 hours (of which 327 were on type) Last 90 days - 36 hours Last 28 days - 13 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and AAIB enquiries

Synopsis

During the landing roll the right mainwheel assembly detached from its axle. Examination revealed that the four fasteners securing the right axle to the landing gear had failed as a result of the nuts having been pulled from the four attachment bolts. The investigation could not determine the cause of the failure.

It was noted that the threads on the attachment bolts can be damaged when the axles are removed from the landing gear. One Safety Recommendation was made to the aircraft manufacturer that new nuts and bolts should be used when the axles are replaced or refitted to the landing gear.

History of the flight

The pilot reported that the wind was light and variable and the approach to Runway 29 at White Waltham was uneventful. The touchdown and landing roll felt normal until just after the brakes had been applied, when the tail started to lift. As the pilot moved the control column rearwards to correct the aircraft attitude, the aircraft dropped to the right and the propeller blades struck the ground several times. The aircraft then veered to the right and came to rest across the runway.

Inspection of the aircraft and runway revealed that the right axle and mainwheel assembly had detached from the landing gear, which created a gouge in the grass runway as the aircraft came to a halt.

The aircraft was operated by a small syndicate and the pilot involved in the accident stated that there had been no reports of the aircraft having had either a heavy landing, or having landed with a large amount of side slip.

Runway condition

There are three grass runways at White Waltham and the Aeronautical Information Publication (AIP) includes a warning:

> *'the aerodrome surface is rough and undulating.'*

The airfield manager advised the AAIB that Runway 29 probably has the worst surface on the airfield and that they are trialling a realigned runway on a smoother piece of ground.

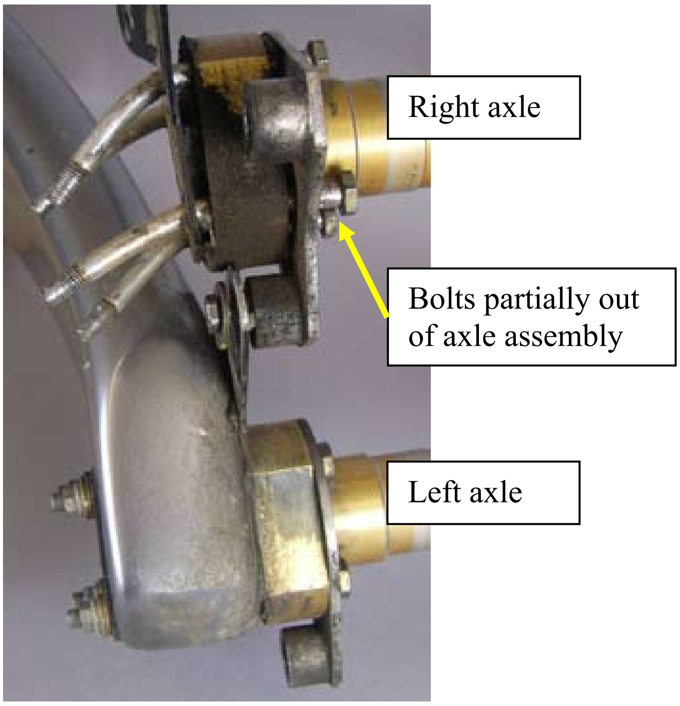


Figure 1

Right and left axles and securing bolts

Aircraft information

The Extra EA 300 is a tandem, two-seat, low-wing aerobatic aircraft equipped with a tailwheel and fixed main landing gear. The axles for the mainwheel assemblies are secured by four bolts to a single U-shaped composite-constructed landing gear, which is attached to the underside of the fuselage. A spat is fitted to each mainwheel and it is not possible to inspect the four bolts, securing each axle to the landing gear, without first removing an access panel.

Damage to the landing gear

Following the accident, the four bolts, which had secured the right axle to the landing gear, were found to be bent and the threads were severely damaged; the nuts were not recovered. The bend in the bolts was consistent with a side load having been applied to the outside of the bottom of the tyre after the bolts had withdrawn out of the axle by around 10 mm to 15 mm. Figure 1 shows the damaged bolts on the right axle next to the left axle, which is still attached to the landing gear.

The landing gear had partially failed at the position where it was attached to the right side of the fuselage. This failure was consistent with the right side of the leg having been dragged along the ground after the wheel assembly had detached from the aircraft.

Previous work on the landing gear

The landing gear leg was last removed in September 2009, 65 flying hours prior to the accident, and the axles were subsequently refitted using the existing nuts and bolts. The maintenance company who carried out the work reported that the nuts had been torqued to approximately 10 nm. The bolts were last inspected when the spats had been removed during the annual inspection, which was carried out on 23 November 2009, 25 flying hours prior to the accident.

Examination of the bolts

The bolts used to secure the right and left axles to the landing gear leg were identified as AN4-28[1] and manufactured from cadmium-plated low-carbon steel. Industry guidelines recommend that the securing nuts should be torque loaded to between 5.6 Nm and 8 Nm. The left axle nuts were assessed as being the correct nuts to be used with the AN4-28 bolts.

Right axle

The threads on all four securing bolts, Figure 2, were extensively damaged and scored as a result of having been pulled through the locating holes in the landing gear leg; this action had destroyed any evidence that might have indicated the nature of any pre-detachment thread failures. However, examination by scanning electron microscopy (SEM) did reveal that the damage to the threads on the bolts was consistent with overload failure in a ductile manner. This damage may have been as a result of the nut having been pulled from the bolt. There was no evidence that any of the nuts had unwound prior to the failure of the threads.

Figure 2

Damaged threads on bolt from right axle

Footnote

[1] ¼ inch diameter, 28 thread per inch, American Unified Fine (UNF) pitch.

Left axle

The bolts securing the left axle to the landing gear were also inspected by the AAIB and an independent metallurgist.

On each bolt, two washers were fitted between the head of the nut and the backing plate. The torque loading applied to the nuts was assessed as being between 7 Nm and 10 Nm. It was noted that the action of withdrawing the bolts from the axle and landing gear damaged the threads on two of the four bolts. This damage was difficult to detect visually without the use of optical viewing equipment.

One of the bolts was examined by SEM, which revealed cracking and damage to the threads, Figure 3.

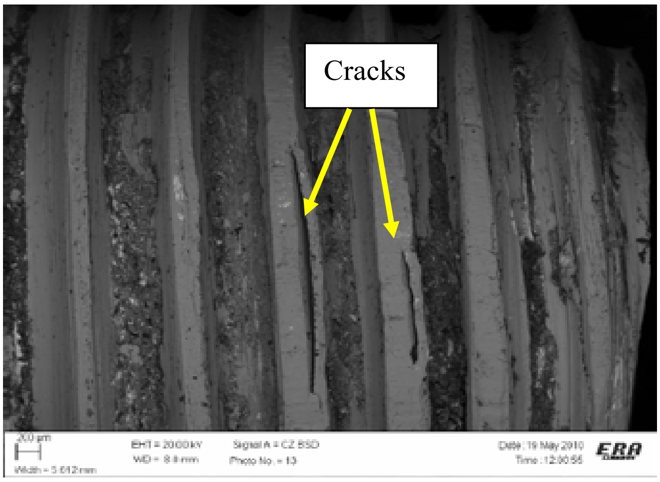


Figure 3

SEM image showing cracks in thread

Manufacturer's comments

The aircraft manufacturer stated that this is the first time they have seen this type of failure on any of the EA 300 series of aircraft, all of which have the same design of landing gear and axles. The policy at the manufacturer's factory is that the nuts and bolts should be replaced with new ones following the removal of the landing gear and axles, although, this advice is not included in the aircraft maintenance manuals. The manufacturer also commented that the nuts should be torqued to 9.5 Nm and that operating from a rough surface can result in a relatively large amount of flexing of the landing gear legs.

Discussion

The four fasteners securing the right axle to the landing gear had failed as a result of the nuts having been pulled off the bolts. However, because of the damage to the threads on the bolts, it was not possible to establish the reason why they failed. There was also no evidence that any of the nuts had unwound prior to the failure of the threads. The bolts on the left axle were identical to those used on the right axle and both sets of bolts were fitted to the aircraft at the same time. The torque on all four bolts on the left axle was found to be close to the industry guidelines, and the manufacturer's recommendation[2]. There is no evidence that the torque on the bolts on the right axle was incorrect.

The damage to the aircraft could not have been due to a heavy landing and, while the bend in the bolts is consistent with a side force having been applied to the outside of the right tyre, there have been no reports of the aircraft having landed with a large amount of sideslip; both mainwheel tyres were undamaged. Runway 29 at White Waltham is considered to be *'rough and undulating'* and the manufacturer has advised that operating on such a surface can cause a relatively large amount of flexing of the landing gear. This flexing, and condition of the runway surface, might result in a large side force on the tyres. However, there have been no failures on other aircraft of similar weight equipped with the same landing gear and axles.

It was noted, from the SEM examination of one of the bolts from the left axle, that there were cracks in a number of threads. It was also noted that the threads can be damaged when the bolts are withdrawn from the landing gear. Had the threads of the attaching bolts on the right axle been cracked, or damaged when the landing gear and existing bolts were refitted 65 flying hours prior to the accident, then it is possible that they might have subsequently failed as a result of normal landing loads. While the manufacturer uses new bolts and nuts each time the axles are fitted to the aircraft, there is no such instruction in the aircraft maintenance manuals. Therefore the following Safety Recommendation is made to the aircraft manufacturer:

Safety Recommendation 2010-046

It is recommended that Extra Aircraft Company advise owners, and include an instruction in the maintenance manual, that new nuts and bolts are to be used when the wheel axles are replaced or refitted.

Footnote

2 It is not unusual for the torque to relax slightly during normal service.

ACCIDENT

Aircraft Type and Registration:	Hunting Percival P56 Provost T1, G-AWVF
No & Type of Engines:	1 Alvis Leonides 503/6A radial piston engine
Year of Manufacture:	1955
Date & Time (UTC):	8 July 2009 at 1334 hrs
Location:	1.3 nm east of Bishop Norton, Lincolnshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Fatal) Passengers - N/A
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	74 years
Commander's Flying Experience:	13,750 hours (of which 150 were on type) Last 90 days - 11 hours Last 28 days - 2 hours
Information Source:	AAIB Field Investigation

Synopsis

While cruising at 2,500 ft the aircraft suffered a mechanical engine failure which led to an in-flight fire. The pilot was probably rendered unconscious by the smoke and fumes from the fire; the aircraft crashed into a field and the pilot was fatally injured. The engine failure was initiated by a fatigue crack of the No 6 piston gudgeon pin. The cause of the fatigue crack initiation could not be determined but it is likely that a high-load event, such as a partial or full hydraulic lock, initiated the crack in the pin. The presence of corrosion pits on the inner surface of the pin was probably a contributory factor and the aircraft's low utilisation rate during the previous 45 years probably contributed to the formation of corrosion. In addition to the initial CAA safety actions, three AAIB Safety Recommendations are made.

History of the flight

A pilot (not the pilot in this accident) had flown the aircraft from its base at Brimpton, Aldermaston to Old Buckenham Airfield, Norfolk, on 28 June 2009 and performed a flying display. The following day he flew it to RAF Waddington where it was to form part of a static display later in the week. The pilot, one of three pilots who flew the aircraft, described the performance of the aircraft and the engine during these flights as "normal". On 3 July 2009 the aircraft was refuelled to full tanks but other than removing and replacing the covers on the aircraft for static display purposes, no other work was carried out on the aircraft while it was at RAF Waddington.

On 8 July 2009 the aircraft was to be flown to RAF

Linton-on-Ouse to participate in another display. The pilot for this flight regularly flew the aircraft, and had last flown it on 21 June 2009. At around 1130 hrs, he was collected from Grantham railway station and taken to the aircraft, where the aircraft covers were removed and he stowed the covers and his personal kit bag in the aircraft. The pilot was then escorted to the briefing facilities at RAF Waddington where he was seen to check the NOTAMs, the meteorological conditions, and to book the flight out to RAF Linton-on-Ouse with airfield operations. The weather conditions were suitable for the planned flight, and the pilot was observed to be in good spirits. He was then taken back to the aircraft where he was seen to perform his pre-flight walk-around, which included turning the propeller through 15 blades in the direction of rotation, before he entered the cockpit.

Just after 1300 hrs the pilot started the aircraft. It seemed to an observer to be reluctant to start as it took about 10 starter engagements before the propeller made a complete revolution. Eventually the engine started with a cloud of white-grey smoke which the observer, who had seen this aircraft start before, considered normal. At 1311 hrs the pilot was given his taxi clearance. The aircraft appeared to be performing normally to people who watched the aircraft as it taxied out and at 1322 hrs the aircraft commenced its takeoff from Runway 02. The aircraft continued to the north, climbing initially to 2,000 ft, and the pilot was given a radio frequency change to receive a Basic service from Waddington Radar. At 1326 hrs the pilot requested, and was granted permission, to climb to 2,500 ft to remain clear of the Wickenby Aerodrome Traffic Zone. The aircraft was then allocated a Humberside transponder code, and the pilot changed radio frequency to Humberside Radar. At 1332 hrs Humberside Radar confirmed that G-AWVF was identified, and the pilot confirmed that the aircraft was at 2,500 ft.

At 1333 hrs ATC gave radar instructions to another aircraft, in the north of the Humberside area but the response was blocked by another aircraft transmitting. ATC repeated its radar instructions and again the reply was blocked. ATC asked the pilot to confirm he had received the instructions, and its third reply was uninterrupted. When two stations transmit simultaneously the resultant 'noise' is normally indecipherable but, in a controlled environment, an analysis of the 'noise' revealed that, at 1333.18 hrs the word "MAYDAY" was part of one of the transmissions.

At approximately 1335 hrs a person, driving his car along the A631, observed what he considered was an "old" aircraft trailing thick black smoke and descending rapidly towards the ground. The aircraft disappeared behind some trees, and shortly afterwards a cloud of black smoke appeared. The driver rang the emergency services and drove to the likely source of the smoke; on arrival he found that the aircraft was badly disrupted in a field, with several small fires around it. He ran to the aircraft to try and offer assistance, but as he got closer he realised that the cockpit area had been destroyed and so he looked around the area for survivors. He quickly located the body of the pilot, who had been thrown clear from the aircraft, but it was immediately obvious that the pilot had received fatal injuries.

There were many witnesses to the aircraft accident and all of them observed thick black smoke coming from the aircraft in the air. About half the witnesses saw flames, which they described as intense, coming from just behind the propeller, and a few witnesses observed objects dropping from the aircraft during the last 500 ft of its descent.

At 1334:48 hrs the Humberside Radar controller noticed that G-AWVF was no longer showing on radar and so he requested a radio check. He received no reply, and after having checked that the aircraft had not returned to RAF Waddington's frequency, he asked a nearby light aircraft to check the last known radar position for G-AWVF. The light aircraft quickly located the burning aircraft in a field, with people in attendance.

The air ambulance was on scene within 20 minutes of the accident, and paramedics confirmed that the pilot had received fatal injuries.

Investigation flight in a P56 Provost aircraft

The Royal Navy Historic Flight assisted the AAIB investigation by providing a flight in a P56 Provost aircraft in order to determine an approximate normal cruise speed and the stick-free response to a simulated engine failure. The aircraft was trimmed for level flight at 3,000 ft amsl with a normal cruise power setting of 0 boost and 2,150 propeller rpm, which gave an indicated airspeed of 120 kt. The control column was then released and the engine power reduced to idle. The nose of the aircraft slowly pitched down and the airspeed increased. At 1,000 ft amsl the aircraft had achieved a pitch attitude of around 35º nose-down and the ASI was indicating 160 kt.

Post-mortem examination

A post-mortem examination found evidence of soot in the airway of the pilot, which indicated that he had been breathing during exposure to smoke. Toxicology results showed the presence of cyanide in the pilot's blood at a significantly elevated level; cyanide is a common combustion product of some materials found in aircraft construction. A specialist aviation pathologist considered the level of cyanide meant that the pilot may have been unconscious, or otherwise incapacitated, prior to the aircraft hitting the ground. He judged that the forces involved in the accident were not survivable and that the pilot would have died instantaneously in the impact.

P56 Provost Pilot's Notes

The Pilot's Notes for the P56 Provost date back to when the aircraft was used as a training aircraft for the RAF. They state that, in the event of an in-flight engine fire which does not go out after turning off the fuel shutoff valve, the pilot should abandon the aircraft if height is sufficient. Parachutes were not carried in this aircraft at the time of the accident and, as the aircraft was on the civil register, they were not required. However, the CAA's CAP 632 ('*Operation of 'Permit to Fly' Ex-Military Aircraft on the UK Register*') recommends:

> *'Parachutes should be worn on all flights in ex-military aircraft.'*

Recorded radar data

Radar data was recorded for the accident flight. The aircraft was fitted with a transponder but this was not Mode C enabled so no height information was available. The radar returns were from Secondary Surveillance Radar (SSR) apart from the last two, which were primary returns.

Figure 1 shows the accident track which started at 1323:34 hrs at Waddington Airfield and ended at 1333:41 hrs, approximately 0.33 nm south of the accident site. Figure 2 shows a close-up of the radar track in the vicinity of the accident site.

The average groundspeed between each radar point was calculated and is presented in Figure 3 (note that these groundspeeds do not have any vertical speed component). This figure shows that the groundspeed during the majority of the flight was about 100 kt. Towards the end of the flight the groundspeed started to

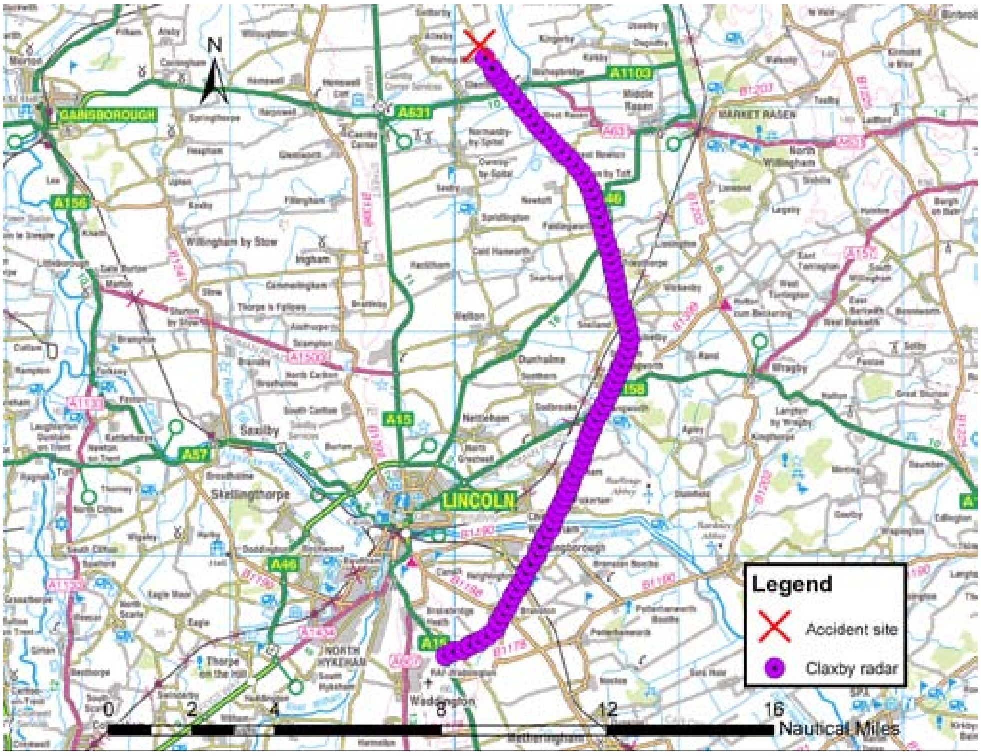


Figure 1

Radar track of G-AWVF and position of accident site

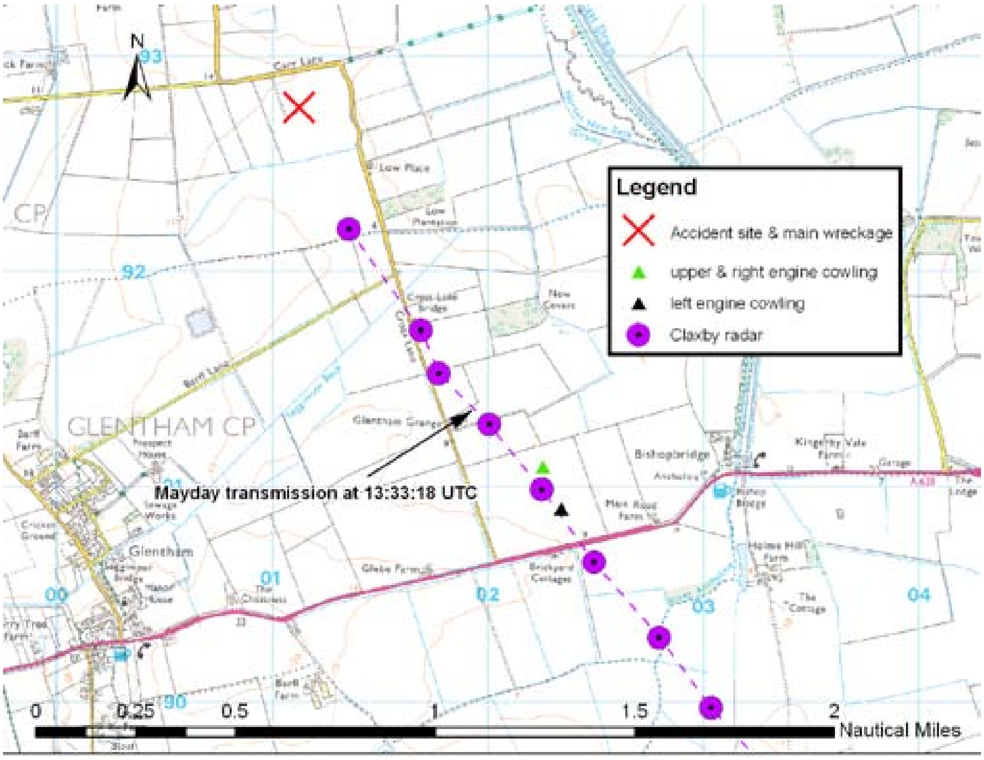


Figure 2

Radar track of G-AWVF approaching the accident site reduce. However, the reduced positional accuracy of the last two points (primary returns) compared to the rest (SSR) means that the calculated groundspeeds for these points are less reliable.

