AAIB
Air Accidents Investigation Branch

AAIB Bulletin 9/2026

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(ALL TIMES IN THIS BULLETIN ARE UTC)

AAIB Field Investigation Reports

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

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

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

Serious Incident

Aircraft Type and Registration:	Boeing 747-433, G-ONEE
No & Type of Engines:	4 Pratt & Whitney turbofan engines
Year of Manufacture:	1991 (Serial no: 24998)
Date & Time (UTC):	8 February 2024 at 0813 hrs
Location:	After departure from London Heathrow Airport
Type of Flight:	Commercial Air Transport (Cargo)
Persons on Board:	Crew - 5 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	None reported
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	61 years
Commander's Flying Experience:	14,600 hours (of which 12,600 were on type) Last 90 days - 127 hours Last 28 days - 17 hours
Information Source:	AAIB Field Investigation

Synopsis

The flight involved a freighter variant of the Boeing 747-400 that was due to fly from London Heathrow Airport to Hong Kong International Airport. The aircraft suffered numerous electrical issues which began during the takeoff roll and worsened during the climb. These were caused by the loss of AC electrical buses 1 and 4, which resulted in multiple failure messages for the flight crew to manage as well as the loss of all pitot tube heating. The flight crew carried out numerous, concurrent checklists to deal with the system failures, declared a PAN and started to divert to Amsterdam Schiphol Airport. When a pressurisation issue caused the crew to initiate a descent, the aircraft entered icing conditions and the pitot tubes froze, resulting in all three airspeed indicators indicating an erroneously low airspeed. The autopilot remained engaged and pitched the aircraft nose-down to regain indicated airspeed. The pitch reached 7.6° nose-down with an associated 6,240 ft/min descent rate, before the aircraft exited icing conditions, correct airspeed was regained and the autopilot pitched up. The descent had resulted in an 18 kt overspeed. The flight crew declared a MAYDAY, dealt successfully with a flap issue and landed safely at Schiphol Airport.

The loss of power to the two AC buses was the result of water ingress into Generator Control Units (GCUs) 1 and 4, located in the E1/E2 rack in the Main Equipment Centre beneath the cargo deck floor. The water led to the GCUs commanding contactors to open, which isolated AC Bus 1 and 4. Water had entered the main cargo deck prior to departure because the L1 door had been left open during rain. The investigation was unable to determine the exact path that water took from the cargo deck floor to the GCUs, but a number of weaknesses

in the water ingress protection measures were found that could have caused or contributed to the water ingress.

There have been previous events of water ingress into GCUs and other events of water contamination of the electrical/electronic units in the E1/E2 rack on the 747-400, which can lead to the loss of flight critical systems. This has led to Service Bulletins and Airworthiness Directives to introduce measures such as installing a fibreglass reinforcing overcoat on the drip shield above the E1/E2 rack, but there was no requirement for a repetitive inspection of the drip shield. There was also no maintenance requirement to repetitively inspect in detail the condition of the floor panel seals, waterproof tape, power drive units and L1 door floor mat in the area above and near the Main Equipment Centre. Therefore, the AAIB has made four safety recommendations to address these maintenance concerns.

History of the flight

The flight was planned to depart from London Heathrow for Hong Kong with no cargo onboard. During the night before the flight there was maintenance activity and the left forward L1 door was open throughout. During the two hours before maintenance activity ended at 0700 hrs there was moderate rainfall (4.6 mm) with a 6 to 10 kt easterly wind which was blowing in the direction of the open door.

When the crew boarded at about 0615 hrs, they noticed water on the door mat and the aircraft floor area around the mat. The commander, a training captain, operated as Pilot Flying (PF) in the right-hand seat. A trainee captain, operating one of his first line training flights on this aircraft type, was Pilot Monitoring (PM) in the left seat, and a third pilot occupied the jump seat acting as a safety pilot. During takeoff and initial climb from Runway 09R multiple EICAS[1] messages related to AC electrical system 4 were annunciated[2]; the autothrottle disconnected and became unavailable, and the LNAV and VNAV[3] autopilot flight director system (AFDS) modes became inoperative. The crew followed the departure profile using HDG SEL and FLCH[4] AFDS modes and carried out the after-takeoff checklist.

After the crew analysed the substantial number of EICAS messages[5], they performed the Quick Reference Handbook (QRH) procedure for ELEC AC BUS 4[6]. The commander advised ATC they had an electrical problem and around four minutes later AC Bus 1 lost power, causing the loss of the Cockpit Voice Recorder (CVR) for the remainder of the flight. During the next 20 minutes, the crew were able to manually reset AC Bus 4 three times, but it kept losing power, eventually becoming completely unpowered for the remainder of the flight. During this time a PAN was declared and having climbed above cloud, the crew levelled the aircraft at FL250 to discuss their options.

Footnote

1 Engine Indication and Crew Alerting System
2 The first EICAS message appeared after V_1 on the aircraft's takeoff roll.
3 LNAV and VNAV – the lateral and vertical navigation autopilot modes using information provided by the Flight Management Computer (FMC).
4 HDG SEL and FLCH – basic lateral and vertical autopilot navigation modes.
5 EICAS alert messages of the same status appear in failure order and require crews to manually prioritise.
6 The procedure objective is to reset the generator, then the bus tie, and to reset the Electronic Engine Control (EEC) if the bus recovers. The QRH states the following regarding both the Generator Control Switch and Bus Tie Switch: '*Attempt only one reset per flight*'.

The QRH procedure implied that with the cumulative failure of AC Bus 1 and AC Bus 4, the pitot probe heaters on both sides of the aircraft would be inoperative (Figure 1). It states *'Avoid icing conditions'* which *'may result in unreliable captain's… standby…* [and] *first-officer's flight instrument indications'*. The commander requested radar vectors while maintaining FL250, saying "WE'D LIKE TO STAY CLEAR OF ICING… AS BEST WE CAN, THAT'S OUR PRIMARY CONCERN". He asked which airports within 90 minutes of flying time gave the best chance for VMC during descent and arrival. Other aircraft on frequency suggested Amsterdam Schiphol Airport (Schiphol). The ATCO confirmed Schiphol's weather was clear with no significant weather, wind 5 kt, and temperature 4°C, and gave alternatives of Newcastle, Glasgow, and Edinburgh airports. The aircraft takeoff weight from Heathrow was 299 tonnes. When the decision to divert was taken, the aircraft weight was approximately the maximum landing weight, 290 tonnes. After assessing the weather and runway landing distance available at each airport, the crew agreed on diverting to Schiphol.

The crew recognised that they would descend through icing conditions and began briefing for potential unreliable airspeed using the QRH but were interrupted by noticing the cabin altitude indication had automatically appeared on the upper EICAS display, showing it increasing through 8,600 ft and displayed in amber. In order to avoid complexities of wearing oxygen masks if the cabin altitude were to reach 10,000 feet, the commander began descending the aircraft using FLCH[7], while initiating a diversion to Schiphol - the cabin altitude started to reduce steadily.

The crew discussed their actions in the event of the airspeed indications being affected by icing conditions. Using the pitch and power settings in the QRH checklist for unreliable airspeed ensures that the aircraft remains in level flight or climbs, depending on weight and altitude, but the crew did not feel that the actions suggested were appropriate for their situation as they needed to descend and were likely to encounter icing during the descent. As a result the safety pilot used the QRH[8] '*Flight With Unreliable Airspeed'* table to identify a descent target pitch attitude, which was approximately 0° with idle thrust giving an approximate airspeed of 0.84 M or 290 KIAS and a descent rate of 2,100 ft/min, so that they were prepared in the event that the airspeed became unreliable.