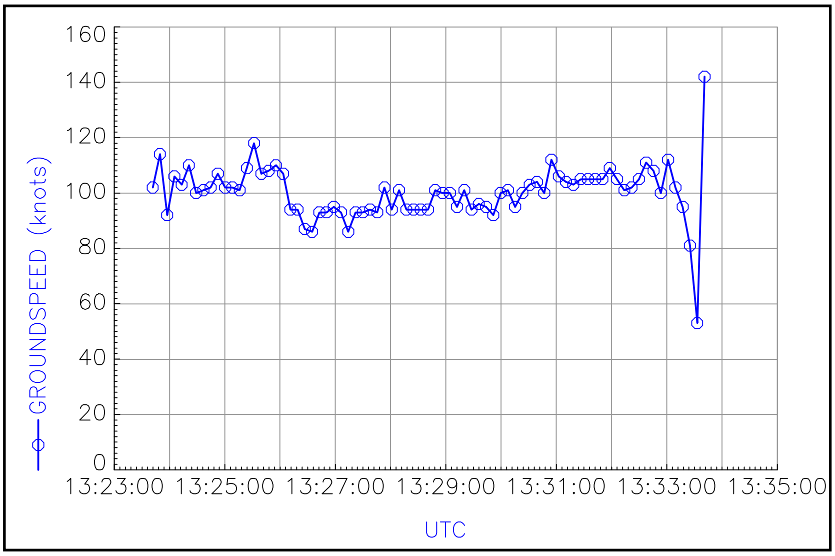


Figure 3

Accident flight calculated groundspeed from radar data

Aircraft information

The Hunting Percival P56 Provost T1, also known as a 'Piston Provost', is a single-engined two-seat military training aircraft with a fixed landing gear (Figure 4). It is powered by a 550 hp Alvis Leonides 503/6A 9-cylinder radial engine which, through a reduction gearbox, drives a three-bladed constant-speed propeller. The aircraft has conventional flying controls operated by push-pull rods and cables. It has a 24V electrical system and a pneumatic system which powers the flaps, wheel brakes and windscreen wipers.

G-AWVF (military registration XF877) was operated by the Royal Air Force (RAF) from 1955 to 1969 during which time it accumulated 3,735 flying hours. It then entered private use and had accumulated 4,100 hours at the time of the accident. The aircraft was operated under a CAA Permit to Fly and maintained by its owner under the supervision of a Licensed Aircraft Engineer.

Figure 4

P56 Provost T1, G-AWVF
(photograph courtesy Brian Nicholas)

The owner of G-AWVF had been operating the aircraft for the previous 19 years, but had only taken ownership of it in April 2004. The owner last flew the aircraft in August 2007, but it continued to be flown by the accident pilot and one other pilot. On this aircraft the cartridge-type engine starter had been replaced by an electric starter.

Accident site examination

The aircraft had crashed in a field of tall crops about 1.3 nm east of Bishop Norton. From the initial impact point the aircraft had travelled 21 m in the direction of 340°(M) before coming to rest. The damage to the crops near the initial impact crater indicated a steep nose-down impact of approximately 35° to 40° with the wings nearly level. The aircraft's right wing had sheared near the root and its centre fuselage and cockpit area were almost completely destroyed by fire. The pilot's body had been thrown clear of the aircraft and was found 22 m beyond the main wreckage in the approximate direction of aircraft travel. The cockpit's sliding canopy was found 16.5 m north-west of the main wreckage (Figure 5).

A number of flight instruments and components from the instrument panel had been thrown clear of the post-impact fire, but exhibited evidence of sooting and high temperature exposure. The sliding canopy also exhibited evidence of exposure to high temperature, and sooting, but was surrounded by crops that were unburnt. A few large sections of broken transparency had become opaque and discoloured as a result of heat exposure but were surrounded by unburnt crops.

Both wing fuel tanks had ruptured, the separated engine was resting underneath the remains of the right wing fuel tank and the right side of the aircraft had been exposed to more fire than the left side. The paint scheme on the left wing upper surface and left side of the vertical tail was mostly untarnished by fire or heat; these parts of the aircraft were facing into the prevailing wind at the time of the accident. The three-bladed propeller exhibited chordwise scratches and leading edge nicks consistent with rotation at impact, but not with high power. The engine had suffered significant fire damage and its three lower cylinders (No 5, 6 and 7) had detached. The No 5 and 6 cylinders were located within the initial wreckage trail, while the No 7 cylinder was located about 40 m north-east of the impact site[1].

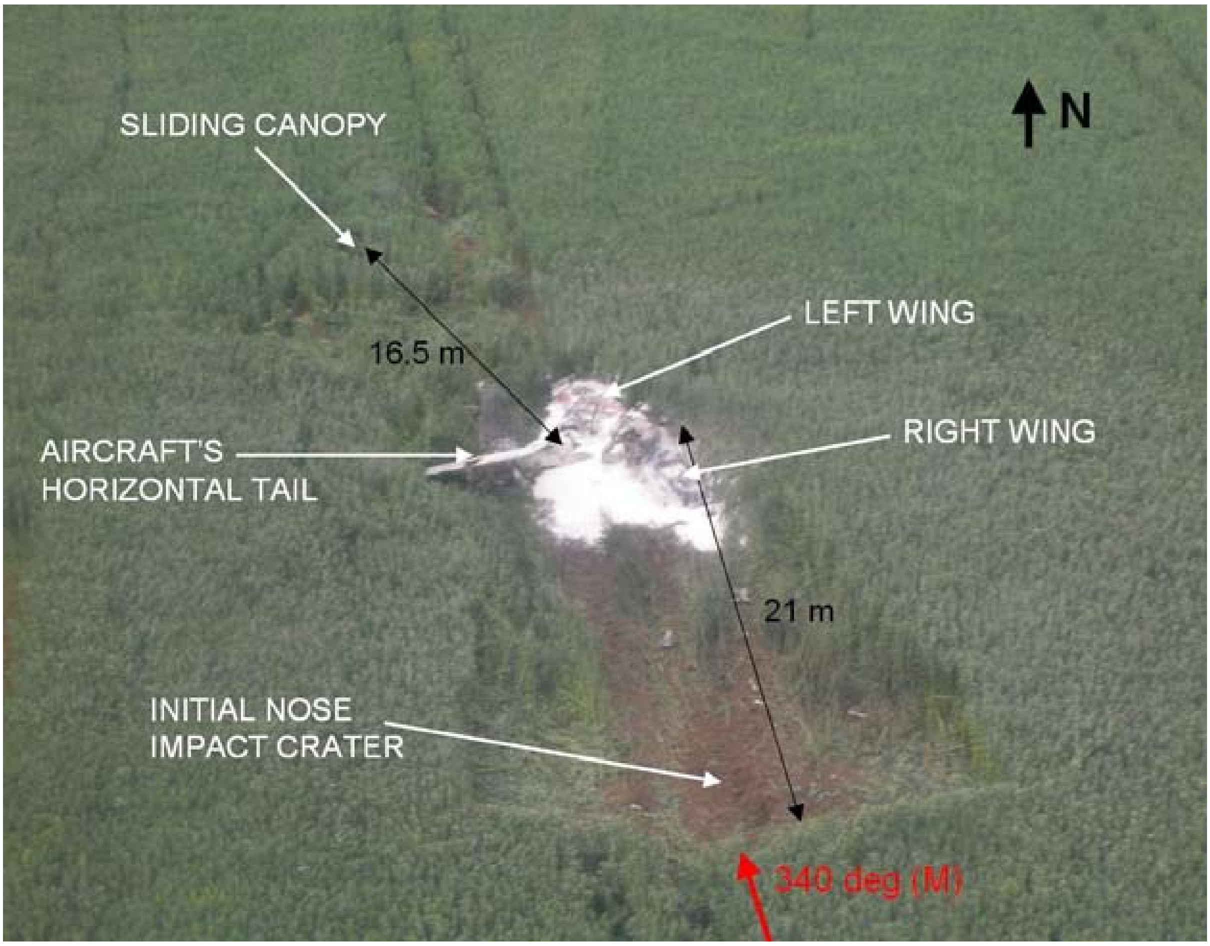


Figure 5

Accident site location – the main wreckage is surrounded by white fire-retardant foam that was applied by the fire service after the accident

Footnote

1 The missing No 7 cylinder was found by farmers while harvesting the field in September 2009.

All major aircraft components were accounted for at the accident site, apart from the engine cowlings. The engine cowlings were found, one month after the accident, in a field 1.1 nm south-south-east of the accident site (Figure 2). The upper and right side cowlings were still attached to each other at the hinge. The left side cowling had detached at its hinge and was found 212 m south of the upper and right cowlings. The lower rear corner of the right cowling was burnt and sooted.

The aircraft wreckage was transported to the AAIB headquarters near Farnborough for detailed examination.

Detailed wreckage examination

Engine cowlings

The latches securing the engine cowlings to the aircraft had failed in overload. The right engine cowling was missing a small portion of its rear lower corner and this area was surrounded by black burn marks and blistered paint (Figure 6). On the internal surface of the right engine cowling, in the lower forward section, there were a number of puncture indentations (Figure 7). With the cowling installed these indentations would have been adjacent to the No 7 engine cylinder, and would have been aligned with the bolt ends protruding from the cylinder head's two rocker covers.

Fuel system

The aircraft contained two main fuel tanks, one inside each inboard wing section, which were connected to a 2.9 gallon collector fuel tank located centrally on the belly of the aircraft, aft of the engine firewall. A 'Saunders' shutoff valve was installed between each main fuel tank and the collector tank. These valves were wire-locked to the open position and were used solely for maintenance purposes. A third 'Saunders' shutoff valve was located between the collector tank and the fuel pipe passing through the engine firewall; this valve was controllable from the cockpit.

The left tank's shutoff valve was found in the wire-locked open position. The right tank's shutoff valve was badly burnt and had separated from the fuel lines, but it was also in the open position. The main

Figure 6

Right engine cowling external surface – burnt area on lower aft corner

Figure 7

Right engine cowling inner surface – same burnt area visible on lower aft corner, and indentations near forward edge pilot-controllable shutoff valve, which was also burnt and had separated from the fuel lines, was in an almost fully closed position.

The fuel collector tank and surrounding pipework were severely fire damaged and it was not possible to determine if they had been exposed to an in-flight fire before the post-impact fire.

Electrical system

The aircraft was equipped with a 24V electrical system. The battery cells had suffered fire damage and all the fuses and electrical wiring in the fuselage and engine bay were so severely burnt during the post-impact fire that a meaningful electrical failure analysis could not be carried out. SSR radar returns can only be received when an aircraft's transponder is powered; therefore, the last SSR radar return indicated that the aircraft still had some electrical power when it was within 0.75 nm of the accident site.

Ventilation system

The aircraft's ventilation system takes cold air from the engine air-intake and directs it via a series of ducts and pipes to two 'punkah louvres' on the instrument panel and two windscreen spray nozzles mounted below the windscreen (Figure 8). For the hot air supply, separate air inlet ducts, mounted on both sides of the engine, direct

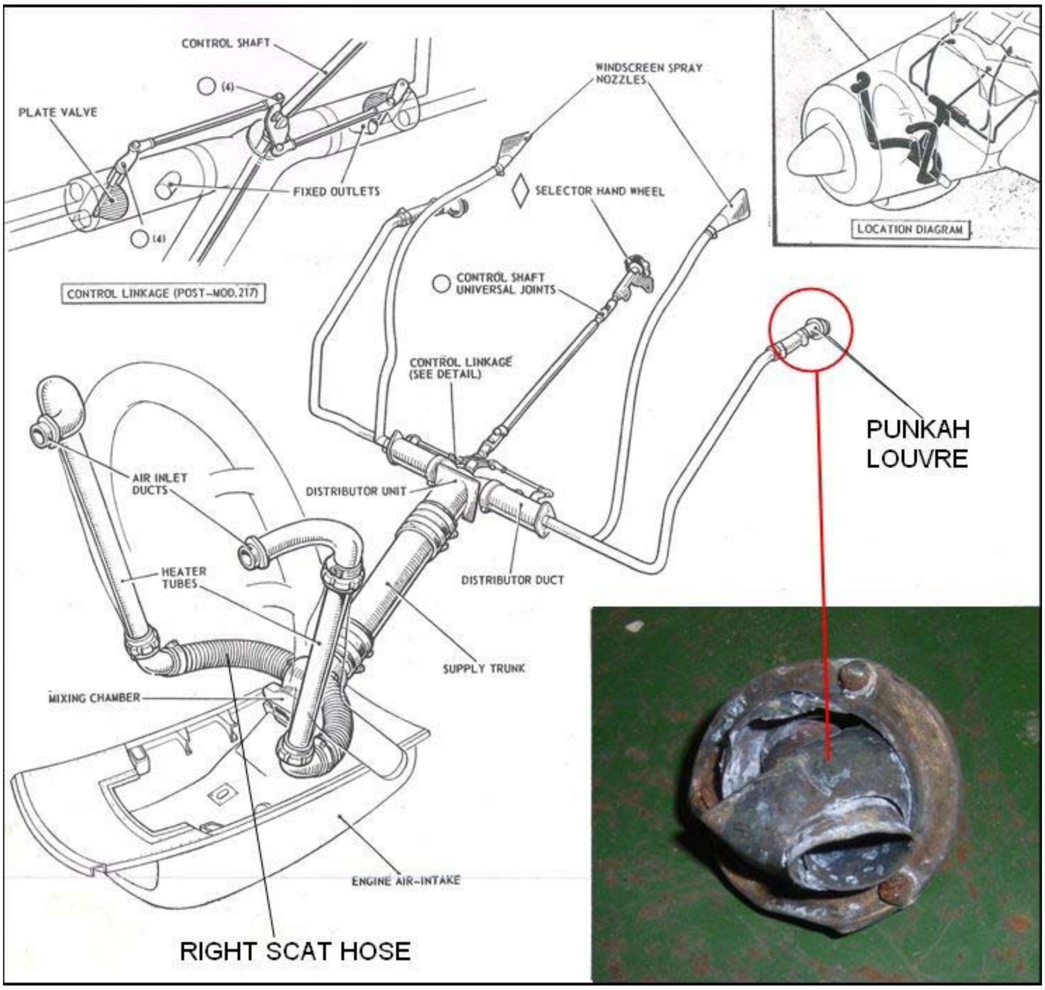


Figure 8

Ventilation system diagram showing location of right SCAT hose and punkah louvres.
The burnt punkah louvre shown in the photograph was either from the left or right side of the instrument panel.

air through heater tubes and SCAT hoses[2] to a mixing chamber where it is mixed with cold air and directed through the same pipework to the punkah louvres and windscreen spray nozzles.

The majority of the components of the ventilation system, including the SCAT hoses, had suffered from severe fire damage and it was not possible to determine if they had been exposed to an in-flight fire before the post-impact fire. However, one of the punkha louvres (shown in Figure 8) was found on the ground, well clear of the main wreckage and surrounded by unburnt crops. Despite this, it exhibited evidence of having been exposed to high temperature and possibly fire. The right SCAT hose, between the heater tube and mixing chamber, passed close to the aft lower corner of the right engine cowling, which had exhibited evidence of in-flight fire.

Pilot restraint system

The pilot restraint system on the aircraft consisted of a four-point harness, with the lap belts secured to the seat and the shoulder harness secured to a cable within an inertial reel attached to the rear cockpit structure. The harness buckle, with its four points still attached, and remains of the harness, were found severely burnt next to the pilot's body. Nearby was a small section of burnt seat material with a lap belt fitting attached. The pilot's shoulder harness inertial reel was still attached to the aircraft structure, and its cable end was attached to a small piece of burnt shoulder harness.

The canopy jettison handle was found in the wire-locked closed position.

Engine examination

The Alvis Leonides 503/6A is a piston engine with nine cylinders mounted radially. The No 1 cylinder is located at the top ('12 o'clock') position, and the No 5 and No 6 cylinders are located at the bottom, either side of the 6 o'clock position. The No 6 cylinder contains the master rod (shown in Figure 9). This is the strongest connecting rod, and the other eight connecting rods, called 'articulating rods', are connected to the master rod. The crankshaft passes through the centre of the master rod which contains a plain bearing. The master rod and the eight articulating rods (the connecting rods) are connected to their respective pistons via a gudgeon pin (Figure 9). Each gudgeon pin is free to rotate within the bores of the piston bosses.

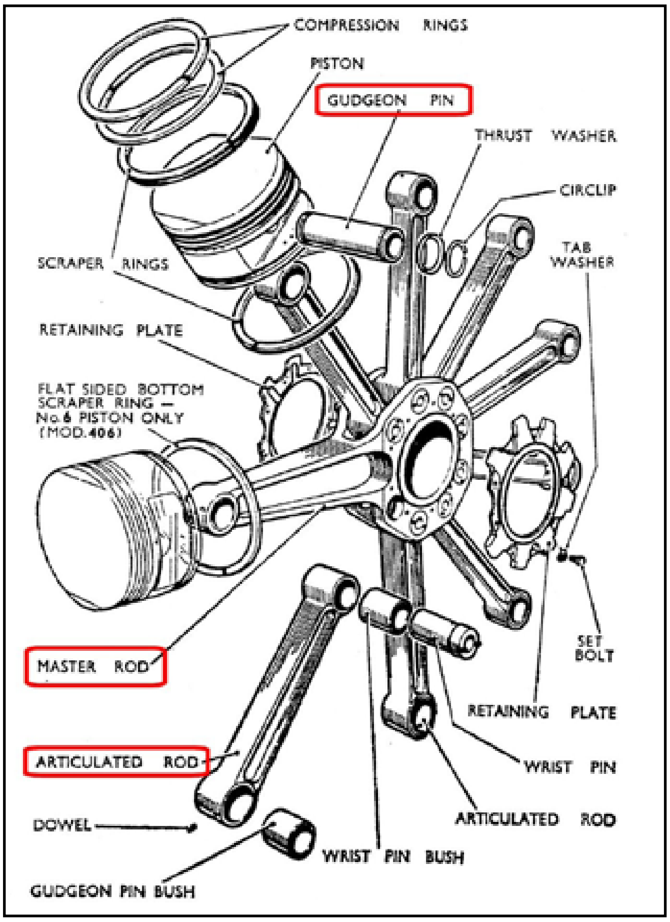


Figure 9

Connecting rod and piston arrangement in Alvis Leonides 503/6A radial engine

Footnote

2 SCAT hose is a type of thin-walled flexible hose made of plastic reinforced with wire.

The engine had suffered from significant fire damage, and its No 5, 6 and 7 cylinders had detached (Figure 10). The cylinders had detached as a result of failure of some cylinder retaining bolts and the failure of engine casing material around the remaining cylinder retaining bolts. The master rod and all the articulating rods had failed near their roots. The section of master rod between the piston and root was missing. All the cylinders had damage of varying degrees to their skirt, consistent with impact from the connecting rods. The gudgeon pin from the No 6 piston, to which the master rod had been connected, had 'sheared' at its centre (Figure 11). The No 6 piston had suffered from multiple impact damage to its base and sidewalls, consistent with a flailing master rod. The No 5 and No 7 pistons were missing. Multiple sections of articulating rod material were also missing. The gudgeon pins from the remaining pistons (No 1, 2, 3, 4, 8, 9) were intact and still connected to sections of articulating rod of varying lengths. None of the pistons had seized in their cylinders, and although some articulating rod small end bearings were stiff, this could have been a consequence of the significant mud, debris and fire damage associated with the impact.

Figure 10

Front face of engine, positioned upside down, showing missing No 5, 6 and 7 cylinders (when the engine is installed, the No 1 cylinder sits at the '12 o'clock' position)

Figure 11

View inside No 6 cylinder showing damaged cylinder skirt, damaged piston and 'sheared' gudgeon pin

The engine was stripped and no other mechanical failures of significance were found. There was evidence that the crankshaft journal had been overheated, but it had not seized, and the crankshaft bearings were in satisfactory condition.

Metallurgical examination of engine components

The pistons and the remains of the master rod and articulating rods were examined by a metallurgist. The fracture surfaces of the master rod and of each of the articulating rod ends had been almost completely destroyed by post-failure mechanical damage (Figure 12). Areas which were not damaged exhibited dull, fibrous fractures and angled fracture surfaces which were characteristic of overload failure.

Figure 12
Remains of master rod and articulating rod ends

During the examination the sheared halves of the gudgeon pin from the No 6 piston were pushed inwards to their normal position (Figure 13). This revealed that between 5 and 20 mm of the pin was missing from its centre. The two portions of the pin (section A and section B) were removed from the piston and cleaned for more detailed examination and a close-up view of the two sections is shown in Figure 14. The fracture surface of section A was helical and had suffered from some post-failure mechanical damage. In the undamaged areas, the majority of the circumferential fracture surface was angled at 45° to the pin surface, which is characteristic of overload failure. However, the longitudinal fracture surface (annotated in Figure 14) was relatively flat and extended along a crack line to the end of the pin. This crack line also extended into the other half of the pin, section B.

The two sections of pin were opened along the crack line to permit examination with a Scanning Electron Microscope (SEM) and Figure 15 shows an SEM image of the longitudinal fracture surface of section A. There was clear evidence of beachmarks, which are associated with metal fatigue, and these indicated the origin of the fatigue crack. A higher magnification image of this area revealed striations, which are another characteristic of metal fatigue. SEM examination of the crack in section B also revealed beachmarks and striations. The beachmarks on the longitudinal fracture surface of section A were counted several times, on the sample and from photographs. The number of beachmarks observed was in the range of 30 to 35. Beachmarks relate to a major load cycle or a change in load cycle. The metallurgist indicated that for engine components, beachmarks usually relate to engine stop/start cycles, and therefore it was likely that at least 30 to 35 engine stop/starts had occurred during the life of the longitudinal fatigue crack.

A more detailed SEM examination of the fatigue crack origin revealed that it had initiated at a corrosion pit approximately 150 µm deep. There were a number of other corrosion pits on the inner surface of the pin in the vicinity of the fatigue crack origin; some of these are highlighted in Figure 15. Corrosion pits act as stress raisers and are a common initiation point for fatigue. The crack growth had not been caused by Stress Corrosion Cracking (SSC), as the striations were trans-granular, whereas SSC generates inter-granular failures.

The gudgeon pins from the remaining pistons (No 1, 2, 3, 4, 8 and 9) were removed, cleaned, and

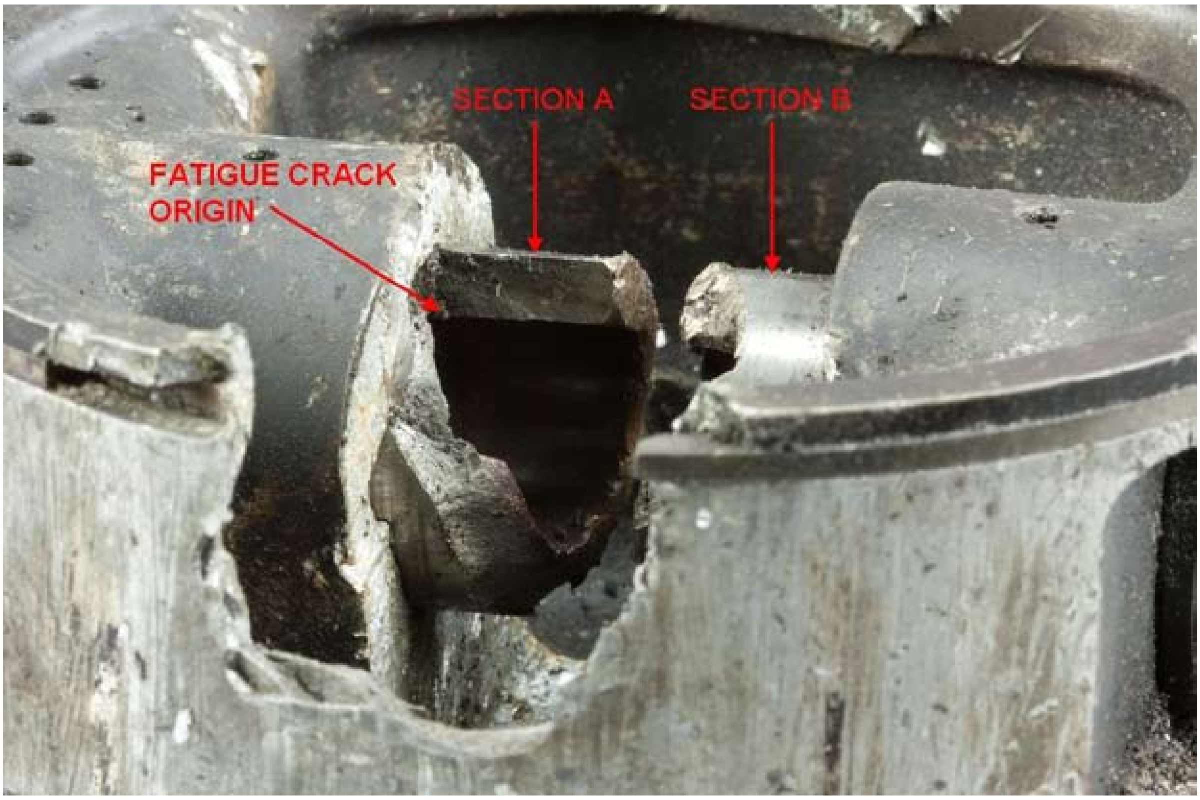


Figure 13

No 6 piston. Both portions of the failed gudgeon pin have been pushed back into their original seating position (compare to Figure 11 for their post-failure position)

Figure 14

Both portions of No 6 gudgeon pin, showing fatigue crack origin

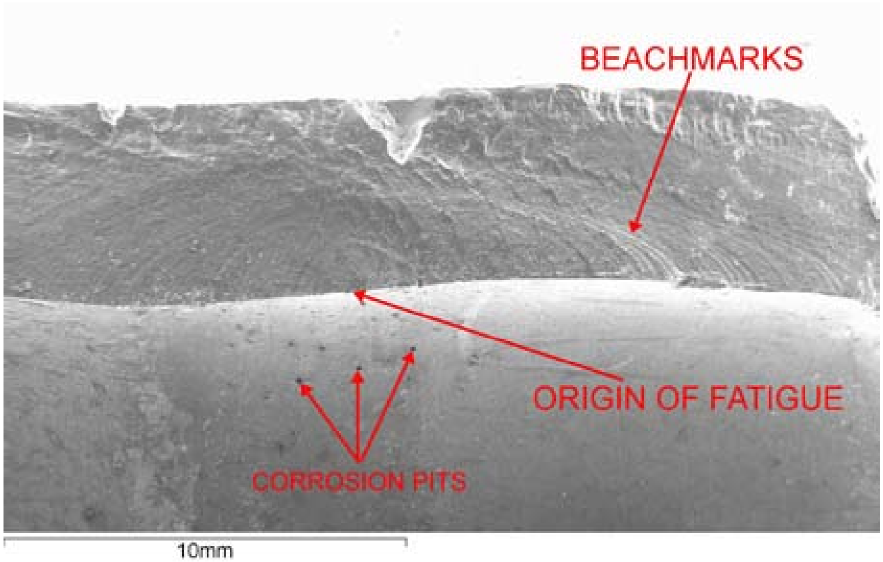


Figure 15

Scanning Electron Microscope (SEM) image of longitudinal fracture surface from section A, showing fatigue crack origin, beachmarks and corrosion pits

inspected with fluorescent dye penetrant to determine if any fatigue cracking was present. There were no indications of cracks on the external surfaces or the internal surfaces of the pins, although some dye was retained on the internal surfaces, which was indicative of general surface corrosion. The gudgeon pins were then sectioned longitudinally to permit a more detailed examination of their inner surfaces. All the pins exhibited some degree of internal surface corrosion, with pins No 4 and 8 having the most severe corrosion (see Figure 16 for a section of the No 8 pin). Pins No 1, 2, 3 and 9 showed a similar degree of corrosion. All the pins, except No 1, contained some corrosion pits. These pits were not visible with the naked eye, but became visible with at least x10 magnification. Surface roughness associated with the general corrosion could be felt by finger touch, but the corrosion pits could not be identified by touch.

Prior to removing the gudgeon pins from the pistons the metallurgist tried to measure the clearance between the pin and the piston bores. The manufacturer's tolerance for this clearance was between 0 and 0.015 mm for a new installation and up to 0.05 mm for a worn installation. Measuring this clearance did not prove possible due to the build-up of sludge, oil and debris – most of which would have been as a consequence of the post-impact fire and break-up. Some of the gudgeon pins were free to rotate within the piston bores but others were

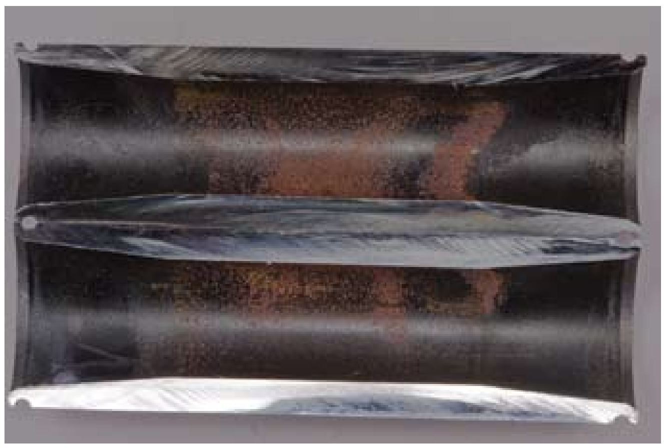


Figure 16

No 8 gudgeon pin sectioned, showing corrosion on internal surface too stiff to rotate. However, this stiffness would not be abnormal at room temperature, as the assembly procedure calls for the piston to be heated prior to insertion of the pin. The pins were removed from the pistons and their diameter measured after cleaning with solvent in an ultrasonic bath. Apart from three pins, which had measured diameters at their mid-section of 28.03 mm, 28.04 mm and 28.04 mm, the remaining pins had diameters greater than the minimum 28.05 mm worn limit (at both ends and at their mid-sections). The piston bore diameters were also measured after cleaning, and then the pin-to-bore clearance was calculated. Apart from piston No 2, which had a calculated clearance of 0.14 mm, the remaining calculated clearances were all less than the 0.05 mm worn limit.

The metallurgist concluded in his report that fatigue, initiating from corrosion pitting on the internal surface of the No 6 gudgeon pin, was the cause of the pin failure. However, for the fatigue crack to propagate, the direction of the applied cyclical loads to the pin would have had to remain constant. The gudgeon pin is normally free to rotate within the piston bores, so some other factor had caused the pin to stop rotating in order to allow the fatigue crack to propagate.

Engine history

The engine logbook listed the engine's date of manufacture as 1 May 1964 but records obtained from a retired Alvis engineer revealed that the actual date of manufacture was 24 August 1954. These records also showed that between 1954 and 1964 the engine was overhauled three times and repaired once, with the last overhaul completed on 4 May 1964. The engine's total run time (TRT) at this time was 1,545 hours. The engine logbook stated that as of 10 April 1969 the engine had accrued 134 hours in RAF service, so these were probably the hours since the last overhaul in 1964.

The first logged hours under civilian use were recorded on 17 April 1969. In June 1972 the CAA decided that the engine hours under RAF service should be counted double towards the 'Time Between Overhauls' (TBO). Therefore, an additional 134 hours were added in the logbook. Between 4 May 1964 and 8 July 2009, the day of the accident, the engine was not overhauled. The last entry in the engine logbook was on 29 June 2009 which listed the logged time as 539.6 hours[3]. The subsequent flight was the accident flight which lasted about 12 minutes, so the engine logbook hours at the time of the accident would have been 539.8 hours. However, detailed examination of the logbook revealed an arithmetic error on 17 April 1984 whereby 100 hours were lost. So, the actual logged time at the time of the accident was 639.8 hours: the TBO for this engine was 800 hours and there was no calendar limit. The hours in the logbook and the TBO relate to engine flying hours. There is no requirement to log engine ground run time.

Examination of another Alvis Leonides engine

The owner of G-AWVF had bought a number of spare engine parts from the engine manufacturer when the company ceased production during the late 1980s. One of the items he purchased was an Alvis Leonides engine Mk 12701[4] that had been fitted to a twin-engine Pembroke. This engine had failed during a flight from Wildenrath, Germany, at some time during the 1970s. The aircraft returned safely to land so no details of the incident could be found. This engine was missing two cylinders, No 6 and No 7, and according to the owner of G-AWVF, these cylinders detached in flight and were never recovered. The internal damage

Footnote

[3] This figure includes the 134 hours under RAF service counted twice.

[4] The Mk 12701 is very similar to the 503/6A engine fitted to G-AWVF, which has a military designation of Mk 12601.

to this engine was very similar to the damage seen on G-AWVF's engine. The master rod and all the articulating rods had failed near their root. Without the No 6 cylinder available to examine, it was not possible to determine if the cause of failure had been the same as on G-AWVF.

Maintenance history

At the time of the accident the airframe had accumulated 4,100 flying hours, of which 3,735 hours were under RAF service between 1955 and 1969.

The aircraft was maintained in accordance with the CAA's Light Aircraft Maintenance Schedule (LAMS). The aircraft's last annual maintenance inspection for its permit renewal was completed on 14 August 2008. During this maintenance inspection a surveyor from the CAA carried out a survey of G-AWVF and no anomalies were noted in the Aircraft Survey Report. In May 2009 the owner had started carrying out some of the checks as part of the aircraft's annual inspection to renew the aircraft's permit before it expired on 13 August 2009.

In February 2005 the aircraft had suffered a propeller strike when the aircraft nosed over during taxi at Middle Wallop Airfield. The propeller was damaged and overhauled. In accordance with the instructions in the maintenance manual for propeller strikes, the engine's reduction gearbox was removed for inspection. No damage to the gearbox was found, but as a precautionary measure the gearbox was replaced with one from a spare engine which had accrued 308 hours since overhaul. While the gearbox was removed, a borescope inspection of the engine was carried out, with no anomalies noted.

A cylinder compression check was carried out on the engine on 6 May 2009. The compression readings of all the cylinders were between 75 and 79 psi which were considered 'good' by the Licensed Aircraft Engineer.

Aircraft utilisation history

Since leaving RAF service in 1969, the aircraft had logged 365 flying hours. This equates to an average flying rate of 9.1 hours per year, over a period of 40 years. In the year leading up to the accident the aircraft had logged 11 hours.

Between August 1977 and April 1979, a period of 20 months, there were no flights recorded in the airframe logbook. Between September 1984 and February 1988, a period of almost 4 years, there were no flights recorded in the logbook, although an un-dated note in the logbook during this period added 30 hours to the total time '*due unknown records*'. In both 1995 and 1996 the aircraft logged 4 hours, and in 1997 only 2.5 hours. The aircraft's monthly utilisation rate between January 2000 and the date of the accident is shown in Figure 17. Between June 2001 and July 2003 the aircraft did not fly for 23 months. However, an entry in the engine logbook for this period stated:

> *'Maintenance Statement: This is to confirm that this engine has been run monthly during long term storage.'*

The owner stated that he also squirted inhibiting oil into the cylinders via the spark plug holes.

From Figure 17 it can be seen that, in the last six years, the aircraft usually flew between 0.5 hours and 2 hours each month, but did not fly during the winter months. The last extended period of no flight was between 22 November 2008 and 15 March 2009. Between 15 March 2009 and the accident date, the aircraft carried out 17 flights. Seven of these flights were 10 minutes in duration, and three of these 10-minute flights included 5 minutes of aerobatics.

During the winter months between 22 November 2008 and 15 March 2009, the aircraft was stored in a hangar at a private airstrip in Bossington, Hampshire. This was close to where the accident pilot lived, and he was known to go to the airstrip to carry out engine ground runs during the winter months. The pilot's farming director recalled two or three occasions during the winter when he assisted in removing the aircraft from the hangar for an engine run and the farming director's foreman was also involved on three separate occasions in running up the aircraft, Neither of them was aware if the aircraft had flown after they had provided this assistance, so some of this assistance might have been provided in November or March when the aircraft had flown. It was, therefore, not possible to establish the number of occasions that the engine had been ground-run during the three months that it had not flown.

Engine manufacturer's recommended procedures for engine inhibition and storage

The '*Operation, Maintenance and Overhaul Handbook*', for Leonides 500 and 510 series engines, contains a chapter on '*Inhibition for Storage*' which recommends that for 'short term' storage of an engine that can be run, where 'short term' is defined as a storage period of less than one month, '*the engine should be run at least once in every seven days*.' The procedure involves a stepped increase in engine rpm, resulting in a final run at 2,600 rpm until an oil inlet temperature of approximately 75°C is obtained. The handbook states that if it is not practicable to run the engine then '*it must be inhibited and externally protected*.' For 'long

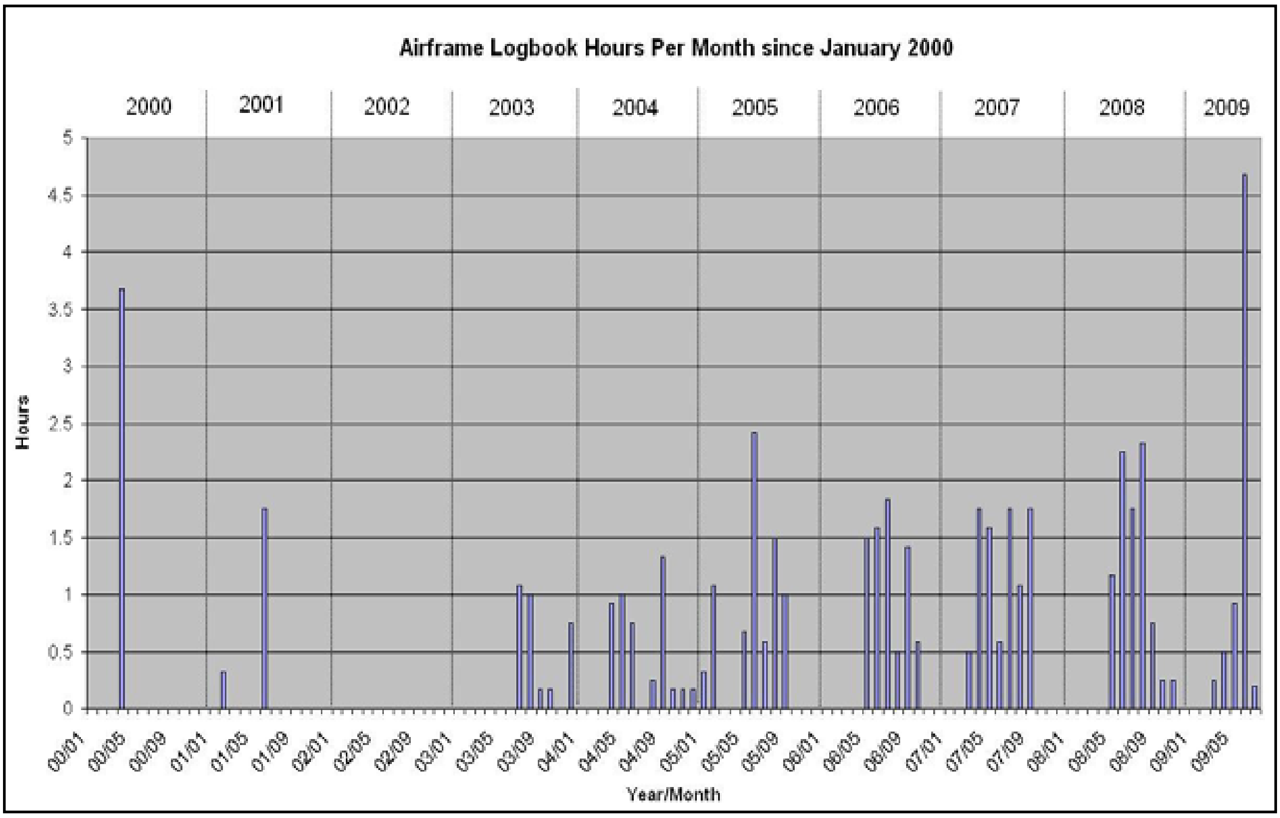


Figure 17

G-AWVF airframe logbook hours per month between January 2000 and July 2009 term' storage, defined as a period when the engine is expected to be out of service for one month or more, the handbook states that the engine '*should be fully inhibited as detailed in the following paragraphs*.' The ensuing procedure includes running the engine, draining all the oil and replacing it with storage oil, and then running the engine again. A detailed inhibiting procedure of each engine cylinder and its components is then described.

Hydraulic lock

Hydraulic lock is a phenomenon that can occur on piston engines that have downward-pointing cylinders, that is, cylinders orientated such that the piston is moving down during the compression stroke. All radial engines have some cylinders that are pointing downwards and are, therefore, susceptible to hydraulic lock. After a radial engine has been shut down for a period, oil may drain into the combustion chambers of the lower cylinders or accumulate in the lower intake pipes, ready to be drawn into the cylinders when the engine starts. As the piston approaches top dead centre (TDC) of the compression stroke (both valves are closed at this point), the oil, being incompressible, can stop the piston movement (Figure 18). If the crankshaft continues to rotate then damage to the engine will occur – this could result in a cylinder being blown out, a bent or fractured connecting rod, or damage to the gudgeon pin. This phenomenon is known as 'hydraulic lock'. A partial hydraulic lock can also occur when liquid is inside the combustion chamber, but is not sufficient to fill the space between the cylinder head and the piston when it is at TDC. In this situation, the air gap is still reduced and, therefore, the pressure rise within the cylinder can still be sufficient to stop the piston or to result in damage if the piston is forced through TDC during engine start. Damage resulting from a partial hydraulic lock can be more serious as it could go undetected during the engine start, and then result in failure at some later time in flight.

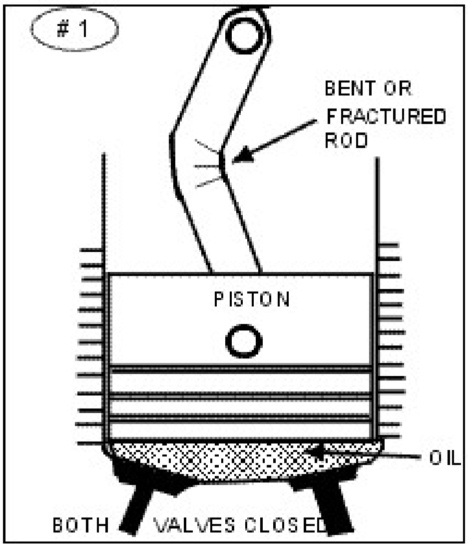


Figure 18

Diagram showing the possible effect of hydraulic lock on a piston connecting rod

To avoid hydraulic lock during engine start, the propeller should be turned through a few revolutions by hand in the direction of rotation (with the ignition switches off). If any excessive resistance is felt while pulling the propeller through a compression stroke, then liquid is present in one of the cylinders, and the propeller should not be pulled through any further.