As the aircraft passed through approximately 12,000 ft in the descent it entered icing conditions, at which point the speeds on all three airspeed indicators began to drop and the aircraft began to pitch down. The handling pilot increased thrust slightly to compensate for the reduction in airspeed and pitch but the speed continued to decay, and the aircraft continued to pitch further nose-down reaching a recorded 7.6° nose-down with associated 6,240 ft/min rate of descent. The crew recalled receiving an IAS DISAGREE alert and they reported that they were about to intervene, when descending through 10,000 ft the indicated airspeed rose rapidly as the aircraft left icing conditions and the pitot probes cleared. The autopilot reacted to the speed increase by increasing pitch, and at about the same time

Footnote

7 FLCH is a vertical autopilot mode that changes the pitch of the aircraft to maintain a selected speed or Mach number.

8 The Performance Inflight, flight with unreliable airspeed table includes this note. *'Altitude and/or vertical speed indications may also be unreliable.'*

the handling pilot reduced the thrust to idle. The corrective actions were not fast enough to prevent the OVERSPEED warning triggering. The commander advised ATC "WE'RE ALSO LOSING OUR AIRSPEED AT THE MOMENT SO CAN WE CONTINUE DESCENT BELOW SEVEN" and shortly after declared a MAYDAY. The aircraft broke cloud at 6,000 ft and remained in clear air for the remainder of the flight.

The main landing runway in use at Schiphol was 36R but ATC offered the possibility of using Runway 06 which the crew accepted. As they began configuring the aircraft to slow down for the approach, they received a FLAPS DRIVE caution requiring them to carry out a further checklist and land with a higher landing speed. ATC provided heading instructions to give the crew time to complete their checks and then positioned them to land on Runway 06. The landing was uneventful and the aircraft was taxied to its parking bay where engineers were available to start investigating the cause of the electrical issues.

Additional information from the flight crew

The QRH does not have a checklist for multiple AC bus failures so the crew combined the information from ELEC AC BUS 4 and ELEC AC BUS 1 (Figure 1) to understand the system failures, specifically the possibility that all flight instrument indications may become unreliable.

BOEING 6.3

747 Flight Crew Operations Manual

▼ELEC AC BUS 1, 2, 3, 4 continued▼

4 Choose one:

◆ELEC AC BUS **1** message is shown:

Avoid icing conditions. Flight in icing conditions may result in unreliable captain's and standby flight instrument indications.

►►Go to step 5

◆ELEC AC BUS **4** message is shown:

Avoid icing conditions. Flight in icing conditions may result in unreliable first officer's flight instrument indications.

►►Go to step 5

Figure 1

Extract from the QRH, ELEC AC BUS 1,2,3,4

The crew reported that they discussed how they would be affected by carrying out the Memory Items[9] associated with the Airspeed Unreliable checklist (Figure 2). It was noted that they would potentially find themselves remaining in icing conditions longer than desired by setting a higher pitch and power setting than required for the descent, and pre-briefed disengaging the autopilot and selecting the reference settings derived from the tables in the QRH to expedite the descent to clear air.

The objective of the Airspeed Unreliable checklist is to identify a reliable airspeed indication, if possible, or otherwise to continue the flight using the '*Flight With Unreliable Airspeed'* tables contained within the '*Performance Inflight'* chapter of the QRH. These tables, located in a separate section of the QRH, use aircraft weight and pressure altitude to provide target pitch attitudes and thrust settings appropriate to the required flight profile, enabling the crew to maintain level flight or to establish a climb or descent as necessary. The required values are derived by the crew, with interpolation permitted between the tabulated gross figures.

BOEING 10.1

747 Flight Crew Operations Manual

IAS DISAGREE
or
Airspeed Unreliable

Condition: The airspeed or Mach indications are suspected to be unreliable. (Items which can indicate unreliable airspeed or Mach are listed in the Additional Information section.)

Objective: To identify a reliable airspeed indication, if possible, or to continue the flight using the Flight With Unreliable Airspeed table in the Performance Inflight chapter.

1 Autopilot disengage switch . . . . .Push

2 A/T ARM switch . . . . OFF

3 F/D switches (both) . . . . OFF

4 Set the following gear up pitch attitude and thrust:

Flaps extended . . . . 10° and 90% N1

Flaps up . . . . 4° and 80% N1

- -

Figure 2

Extract from the QRH, Memory Items from the IAS DISAGREE checklist

Footnote

[9] Memory Items are immediate actions that must be done before reading the rest of the checklist. These actions must be done from memory or from an approved, immediately accessible reference such as a Quick Reference Handbook (QRH) and need to be done prior to doing reference items. The last memory item is followed by a dashed horizontal line.

As the AC buses became unavailable, many systems that receive power from them failed. With each failure an EICAS message was generated and displayed for the crew. It was reported that numerous EICAS alerts had been received before it became apparent that a main AC bus had failed. During this time, they were occupied with flying the Standard Instrument Departure with a degraded autopilot capability. ATC recordings from the Heathrow departure frequency captured several events where the crew were unable to reply to calls evidencing a very high workload.

Having confirmed the aircraft was under control, the crew reported that their use of TDODAR (Appendix) as a step-by-step method to evaluate the failures and develop a plan to manage them allowed them to cope with the number of events.

At the time the crew decided to discontinue the flight to Hong Kong, they were approaching the east coast of the UK heading east.

Several diversion options were suggested by ATC. The crew considered Schiphol to be the best alternative, as it offered a selection of long runways. This choice was further supported by positive confirmation from another crew who had recently departed from Schiphol where there was no cloud below 6,000 ft agl. This minimised the likelihood of flying an approach in icing conditions.

The crew stated they discussed having sufficient fuel to fly to another airfield but, after the string of failures they had already managed, they were unsure as to "what will go wrong next?" so decided to land as soon as practicable.

During the descent, the commander (PF) handed control of the aircraft to the PM so that he could verify the route data in the Flight Management Computer (FMC). Around this time, they entered icing conditions and the aircraft began to pitch nose-down. This was recognised by the commander who alerted the PF and told him to "reduce the body angle". The PF added thrust, which is the normal process to reduce body angle when using FLCH, but the aircraft continued to pitch down as the Indicated Airspeed (IAS) continued to reduce. The crew recalled that the standby IAS was indicating approximately 100 kt. Having recognised that the airspeed information was unreliable, they considered that the overspeed indications were also likely to be erroneous.

Having descended below the icing layer and stabilised the flight path, the crew continued their approach to Schiphol. Whilst configuring the aircraft for landing they received the flap failure FLAPS DRIVE annunciation which prompted an extra landing distance calculation to verify they had sufficient runway length to land and stop the aircraft.

Recorded information

The FDR and CVR were downloaded. Instrument readings recorded by the FDR are predominantly sourced from the captain's side. This is a limitation during periods where there is a potential difference between the captain's and co-pilot's instrument readings such as flying through icing conditions without full pitot-static heating available.

Power to the CVR was lost approximately 19 minutes into the flight when its only source of power, AC Bus 1, was lost.

Central Maintenance Computer (CMC) messages were automatically transmitted from the aircraft during the flight using the aircraft manufacturer's Airplane Health Management (AHM) system. These are timestamped with one minute resolution and can flag issues that were triggered but have since become inactive. The AHM summary provided to the investigation matches maintenance messages with Flight Deck Effects (FDEs) where possible. The activity correlates with the FDR recorded power bus failures.

ATC RT recordings were analysed and those from the Netherlands were provided by the Dutch Safety Board (DSB).

Figures 3 and 4 provide an overview of the flight, and Figure 5 provides more detail during the period affected by icing. A summary of the AHM messages that had an FDE is given in Table 1, highlighting the extent of cockpit indications during the flight.