The Provost T1 Pilot's Notes states:

> *'Unless the engine has been run during the preceding hour, check for hydraulic locking by having the propeller turned by hand through four revolutions.'*

The Pilot's Notes do not state what to do if hydraulic lock is encountered.

The RAF Ground Handling Notes for the Pembroke, which uses a similar Alvis Leonides engine to the Provost, states:

> *'All engines which have NOT been running during the 30 minutes preceeding the intended start, are to have the following 'hydraulic' check carried out:'*

After ensuring that the magneto switches are off the procedure states:

> *'With the right hand cupped about the lower descending propeller blade tip, advance across and forward of the propeller disc, pulling the propeller blade until the right hand releases naturally from the blade. Repeat this exercise until 12 blade tips have passed the lower vertical point. Any resistance to rotation of the propeller is to be reported to the propulsion trade manager. The resistance will indicate excess fluid in the lower cylinders and, in this event, the sparking plugs must be removed from the cylinders and the propeller turned through several revolutions to drain off the fluid.'*

With a three-bladed propeller, turning the propeller through '12 blades' ensures that the engine will have been turned through at least four complete revolutions[5]. The engine manufacturer's '*Operation, Maintenance and Overhaul Handbook*', for Leonides 500 and 510 series engines contains the following similar procedure:

> *'Anti-hydraulicing procedure. To prevent the possibility of a hydraulic lock occurring when an engine is started ensure that the ignition switches are OFF then turn the propeller through twelve blades. If undue resistance to movement is experienced during the above operation or after installation, after storage or when an installed engine has not been run for seven days or more, proceed with either of the two following procedures as applicable.'*

The two procedures which follow the above paragraph both involve removing the spark plugs from the No 4, 5 and 6 cylinders and turning the engine through several revolutions in order to expel the excess fluid.

The owner of G-AWVF, the accident pilot, and the third pilot who was permitted to fly the aircraft, employed different procedures to the aforementioned procedures when they encountered hydraulic lock. These included turning the propeller forward through at least 27 blades and, if any undue resistance was encountered, the propeller would be turned back in order to clear any hydraulic lock. The theory behind this procedure is that, by turning the propeller back, the intake and exhaust ports are opened and the fluid is allowed to drain into these ports. This procedure avoids the more time-consuming and work-intensive procedure of removing the spark plugs to drain the fluid.

Anecdotal evidence suggests that the use of this procedure may be widespread, but it is contrary to the advice from the engine manufacturer, and it has a potential problem. When the propeller is turned backwards, the piston which has encountered the hydraulic lock moves up (assuming it is a 'downward pointing' cylinder), and then the first valve to open is the intake valve. As the propeller continues to be

Footnote

5 The engine has a 0.625 to 1 reduction gearbox, so four complete revolutions of the propeller actually equates to 6.4 revolutions of the engine.

rotated backwards the piston moves down and will help to force any liquid out through the intake port. As the propeller continues to rotate, the exhaust valve will open and some liquid might also drain into the exhaust port. Oil in the exhaust port is safe and will either drain out through drain holes in the exhaust, or result in smoke being produced during engine start. However, oil in the intake port is not safe, as it will not drain away and is likely to be sucked back into the cylinder during engine start, potentially causing damage as a consequence of hydraulic lock.

The US Air Force Powerplant Maintenance Manual (AFM 52-12, May 1953), in a section on hydraulic lock involving radial engines, states:

> *'Never attempt to clear the hydraulic lock by pulling the propeller through in the direction opposite to normal rotation, since this tends to inject the liquid from the cylinder into the intake pipe with the possibility of a complete or partial lock occurring on the subsequent start.'*

The owner of G-AWVF could not recall the last time he had encountered hydraulic lock, but when he had experienced it, he said he turned the propeller backwards and then forwards until it cleared. The third pilot who flew G-AWVF reported that he sometimes encountered undue resistance and that when he encountered this resistance he would "work it out" by turning the propeller backward and forward.

History of in-flight fires on Alvis Leonides series engines

Records obtained from a retired Alvis engineer listed the histories of 390 Provost aircraft, 59 Pembroke aircraft, 48 Sea Prince aircraft, 25 Prince aircraft, and 4 President aircraft, all of which were fitted with Alvis Leonides engines of similar types to the one fitted to the Provost. Out of the 390 Provost aircraft, one aircraft (WV423[6]) was listed as '*Engine failure. Fire destroyed South Cerney March 56*'. Another aircraft, WV507, was listed as '*Engine fire, crashlanded Crewe October 54*' and aircraft XF687 was listed as '*Fire in flt. Crashed on forced ldg. Ingoldsby July 58*'. Four additional Provost aircraft were listed as having crashed after the '*engine cut*'. Further details on these accidents could not be found. Out of the 59 Pembroke aircraft there were three aircraft which were listed as '*Engine fire*. *Damaged on landing.*'. No engine fires were listed for any of the Sea Prince, Prince or President aircraft.

Aircraft operating in the UK with Alvis Leonides series engines

Excluding G-AWVF, in January 2010 there were six remaining Provost aircraft on the UK G-register. Of these six aircraft only three have a valid Permit to Fly (G-AWPH, G-KAPW and G-MOOS). The other three aircraft are, or had been, in the process of being rebuilt or restored. There are two Pembroke aircraft on the G-register, one of which has a valid Permit to Fly. There are three Sea Prince aircraft on the G-register, none of which have a valid Permit to Fly – two are static display aircraft and one is being restored for flight. The last remaining aircraft on the G-register that has an Alvis Leonides engine is a Scottish Aviation Twin Pioneer, but its Certificate of Airworthiness has expired. In summary, there are currently four aircraft on the UK G-register with a valid Permit to Fly that have Alvis Leonides engines fitted (this accounts for five engines in total as there are two fitted to the Pembroke).

Footnote

[6] This is a military aircraft registration.

Anecdotal evidence suggests that there are two Provost aircraft operating in New Zealand and at least one in the USA.

Safety Action taken by the CAA

When the evidence of a fatigue failure of the No 6 gudgeon pin was found, the AAIB and the CAA discussed interim safety action while the investigation continued into the cause of the fatigue crack. The primary concern was to raise awareness of the findings to other operators of Alvis Leonides series engines. As a result, on 22 September 2009, the CAA published an 'Airworthiness Communication' (AIRCOM 2009/11) to '*Owners and Operators of Percival P56 Provost, Percival P50 Prince (and Sea Prince), Percival P66 Pembroke and Scottish Aviation Twin Pioneer aircraft.*' It highlighted the preliminary findings of the investigation and made the following two recommendations:

> *'3.1 Corrosion pitting may initiate on internal engine components for a number of reasons, but low utilisation operations can make components particularly susceptible to deterioration of this nature. It is therefore important that owners/operators of low utilisation engines in particular, take into account the manufacturer's recommendations for engine protection, including any applicable recommendations for storage and inhibiting.*
>
> *3.2 CAA will liase with AAIB as the investigation progresses and issue further information to owners/operators as appropriate. In the meantime, and in light of the apparent consequences of corrosion pitting in this particular case, owners/operators may wish to review the current calendar time since last overhaul and the maintenance history of engines fitted to their aircraft. This should also include any protection arrangements made for these engines during any storage period. Refer to the relevant engine Operation, Maintenance and Overhaul Handbook for the protective measures recommended by the manufacturer for both short and long term storage.'*

The CAA also plans to review its policy on parachute requirements for certain ex-military aircraft types. In the meantime, an AIRCOM will remind aircraft owners of the guidance in CAP 632 which recommends that parachutes should be worn in ex-military aircraft.

Analysis

Probable sequence of events

There were four separate pieces of evidence which showed that the aircraft had suffered from an in-flight fire prior to impact: (1) burnt pieces of wreckage at the accident site were surrounded by unburnt crops; (2) the right engine cowling, which had separated from the aircraft more than a mile south of the accident site, exhibited burn marks; (3) many witnesses reported seeing smoke and flames from the aircraft while it was in flight; and (4) the post-mortem found evidence that the pilot had inhaled smoke. The evidence also suggested that the fire had started in the engine bay and progressed aft into the cockpit.

The time between the fire becoming evident to the pilot and the engine cowlings detaching is not known. However, shortly after the engine cowlings detached, the pilot tried to declare a MAYDAY but his radio transmission was blocked by another transmission.

The main fuel shutoff valve was found in the near fully closed position, which indicated that the pilot probably tried to shut the fuel off the correct action to take following an engine fire. It was not possible to establish an accurate final flight profile from the radar data, but the data indicated that an approximately straight flight path was maintained following the "MAYDAY" transmission and then the aircraft initially slowed, possibly as a consequence of a power reduction, before accelerating just as radar contact was lost. The post-mortem evidence indicated that the pilot would have probably lost consciousness prior to impact, and the ensuing 35° to 40° nose-down impact was consistent with the dive angle obtained during an investigation flight when power was reduced to idle and the control column was released.

The damage to the engine, consisting of a failure of the master rod and all the articulating rods, indicated that a serious mechanical engine failure had occurred in flight. It is probable that the ground impact would have caused some damage to a rotating engine, but it is unlikely that it would have caused the failure of all connecting rods. The indentations on the inside of the right engine cowling were in line with the No 7 cylinder head, indicating that the cylinder head had struck the cowling or the cowling had struck the cylinder head. The No 7 cylinder had separated from the engine and had been thrown 40 m clear of the impact site, which suggested that it may have already been partially detached from the engine prior to impact (cylinders No 5 and 6 were close to the impact site). The engine cowling latches had failed in overload, so the overall evidence indicated that the right cowling probably began to detach as a result of it being struck by the No 7 cylinder, which had been blown out as a result of the mechanical engine failure.

The No 6 gudgeon pin was found to have failed due to a fatigue crack which had been propagating over the previous 30 to 35 engine stop/start cycles. Once this pin failed a catastrophic mechanical engine failure would have ensued. Based on an examination of all the evidence the following probable sequence of events was constructed:

1. The No 6 piston gudgeon pin failed in overload after a fatigue crack reached a critical length.
2. The master rod, no longer retained at the piston end, started to flail, damaging the piston and cylinder skirt.
3. The loss of rigidity of the master rod resulted in excessive loading on the articulating rods, causing them to fail.
4. The master rod impacted into the No 7 cylinder, causing the cylinder partially to separate from the engine and strike the right engine cowling.
5. The No 7 cylinder separation resulted in disconnection of the cylinder's inlet and exhaust pipes.
6. A mixture of fuel and air was released from the disconnected inlet pipe and ignited (possibly due to its proximity to the hot exhaust pipe).
7. The burning fuel travelled aft towards the firewall and burnt the aft lower corner of the right engine cowling.
8. The force of the airstream eventually caused the right engine cowling to detach completely and take the upper and left cowlings with it.

9. The fire in the engine bay probably burnt through the right SCAT hose that forms part of the ventilation system, permitting the fire to enter the cockpit via the punkha louvres. It is also possible that other entry points through the firewall were compromised, permitting the fire to enter the cockpit.

10. It is probable that the pilot lost consciousness due to the build-up of toxic fumes, and released the control stick.

11. The aircraft entered a steep dive due to the loss of engine power and the control stick being released, and then hit the ground.

Probable cause of gudgeon pin fatigue crack

The gudgeon pin had failed due to fatigue, so the investigation considered what might have caused the fatigue crack to initiate. The origin of the fatigue crack was located at a corrosion pit and corrosion pits act as stress raisers which reduce the fatigue life of a component. The longitudinal fatigue crack had propagated along the 'bottom' of the pin, which is the likely direction for such a crack to propagate. The gudgeon pin is a hollow tube that experiences compressive loads perpendicular to its longitudinal axis. Therefore, the inner surfaces at the top and bottom positions would experience cyclic tensile stress during operation, and are therefore the most likely areas to experience fatigue. However, for the fatigue crack to propagate, the direction of the applied cyclical loads would have had to remain constant, which meant that the gudgeon pin would have needed to stop rotating within its piston bores.

The clearance between the pin and bores is small (less than 0.05 mm), so it is possible that, over time, a build-up of debris inside the bore had constrained the pin's rotation. Some of the pistons examined had gudgeon pins that were more difficult to rotate than others as a result of a build-up of debris, but some of this debris could have been introduced during the impact and fire. The clearance between the pins and bores had not been checked since 1964, so it cannot be ruled out that a build-up of debris was a factor in constraining the pin. However, anecdotal evidence from engineers who have experience of dismantling historic radial engines, revealed that although 'fully floating' gudgeon pins may be designed to rotate, in practice many (up to 30% in any given engine) do not, despite there being no faults apparent (ie clearances are within limits, no damage, no excessive sludge or corrosion, and the pin slides and rotates freely). It is thought that, perhaps, the pin finds its own 'niche' due to tiny imperfections on its surface and once it stops rotating for a few cycles, microscopic build-ups reinforce this tendency. In normal circumstances, the fact that the pin has stopped rotating does not appear to result in any adverse effects.

An important factor that helped to initiate the fatigue crack was the presence of corrosion pits on the inner surface of the gudgeon pin. There was corrosion on the inner surface of the failed gudgeon pin and on most of the other gudgeon pins. Corrosion is generally caused by the presence of moisture. Frequent use of an engine usually results in any moisture build-up evaporating during operation, which helps to prevent corrosion from setting in. However, G-AWVF's history reveals long periods of inactivity, which probably resulted in the build-up of corrosion inside the gudgeon pins. During one long period of inactivity, there was a note in the logbook indicating that the engine had been run monthly. However, the engine manufacturer recommended that if the engine was not operated within a seven-day period, then it should be inhibited. It further recommended that an engine be inhibited if it was unlikely to be used for a period of more than one month. There is no evidence from the engine logbooks to indicate that the engine had ever been inhibited.

The presence of corrosion pits on the inner surface of the gudgeon pin would have made it more susceptible to a fatigue crack. It is possible that the presence of these pits alone, combined with normal cyclical loads, caused the crack to initiate. However, it is more likely that a high-load event, such as a partial or full hydraulic lock, caused the crack to initiate and the corrosion pit helped to site it. In discussing this investigation with a number of engineers experienced on working on historic piston engines, the comment was made that gudgeon pin failures for reasons other than hydraulic lock are extremely rare. Some engineers had seen gudgeon pins with a similar or worse degree of corrosion than on the pins found on G-AWVF, and these had not failed or suffered cracks.

If a high load or overload event triggered the fatigue crack, then it is likely to have occurred some 30 to 35 stop/start cycles prior the accident and therefore no earlier than June 2008. The aircraft suffered from a propeller ground strike in February 2005 and therefore it is unlikely, by the stop/start cycles, that this event triggered the onset of the fatigue crack. However, a partial or full hydraulic lock event during start-up was a possibility. The pilots of G-AWVF had not been employing the engine manufacturer's recommended practice of removing the spark plugs to clear a suspected hydraulic lock and their practice of turning the propeller back to clear the lock could have caused oil to be re-introduced into the cylinder during start, and cause hydraulic lock damage. It is also possible that, in turning the propeller forwards, against a high resistance caused by fluid in the compression chamber, a sufficiently high load was applied to the gudgeon pin to cause the fatigue crack to initiate.

The engine had been in service for 45 years without an overhaul so there had not been an opportunity to check for corrosion or the build-up of debris within the piston bores. The TBO was 800 hours without a calendar time limit, and the original engine designers would probably not have envisaged an engine being used for 45 years without exceeding 800 hours. The piston engines built by Lycoming and Teledyne Continental were also originally manufactured with an 'hours-based' TBO and no calendar limit. However, both manufacturers later introduced a recommended 12-year calendar limit between overhauls. Introducing a similar calendar limit for the Alvis Leonides series engines would reduce the likelihood of engine failures caused by factors associated with a lack of use. Therefore, in addition to the safety actions (noted earlier) by the CAA, the following three Safety Recommendations are made:

Safety Recommendation 2010-029

It is recommended that the Civil Aviation Authority consider implementing calendar time limits between overhauls for Alvis Leonides series engines, and other historic aircraft engines that do not have manufacturer-recommended calendar limits.

It could not be conclusively determined if an overload event, such as hydraulic lock, had initiated the gudgeon pin fatigue crack, or if the presence of corrosion pits with normal cyclical loads had initiated the fatigue crack. However, it is more likely that hydraulic lock was a factor. In order to reduce the likelihood of future engine failures caused by hydraulic-lock-induced damage, the CAA should publicise to operators of radial engines the correct technique for clearing hydraulic lock. Therefore:

Safety Recommendation 2010-030

It is recommended that the Civil Aviation Authority notify operators of piston radial engines of the correct technique for clearing a hydraulic lock.

In order to reduce the likelihood of future Alvis Leonides series engine failures due to gudgeon pin corrosion pitting, the CAA should consider introducing a gudgeon pin inspection. However, it is difficult to detect corrosion pits of the small magnitude seen in the G-AWVF gudgeon pins without sectioning the pins and examining them with an SEM. Therefore, a simpler inspection of the pins, examining for cracks and corrosion, may be sufficient. Therefore:

Safety Recommendation 2010-031

It is recommended that the Civil Aviation Authority consider introducing a requirement to inspect the gudgeon pins on Alvis Leonides series engines.

Conclusions

The accident was caused by an in-flight engine fire that probably rendered the pilot unconscious. The fire was caused by a catastrophic mechanical engine failure which was initiated by a fatigue crack of the No 6 piston gudgeon pin. The exact cause of the fatigue crack initiation could not be determined but it is likely that a high-load event, such as a partial or full hydraulic lock, initiated the crack in the pin. The presence of corrosion pits on the inner surface of the pin, which would act as stress raisers, was probably a contributory factor, and the aircraft's low utilisation rate during the previous 45 years probably contributed to the formation of corrosion.

ACCIDENT

Aircraft Type and Registration:	Jodel D117, G-AWVB
No & Type of Engines:	1 Continental Motors Corp C90-14F piston engine
Year of Manufacture:	1957
Date & Time (UTC):	28 April 2010 at 1420 hrs
Location:	Old Park Farm, Margam, Port Talbot
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damaged beyond economic repair
Commander's Licence:	Private Pilot's Licence
Commander's Age:	69 years
Commander's Flying Experience:	960 hours (of which 879 were on type) Last 90 days - 9 hours Last 28 days - 6 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

Whilst landing on an uphill grass runway with a tailwind component, the wheels locked under braking and the aircraft overran the strip, colliding with fences and a hedge.

History of the flight

The pilot had returned from Enstone to Old Park Farm in conditions similar to those he had experienced earlier that day on the outbound flight. The ambient temperature was 16ºC.

He had owned the aircraft for 16 years and had experience of operating it from grass strips. The runway at Old Park Farm is 350 m long and is orientated directly north-south. It has a significant slope, so all landings are made uphill and takeoffs downhill, regardless of wind direction. Runway 36 is the uphill direction. A windsock is positioned to the left at the top end of Runway 36. Approximately one mile from the beginning of this runway are two high voltage cables on pylons approximately 200 ft tall, the cables running at 90º to the runway.

On approaching the vicinity of the airstrip the pilot switched to the Swansea radio frequency, the nearest significant airfield. He was able to obtain the surface wind, which was 220º at 7 kt, and to establish their QNH. He then changed to the Old Park Farm radio frequency.

As he passed abeam Port Talbot steel works he was able to observe the steam plumes. He noted that some were rising vertically, whilst others were indicating a south-easterly wind. He then transmitted a downwind call for Runway 36 left-hand and slowed to 70 mph. No response was heard from any other traffic. He turned onto base leg and then onto final at 300 ft, announcing the fact on the radio, and slowing to between 60 and 65 mph.

He subsequently stated that, since the aircraft type had no flaps, it was his custom on clearing the second cable run to sideslip the aircraft to position it at the correct approach height, with an airspeed of 55 to 60 mph.

On rounding out he became aware that the groundspeed seemed slightly high, although the correct 50 mph airspeed was being indicated. Nonetheless, a normal three-point landing was achieved, albeit followed by poor deceleration as the aircraft ran uphill. The pilot braked gently, but then more firmly. The aircraft continued up the slope and struck the barbed wire fence at the end, before crossing a lane and striking a second fence and hedge.

Subsequent examination of ground marks indicated that both wheels were locked as the aircraft proceeded up the slope. Within the space of two hours, three other aircraft arrived with no problems.

The pilot regarded the failure of the aircraft to stop as perplexing; in his previous experience of G-AWVB this lack of deceleration had not occurred on grass strips. On the contrary, landings at Old Park Farm normally required some application of power to vacate the runway. He considered that the south-westerly wind must have briefly strengthened during the landing roll.

ACCIDENT

Aircraft Type and Registration:	Morane Saulnier MS.894A Rallye Minerva, G-HHAV
No & Type of Engines:	1 Franklin 6A-350-C1 piston engine
Year of Manufacture:	1970
Date & Time (UTC):	18 June 2010 at 1000 hrs
Location:	Perranporth Airfield, Cornwall
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Nose gear, engine mount, wings and propeller damaged
Commander's Licence:	Private Pilot's Licence
Commander's Age:	52 years
Commander's Flying Experience:	4,430 hours (of which 200 were on type) Last 90 days - 1 hour Last 28 days - 1 hour
Information Source:	Aircraft Accident Report Form submitted by the pilot and further enquiries by the AAIB

Synopsis

Following a touch-and-go at Perranporth Airfield, the aircraft suffered a sudden power loss whilst climbing through 400 ft agl. The pilot executed a forced landing in a field during which the aircraft's wings, engine mount, nose landing gear and propeller were damaged. Subsequent engineering examination of the aircraft did not positively identify the reason for the engine failure although an electrical fault was identified in the left magneto primary lead that was sufficient to prevent the left magneto from functioning.

History of the flight

After completing pre-takeoff checks that included engine run-up checks, during which all engine indications and both left and right magneto rpm drops were normal, the pilot departed from Perranporth Airfield with the intention of conducting general handling exercises before returning to the airfield for circuits. On returning to the airfield approximately 25 minutes after taking off, the aircraft completed one circuit to a touch-and-go on Runway 27, following which the pilot applied full power to initiate a climb back into the circuit.

At approximately 400 ft agl during the climbout, two or three loud "pops" were heard from the engine, immediately followed by a total loss of power. The pilot declared a MAYDAY and having insufficient height to land back on the airfield, turned downwind to the south-east towards an area of lower sea cliffs and small fields whilst retaining the option of ditching. The pilot selected a 90 m grass field to land in that was approximately 500 m from the airfield boundary. During the landing roll he elected to steer the aircraft left into a stone boundary wall to arrest the landing, rather than continuing directly ahead and risking a head-on collision with the end boundary wall.

The aircraft came to rest on a heading of approximately 270°M having rotated anti-clockwise through 150°, with the starboard wing and nose of the aircraft touching the boundary wall. The aircraft sustained damage to the left and right wings, engine mount, nose landing gear leg and propeller. A small amount of fuel leaked from the left wing fuel filler cap but there was no fire. The pilot was uninjured and exited the aircraft by sliding the canopy rearwards, as normal.

Engineering examination

Following the accident the owner arranged to have the propeller straightened sufficiently to enable the engine to be ground run. With both primary leads ('p-leads') removed from the magnetos the engine was run successfully.

The ignition starter switch was electrically tested and was in a serviceable condition. No electrical short circuit was detected between the magneto p-leads and airframe ground between the ignition switch and the magneto filter lead terminals.

The left magneto filter lead (Figure 1) was in poor condition, exhibiting fraying of the outer shield material. The lead's insulation had failed at the exit of the filter capacitor body, and thus was electrically short-circuited to earth via the capacitor outer body.

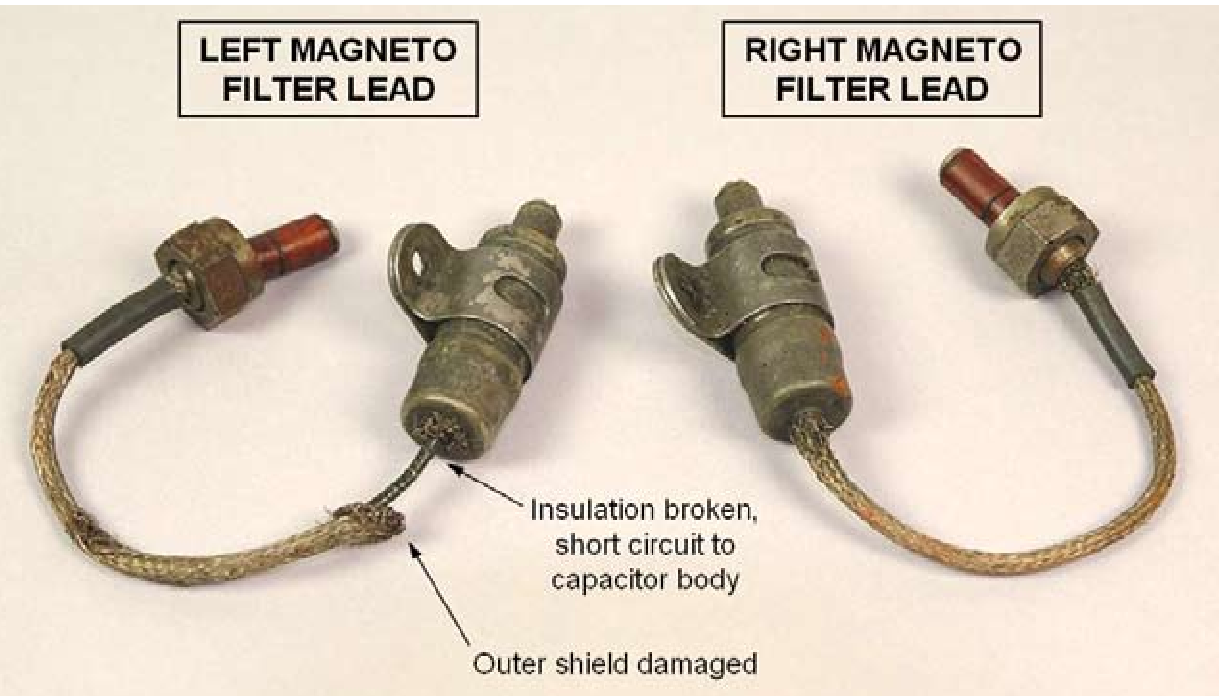


Figure 1
Left and right magneto filter leads

Some of the shield material exhibited evidence of melting and fusing to the capacitor body consistent with high current flow.

The right magneto filter lead also exhibited damage to the shield material at the capacitor body exit but the insulation remained intact and no short circuit to airframe earth was detected.

Both magnetos were removed from the aircraft for examination at an approved overhaul facility, were tested and declared serviceable.

Maintenance requirements for the magneto wiring harness

Prior to the accident flight the aircraft had not flown in the preceding 10 months, during which it had been subject to both an annual check in November 2009 and a six month check in June 2010. The aircraft operated with an EASA Certificate of Airworthiness and was therefore subject to the maintenance requirements contained in CAP 766 – *Light Aircraft Maintenance Programme – Aeroplanes*.

Task 55 of CAP 766 contains the following magneto related maintenance requirement, to be performed at an interval of 150 hours, or annually, whichever occurs, see Figure 2.

CAP 766 defines 'Inspect' as:

> *'Inspect (INSP)*
>
> *An 'inspection' is a visual check performed externally or internally in suitable lighting conditions from a distance considered necessary to detect unsatisfactory conditions/ discrepancies using, where necessary, inspection aids such as mirrors, torches, a magnifying glass etc. Surface cleaning and removal of detectable cowlings, panels, covers and fabric may be required to be able to satisfy the inspection requirements.'*

Analysis

As both left and right magnetos functioned correctly during the pre-takeoff checks, it is probable that the electrical short circuit between the left magneto filter lead and airframe ground occurred during the accident flight, caused by the poor condition of the lead. The electrical grounding of the left magneto filter lead inhibited the left magneto from functioning, leaving the aircraft with only the right magneto system to supply ignition to the engine. The right magneto was subsequently tested and shown to be serviceable.

Following the accident, the aircraft's engine successfully started with both magneto filter leads removed from the magnetos, demonstrating that the engine was capable of running. However, it has not been possible to determine

Task No	Task Description	Task Nature	Task Interval	Qualifying Mechanic		Qualifying Inspector	
				LH	RH	LH	RH
Ignition:							
55	*Magnetos, harnesses, leads, switches, starting vibrators, contact breakers, cooling system and ventilators.*	INSP	150 FH				

Figure 2

Excerpt from CAP 766 Task 55

the reason why the engine stopped producing power despite appearing to have a serviceable right magneto.

Inspection of the condition of the magnetos and their associated leads and harnesses was required at the annual check performed in November 2009 and the aircraft had not operated between that annual check and the accident flight, showing that the condition of the magneto filter leads was not discovered at the annual check.

Following the engine failure, the pilot's forced landing options were limited to either ditching in the sea or landing in a field between the airfield and the sea cliffs; this area consists of steeply sloping scrubland and small fields that reduced the probability of successfully carrying out a forced landing without damaging the aircraft.

Conclusions

Whilst the reason for the aircraft's engine failure was not be positively identified, a short circuit of the left magneto primary lead at the exit of the magneto filter lead capacitor body was discovered during engineering examination of the aircraft's ignition system. This fault was sufficient to prevent the left magneto from functioning. Attention is drawn to the ignition harness maintenance requirements contained in CAP 766 (*Light Aircraft Maintenance Programme*) which requires inspection of the magneto harness for unsatisfactory condition at either a 150 flying hour check, or annual check, whichever occurs first.

ACCIDENT

Aircraft Type and Registration:	Piper L18C Super Cub, G-BLMI
No & Type of Engines:	1 Continental Motors Corp C90-12F piston engine
Year of Manufacture:	1952
Date & Time (UTC):	8 July 2010 at 1430 hrs
Location:	Long Crendon, Buckinghamshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damaged beyond economic repair
Commander's Licence:	Private Pilot's Licence
Commander's Age:	49 years
Commander's Flying Experience:	334 hours (of which 56 were on type) Last 90 days - 14 hours Last 28 days - 3 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

Whilst making an approach to a 300 m long upsloping farm strip in a slight tailwind and high ambient temperature conditions, the pilot allowed the aircraft to become high on the approach to remain clear of power lines. The aircraft touched down long and the pilot made a late decision to go around. There was insufficient distance remaining and the aircraft's landing gear struck a hedge, causing the pilot to lose control and the aircraft to be extensively damaged in the subsequent ground impact.

History of the flight

The pilot undertook a short flight from White Waltham to practise short field landings at Long Crendon airstrip, which is 300 m long and oriented 02/20. He had only landed there once before, some years previously, in a different aircraft type. His passenger on the accident flight was a pilot of greater experience who was familiar with the grass strip. The surface wind was estimated to be 250° at 5 kt and the ambient temperature was approximately 28°C.

An approach to runway direction 20 was made and a go-around initiated when excessive float was encountered. The decision was then taken to land on runway direction 02, which is upsloping and which was at the time subject to a slight tailwind. This approach was considered unsatisfactory and the pilot again carried out a go-around before making a further approach. On this approach he was mindful of the presence of power lines in the field adjoining the strip threshold and carried out an initially high approach. In his attempt to lose the excess height, the airspeed became higher than desired and the aircraft touched down firmly in a three-point attitude about one third of the way along the strip. It bounced and touched down again, but still with excessive speed. Although the pilot considered he could stop in the distance remaining, the passenger then made a go-around call. The pilot then initiated a go-around as he now feared he would strike the boundary hedge. He applied full power but he considered that the aircraft failed to reach flying speed. He attempted to pull up to avoid the hedge, but the landing gear struck the top of the hedge (incorporating strands of wire), pitching the aircraft forward into the adjacent field.

The pilot considered that the upslope, high ambient temperature and slight tailwind rendered the acceleration insufficient to clear the hedge in the remaining distance available following the decision to go around.

SERIOUS INCIDENT

Aircraft Type and Registration:	Piper PA-28-140 Cherokee, G-AVLJ
No & Type of Engines:	1 Lycoming O-320-E2A piston engine
Year of Manufacture:	1967
Date & Time (UTC):	3 July 2010 at 1617 hrs
Location:	Jersey Airport, Channel Islands
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Minor) Passengers - N/A
Nature of Damage:	Left windscreen shattered
Commander's Licence:	Private Pilot's Licence
Commander's Age:	43 years
Commander's Flying Experience:	686 hours (of which 597 were on type) Last 90 days - 24 hours Last 28 days - 13 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft was on final approach and had been cleared to land when a seagull flew into the aircraft's flight path. The pilot was unable to take avoiding action and the bird struck the left windscreen causing it to shatter. The remains of the bird entered the cockpit and hit the pilot, dislodging his headset. The pilot was able to make a normal landing, after which he recovered the headset from the rear of the aircraft and informed ATC of the incident. The pilot then taxied the aircraft to its assigned parking place where he received first aid for minor injuries.

ACCIDENT

Aircraft Type and Registration:	Piper PA-28-161 Cherokee Warrior II, G-BJBX
No & Type of Engines:	1 Lycoming O-320-D3G piston engine
Year of Manufacture:	1981
Date & Time (UTC):	10 July 2010 at 0730 hrs
Location:	Full Sutton Airfield, Yorkshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Nose and right landing gear separated from aircraft, propeller and engine damaged
Commander's Licence:	Private Pilot's Licence
Commander's Age:	68 years
Commander's Flying Experience:	670 hours (of which 369 were on type) Last 90 days - 5 hours Last 28 days - None
Information Source:	Aircraft Accident Report Form submitted by the pilot and further enquiries by the AAIB

The pilot planned to fly some circuits from the grass Runway 22, the middle of which had been reseeded and which pilots were requested to avoid. The weather was "good" with a surface wind from 170° at 13 kt. The pilot reported that after a normal circuit he flew a shallower than normal approach, intending to touch down at the runway threshold and avoid the reseeded area. He commented that there was occasional light to moderate turbulence on the approach and that after the aircraft crossed the airfield boundary, about 60 m short of the threshold, the right wing suddenly dropped. He applied full power but was unable to prevent the wingtip hitting the ground. The aircraft nose and right landing gear detached in the ensuing impact, which also damaged the propeller. The pilot, who was uninjured, made the aircraft safe before leaving unaided through the main door.

ACCIDENT

Aircraft Type and Registration:	Piper PA-28-161 Cherokee Warrior II, G-BSPI
No & Type of Engines:	1 Lycoming O-320-D3G piston engine
Year of Manufacture:	1981
Date & Time (UTC):	22 June 2010 at 1416 hrs
Location:	Gloucestershire Airport, Gloucestershire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to the wing spar, fuselage, landing gear, propeller and engine mounts
Commander's Licence:	Private Pilot's Licence
Commander's Age:	72 years
Commander's Flying Experience:	253 hours (of which 159 were on type) Last 90 days - 1 hour Last 28 days - None
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

During final approach, the pilot increased the throttle but the engine did not respond. The aircraft had insufficient airspeed and altitude to reach the airfield and crashed into a hedge short of the runway.

History of the flight

The pilot was practising circuits at Gloucestershire Airport; he had successfully completed his first circuit and was on short final for a second touch-and-go. The pilot reported that he had satisfactorily completed the downwind checks and had selected carburettor heat ON during the base leg. After selecting full flap, and at a height of about 150 ft, the pilot applied power to remain on the PAPI indicated glideslope, but the engine did not respond. As the pilot was wearing a noise-cancelling headset, he could not determine if the engine was operating at idle or was 'windmilling'. The aircraft did not have sufficient airspeed or altitude to glide to the runway, so the pilot landed it short, heavily impacting a large hedge at the edge of a field. The pilot was uninjured, but the aircraft was extensively damaged.

Discussion

The aircraft was inspected, post-recovery, by the engineering organisation responsible for maintaining it. They could not find any pre-impact defects with either the engine or the fuel system. The weather was conducive to carburettor icing at descent power, but the pilot considered it was unlikely that carburettor icing had occurred as he had confirmed the carburettor heat was working prior to takeoff and found it was selected ON after the aircraft came to rest. He also confirmed that there had been no problem in achieving full power from the engine during the flight up to that point.

ACCIDENT

Aircraft Type and Registration:	1) Piper PA-28-161 Cherokee Warrior II, G-CFMX 2) Piper PA-28-161 Cherokee Warrior III, G-CBYU
No & Type of Engines:	1) 1 Lycoming O-320-D3G piston engine 2) 1 Lycoming O-320-D3G piston engine
Year of Manufacture:	1) 1983 2) 2002
Date & Time (UTC):	17 May 2010 at 1115 hrs
Location:	Stapleford Airfield, Essex
Type of Flight:	1) Training 2) N/A
Persons on Board:	1) Crew - 1 Passengers - None 2) Crew - None Passengers - None
Injuries:	1) Crew - None Passengers - N/A 2) Crew - N/A Passengers - N/A
Nature of Damage:	1) Damage to left wing leading edge; wing tip and shock-loading to engine 2) Damage to nose, left wing and fuselage
Commander's Licence:	1) Student 2) N/A
Commander's Age:	1) 34 years 2) N/A
Commander's Flying Experience:	1) 7 hours (of which 7 were on type) Last 90 days - 7 hours Last 28 days - 7 hours 2) N/A
Information Source:	Aircraft Accident Report Form submitted by the pilot

The student pilot was taxiing the aircraft from its parking stand to the fuel pumps with the intention of refuelling prior to an instructional sortie. He misjudged the clearance between his left wingtip and the nose of another parked PA-28 aircraft (G-CBYU), which he struck, rotating his aircraft to the left through 180°. G-CFMX came to rest with its spinner buried in the side of the rear fuselage of the other aircraft, which was unoccupied.

The student's instructor commented that his pupil had satisfactorily completed Exercise 5 of the syllabus (taxiing) and had shown 'good ability'. However, as a result of the accident, further instruction on taxiing has been given.

ACCIDENT

Aircraft Type and Registration:	Piper PA-28R-180 Cherokee Arrow, N171JB
No & Type of Engines:	1 Lycoming IO-360 piston engine
Year of Manufacture:	1968
Date & Time (UTC):	21 June 2010 at 1011 hrs
Location:	Oban Airport, Argyll
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 2
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to left wing flap, fuselage, nose gear doors and propeller
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	53 years
Commander's Flying Experience:	12,895 hours (of which 445 were on type) Last 90 days - 47 hours Last 28 days - 1 hour
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The pilot reported that he felt the right main gear start to collapse on touchdown. He selected the gear UP and attempted a go-around, but the aircraft touched the ground so the pilot chose to land with the gear retracting.

History of the flight

The pilot had flown an unremarkable private flight with two passengers on board from Kirknewton Airfield, where the aircraft was based, to Oban Airport. On arrival, the pilot reported that he joined the circuit from the overhead and configured the aircraft for landing by extending the gear during the downwind leg. He stated that he confirmed three green 'gear down-and-locked' indication lights were illuminated, but added that it was difficult to see the lights in the bright sunlight.

As the aircraft descended to touchdown on the runway, the pilot reported feeling a bump as the right wheel touched down, but the aircraft continued to descend. No aircraft warnings were reported by the pilot to suggest that the gear was not down or that it was unsafe. The pilot then selected the gear UP and attempted to fly a go-around. As he relaxed back pressure on the control column to level the aircraft, the step protruding from the fuselage touched the ground. The pilot then chose to commit to a landing with the gear retracting; this was later confirmed by post-accident pictures which showed the nose gear doors were still open. The aircraft skidded along the runway for a distance of approximately 100 m before coming to rest. The occupants were not injured and exited the aircraft normally.

ACCIDENT

Aircraft Type and Registration:	Piper PA-28R-201T Turbo Cherokee Arrow III, G-BNNX
No & Type of Engines:	1 Continental Motors Corp TSIO-360-FB piston engine
Year of Manufacture:	1977
Date & Time (UTC):	23 May 2008 at 0851 hrs
Location:	Runway 09, Bristol Airport, Gloucestershire
Type of Flight:	Training
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to propeller and fuselage, shock load to engine
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	45 years
Commander's Flying Experience:	2,242 hours (of which 11 were on type) Last 90 days - 34 hours Last 28 days - 13 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft landed without the landing gear having been selected down.

History of the flight

The student had completed four circuits as part of an instructional flight and on the base leg of the fifth circuit the student called that he was "taking the gear". On finals the student carried out the 'finals' check which included checking the green 'down-and-locked' indications for the landing gear. The approach was normal and there was very little wind. The aircraft touched down with the underside of the fuselage scraping along the runway, before coming to a rapid stop. The engine was shut down immediately and both the student and instructor evacuated the aircraft without difficulty.

The instructor had checked the three green 'down-and-locked' indications for the landing gear on the previous circuit, but on the final circuit she could not see past the student's hand to check the landing gear position indication.

ACCIDENT

Aircraft Type and Registration:	Piper PA 30, M-ALAN
No & Type of Engines:	2 Lycoming IO-320 piston engines
Year of Manufacture:	1969
Date & Time (UTC):	16 December 2009 at 1215 hrs
Location:	Morecambe Bay Gas Field, Irish Sea
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	48 years
Commander's Flying Experience:	2,975 hours (of which 132 were on type) Last 90 days - 11 hours Last 28 days - 5 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and subsequent AAIB investigation

Synopsis

Approximately 38 nm south-east of Ronaldsway, at FL080, the pilot identified a "runaway" (overspeed) of the right engine. She shut down the engine and commenced a diversion to Blackpool Airport. Six minutes into the diversion the left engine also lost power. Despite conducting relevant cockpit procedures the pilot was unable to restore power. Unable to maintain level flight, and having calculated that Blackpool was too far away, she ditched the aircraft and was picked up by a rescue boat from a nearby rig support vessel.

History of the flight

The pilot stated that she planned to fly from Guernsey Airport, Channel Islands, to Ronaldsway Airport, Isle of Man. She donned an immersion suit and a life jacket before takeoff and had a life raft on board the aircraft.

During her pre-flight checks the aircraft's main tanks were filled to 28 US gallons each and an extra 3.5 US gallons was put in each of the auxiliary tanks; she calculated this would give her an endurance of 4 hours. The fuel in the tanks showed no sign of water contamination and each engine indicated 7 quarts of oil remaining. The aircraft took off at 1002 hrs after an uneventful start and power checks. After cruising initially at FL100 the aircraft descended to FL080 to remain clear of cloud north of Cardiff, Wales.

Approximately 38 nm south-east of Ronaldsway the right propeller began overspeeding (in excess of 2,800 rpm). Having attempted unsuccessfully to stabilise it by retarding the throttle and rpm levers, the pilot shut it down and commenced a diversion to Blackpool Airport, Lancashire.