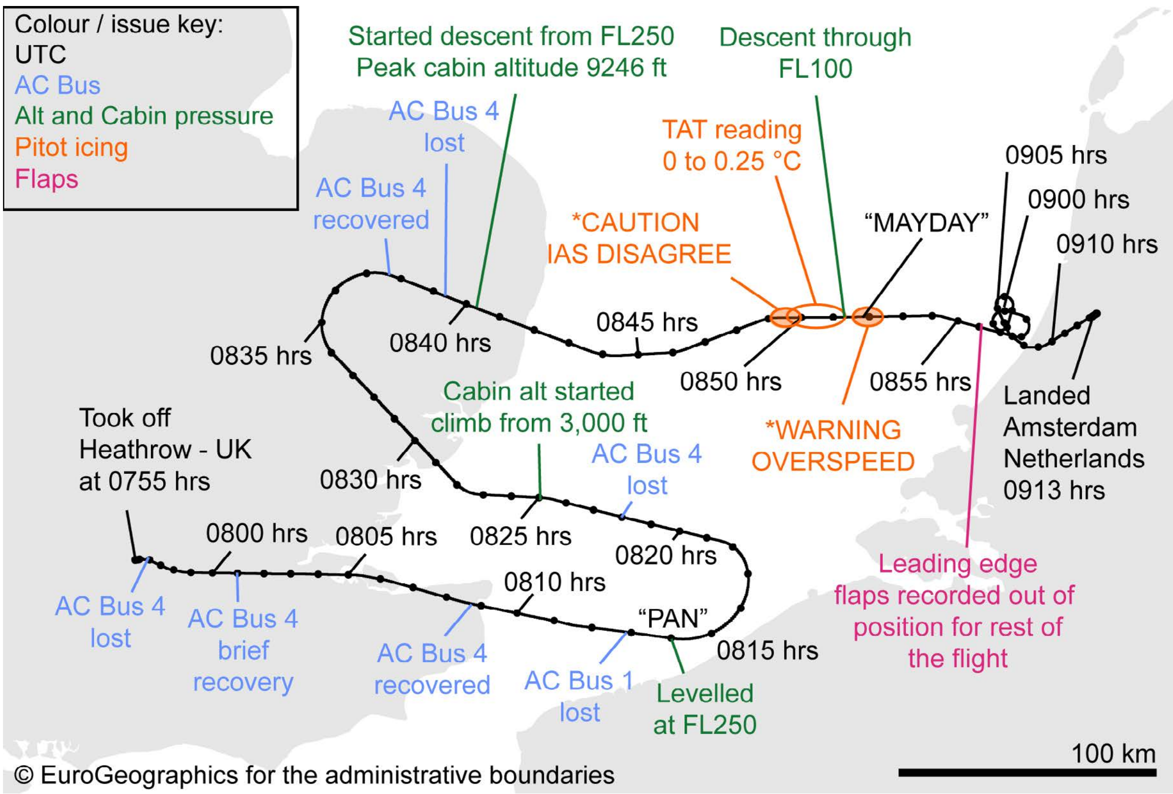

Figure 3

Plan view of the flight
(*AHM speed related alerts with 1 minute time resolution and assuming FDR and AHM clocks aligned)

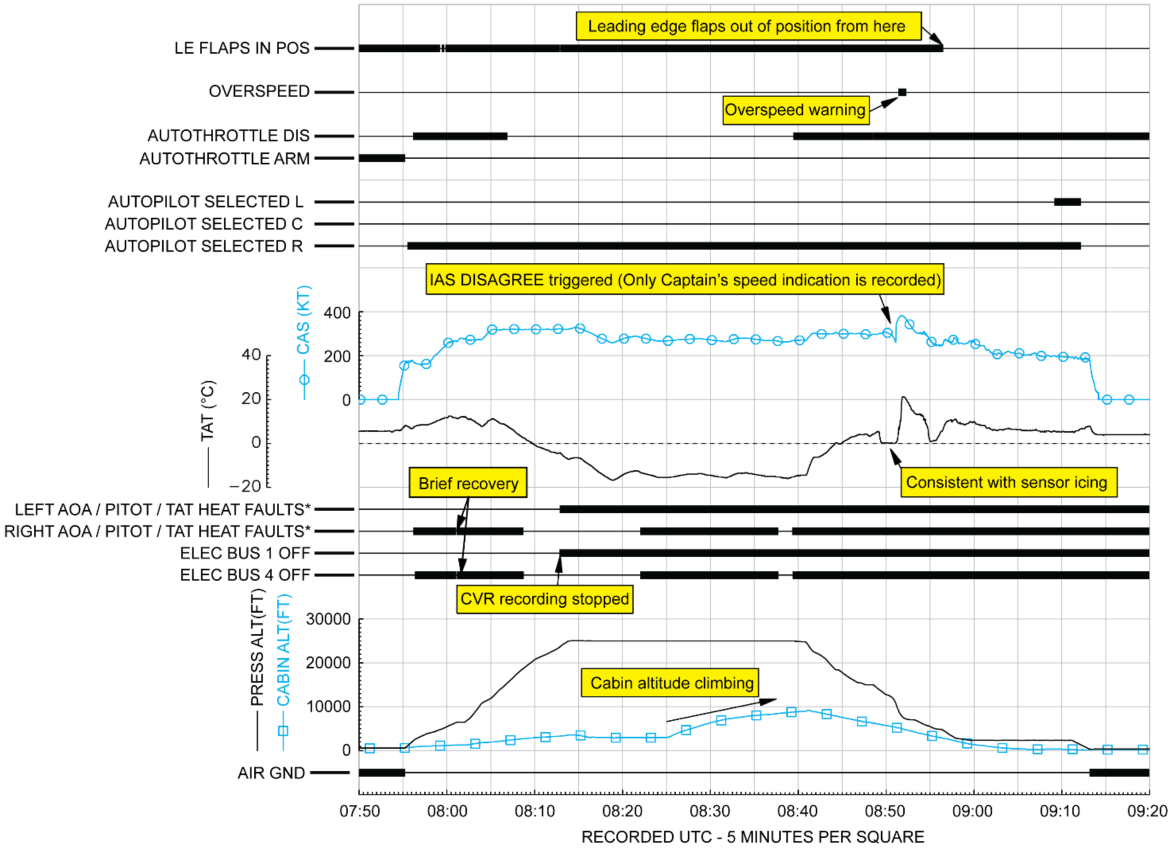

Figure 4

Overview plot of the flight
(*Separately recorded faults with the same timings, TAT is Total Air Temperature sensor and AOA is Angle of Attack sensor)

The data in Figure 4 shows the timings for when AC Bus 1 and 4 were powered and unpowered, and it shows that the cabin altitude started climbing while the aircraft was level at FL250. At the time the cabin altitude started climbing the air conditioning packs showed a change from high flow to normal flow (not plotted).