Six minutes into the diversion, after the aircraft had descended to 4,000 ft amsl to enter VMC, the left engine lost power with the manifold pressure (MP) gauge indicating 17 inches. After completing cockpit procedures intended to restore power the MP remained at 17 inches, insufficient to maintain level flight. Calculating that the aircraft could glide a further 12 nm, with Blackpool 18 nm away, the pilot decided to ditch the aircraft near to some gas rigs (believing that rescue personnel were likely to be nearby) and communicated her intention to ATC. Spotting a rig support vessel, she advised ATC that she would ditch near to this instead; ATC responded that a rig helicopter was monitoring her. She prepared for the ditching by unlatching the door and placing her life raft and a 'grab bag' of essential supplies on the front seat. At approximately 100 ft amsl she shut down the left engine. She then maintained 80 kt until the aircraft was approximately 10 ft amsl, then 'hauled back on the control column' in order to touch down tail first. This caused the aircraft to "belly flop" onto the water.

After vacating the aircraft and inflating her life jacket the pilot climbed onto the wing and discovered that the life raft was already in the water. She swam to the life raft and inflated it but found that there were no steps or handholds to aid her boarding. Accordingly, she hung onto straps fitted to the outside of the life raft to await rescue. She was picked up shortly afterwards by a rescue boat from the rig support vessel.

The pilot was examined aboard the support vessel by medical personnel and found to be uninjured. She was subsequently airlifted to hospital in Blackpool and released that night.

Weather information

An aftercast for the Morecambe Bay Gas Field, obtained from the Met Office, indicated that at the time of the accident there was an area of high pressure centred to the south-east of Iceland and an area of low pressure centred to the east of Denmark. The weather at the accident site included cloud broken to overcast above 2,000 ft, with tops at 6,000 ft. The freezing level was approximately 3,000 ft, with a risk of moderate icing within the cloud. The temperature was between 5 and 7°C and the dew point between 3 to 5°C. The surface wind was from approximately 340° at 5 to 10 kt, locally up to 15 kt. Visibility ranged between 14 and 50 km. The estimated sea surface temperature was approximately 9°C and sea state slight, locally slight to moderate, equating to a wave height of between 0.6 m and 1.5 m.

Survival aids

The pilot commented that although she had conducted sea survival training when she was in the Royal Navy she had not practised using the type of life raft carried on this flight.

Description of aircraft

The Piper PA-30 Twin Comanche is a four-seat, low-wing, twin engine aeroplane of metal construction. The engines on the accident aircraft were fuel injected and fitted with feathering constant speed propellers. The propellers are fitted with start lock latches, which prevent the propeller moving to the feather position during normal shutdowns, to aid subsequent starting.

Fuel is contained within four integral fuel cells located in the leading edge sections of the wings. The main cell in each wing has a capacity of 28 US gallons of useable fuel and the auxiliary cell in each wing has capacity for a further 15 US gallons. Fuel is fed from the cells in each wing to a selector valve for the engine on that wing. It is also possible to cross-feed fuel from the fuel cells in one wing to the opposite engine. An electric auxiliary fuel pump was provided for each engine to back up each engine's mechanically driven fuel pump.

Examination of wreckage

The wreckage was not recovered for five months after the ditching and was therefore heavily contaminated by exposure to the sea and sea bed. The structure sustained damage during the ditching. It suffered further damage when it became caught in the nets of a fishing boat and subsequently during the recovery operation.

Approximately 6.5 US gallons of AVGAS were recovered from the right main tank. No other fuel was recovered but fuel supply lines from the left main and auxiliary tanks to the left selector were fractured.

The control positions of both engines were examined.

Right engine

The throttle, propeller and mixture control levers were all in the fully forward positions. This was likely to be as a result of engine detachment, during the recovery operation, pulling on the operating cables and thereby moving the levers. Both magneto switches were in the OFF position. The fuel booster pump switch was in the OFF position and the fuel selector lever was close to the OFF position; disruption of the fuselage floor between the selector lever and the selector valve most likely accounts for the misalignment. The propeller pitch was engaged in the start lock latches.

Left engine

The throttle, propeller and mixture controls were all in the fully aft position. Both magneto switches were in the ON position. The fuel booster pump switch was in the OFF position and the fuel selector lever was between the MAIN and AUX TANK positions. As with the right engine, this misalignment is most likely due to disruption of the fuselage floor in the area between selector lever and selector valve. The propeller was in the feather position.

No examination of flying controls or other systems was conducted as the pilot did not report any abnormalities with them.

Detailed examination

Right engine

The pilot reported that the propeller rpm ran away and oversped the engine. When she could not stabilise it, she shut the engine down. The examination therefore focussed on the propeller control governor and the propeller.

The propeller control governor was removed from the engine and taken to a specialist overhaul organisation for examination. It was not possible to conduct a function test of the governor due to the contamination but it was disassembled to check its mechanical condition. No mechanical anomalies were identified.

The right engine propeller was removed from the aircraft and taken to a specialist overhaul organisation for examination. The propeller was confirmed to have the start lock latches engaged and the pitch was measured as 12°, which is the value specified in the overhaul manual. The air charge pressure was under 10 psi compared to the 45-50 psi expected. The propeller was function-checked through its normal range using compressed nitrogen. The propeller operated smoothly throughout the normal pitch range. The propeller operating mechanism was disassembled and no mechanical anomalies were identified.

Left engine

The pilot reported the left engine lost power to such a degree that level flight was no longer possible. She later feathered the propeller and shut down the engine in preparation for ditching. The examination of this engine concentrated on the mechanical condition of the engine and its fuel and ignition components.

The magnetos and fuel system components were removed for separate examination. The alternate air inlet door was in good condition and opened smoothly against its spring.

The engine was partially disassembled to allow inspection of the main internal components. No mechanical defects were identified and wear patterns were consistent with normal in-service expectations. The magnetos were disassembled and were found to have no mechanical defects. It was not possible to check their electrical condition due to the corrosive effects of the seawater.

The fuel system components were disassembled and found to be in good condition with normal wear patterns. The throttle servo valve fuel inlet filter was free of contamination.

Other information

The FAA promulgated information relating to induction icing problems associated with fuel injection systems in their General Aviation Airworthiness Alerts No 231, published October 1997. The publication states:

'The FAA continues to receive reports of induction icing problems associated with fuel injection systems having metering components on which impact ice may accumulate. (Reference Title 14 of the Code of Federal Regulations (14 CFR) part 23, section 23.1093(a)(5).) In some situations, the FAA has written airworthiness directives (AD's) on aircraft certificated to earlier regulations to require compliance with the intent of section 23.1093(a)(5). However, the reports of induction icing problems on some aircraft models, equipped with the type of fuel metering systems described above, are not numerous enough to justify design changes to meet the later regulations.

When in-flight engine induction icing problems are encountered on aircraft that do not meet the intent of section 23.1093, the pilot has no choice except to descend to warmer air. The cause of induction icing problems is often that the pin size impact tubes, which are upstream of the throttle plate, become obstructed with frozen water droplets that pass through the induction air filter. When these tubes become obstructed, fuel flow is rescheduled to idle fuel flow when the throttle plate is in the normal cruise or takeoff position.

Pilots, operators, and mechanics are encouraged to submit accurate, descriptive reports of induction icing problems on aircraft equipped with fuel injection systems having metering components on which impact ice may accumulate.'

Analysis

Engineering

Due to the extended period of submersion it was not possible to draw any firm conclusions about the fuel quality or quantity on board. The aircraft was refuelled in Guernsey and no other aircraft using the facility have reported any problems with the fuel supplied. The pilot reports that sufficient fuel was uplifted for the flight and en-route checks did not indicate any leaks or excessive consumption.

Right engine

The pilot reported that she was unable to control the right engine propeller rpm. The positions of the right engine fuel selector and magnetos indicated that the right engine had been shut down as described by the pilot.

The symptoms described by the pilot were used to reference the troubleshooting section of the Propeller Owner's Manual. This indicated that a propeller overspeed condition could be caused by a sticking governor pilot valve or low air charge pressure. No mechanical anomalies were found with the governor or the propeller. The air charge pressure was low but it was not possible to prove whether or not the governor pilot valve had stuck.

The propeller was found engaged in the start lock latches which indicated the propeller rpm had decreased to below 800 rpm by the time the propeller pitch had reached this position. The low air charge pressure could lead to a failure to feather or feather slowly according to the troubleshooting section of the Propeller Owner's Manual.

Left engine

Examination of the left engine and its fuel and ignition components did not reveal any mechanical anomalies that would account for the loss of power. It was not possible to check the electrical condition of the magnetos but it is unlikely that both would suffer the same fault at the same time.

The left fuel selector and magnetos were found in positions typical of normal operation, but the throttle, mixture and propeller lever positions indicated the engine had been shutdown. As this engine was shutdown at a late stage in the flight and the pilot had achieved its desired configuration, she was probably concentrating on flying the aircraft on to the sea rather than completing the remaining selections.

The left propeller appeared to be working correctly as no problems were reported by the pilot and it was found in the feather position as selected.

Conclusion

The two engines appeared to have suffered different failures.

Due to the long period of immersion it was not possible to conclude any meaningful analysis of the fuel quantities or quality at the time of the accident.

Right engine

The pilot shut the right engine down after experiencing an uncontrollable propeller overspeed. This was possibly due to the low air charge pressure or a stuck governor pilot valve. No mechanical anomalies were found with the governor but it was not possible to prove whether or not the pilot valve had stuck and therefore it cannot be ruled out.

Left engine

No mechanical reason could be found for failure of the left engine to produce sufficient power for level flight. It is possible that ice formed on the impact tubes of the throttle servo valve and this reduced fuel flow to the engine and thereby limited power regardless of the throttle position.

Survival equipment training

The commander stated that she had performed sea survival training while in the Royal Navy but had not practised using the type of life raft carried on the aircraft. Had she done so she might have known that the life raft had no straps or steps to aid her boarding, and would also have been able to practise boarding it in a controlled environment. Unable to board the life raft, her survival time would have been greatly reduced without expeditious rescue.

ACCIDENT

Aircraft Type and Registration:	Piper PA-30, N7976Y
No & Type of Engines:	2 Lycoming IO-320 piston engines
Year of Manufacture:	1966
Date & Time (UTC):	18 June 2010 at 0922 hrs
Location:	Private airstrip, Lymington, Hampshire
Type of Flight:	Private
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - 1 (Minor) Passengers - N/A
Nature of Damage:	Propeller, landing gear, wings and underside of fuselage
Commander's Licence:	Private Pilot's Licence
Commander's Age:	62 years
Commander's Flying Experience:	1,571 hours (of which 82 were on type) Last 90 days - 16 hours Last 28 days - 7 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopisis

The aircraft was being flown from Jersey to Southampton at an altitude of 3,500 ft in Visual Meteorological Conditions when the pilot noted a marked drop in performance of the left engine. Despite checking engine control positions and selecting an alternative fuel tank, he could not restore power. He decided to keep the engine running as it appeared to be producing some power and the oil pressure was normal. A PAN was declared to Solent Radar who gave permission for a straight-in approach to Southampton Airport.

As the flight continued the pilot found it increasingly difficult to maintain height and he decided to land at an airstrip near Lymington as he thought he would be unable to reach Southampton. To avoid creating extra drag, he did not extend the landing gear or flaps until on final approach. The landing gear had not locked down by the time the aircraft landed and it collapsed on touchdown causing the aircraft to stop quickly. The pilot and passenger were able to vacate the aircraft unaided and once clear they advised Solent Radar of the outcome via the emergency services.

Other information

The pilot reported that the aircraft had flown previously that day and that he had uplifted 50 litres of Avgas before this flight to fill the main tanks, giving a total of 50 US gal. In addition the two auxiliary tanks contained 10 US gal each and the two tip tanks contained 7 US gal each. Before departure the fuel levels were checked using a dipstick and a check of the water drains was satisfactory.

Following the emergency landing, the fuel system water drains were checked again and no water was found. The aircraft was recovered to a maintenance facility in order to investigate the cause of the engine failure and complete the required repairs. If a definitive cause for the engine failure is found, it will be reported in a future AAIB bulletin.

Discussion

The pilot candidly commented that with the benefit of hindsight the ailing left engine may not have been producing any power and that it might have been better to feather its propeller and shut it down. He considered that the extra drag of the windmilling propeller may have been the reason for the aircraft's failure to maintain height.

ACCIDENT

Aircraft Type and Registration:	Taylorcraft F-22, G-BVOX
No & Type of Engines:	1 Lycoming O-235-L2C piston engine
Year of Manufacture:	1991
Date & Time (UTC):	3 July 2010 at 0945 hrs
Location:	Orchard Farm Airstrip, Sittingbourne, Kent
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Substantial
Commander's Licence:	Private Pilot's Licence
Commander's Age:	50 years
Commander's Flying Experience:	325 hours (of which 246 were on type) Last 90 days - 14 hours Last 28 days - 6 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

Whilst landing at a farm strip the aircraft departed the runway and collided with a hedge. The pilot and passenger were uninjured but the aircraft was substantially damaged.

History of the flight

The 600 m long grass runway, orientated 120°/300°, slopes upwards in the runway 12 direction. There are trees, approximately 7 m tall, at the start of runway direction 30 and a hedge and overhead power line at the start of runway direction 12. The terrain surrounding the farm strip includes a small but steep valley perpendicular to the approach to runway direction 12, which is noted for causing unpredictable turbulence when the wind is blowing from a northerly to westerly direction. There was no windsock. The pilot had made five landings at the farm strip over four previous visits.

The wind was from 280° at 10 kt and the pilot had intended to land into wind on runway direction 30 but decided, due to the trees at the threshold and the downslope of the runway, to reposition for a landing on runway direction 12. During the approach, the aircraft drifted left and he corrected this by increasing power and crabbing to the right to regain the intended approach path. The aircraft then drifted to the right of the runway during the flare. He partially corrected so the touchdown was on the runway but the aircraft was not aligned with the runway direction and he was unable to prevent it departing to the left and colliding with a hedge.

Discussion

The pilot made a decision to accept a tailwind to take advantage of the upslope and clearer approach of runway direction 12. However, the local variations in wind strength and direction appear to have been greater than he anticipated leading to the loss of control. In this case, accepting a tailwind instead of a headwind meant a 40% increase in groundspeed at touchdown.

The pilot candidly commented that flying to farm strips requires a great deal more preparation and thought than licensed airfields. In particular the interaction between the prevailing weather conditions and the local landscape needs to be carefully considered during planning and execution phases of the flight.

The CAA Safety Sense Leaflet, Number 12, *Strip Flying*, contains useful information and guidance on operating from small unlicensed strips

ACCIDENT

Aircraft Type and Registration:	Vans RV-9, G-CFED
No & Type of Engines:	1 Lycoming YO-320-D1A piston engine
Year of Manufacture:	2008
Date & Time (UTC):	6 July 2010 at 1000 hrs
Location:	White Fen Farm, Cambridgeshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to right wing, right main gear leg and fairing, right wheel and engine mounting frame
Commander's Licence:	Private Pilot's Licence
Commander's Age:	57 years
Commander's Flying Experience:	141 hours (of which 81 were on type) Last 90 days - 3 hours Last 28 days - 1 hour
Information Source:	Aircraft Accident Report Form submitted by the pilot

The pilot had conducted an uneventful local flight to refresh his skills following a month without flying. He returned to his departure airfield, which was a private farm strip at White Fen Farm, and landed the aircraft on Runway 18. The weather was clear with a 5 kt breeze from the south-west. During the landing rollout, and as the aircraft decelerated to a safe taxi speed, the pilot noticed that the left wingtip was brushing the crops in the field adjacent to the runway. Before he could respond, the aircraft yawed abruptly to the left. The main gear wheels dropped into a furrow and the aircraft 'nosed over', resulting in significant structural damage. The pilot was uninjured and candidly stated that lack of attention to the aircraft's position relative to the runway had resulted in the accident.

ACCIDENT

Aircraft Type and Registration:	Yak-52, G-YKCT
No & Type of Engines:	1 Ivchenko Vedeneyev M-14P piston engine
Year of Manufacture:	1990
Date & Time (UTC):	24 April 2010 at 1420 hrs
Location:	1 km west of Kilkerran Airstrip, Ayrshire
Type of Flight:	Training
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to propeller, right main landing gear leg and uplock mounts
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	40 years
Commander's Flying Experience:	9,676 hours (of which 140 were on type) Last 90 days - 138 hours Last 28 days - 17 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and telephone enquiries by the AAIB

Synopsis

Whilst practising circuits at Kilkerran Airstrip, the aircraft experienced a reduction in engine power leading to a wheels-up forced landing in a field with minimal damage.

History of the flight

The aircraft had been airborne for some 40 minutes conducting a dual recurrent training sortie with two members of the ownership group. The briefed profile for the sortie comprised a normal takeoff and climb to 5,000 ft, stalls, spins, unusual attitude recovery and basic aerobatics. This was followed by a return to Kilkerran Airstrip where circuit work would be practised. During the first planned go-around from a normal approach, full power was applied, the go-around attitude adopted and 100% was noted on the rpm gauge; however shortly afterwards, the pilots felt a vibration and sensed a loss of engine power, noting fluctuations on the engine rpm gauge. The nose was lowered and the landing gear and flaps raised to maintain airspeed. The engine continued to run but with significantly reduced power and fluctuating rpm.

With obstacles ahead and no noticeable rate of climb, the decision was made to execute a 'gear-up' flapless forced landing into a field to the right of the runway extended centreline. The landing on very short grass resulted in minimal damage to the aircraft as, in its original role as a military/civilian aerobatic trainer, the YAK-52 was designed to perform such landings without major structural damage as the wheels protrude from the wings and the fuselage even when retracted.

Damage was limited to the propeller, a bent right MLG oleo strut and both MLG uplock brackets. The fuel tanks were checked for the presence of water and none was found. The engine was removed from the aircraft and sent to a specialist on this type of powerplant for inspection and possible fault identification. No faults were found which could account for the power reduction.

ACCIDENT

Aircraft Type and Registration:	Aerola Alatus-M, G-CFDT
No & Type of Engines:	1 Corsair M25Y piston engine
Year of Manufacture:	2008
Date & Time (UTC):	11 June 2010 at 1400 hrs
Location:	Davidstow Airfield, Cornwall
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Propeller separated, damage to right wing and fuselage/ engine
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	72 years
Commander's Flying Experience:	n/k hours (of which 2 were on type) Last 90 days - n/k hours Last 28 days - n/k hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

When reducing engine power after a powered takeoff the pilot experienced high levels of vibration followed by a loud bang, which was caused by the separation of the pylon mounted propeller from the motor glider. The pilot completed an uneventful glide approach and landing. The cause of the propeller loss was the failure of the aluminium propeller shaft. The shaft may have failed during one of two events where movement of the engine pylon structure was sufficient to allow the propeller to strike the engine bay doors whilst it was under power.

History of the flight

After what appeared to be a normal powered takeoff and initial climb to 1,000 ft, the pilot began to reduce the engine power, at which point there was a significant increase in vibration, followed by a loud bang and a rapid increase in engine rpm. After switching off the engine the pilot observed that the propeller had separated from the glider and that the right wing panel had sustained damage. The pilot completed an uneventful glide approach and landing.

Description of the aircraft

The Aerola Alatus-M is a deregulated self-launching motor glider. A propeller is mounted at the top of a hinged pylon located immediately behind the cockpit.

The propeller is attached to the pylon via a pulley and bearing assembly secured to the pylon by an aluminium shaft and a 10 mm diameter steel nut and bolt. A multiple vee belt connects the propeller pulley to a crankshaft pulley on the single cylinder engine, which is mounted at the base of the pylon.

In gliding flight the pylon lies horizontally within the fuselage and is covered by a pair of hinged doors, which are held in the closed position be a rubber bungee. To use the engine for powered flight, an electrical actuator rotates the pylon and propeller assembly into the vertical position, pushing open the engine bay doors in the process, after which the engine can be started.

The engine is controlled through a throttle lever on the left side of the cockpit. After stopping the engine, the pylon can be retracted. This requires the propeller to be in the vertical position, and is accomplished by opening the decompressor valve, which allows the propeller to windmill freely, then extending the propeller lock. The controls for both the decompressor valve and the propeller lock are located on the right side of the cockpit; the propeller lock actuation control is mounted immediately behind the decompressor valve control to prevent inadvertent extension of the propeller lock while the engine is operating.

The propeller lock consists of an aluminium alloy bar pivoted about a point on the pylon structure. When extended, the propeller lock lies in the arc of the propeller, stopping the propeller blades in the vertical position. A rubber cap on the end of the bar prevents damage to the propeller. In the stowed position the lock lies against the pylon structure in a near vertical position. It is spring-loaded to the stowed position.

Previous operational history

Prior to being purchased by the current owner, G-CFDT had been involved in an accident where the propeller had struck the engine bay doors, whilst under power, which damaged the propeller and the bay doors. The manufacturer attributed this event to the limited clearance between the engine bay doors and the propeller, coupled with movement of the pylon in flight. The previous owner had the propeller repaired and, in order to prevent a reoccurrence, 'cut back' the engine bay doors to provide sufficient clearance for the propeller. After completing approximately six flying hours (since new) and replacement of the propeller, the glider was sold.

After purchasing G-CFDT, the current owner had the doors returned to their original profile; on the subsequent powered takeoff the propeller blades struck the engine bay doors. The propeller was repaired and rebalanced and the engine bay doors re-profiled to provide increased clearance for the propeller. The glider completed approximately two additional flying hours before the separation of the propeller on the accident flight.

Examination

The propeller and associated pulley were not recovered but the remains of the shank of the 10 mm mounting bolt, together with its nut were found within the propeller mounting structure. The propeller shaft had failed at the point where it was fitted to the mounting structure. The propeller lock had also been deformed and the rubber end cap was missing. Examination of the bolt shank confirmed that the fracture surface was characteristic of having failed in bending overload; there was no evidence of crack propagation in fatigue.