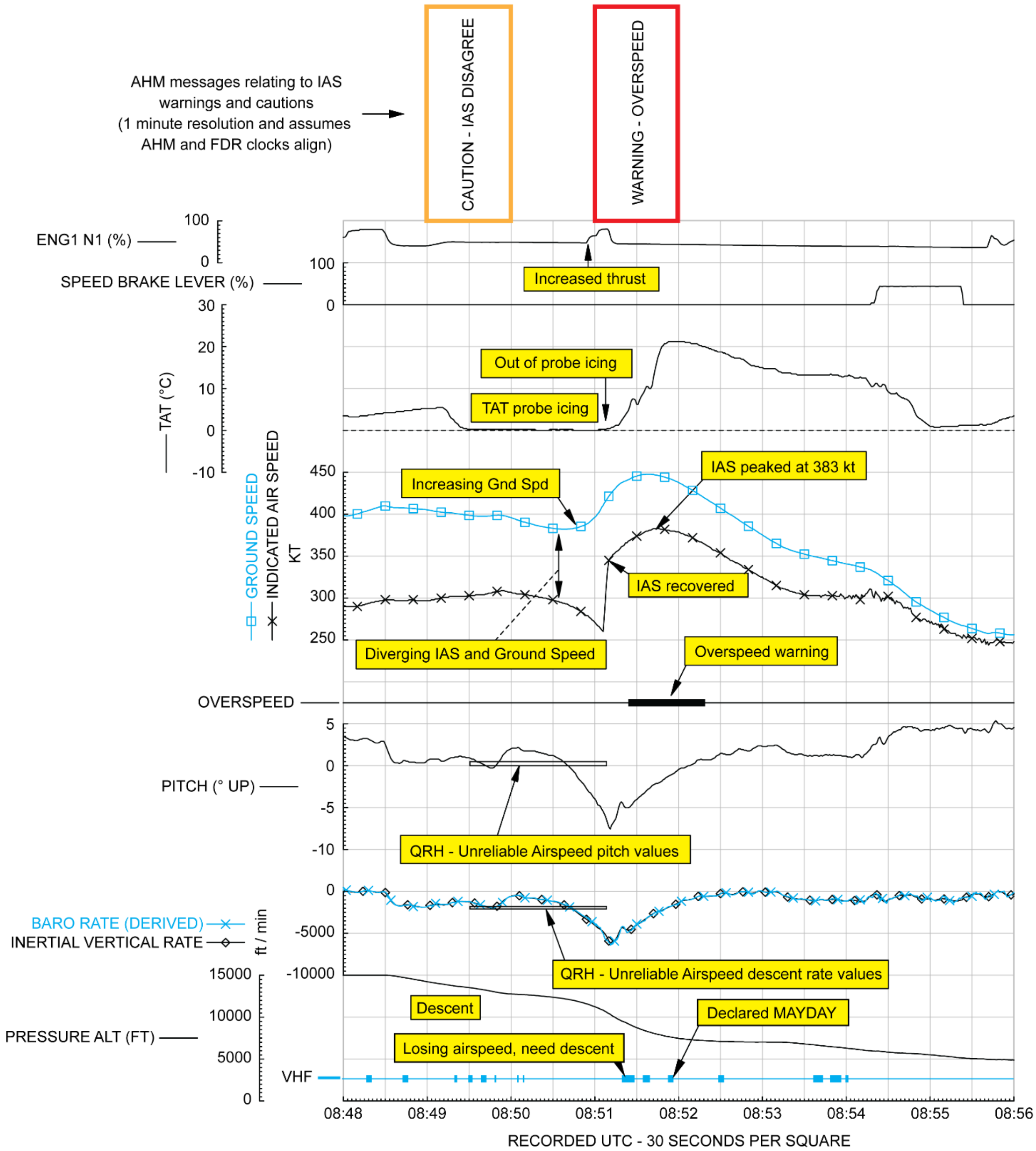

Figure 5

Unreliable airspeed event

The data for the unreliable airspeed event (Figure 5) shows that throughout this period the right autopilot was engaged, the autothrottle was disengaged, the pitot, Total Air Temperature (TAT) and Angle of Attack (AOA) heat faults were active, and the AOA recorded values did not indicate icing of the AOA sensors.

The TAT parameter holding at freezing point indicates left sensor icing - no data for the right probe was recorded. The IAS and ground speed diverged significantly. The dropping IAS, diverging from the ground speed in the descent, while the TAT sensor indicated it was iced, is consistent with pitot probe icing. Only the captain's IAS, nominally from the left Air Data Computer (ADC), was recorded. However, faults recorded by the AHM indicated that at some point between 0849 hrs and 0850 hrs an IAS DISAGREE fault was triggered due to the captain's and co-pilot's IAS disagreeing by more than 5 kt for more than 5 seconds. Additionally, in the minute before that, between 0848 hrs and 0849 hrs, a message associated with the centre ADC IAS value being different from the left and/or right ADC IAS values was triggered.

The engaged autopilot mode was not explicitly recorded on this installation type. Recorded aircraft behaviour and system availability given the recorded AC bus failures made it likely that FLCH mode was engaged during the descent in icing conditions. In this mode the autopilot controls pitch to achieve the IAS or Mach values selected by the crew on the mode control panel.

The aircraft pitch reached 7.6° nose-down and the descent rate reached approximately 6,240 ft/min. With decreasing recorded IAS, the crew briefly manually increased the thrust.

As the TAT probe temperature started to climb from freezing point, indicating that it was no longer iced, the IAS jumped approximately 85 kt in 4 seconds, consistent with an iced pitot probe becoming unblocked and indicating a more accurate speed. The engine thrust was returned to the previous level.

The autopilot started recovering the pitch, but the increasing IAS triggered an overspeed warning, reaching a peak of 383 KIAS. The overspeed warning lasted 55 seconds, and then the IAS returned to the pre-icing speed. The speed brakes were not deployed during the overspeed event.

The QRH unreliable airspeed pitch and descent rate reference values, shown in Figure 5, are those that were determined by the flight crew from the '*Flight With Unreliable Airspeed/ Turbulent Air Penetration*' table.

AHM Time	**AHM summary – Flight Deck Effect (FDE) correlated with CMC maintenance messages – (intermittent unless otherwise stated)**
07:54 / 07:55	ADVISORY and STATUS indications relating to GCU 4 failure.
07:56	CAUTIONS associated with the loss of AC Bus 4 and the autopilot. ADVISORY and STATUS indications associated with pack control B, rudder ratio, flap load relief, fuel pump 1 forward, fuel pump 4 aft, loss of heat for the right pitot/static, AOA and TAT sensors, loss of left window heat and engine 4 controller mode issues.
08:08	Maintenance message 'DC Bus 4 not powered' associated with ADVISORY and STATUS indications regarding fuel jettison B, right jet nozzle, hydraulic pressure demand pump 4, Nacelle Anti Ice (NAI) valve 4 and engine 4 controller.

AHM Time	AHM summary – Flight Deck Effect (FDE) correlated with CMC maintenance messages – (intermittent unless otherwise stated)
08:09	A STATUS indication associated with engine 4 28V DC power issues affecting the engine controller and probes.
08:12	Many maintenance messages associated with hard failures of various parts of AC Bus 1, resulting in AC Bus 1 related CAUTION, ADVISORY and STATUS indications. Additional ADVISORY indications related to autoland capability and engine 1 controller mode. STATUS indications related to flap control and monitoring, and the centre instrument landing system and centre radio altimeter systems.
08:13	ADVISORY and STATUS indications associated with the main tank 2 aft boost pump system failure and an ADVISORY associated with Engine 1 controller mode and a pneumatic line input.
08:29	DC Bus 1 loss of power associated with a door CAUTION, an NAI valve 1 ADVISORY, and STATUS indications associated with engine 1 controller and engines 1 and 4 reversers.
08:30	Maintenance message for DC Bus 1 circuit breaker open was associated with a door CAUTION, an NAI valve 1 ADVISORY and STATUS indications associated with engine 1 controller and engines 1 and 4 reversers. An engine 1 controller STATUS indication was also associated with an engine 1 controller 28V DC power fail.
08:47	BLEED 3 temperature ADVISORY and STATUS indications.
08:48	STATUS indication for IAS/ALT CTR disagree (see overspeed data plot), BLEED 3 valve ADVISORY and STATUS indications.
08:49	CAUTION – IAS disagree (see overspeed data plot). Elevator feel computer fail STATUS indications.
08:51	WARNING - overspeed. Rudder ratio ADVISORY and flap load relief STATUS indications associated with ADC disagreement.
08:58	CAUTION and STATUS indications associated with leading edge flap drives left and right, 2, 3 and 4.

Table 1

Summary of AHM messages transmitted during the flight, that had an associated Flight Deck Effect (FDE). Additional maintenance messages not associated with an FDE by the AHM were also recorded

Maintenance prior to the flight

There had not been any recent maintenance related to the affected electrical systems. During the night before the flight the engineers were replacing smoke detectors which involved them leaving and re-entering the aircraft multiple times, so they left the L1 door open. One of the engineers said there was light rain, occasionally heavier but not enough that he was concerned about leaving the door open. He was also in the Main Equipment Centre (MEC) changing a brake monitor and did not see any water. Another engineer said that he would not have even thought to close the door based on the amount of rain. They both reported the mat at the L1 door being wet but not "puddling".

The engineer who flew onboard during the incident flight stated that when he boarded the aircraft the mat was wet and there was water on the floor panels around the mat. He said there were no puddles.

Aircraft information

Background

The Boeing 747-400, G-ONEE, was manufactured as a passenger variant in 1991. In 2006 it was converted to a freighter (747-400 SF) by Israel Aerospace Industries (IAI), known hereafter as the freighter manufacturer. This work involved converting the main passenger deck into a cargo deck with Power Drive Units (PDUs) installed in the floor to move cargo pallets around. Modification work related to the conversion was certified by the Civil Aviation Authority of Israel. The Boeing Company, known hereafter as the aircraft manufacturer, also converted passenger variants of the 747-400 to freighters (747-400 BCF) and there are some differences in the conversion. There is also a factory-built freighter designated as the 747-400 F.

According to the aircraft manufacturer there were 287 Boeing 747-400 passenger and freighter variants remaining at the end of 2025, of which 236 were active in-service.

AC[10] electrical system description

In-flight electrical power is provided by four Integrated Drive Generators (IDGs) – one installed on each engine[11]. Each IDG supplies power to an independent bus, so there are four AC buses. Each bus has a dedicated Generator Control Unit (GCU) that controls power to and from its bus. The GCU can detect faults such as short circuits and can isolate the bus from its IDG by commanding a Generator Control Breaker (GCB) to open. The four AC buses are connected to a Synchronous bus via individual Bus Tie Breakers (BTBs). The Synchronous bus allows an AC bus to receive power from the other AC buses if an IDG were to fail. The GCUs and Bus Control Units (BCUs) control the BTBs. These components are depicted in Figure 6.

Footnote

10 AC is Alternating Current.

11 Unlike on some other airliner types the APU is not used in-flight for emergency electrical power on the Boeing 747-400.

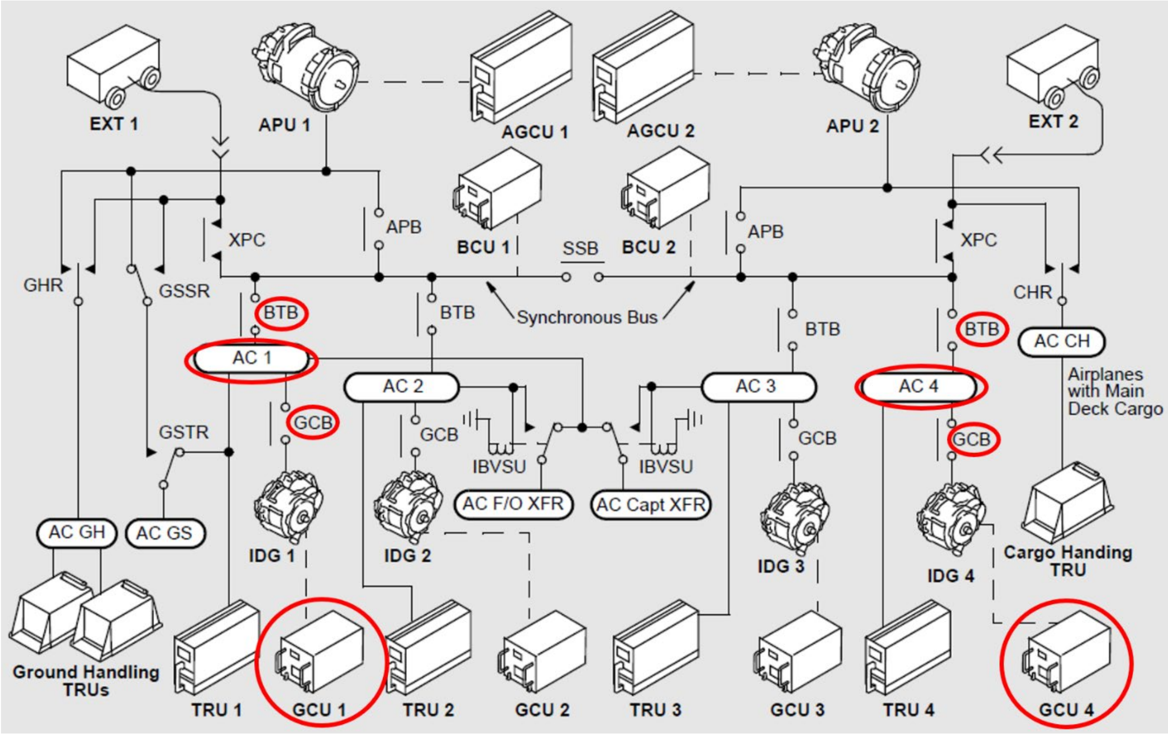

Figure 6

AC Power Supply System with the relevant components from this incident highlighted (image © The Boeing Company)

GCU and BCU locations

The four GCUs and two BCUs are located on the top rows of the E1 and E2 avionics racks in the MEC, below the main cargo deck floor and forward of the left forward L1 door (Figure 7). GCU 1 is in the far-left corner of the E1 rack and GCU 4 is in the far-right corner of the E2 rack.

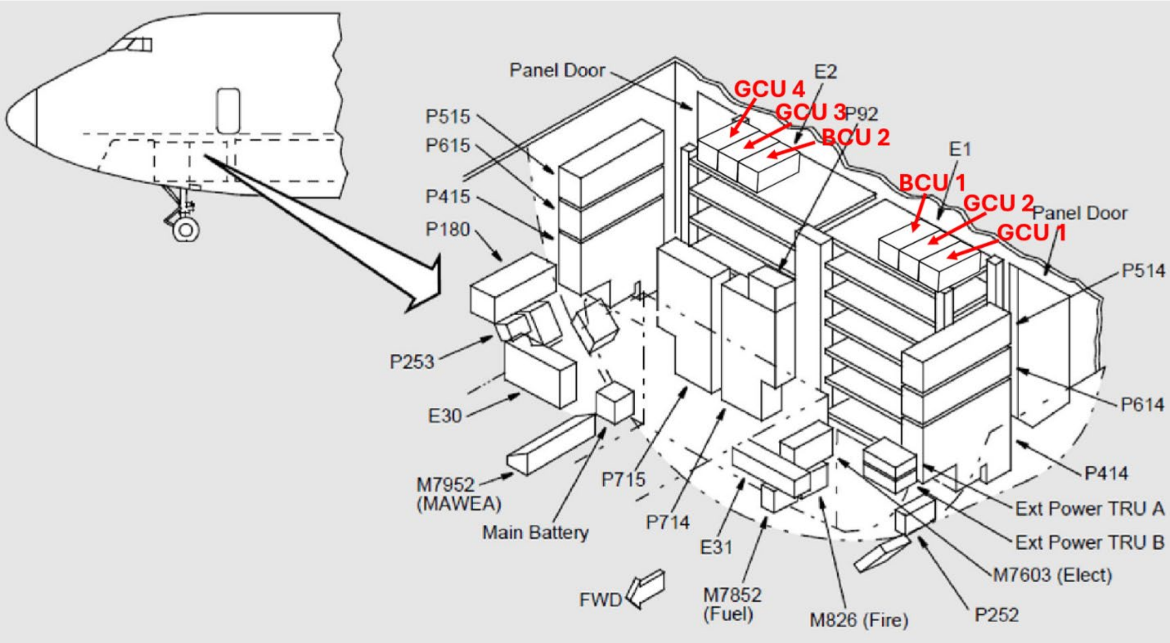

Figure 7

GCU and BCU locations on top shelf of E1 and E2 racks in Main Equipment Centre (image © The Boeing Company)