The fracture surface of the propeller shaft was covered in a thin layer of oily dirt. After cleaning, the fracture surface was found to show characteristics of a failure in bending. The fracture surface had been subject to mechanical wear, which made some of the features indistinct, but no evidence of crack propagation in fatigue was found. Some scoring of the inner diameter of the shaft was also identified. The deformation of the propeller lock was consistent with it having been struck by the rotating propeller, see Figure 1.

Figure 1
Damaged propeller lock

Paint had been transferred from the propeller onto the lock. The pattern of paint transfer indicated that the propeller lock had not been in the fully deployed position when it was struck by the propeller and that after the initial impact the lock had been moved into the fully deployed position before being deformed against the pylon structure.

Analysis

The damage and paint transfer on the propeller lock indicated that it was in a partially extended position when it was struck by the rotating propeller. The position of the throttle and propeller lock control on opposite sides of the cockpit are such that when operating the throttle the pilot would be unable to operate either the decompressor valve or the propeller lock without first releasing the control column. It is therefore possible that the extension of the propeller lock into the arc of the propeller may have been caused by the vibration experienced immediately before the loss of the propeller.

The condition of the fracture surface of the propeller shaft indicated that it had failed some time prior to the release of the propeller, possibly prior to the change of ownership. Given the operational history of the glider it is probable that the propeller shaft failed as a result of one of the two previous propeller strike events. Failure of the shaft would have increased the likelihood of the propeller moving 'out of plane' when rotating, but was not obvious enough to allow easy identification of the shaft's condition. It is possible that, during the incident flight, the increased movement of the propeller caused it to strike the glider's structure when the pilot reduced the engine power during the climb. The subsequent vibration resulted in the movement of the propeller lock which was then struck by the propeller and resulted in the failure of the propeller-retaining bolt and the separation of the propeller assembly.

Safety action taken

As a result of this incident, and reports of a previous propeller shaft failure on another Alatus-M, the manufacturer has produced a new shaft made of stainless steel which will be fitted to all new gliders. The manufacturer will recommend that owners replace the aluminium shaft currently fitted with the stainless steel shaft.

In order to increase the clearance between the engine bay doors and the propeller, the manufacturer has redesigned the engine bay doors fitted to new-build gliders. The manufacturer will recommend that current owners 'cut back' the engine bay doors fitted to their gliders to provide increased clearance.

ACCIDENT

Aircraft Type and Registration:	Cyclone AX2000, G-MZJR
No & Type of Engines:	1 HKS 700E V3 piston engine
Year of Manufacture:	1998
Date & Time (UTC):	24 July 2009 at 1024 hrs
Location:	Near Shoreham, Kent
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - 1 (Serious) Passengers - 1 (Minor)
Nature of Damage:	Substantial
Commander's Licence:	Private Pilot's Licence (Microlight)
Commander's Age:	44 years
Commander's Flying Experience:	750 hours (of which 150 were on type) Last 90 days - 20 hours Last 28 days - 4 hours
Information Source:	AAIB Field Investigation

Synopsis

The aircraft was flying at 600 ft agl when the engine suddenly stopped. The pilot chose a small field for a forced landing and landed downwind with a tailwind of 10 to 15 mph. The aircraft landed well into the field and the combination of a late touchdown with a high groundspeed and poor braking action on wet grass caused the aircraft to run on into a substantial wooden fence. Both the pilot and his passenger were injured in the accident.

History of the flight

The flight was planned to cross the English Channel to France, with a view to returning the next day as one of a large number of microlight aircraft taking part in a Bleriot Centenary celebration.

The aircraft was based at Clench Common microlight site, Wiltshire. When the passenger arrived on the morning of the accident the pilot, who was a part-owner of the aircraft, had refuelled it and prepared it for flight. They both ensured that their baggage weight was kept to a minimum. The pilot calculated the takeoff weight as 415 kg. The fuel on board at departure was 45 litres, giving an endurance of more than four hours.

The pilot planned to fly from Clench Common to Headcorn Airfield, Kent, to clear customs before continuing on to Le Touquet, France. Aware that the weather was changeable with rain showers forecast, he planned two possible routes and drew them on his map. The aircraft took off from Clench Common at 0835 hrs and flew in an easterly direction at first, but soon the pilot decided to take the more southerly of the two routes and flew in a south-easterly direction towards a turning point north of Chichester. This route took the aircraft close to Popham Airfield and, while en route, the pilot decided, in view of the prevailing showery conditions, to land there and reassess the weather. The aircraft landed at Popham at 0905 hrs.

The pilot and his passenger spent their time at Popham looking at a radar chart of the weather activity and discussing possible routings. At 0925 the aircraft took off and headed in a north-easterly direction before intercepting the M25 motorway and following it for a time. The pilot then decided that further progress towards Headcorn Airfield was not possible, and turned north-east towards Biggin Hill. He contacted Biggin ATC and arranged to route overhead at 2,000 ft amsl. Once he had passed overhead he descended to 1,100 ft amsl to avoid more showers, and considered where to route next. He had just decided to continue towards Rochester Airfield when, suddenly, the engine stopped. The pilot made an unsuccessful attempt to restart the engine and selected a field for a forced landing. He broadcast a MAYDAY message to Biggin ATC informing them of the problem and that he would be landing in a small field.

When the engine failed the propeller stopped immediately and the aircraft began to descend. The passenger commented that the descent was steep and time appeared short. The pilot lined up on his chosen field, which was rectangular and orientated in an east-west direction, and made an approach crossing low over the fence at the upwind (western) end. The aircraft travelled approximately 400 ft into the field before touching down. The passenger remembered that after the touchdown there seemed to be very little retardation before the aircraft ran into the fence at the far end.

The impact with the fence and a vertically embedded railway sleeper was severe and the pilot was rendered unconscious. The passenger exited the aircraft and, concerned about the possibility of a fire, attempted to help the pilot out. However, he was unable to do so and instead, having some knowledge of first aid, made sure that the pilot was in a safe position and able to breathe.

Biggin Hill ATC made several attempts to call G-MZJR but received no response and asked a training aircraft with an instructor on board to attempt to locate the missing aircraft. The training aircraft soon found the wreckage and circled overhead at the request of ATC in order to enable the Distress and Diversion (D&D) cell of the London Area and Terminal Control Centre to obtain a position fix on the accident site. The emergency services arrived soon afterwards and the pilot, who had sustained a head injury, was subsequently transferred to hospital in an air ambulance helicopter. The passenger, who suffered extensive bruising, was taken by road to a local hospital. He was discharged later the same day and subsequently had a good recollection of events throughout the flight. He was not a qualified pilot but was undergoing training on flex-wing aircraft towards a Private Pilot's Licence (Microlight).

The radio communications between Biggin Hill ATC and the aircraft were recorded and were available to the investigation.

Meteorological conditions

The south of England was subject to a strong westerly airflow with areas of cumulus and cumulonimbus cloud giving rise to heavy rain showers. The surface winds in the area of the accident were from a westerly direction at 10 to 15 kt, the visibility was good away from the rain showers. There had been recent showers in the area of the accident and the surface of the chosen landing field was wet.

Pilot information

The pilot had been flying microlight aircraft for 11 years. He flew regularly and was currently flying a number of different types of aircraft. He had owned this aircraft for a number of years and it was very familiar to him.

Aircraft information

The Cyclone AX2000 is a two-place side-by-side three-axis microlight aircraft. The maximum all up weight is 450 kg. The aircraft has forward-hinged removable doors; they were removed for this flight. There are two fuel tanks providing a maximum capacity of 50 litres. The recommended best glide speed is 45 mph.

The engine manufacturer provides the following advice to pilots in the HKS 700E Operations Manual:

> *'WARNING!*
>
> *This is a non-certified aircraft engine, the possibility of engine failure exists at all times. Do not operate this engine over terrain where a safe, power off landing cannot be performed.'*
>
> *The operating and maintenance instructions supplied with this engine must be followed at all times. Flying any aircraft involves the risk of injury or death, building and maintaining your own aircraft requires great personal responsibility.*

Landing field

When the engine stopped the ground below was undulating, with an elevation between 400 to 500 ft amsl. The general area was part built-up, part woodland and part fields with several major roads and power lines in the vicinity. There were no fields obviously suitable for a forced landing. The pilot's chosen field was level, with a grass surface and measured 150 m from west to east. The grass was approximately 15 cm long and was wet from recent rain. There was a 1 m high wire fence at the western end and a more substantial wooden post and rail fence with a number of vertically embedded old railway sleepers supporting cattle water troughs at the other end. On the southern boundary of the field were telegraph poles carrying power lines and in the adjacent field to the south was a line of pylons running from west to east.

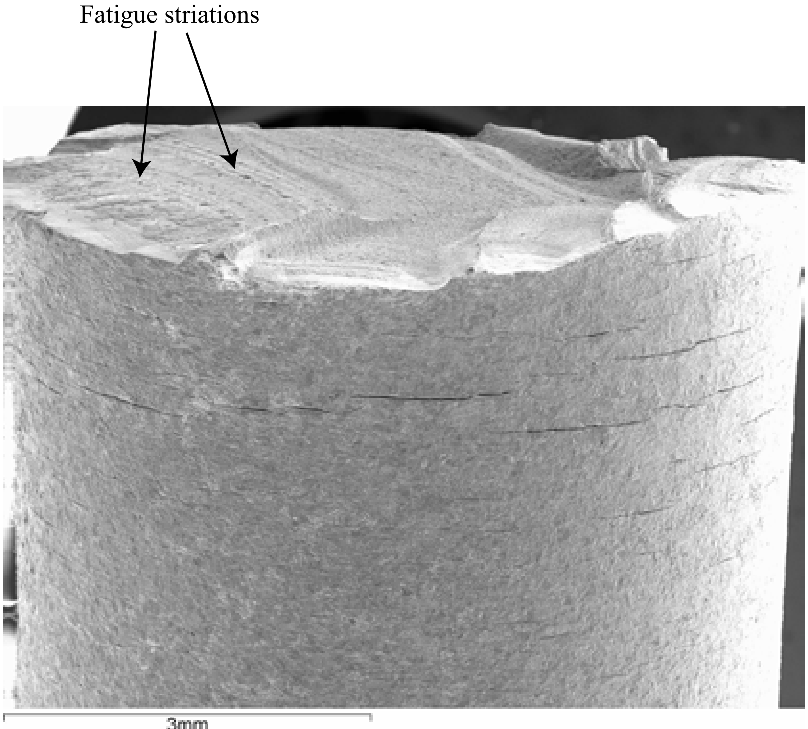
Engineering investigation

Examination of the aircraft at the accident site indicated that the engine had seized due to an internal failure. The engine was taken to the manufacturer's UK agent's facility where, under AAIB supervision, a strip examination was carried out. This revealed that the head of one of the two exhaust valves in the No 1 (right) cylinder had separated from its stem and caused severe disruption and break-up of the piston, which had eventually resulted in the seizure of the engine. The cylinder head, complete with three intact valves and the failed valve stem, was submitted for specialist metallurgical examination.

The valves were cleaned using acetic acid in an ultrasonic bath to remove surface deposits prior to examination in a scanning electron microscope. The examination showed that the failure of the exhaust valve was the result of fatigue that had initiated from multiple origins in the valve stem. Examination of the stem in the region of the failure (Figure 1) highlighted thermally-generated corrosion, which provided the stress concentration to initiate fatigue.

It was noted that the microstructure of the valve material at the points of failure had been altered by the effects of temperature to a condition that was more susceptible to corrosion and hence fatigue initiation. The rate of such changes in microstructure is temperature dependent. Therefore, failure could occur prematurely in these valves if the operating temperature is higher than 'normal'. However, even at 'normal' operating temperatures, it is expected that failure would eventually occur after many hours in service.

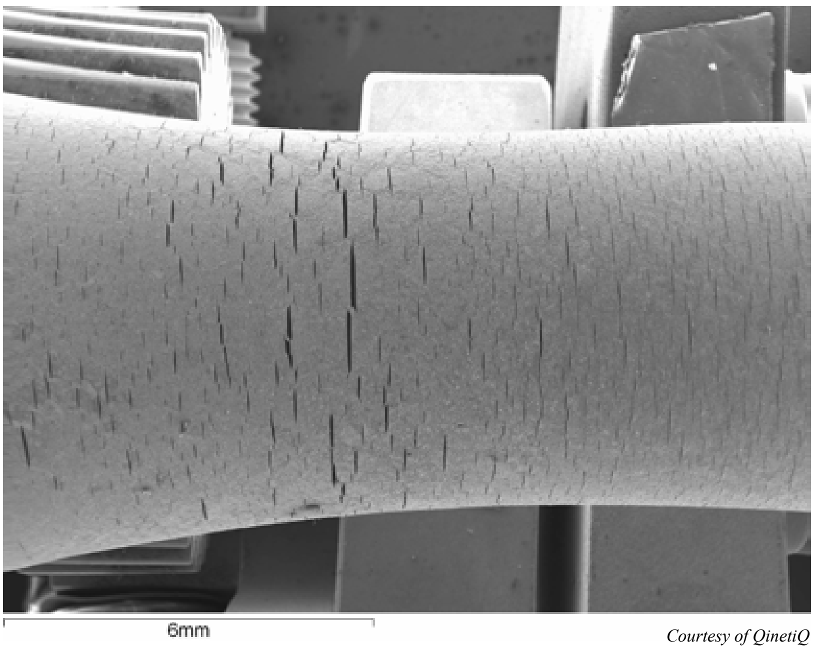
The exhaust valve that had not failed was also examined; numerous cracks were observed in the surface (Figure 2). These also appeared to be fatigue cracks and this valve, if allowed to continue in service, would have failed in the same manner as the fractured valve.



Courtesy of QinetiQ

Figure 1

Failed exhaust valve stem showing secondary fatigue cracks



Courtesy of QinetiQ

Figure 2

Surface cracking on stem of non-failed exhaust valve

Engine history

The engine fitted to this aircraft was an HKS 700E V3, serial number 100202, built in 2000. It is a horizontally-opposed, two-cylinder, four-stroke air-cooled engine with pumped oil for lubrication and cylinder head cooling. Each cylinder has two inlet and two exhaust valves. Following a short period in service the manufacturer became aware of a number of problems which included poor cylinder head cooling and poor oil scavenge performance. The engine was redesigned and given the designation HKS 700E Beta. This redesign included cylinder heads manufactured from a modified casting with a much improved oil system to increase the oil flow and improve cooling. The engine fitted to G-MZJR had the Beta model cylinder heads fitted in December 2002, when it had completed 287 hours since new. In July 2003 the oil system on this particular engine was modified, to an approved one-off modification scheme, to increase the oil flow to improve cooling and thereby maintain the cylinder head temperatures within the limits specified for the V3 and Beta models. At the time of the accident the engine had completed 831 hours since new; the valves had completed 544 hours since they were fitted in 2002. The engine manufacturer replaced engines up to serial number 100300 but a small number of engines, such as the one fitted to G-MZJR, remained in service.

Engine valve service life

The manufacturer's recommended overhaul life for the 700E V3 engine was 300 hours or 5 years and the inlet and exhaust valves had to be replaced at overhaul. In April 2004 the overhaul period for the 700E engines with serial numbers from 100600 was increased to 800 hours or 8 years (HKS 700E Service Letter SL-700-001). In March 2007 the overhaul period for the 700E engines with serial numbers up to 100600 was increased to 500 hours or 5 years (HKS 700E Service Letter SL-700-002). The engine manufacturer stated that neither of these Service Letters applied to the engine fitted to G-MZJR and they were issued in the belief that all engines up to serial number 100300 had been replaced.

The pilot believed that the installation of the Beta cylinder head and the improvement of the lubrication system on the engine fitted to G-MZJR would have improved its longevity and therefore took the decision to extend its service life. This decision was also based on his experience of other, similar four-stroke engine types for which the service life had been successfully increased with only standard regular maintenance.

Analysis

The engine failure was caused by the fracture of an exhaust valve due to a fatigue failure initiated by thermally-generated corrosion. This could occur if the valve had been operating above the material's maximum operating temperature, or for a time in excess of the valves recommended operating life, or a combination of the two. The engine manufacturer recommended that all valves be replaced at overhaul. This particular engine should have been overhauled every 300 hours or 5 years. However, at the time of the accident the valves in the No 1 (right) cylinder had completed 544 operating hours and 6 years 7 months had elapsed since fitment. The pilot, based on his experience with other, similar engine types, and the improved modification state of the engine, considered that an extension of the service life of this engine was justifiable.

The pilot had been altering his route and diverting around areas of rain showers for much of the flight. He had flown overhead Biggin Hill Airport at 2,000 ft amsl, where he could have landed if he had chosen, a few minutes before the engine failure.

When the engine stopped, the aircraft was flying beneath rain showers at an altitude of 1,100 ft amsl. The terrain in the area was between 400 and 500 ft amsl, so the height of the aircraft was about 600 ft agl. When the engine stopped the propeller also stopped, which created additional drag. The result of these factors was that the range of the aircraft was limited and therefore the time available for the pilot to find a suitable landing field was short. The pilot managed the primary task of flying the aircraft and maintaining control as he made an approach into a field. However, the field was short, the surface was wet and the aircraft landed directly downwind. The result was that the aircraft ran on into the fence at a considerable speed, leading to the pilot sustaining a serious injury.

The tailwind was a significant factor in the outcome of the forced landing. The glide speed of the aircraft was 45 mph, thus with a tailwind of 10 to 15 mph the landing speed was increased by some 25% to 30%. The tailwind would also have had the undesirable effect of flattening the trajectory of the final approach, thereby leading to a longer touchdown into the field. This is a factor which may not always be taken into account when considering the suitability of a landing field. The result was that, although the aircraft passed low over the boundary fence, it touched down 400 ft into a field that was only 500 ft long. The combination of a high groundspeed and poor braking effectiveness on the wet grass meant that there was little reduction in speed before the impact with the fence.

Conclusions

Pilots of single-engined aircraft should be aware that an engine failure can occur at any time. A forced landing is more likely to be successful if the aircraft is flown at a height which affords more choices of suitable landing sites, especially in areas of difficult terrain. On this occasion the choice of fields available to the pilot was reduced because he had descended beneath some showers and was passing over relatively high ground.

The engine seizure was precipitated by the failure of an exhaust valve due to thermally-generated fatigue cracking in the valve stem. This was caused by operation of the engine beyond the manufacturer's recommended engine overhaul life of 300 hours or 5 years.

ACCIDENT

Aircraft Type and Registration:	Jabiru UL-450, G-BZMC
No & Type of Engines:	1 Jabiru Aircraft Pty 2200A piston engine
Year of Manufacture:	2001
Date & Time (UTC):	21 July 2010 at 1745 hrs
Location:	Headon Farm Airstrip, near Gamston, Nottinghamshire
Type of Flight:	Training
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Nose landing gear, propeller and underside of nose cowling damaged
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	67 years
Commander's Flying Experience:	3,143 hours (of which 2,214 were on type) Last 90 days - 6 hours Last 28 days - 3 hours
Pilot's Licence:	National Private Pilot's Licence
Pilot's Age:	62 years
Pilot's Flying Experience:	96 hours (of which 12 were on type) Last 90 days - 15 hours Last 28 days - 6 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The pilot was converting from a flex-wing aircraft to the Jabiru, a three-axis-control type aircraft. An instructor, the pilot in command, was accompanying the pilot and circuits were being flown using grass Runway 32 at Headon Farm Airstrip. The runway is 545 m in length, with the width varying between 20 m and 30 m. The weather conditions were fine and dry, with light winds from 010°.

The pilot reported that the approach was normal but that he had flared too high and then bounced on landing. Following the bounce, he attempted to recover and land again but the aircraft pitched nose-down, causing the nose landing gear to collapse and the propeller to strike the ground. The aircraft came to a stop after rolling along the ground for approximately 20 m.

The instructor reported that he had tried to apply power in an attempt to prevent the aircraft from stalling during the flare but that he was unable to intervene quickly enough to avert the accident.

ACCIDENT

Aircraft Type and Registration:	Maule MX-7-180C Super Rocket, with floats, G-OMOL
No & Type of Engines:	1 Lycoming O-360-C1F piston engine
Year of Manufacture:	2000
Date & Time (UTC):	23 May 2009 at 1013 hrs
Location:	Goles Forest, County Tyrone, Northern Ireland
Type of Flight:	Private
Persons on Board:	Crew - 1 Passenger - 1
Injuries:	Crew - None Passenger - 1
Nature of Damage:	Damaged beyond economic repair
Commander's Licence:	Private Pilots's Licence
Commander's Age:	39 years
Commander's Flying Experience:	2,053 hours (of which 8 were on type) Last 90 days - 8 hours Last 28 days - 5 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and additional inquiries by the AAIB

Synopsis

Whilst avoiding heavy showers the aircraft was subjected to severe turbulence and downdrafts which resulted in it descending and unable to outclimb the terrain, the pilot made a forced landing into a forest. Both occupants escaped uninjured.

History of the flight

The commander reported that he planned to fly VFR from Aghadowey, 6 nm south of Coleraine, Northern Ireland, to Enniskillen via Draperstown, 20 nm south-south-west of Coleraine, to visit an associate. He had flown this route several times and normally avoided high ground that lies west and north-west of Draperstown. Weather along the route was generally overcast between 1,800 and 2,200 ft amsl with light, occasionally heavy, showers, visibility between 5 and 15 km and wind from 210° at 15 kt.

The first leg to Draperstown was uneventful with the exception of a few light showers which the commander avoided. As the aircraft approached Draperstown he could see some heavy showers to the south and east which caused him to alter his course to a clear route to the west and climb the aircraft to 2,050 ft amsl to clear the higher ground.