Water ingress protections

The entire main cargo deck of the aircraft is designed to be a 'wet area', and this includes the floor panels over the MEC. This means that cargo pallets that have been left out in the rain can be loaded onto the aircraft. There are, therefore, a number of protections to help prevent water ingress into the MEC from the main cargo deck. These include:

- A sealant material between the floor panels.
- 10 cm wide polyurethane tape over the top of the sealant and overlapping the edges of the floor panels.
- 91 cm wide 3M 8663 moisture barrier tape applied over the entire deck area.
- Drains in some floor panels and below the PDUs.
- A drip shield over the E1/E2 rack with drains at both ends (Figure 8).
- Moisture barrier 'curtains' attached to the front of the E1/E2 rack (which were not fitted on G-ONEE at the time of the incident).

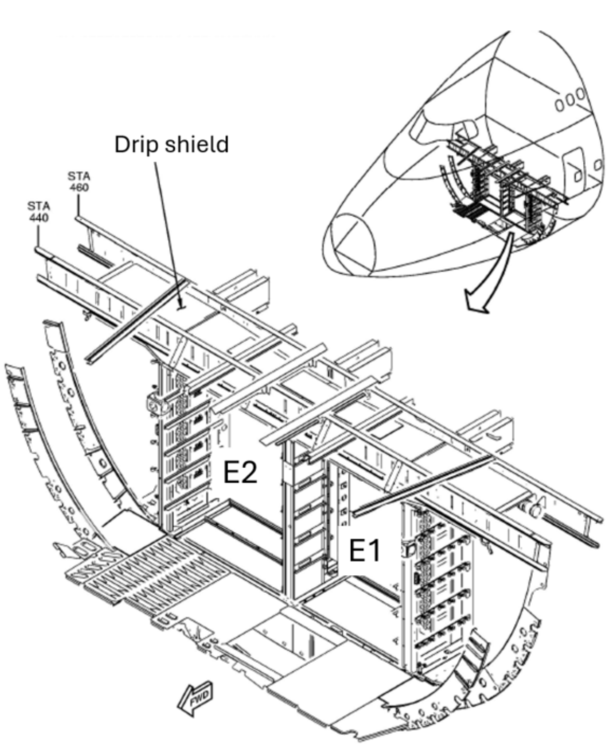

Figure 8

Location of drip shield above E1 and E2 avionics racks
(image © The Boeing Company)

The drip shield also houses a plenum chamber that channels cooling air that has been blown upwards through the electrical and electronic components located in the E1 and E2 racks.

Pitot-static system

The aircraft is equipped with four combined pitot-static probes and four flush static ports. The airspeed and altitude information on both the captain's and co-pilot's Primary Flight Displays are determined based on the pitot and static pressures sensed by the four combined pitot-static probes. The airspeed and altitude information on the 'Integrated Standby Flight Display' is from the left auxiliary pitot-static probe and from one pair of the flush static ports.

The pitot-static probes are heated to prevent blockages from ice formation, but the flush static ports are not as they are less prone to ice formation. The power to heat the four pitot-static probes comes from AC Bus 1 and AC Bus 4. If both buses lose power, then none of the four pitot-static probes will be heated, and if the pitot tubes freeze this will result in erroneous airspeed displayed on all three flight displays.

The left and right TAT probes and both AOA vanes are also heated using power from both AC Bus 1 and 4, so can also be affected by ice in the event these buses lose power.

Static pressure provides a direct measure of pressure altitude, whereas airspeed is computed using the difference in pressure between the pitot tube (pitot or stagnation pressure) and the static pressure. The greater the difference between the pitot pressure and the static pressure, the greater the indicated airspeed. If the pitot tube freezes, trapping the pitot pressure, while the static pressure continues to sense correctly, then in a climb the airspeed indicators will over-read (pitot pressure remains the same while static pressure reduces), and in a descent the airspeed indicators will under-read (pitot pressure remains the same while static pressure increases). Actual airspeed changes will have no effect on the indicated airspeed.

The aircraft manufacturer stated that if pitot-static probe heating is lost then it is more likely that the pitot pressure port is affected rather than the static ports which are located on the top and bottom of the probe head. They stated that it was possible ice could form over the static ports as well but that they had no data on this.

Autopilot vertical modes

The autopilot has three different modes for controlling climbs and descents, VNAV, FLCH and V/S. In VNAV mode the autopilot flies a pre-programmed path using pre-programmed airspeeds or a selected airspeed. In FLCH mode the autopilot maintains a selected airspeed by adjusting the pitch angle. In V/S mode the autopilot maintains a selected vertical speed by adjusting the pitch angle. If the pitot tubes freeze, then using VNAV or FLCH modes will result in the autopilot flying too nose-up (too slow) in a climb or too nose-down (too fast) in a descent. For V/S mode to be affected the static ports would need to freeze.

Cabin pressurisation system

The Cabin Pressure Controller System (CPCS) is a dual-channel, digitally-controlled, fully automatic system that regulates cabin pressure using two outflow valves, automatic/alternate/manual modes, and multiple safety valves to maintain structural integrity and passenger comfort. Bleed air from the engines is routed through the pneumatic system and flow control valve to the air conditioning packs, where it is cooled, regulated, and then supplied to the cabin for both air conditioning and pressurisation. The flow control valve changes the bleed air flow to the air conditioning packs from high flow to normal flow depending on the aircraft configuration.

The left and right pressurisation controllers continuously compare the actual cabin pressure with the target cabin altitude and then open the outflow valves slightly to let more air out (cabin climbs) or close them to retain air (cabin descends). By modulating the valves in small increments, the system keeps the cabin climbing or descending smoothly at a controlled rate while maintaining a safe differential pressure. One pressurisation controller is active while the other is in standby.

The CPCS is powered by AC Bus 1 and AC Bus 2. Each pressurisation controller receives input from several components. The two outflow valves are each actuated via separate AC motors by the active cabin pressurisation controller when in the normal automatic mode. If the automatic mode fails and/or manual control on an outflow valve is enabled, the flight crew can use a switch on the CPCS selector panel to individually control each outflow valve via individual DC motors.

A loss of either AC Bus 1 or AC Bus 2 would result in a loss of one pressurisation controller, and its respective outflow valve would remain stuck in its last position, until either the bus was recovered or the flight crew took manual control of the valve.

Engine Indication and Crew Alerting System (EICAS)

The Engine Indication and Crew Alerting System (EICAS) on the Boeing 747-400 is the central crew-information system that displays engine parameters, aircraft systems data, status messages, and alerts. It is integral to situational awareness and crew workload management. The 747-400 uses two dedicated EICAS display units. The 'Primary EICAS (Upper Screen)' (Figure 9) is always displayed and shows the critical engine parameters; it also displays crew alerting messages (warnings, cautions, advisories). The 'Secondary EICAS (Lower Screen)' displays status level messages and graphical synoptic pages for major systems; these synoptics update dynamically based on system state and sensor inputs.

Figure 9

Example image of a 747-400 upper EICAS display (not from G-ONEE event)

Crew Alerting System (CAS)

EICAS categorises messages by priority with warning messages being the highest priority (eg engine fire), displaying in red text, accompanied by master warning lights and aural alerts - they normally require immediate action. Caution messages are the next highest priority, displayed in amber text with aural alert and master caution lights and require prompt action. Advisory messages are displayed in amber text but have no master warning lights. They indicate configuration changes and noncritical issues. Finally, status messages are in white text and display on the secondary EICAS screen. They indicate deferred or maintenance-related items.

Unlike warnings (which always take priority over cautions and are internally prioritised to only show one warning at a time), caution messages do not queue or reorder. If multiple cautions are triggered, they will appear in the order they are generated, and none is considered "higher priority" than another. All active cautions are shown on the upper EICAS screen, but when they exceed 11 alerts, the pilot is required to scroll the message list to the next page by pressing the cancel (CANC) switch. In the G-ONEE incident the crew reported receiving a high volume of messages which exceeded the number that could be displayed on a single screen.

Information from the aircraft's Quick Reference Handbook (QRH), Flight Crew Training Manual (FCTM) and Flight Crew Operations Manual (FCOM)

During the flight, the crew were faced with multiple, complex procedures taking them outside the scope of normal operations. Both the FCOM and QRH are explicit in stating that some events are beyond the scope of the manuals and inform the crew that altering processes may be essential to ensure a safe outcome.

In any non-normal situation, once the aircraft is stable and trimmed, the FCTM recommends engaging the autopilot as soon as practicable to reduce workload, prevent errors, and support safe, methodical execution of Non-normal checklists (NNCs) - while being ready to reduce automation if it does not perform as expected. During multiple failures or ambiguous situations, when malfunctions exceed the scope of normal checklists the autopilot may be used to hold a safe flight path while the crew evaluates the situation. When reading the QRH it should be noted that each checklist assumes that configuration of the aircraft was normal at the start of the checklist. In situations where multiple failures require several checklists to be actioned simultaneously, they cannot account for different switch positions or system selections.

QRH[12] extract:

> ***'Checklist Instructions – Non-normal checklist'***
>
> ***'Assumptions***
>
> *Non-normal checklists also assume:*
>
> - *System controls are in the normal configuration for the phase of flight before the start of the non-normal checklist.'*

Footnote

[12] 747 Quick Reference Handbook (QRH) D6-30151-532(AT1), 1 April 2023.

*‘**Use of Captain’s Discretion***

The flight crew must be aware that checklists cannot be created for all conceivable situations and are not intended to replace good judgment. In some situations, at the captain’s discretion, deviation from a checklist may be needed.’

FCTM[13] extract:

‘Landing at the Nearest Suitable Airport’

During non-normal or emergency situations the QRH will instruct the crew to ‘land at the nearest suitable airport’. A ‘suitable’ airport is one that meets the required weather, runway and facility criteria, with ‘nearest’ generally indicating the closest in time rather than distance. Whilst the QRH highlights situations where a diversion is required, it remains the discretion of the pilot-in-command to choose a more distant airport if it offers greater overall safety given the circumstances.

‘Overspeed’

V_{MO}/M_{MO} is the maximum certified operating speed[14] and should not be intentionally exceeded, although brief inadvertent overspeeds may occur and aircraft are tested to safely recover from them. During an inadvertent overspeed, crews are generally advised to keep the autopilot engaged and use speedbrakes, unless it is not effectively correcting the condition, in which case manual control may be required with awareness of possible abrupt pitch changes. If VNAV or FLCH modes do not adequately control speed in climb or descent, temporarily selecting V/S mode can help adjust pitch until the speed is reduced, after which normal modes may be reselected.

*‘**Rapid Descent’***

Should the cabin pressurisation system fail to maintain cabin altitude below 10,000 feet then the crew would be required to carry out a rapid descent. This manoeuvre can be flown pre-emptively to avoid the requirement to don the crew oxygen masks.

‘This maneuver is designed to bring the airplane down smoothly to a safe altitude, in the minimum time, with the least possible passenger discomfort.

Note: Use of the autopilot is recommended.’

Footnote

13 747 Flight Crew Training Manual FCT 747 (TM), 30 June 2023.
14 Velocity (V) and Mach (M) Maximum Operating (MO).

*'**Autopilot Entry and Level Off***

Flight Level Change (FLCH)

Because of airspeed and altitude protection and reduced crew workload, use of the autopilot with FLCH mode is the recommended technique for rapid descents. Use of the V/S mode is not recommended… During descent, the IAS/MACH speed window changes from MACH to IAS at approximately 310 KIAS. Manually reset to VMO as needed.

When descending at speeds near VMO/MMO with the autopilot engaged, short-term airspeed increases above VMO/MMO may occur... These short-term increases are acceptable for this maneuver and the autopilot should adjust the pitch to correct the airspeed to below VMO/MMO. Do not disengage the autopilot unless autopilot operation is clearly unacceptable.'

*'**Situations Beyond the Scope of Non-Normal Checklists***

It is rare to encounter in-flight events which are beyond the scope of the Boeing recommended NNCs… flight crew may be required to accomplish multiple NNCs, selected elements of several different NNCs applied as necessary to fit the situation, or be faced with little or no specific guidance except their own judgment and experience. Because these situations are rare, it is not practical or possible to create definitive flight crew NNCs to cover all events.'

Aircraft examination

Initial aircraft examinations

After the aircraft arrived at Amsterdam Schiphol Airport the engineer onboard carried out initial troubleshooting. He noticed that the circuit breaker on GCU 4 had tripped and when he removed the GCU, a few drops of water came out the bottom of it, and there was slight wetness in the base of the area the GCU was removed from. When he shook the GCU a few more drops came out. When GCU 1 was removed it was dry. The GCUs have multiple small holes on their upper and lower surfaces to allow cooling air to pass through from below (Figure 10).

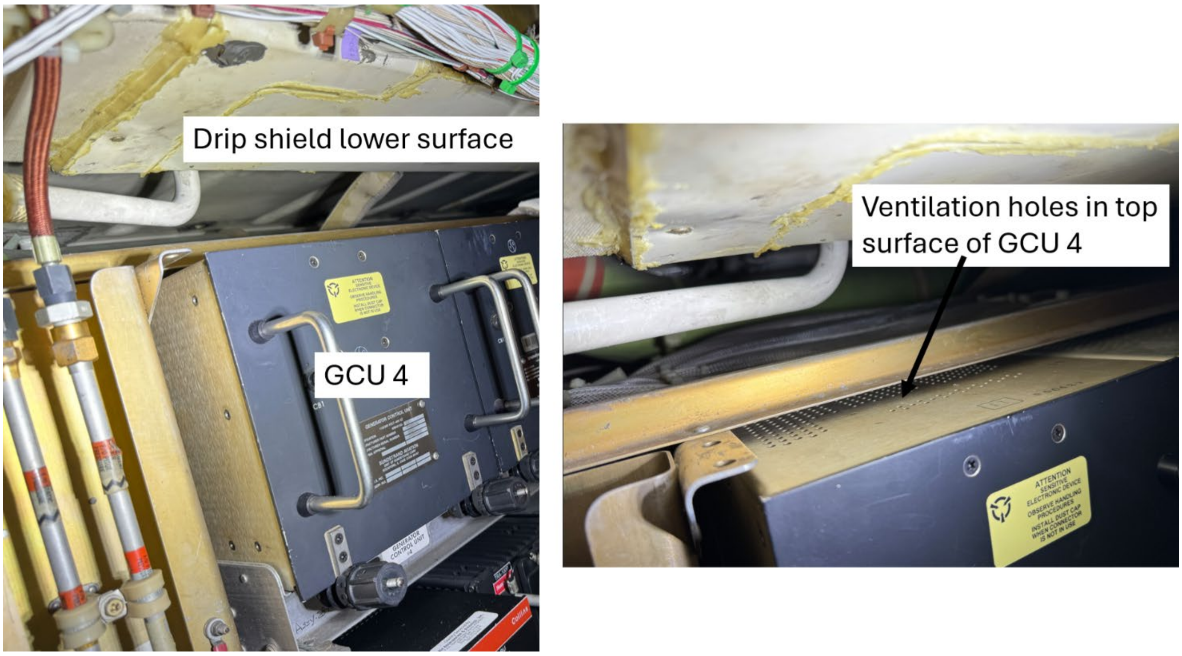

Figure 10
GCU 4 location below drip shield and ventilation holes in top surface

Two investigators from the DSB arrived to oversee subsequent work. GCU 4 was replaced, and tests revealed that all faults had disappeared with both AC buses 1 and 4 being powered. As a precautionary measure GCU 1 was also replaced.