When the aircraft was about 4 nm west of Draperstown it encountered severe turbulence, windshear and rain which resulted in it descending in downdrafts. With full power applied and maintaining 72 kt (the best angle of climb speed) the aircraft continued to descend. Unable to climb above the terrain ahead, the commander made a forced landing into the surrounding dense coniferous forest.

After the initial impact the aircraft decelerated slowly and rolled left as it descended through the trees, coming to rest on the forest floor. The occupants vacated the aircraft after selecting off the fuel and electrical systems. The passenger suffered mild bruising and the pilot was uninjured.

Manufacturer's comments

The manufacturer commented that they do not publish climb performance figures but the actual rate of climb at MTOW, as recorded during the official Flight Test Report, was 870 ft/min.

Commander's comments

The commander commented that he had taken delivery of the aircraft about 2 months prior to the accident. During that time he and other pilots noticed that it achieved a climb rate of approximately 400 ft/min. He added that he believed virtually all other amphibious Maule MX-7 aircraft had larger engines, affording better climb performance.

ACCIDENT

Aircraft Type and Registration:	Mainair Blade 912, G-BYRP
No & Type of Engines:	1 Rotax 912-UL piston engine
Year of Manufacture:	1995
Date & Time (UTC):	19 May 2010 at 1739 hrs
Location:	Guy Lane Farm, Waverton, Chester
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - 1 (Serious) Passengers - 1 (Minor)
Nature of Damage:	Severe damage to trike and wing
Commander's Licence:	National Private Pilot's Licence (Microlights)
Commander's Age:	64 years
Commander's Flying Experience:	102 hours (of which 80 were on type) Last 90 days - 9 hours Last 28 days - 4 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft was about to touch down when the pilot realised that he would be unable to stop within the remaining runway length ahead of him. He elected to go around, however the aircraft struck the top of a tree.

History of the flight

The aircraft was landing at Guy Lane Farm at Waverton, having completed a flight from Arclid Airfield. Just before touchdown the pilot realised that he was unlikely to be able to stop within the remaining length of runway, so he applied power for a go-around. The aircraft collided with the top of a tree at the edge of the field and collided with the tree, before falling approximately 15 ft to the ground. The pilot sustained several fractures, including four vertebrae fractures, and the passenger sustained minor injuries. The pilot, who is likely to make a near full recovery, considered that the aircraft's climb performance was less than he expected possibly due to the lack of headwind, the additional weight of the passenger and his late decision to go around.

ACCIDENT

Aircraft Type and Registration:	P&M Aviation Ltd Quik GT450, G-RAYB
No & Type of Engines:	1 Rotax 912ULS piston engine
Year of Manufacture:	2007
Date & Time (UTC):	30 May 2010 at 1400 hrs
Location:	Abbeville Airfield, France
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Trike, forks, propeller, engine mount, and wing damaged
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	41 years
Commander's Flying Experience:	298 hours (of which 257 were on type) Last 90 days - 24 hours Last 28 days - 12 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

History of the flight

The aircraft was approaching to land on Runway 31 at Abbeville. The wind was from between 280º and 300º at 5 kt, gusting to 15 kt, there was visibility of 25 km and few clouds at 4,000 ft. The pilot reported that the conditions were "bumpy" and that the wind was "gusty". As the aircraft touched down, it turned over onto its right side and the engine stopped. The pilot was unhurt. He believed that immediately before touchdown the wind "got under" and lifted the left wing, causing the aircraft to turn slightly, touch down with some right drift and turn over.

ACCIDENT

Aircraft Type and Registration:	P&M Aviation Ltd Pegasus Quik, G-RITT
No & Type of Engines:	1 Rotax 912ULS piston engine
Year of Manufacture:	2006
Date & Time (UTC):	24 June 2010 at 1700 hrs
Location:	Damyns Hall Airfield, Upminster, Essex
Type of Flight:	Training
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Extensive
Commander's Licence:	Private Pilot's Licence
Commander's Age:	42 years
Commander's Flying Experience:	3,000 hours (of which 1,820 were on type) Last 90 days - 135 hours Last 28 days - 43 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

During the takeoff roll the student pressed the foot brake while making steering inputs. As a result the aircraft turned abruptly and rolled over.

History of the flight

The instructor planned to fly a dual instructional sortie with an inexperienced student who had not flown this aircraft previously and was not used to its responsive disk brakes. During the takeoff roll, at about 30 mph, the student inadvertently applied the right foot brake firmly while making steering inputs. As a result the aircraft turned abruptly to the right and rolled over. The aircraft came to rest on its left side, facing in the opposite direction to the takeoff roll, and was extensively damaged. Both occupants vacated the aircraft uninjured.

Instructor's comments

The instructor commented that on previous flights in other aircraft the student had not shown any tendency to use the brakes while taxiing or taking off. He added that in hindsight he should have given the student a more detailed briefing about the effectiveness of the disc brakes and more practice at taxiing and manipulating the foot controls prior to takeoff.

ACCIDENT

Aircraft Type and Registration:	Pegasus Quantum 15, G-MYRM
No & Type of Engines:	1 Rotax 582-40 piston engine
Year of Manufacture:	1994
Date & Time (UTC):	2 July 2010 at 1302 hrs
Location:	Porth Kidney Beach, near St Ives, Cornwall
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to the nosecone and wing
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	46 years
Commander's Flying Experience:	200 hours (of which 200 were on type) Last 90 days - 10 hours Last 28 days - 6 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The aircraft departed from Perranporth, Cornwall intending to fly along the coast to Land's End. The weather conditions were good with a light south-westerly wind. Whilst flying at approximately cliff-top height over a deserted beach, the aircraft suddenly rolled to the right and it required full movement of the control bar to return the aircraft to a wings level attitude. The pilot was concerned by this sudden and unexpected departure from level flight and elected to make a precautionary landing to check that there was no fault with his aircraft. He identified an area on the deserted beach, near the waters edge, that looked suitable and flew an uneventful approach to the beach. When the aircraft landed, the nosewheel dug into soft sand and the aircraft flipped over before stopping. The nosecone and wing were damaged but both the aircraft's occupants were uninjured and they vacated the aircraft. There was no fire.

The pilot later considered that the most likely reason for the unexplained roll to the right was air turbulence.

ACCIDENT

Aircraft Type and Registration:	Quik GT450, G-CEBD	
No & Type of Engines:	1 Rotax 912ULS piston engine	
Year of Manufacture:	2006	
Date & Time (UTC):	16 May 2010 at 1905 hrs	
Location:	Arclid Airfield, Cheshire	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - 1
Injuries:	Crew - 1 (Minor)	Passengers - 1 (Serious)
Nature of Damage:	Damaged beyond economic repair	
Commander's Licence:	National Private Pilot's Licence	
Commander's Age:	57 years	
Commander's Flying Experience:	113 hours (of which 113 were on type) Last 90 days - 21 hours Last 28 days - 7 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

During the approach the aircraft encountered turbulence whilst passing over trees short of the runway threshold, causing the touchdown to be later than planned. The pilot did not appreciate the need to execute a go-around sufficiently early and the aircraft collided with the far boundary hedge, embedded in which was a wire fence. This resulted in the aircraft suddenly coming to rest on its side, just beyond the hedge.

ACCIDENT

Aircraft Type and Registration:	Rans S6-ESD Coyote II, G-MYDK
No & Type of Engines:	1 Rotax 503 piston engine
Year of Manufacture:	1992
Date & Time (UTC):	6 July 2010 at 1010 hrs
Location:	Bockenfield, Northumberland
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Nosewheel buckled
Commander's Licence:	Private Pilot's Licence
Commander's Age:	62 years
Commander's Flying Experience:	491 hours (of which 2 were on type) Last 90 days - 3 hours Last 28 days - 1 hour
Information Source:	Aircraft Accident Report Form submitted by the pilot

History of the flight

The aircraft took off from Runway 26 at Bockenfield. The wind was from 270º at between 10 and 12 kt, visibility 20 km, cloud scattered at 3,000 ft amsl and the temperature was 17ºC. Although the before-takeoff power checks and the takeoff itself were normal, the climb rate seemed to the pilot to be lower than normal. On reaching 250 ft agl, the pilot turned the aircraft right through 90º, at which point the engine "lost power". The pilot reported that he selected the most suitable landing area available noting that its orientation meant he would have to make a downwind landing. Following touchdown the aircraft ran towards the fence at the far end of the field. The pilot managed to turn the aircraft away from the fence but the nosewheel buckled before the aircraft came to a halt. When submitting his report the pilot did not know the cause of the engine failure.

ACCIDENT

Aircraft Type and Registration:	Rans S6-ESD (Modified) Coyote II, G-MYLF
No & Type of Engines:	1 Rotax 912-UL piston engine
Year of Manufacture:	1993
Date & Time (UTC):	26 June 2010 at 1100 hrs
Location:	Wharf Farm, Market Bosworth, Leicestershire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to nose gear leg and propeller
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	69 years
Commander's Flying Experience:	119 hours (of which 100 were on type) Last 90 days - 12 hours Last 28 days - 4 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The aircraft was landing on Runway 20 at Wharf Farm when it touched down heavily and then bounced. The nose gear collapsed during the subsequent touchdown and the propeller was damaged. The pilot and passenger exited the aircraft without injury after it had slid to a stop.

AIRCRAFT ACCIDENT REPORT No 5/2010

This report was published on 14 September 2010 and is available on the AAIB Website www.aaib.gov.uk

REPORT ON THE ACCIDENT BETWEEN GROB G115E (TUTOR), G-BYXR and STANDARD CIRRUS GLIDER, G-CKHT AT DRAYTON, OXFORDSHIRE 14 JUNE 2009

Registered Owner and Operator	1. VT Aerospace Ltd/ Royal Air Force 2. Private owner
Aircraft Type	1. Grob G115E (Tutor) 2. Standard Cirrus glider
Nationality	1. British 2. British
Registration	1. Tutor G-BYXR 2. Glider G-CKHT
Place of Incident	Drayton, Oxfordshire
Date and Time	14 June 2009 at 1317 hrs (All times in this report are UTC)

Synopsis

A Grob 115E Tutor aircraft, operated by the Royal Air Force (RAF), was undertaking a cadet air experience flight from RAF Benson. The visibility was good and the aircraft was conducting aerobatics, in uncontrolled airspace, when it collided with a glider. The left wing of the Tutor struck the fin of the glider causing the tail section to break away. The glider pilot parachuted to safety. The Tutor entered a spiral / spinning manoeuvre before diving steeply into the ground. The Tutor pilot and cadet were both fatally injured.

The Tutor pilot had a long term medical condition which restricted the movement of his head and affected his ability to conduct an effective look-out; this condition also made him more vulnerable to impact fractures of the spine. Following the collision it is probable that the Tutor remained controllable, suggesting that the pilot had become incapacitated.

The cadet's harness had been released and the canopy operating handle had been moved to the open position before the Tutor impacted the ground. The canopy jettison mechanism had not been operated.

The accident was notified to the Air Accidents Investigation Branch (AAIB) at 1350 hrs on 14 June 2009 and an AAIB field investigation was commenced immediately. The investigation was conducted by:

Mr P Claiden	Investigator-in-charge
Mr A Blackie	Operations

Mr B D McDermid	Engineering
Mr M Ford	Flight Data Recorders

The investigation identified the following causal and contributory factors:

Causal factor

1. Neither pilot saw each other in sufficient time to avoid the collision.

Contributory factors

1. The Tutor pilot's medical condition, Ankylosing Spondylitis, limited his ability to conduct an effective look-out.

2. The high density of traffic, in an area of uncontrolled airspace, increased the risk of a collision.

Thirteen Safety Recommendations have been made.

Conclusions

The Tutor pilot was conducting air experience flights for Air Cadets from RAF Benson and the glider pilot was flying a 300 km task that had been suggested by his gliding club. At the time of the accident both aircraft were operating in an area which was relatively congested due to the good weather conditions on the day and the constraints of the local airspace.

The Tutor pilot was conducting aerobatics and the glider was on a constant track when the mid-air collision occurred and the evidence indicates that the Tutor pilot did not see the glider before he pulled up into a vertical manoeuvre. Whilst the glider pilot became aware of the Tutor, and attempted to take avoiding action, he was unable to prevent the collision.

It is probable that the Tutor pilot's long term medical condition, Ankylosing Spondylitis, restricted the mobility of his head, and therefore affected his ability to conduct a look-out to the RAF standard. His medical condition also resulted in his spinal column becoming fused, making it more vulnerable to fracture from trauma.

There was no evidence that any part of the glider had penetrated the cockpit of the Tutor and the aircraft was assessed as capable of controlled flight following the collision. The apparent lack of recovery of the aircraft, or abandonment action by the pilot, led to the conclusion that he was probably incapacitated during the collision. Following the collision, the Tutor probably entered a spin from which it recovered, before diving steeply to the ground.

Following the collision the cadet released his QRF and moved the canopy operating handle to the open position. Although he had been shown the Tutor passenger safety video, the red 'jettison' handle had not been removed from its housing, which is the first action required to jettison the canopy prior to abandoning the aircraft.

Findings

General

1. The Tutor and glider were serviceable prior to the mid-air collision.

2. The mass and centre of gravity of both aircraft was within the prescribed limits.

3. The Tutor and glider pilots were properly licensed and held the required medical certificates.

4. At the time of the accident the weather was fine with visibility in excess of 25 km.

The mid-air collision

5. The glider pilot was flying at a constant speed and on a constant heading just prior to the collision.

6. The Tutor pilot had completed at least two aerobatic manoeuvres before the collision.

7. The Tutor was on a constant closing bearing with the glider just prior to the collision.

8. The Tutor pilot was flying the aircraft from the right seat.

9. The glider was in the Tutor pilot's field of view, but might have been hidden by the windscreen frame.

10. The glider pilot sighted the Tutor below him and took evasive action in an attempt to avoid the collision.

11. The Tutor pitched up into a vertical manoeuvre and the outer section of the left wing struck the fin and right tailplane of the glider.

12. The tail section of the glider broke away causing the glider to become uncontrollable.

13. The glider pilot opened his canopy and parachuted safely to the ground.

14. The impact of the collision probably fractured the Tutor pilot's spine, leaving him incapacitated.

Post-collision

15. The Tutor probably entered a spin immediately after the collision.

16. The Tutor exited the spin in a steep dive, from which it did not recover.

17. The Tutor's longitudinal static stability, although weak, is within the required limits.

18. The damage sustained by the Tutor during the collision would not have prevented it from being recovered from the spin and steep dive.

19. It is unlikely that the cadet would have been able to recover the aircraft from the spin.

20. The Tutor's canopy red 'jettison' handle (locking lever) had not been removed from its housing.

21. Even if he had used the correct procedure, it is unlikely that, in the time available the cadet could have successfully abandoned the aircraft.

22. The impact with the ground was not survivable.

The Tutor pilot

23. The Tutor pilot had Ankylosing Spondylitis, which affected his ability to conduct an effective look-out to the RAF standard.

24. The Tutor pilot had an increased risk of developing a fracture of the cervical spine.

25. An entry, dated 1976 in the Tutor pilot's medical records, stated that he should not undergo parachute training involving falls, due to the risk of fracture to his spine.

26. The Tutor pilot was not restricted from flying aircraft equipped with parachutes.

27. Specialist reports in the Tutor pilot's medical records stated that his Ankylosing Spondylitis was effectively 'burnt out' (not likely to deteriorate further).

28. The Tutor pilot's medical records included a comment that in certain types of aircraft he would have difficulty with vertical look-out.

29. The Tutor pilot's FMed4 folder, containing his medical records, was not reviewed when his medical examination was carried out in 2005.

30. The increased vulnerability for the Tutor pilot's spine to fracture was not identified during the medical examinations undertaken at RAF Benson since joining the AEF in 2005.

31. The Tutor pilot's ability to conduct a look-out to the RAF standard was questioned by instructors at 115 Squadron during his instructional technique course.

32. The Tutor pilot's inability to conduct an effective look-out to RAF standards was not identified during flight and cockpit checks undertaken by the AEF.

The Cadet

33. The accident occurred on the cadet's second flight in a Tutor.

34. The cadet was shown a safety video on the morning of the accident on how to abandon the Tutor.

35. The safety video emphasised that cadets should follow the pilot's instructions, including those relating to the abandonment of the aircraft.

36. Several cadets who were also shown the safety video were unsure as to how to jettison the aircraft's canopy.

37. The cadet released his harness and probably opened the canopy after the aircraft collided.

Airspace and traffic management

38. Air experience flights conducted by 6 AEF normally lasted 25 minutes and routinely included some aerobatic manoeuvres.

39. Flight duration constrained the areas in which the Tutors could operate.

40. The Tutor and the glider were both operating in the Oxford AIAA, in the airspace (gap) between RAF Brize Norton CTR and RAF Benson ATZ.

41. Traffic levels in the 'gap' at the time of the collision were very high.

42. RAF Benson ATC broadcast a message that there was intense gliding activity in the local area during the time the Tutor pilot was in his aircraft.

43. The message from RAF Benson ATC regarding the gliding activity was not passed to the AEF supervising officer.

44. The aircraft were operating outside controlled airspace and neither was in receipt of an air traffic service.

45. There was no onboard traffic alerting system fitted to the Tutor.

46. The FLARM system fitted to the glider was not designed to detect the transmissions from the transponder fitted to the Tutor.

47. Both aircraft were relying on the 'see-and-avoid' principle for collision avoidance in an area of high traffic density.

Safety Recommendations

The following Safety Recommendation was made on 21 July 2009:

Safety Recommendation 2009–079

It is recommended that 1 Elementary Flying Training School of the Royal Air Force review the passenger safety brief relevant to the Grob GE115E (Tutor) to ensure that passengers are briefed on the circumstances when the harness Quick Release Fitting may be released and the procedure to operate and jettison the canopy, when sat in the aircraft immediately prior to the flight.

The following Safety Recommendations were made in this report

Safety Recommendation 2010–032

It is recommended that the Royal Air Force standardise the terminology used to describe the canopy 'jettison' handle (locking lever) fitted to the Grob 115E (Tutor) in order to avoid confusion and to clarify its function.

Safety Recommendation 2010–034

It is recommended that the European Aviation Safety Agency review the certification of the canopy jettison system on the Grob 115 E, to ensure that it complies with the requirements of CS 23.807 with specific regard to the jettison characteristics up to V_{DO} and simplicity and ease of operation.

Safety Recommendation 2010–035

It recommended that the Royal Air Force consider standardising the position and operation of the D-ring on parachutes used in Tutor, Viking and Vigilant aircraft.

Safety Recommendation 2010–036

It is recommended that the Royal Air Force ensure that the medical history of pilots is reviewed when they initially apply to join an Air Experience Flight.

Safety Recommendation 2010–037

It is recommended that the Royal Air Force ensures that all medical limitations relating to Air Experience Flight pilots are recorded in their F5000 (record of flying training).

Safety Recommendation 2010–038

It is recommended that the Royal Air Force review their policy on pilots flying with Ankylosing Spondylitis.

Safety Recommendation 2010–039

It is recommended that the Royal Air Force review their policy for the retention of the complete flying training records of Volunteer Reserve pilots, so that they are available to their supervising officers.

Safety Recommendation 2010–040

It is recommended that 1 Elementary Flying Training School review their risk assessment for Air Experience Flight aircraft operating in areas of high traffic density.

Safety Recommendation 2010-041

It is recommended that the Civil Aviation Authority, in light of changing technology and regulation, review their responses to AAIB Safety Recommendations 2005-006 and 2005-008 relating to the electronic conspicuity of gliders and light aircraft.

Safety Recommendation 2010-042

It is recommended that the Civil Aviation Authority liaise with the Sporting Associations and the Ministry of Defence, with a view to developing a web-based tool to alert airspace users to planned activities that may result in an unusually high concentration of air traffic.

Safety Recommendation 2010–043

It is recommended that the Royal Air Force review the communication procedures between military Air Traffic Control units and Air Experience Flights to ensure that the supervising officer is made of aware significant changes to the local flying environment.

Safety Recommendation 2010–065

It is recommended that the Royal Air Force review their policy concerning cockpit checks undertaken to support medical assessments.

FORMAL AIRCRAFT ACCIDENT REPORTS ISSUED BY THE AIR ACCIDENTS INVESTIGATION BRANCH

2009

2/2009 Boeing 777-222, N786UA
at London Heathrow Airport
on 26 February 2007.

Published April 2009.

3/2009 Boeing 737-3Q8, G-THOF
on approach to Runway 26
Bournemouth Airport, Hampshire
on 23 September 2007.

Published May 2009.

4/2009 Airbus A319-111, G-EZAC
near Nantes, France
on 15 September 2006.

Published August 2009.

5/2009 BAe 146-200, EI-CZO
at London City Airport
on 20 February 2007.

Published September 2009.

6/2009 Hawker Hurricane Mk XII (IIB), G-HURR
1nm north-west of Shoreham Airport,
West Sussex
on 15 September 2007.

Published October 2009.

2010

1/2010 Boeing 777-236ER, G-YMMM
at London Heathrow Airport
on 28 January 2008.

Published February 2010.

2/2010 Beech 200C Super King Air, VQ-TIU
at 1 nm south-east of North Caicos
Airport, Turks and Caicos Islands,
British West Indies
on 6 February 2007.

Published May 2010.

3/2010 Cessna Citation 500, VP-BGE
2 nm NNE of Biggin Hill Airport
on 30 March 2008.

Published May 2010.

4/2010 Boeing 777-236, G-VIIR
at Robert L Bradshaw Int Airport
St Kitts, West Indies
on 26 September 2009

Published September 2010.

5/2010 Grob G115E (Tutor), G-BYXR
and Standard Cirrus Glider, G-CKHT
at Drayton, Oxfordshire
on 14 June 2009

Published September 2010.

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