As the aircraft was registered in the UK the DSB handed the investigation to the AAIB and an AAIB inspector arrived to examine the aircraft the following day. Water was poured down the drain in the mat near the L1 door and the drain on the opposite side of the aircraft, but no leaks were found. Some water was found in the bilge at the bottom of the fuselage but that was not unusual. There were no obvious defects in the visible part of the drip shield that overhung the E1/E2 racks. No moisture or dampness was found in the intake of the air duct fan that provided cooling air to the E1/E2 racks. The moisture barrier curtains in front of the E1/E2 racks were not fitted (Figure 11).

A test involving powering the aircraft with both GCU 1 and 4 removed resulted in the same cockpit indications and symptoms that the flight crew had reported.

No cargo pallets had been placed above the MEC during the incident flight.

Figure 11

Left image taken on day after the incident. Right image shows moisture barriers, which were fitted in March 2024, to the front of the E1 and E2 racks, covering the GCUs and other equipment

GCU examinations

GCU 1 and 4 were sent to the component manufacturer for examination under supervision of an investigator from the US National Transportation Safety Board. GCU 1 passed the acceptance test procedure apart from one anomaly which was not related to the event. When GCU 1 was opened, there were indications of corrosion and moisture residue on the bottom of the GCU.

GCU 4 initially passed the acceptance test but then failed some impedance checks on subsequent re-tests. The GCU was opened and the circuit boards were removed for examination. Corrosion was observed on several integrated circuits, and there were indications of water intrusion in several places around the base of the chassis.

The non-volatile memory (NVM) from both GCUs was downloaded. The data revealed that AC Bus 4 lost power due to a Sync Bus Protection fault followed by a Shorted Rotating Diode fault within GCU 4. Coupled together these faults would result in GCU 4 tripping its BTB and GCB, isolating AC Bus 4 from all sources of power. Water ingress could have caused both faults. The NVM also indicated that the cycling nature of the loss of AC Bus 4 was due to the flight crew pressing the Generator Control Switch (GCS) twice, which will reclose the GCB until the fault trips it again, and later pressing the Bus Tie Switch (BTS) which will reclose the BTB, until the fault trips it again.

The NVM from GCU 1 revealed that a differential protection fault had been triggered. This type of fault locks out the bus by tripping the BTB and GCB, and they cannot be reset by the flight crew. A differential protection fault is normally an indication of a short external to the GCU, but the component manufacturer stated that this type of failure could be triggered by an internal short due to moisture ingress.

The component manufacturer considered that GCU 1 had passed its acceptance test because the moisture was no longer present, and that GCU 4 had passed almost all its tests for the same reason.

Aircraft examination during A-check

Further examination by the operator revealed that there were areas on the main deck, above the E1/E2 racks, where the moisture barrier tape and polyurethane tape were in poor condition. This was rectified at the subsequent A-check in March 2024 and the missing moisture barrier curtains were fitted (Figure 11). Examination of the drip shield above the E1/E2 racks revealed that the drip shield end cover plate, above the location of GCU 4, had compromised sealant (Figure 12) which could have provided a path for water to travel to the GCU from above the drip shield. The sealant on the end cover plate on the opposite side, above the location of GCU 1, was similarly compromised. These areas were both re-sealed.

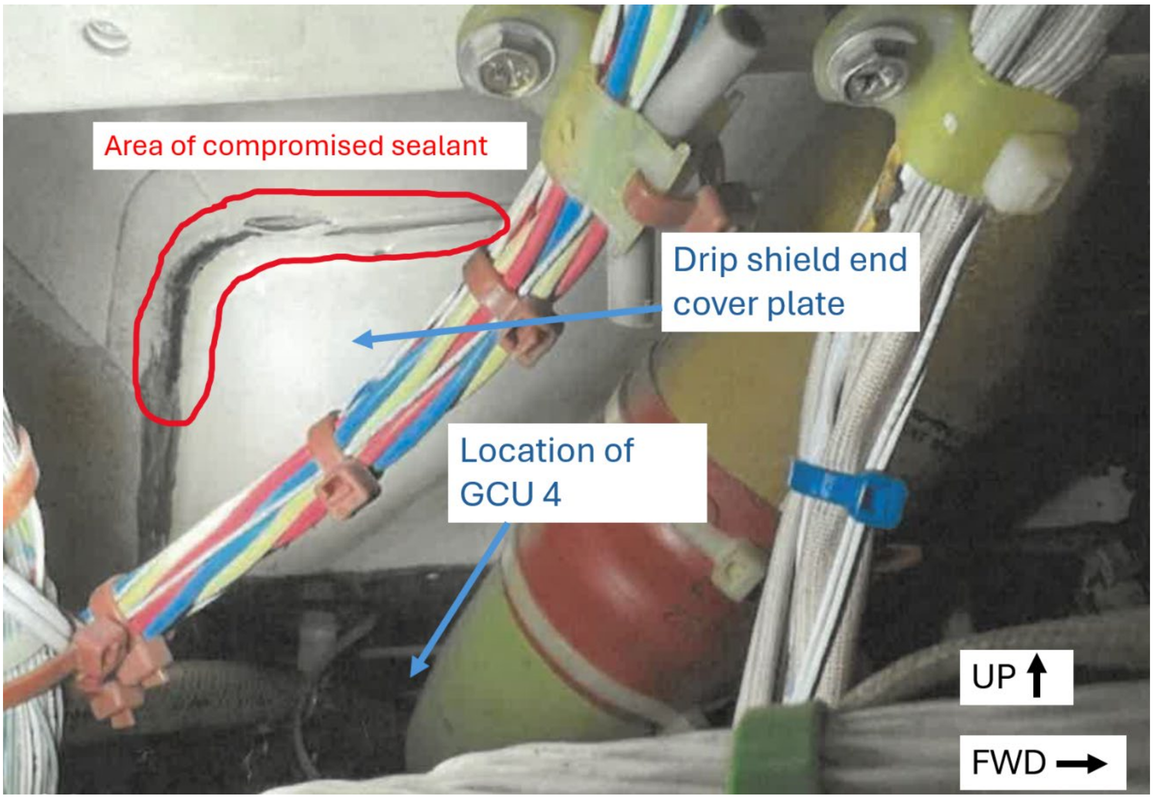

Figure 12

Compromised sealant in drip shield end cover plate above GCU 4 location

Second AAIB aircraft examination

In June 2024 the AAIB carried out an additional examination of the aircraft. Figure 13 shows the L1 door mat that was wet prior to the incident flight, and its location relative to the E1 and E2 racks containing the GCUs. The door mat has a rubber barrier surrounding it to contain any water and help ensure the water passes down the drain hole in the mat.

A close examination of the door mat revealed that the forward right corner was missing sealant between the rubber barriers, creating a path for water to travel along the floor above the E1/E2 racks (Figure 14).

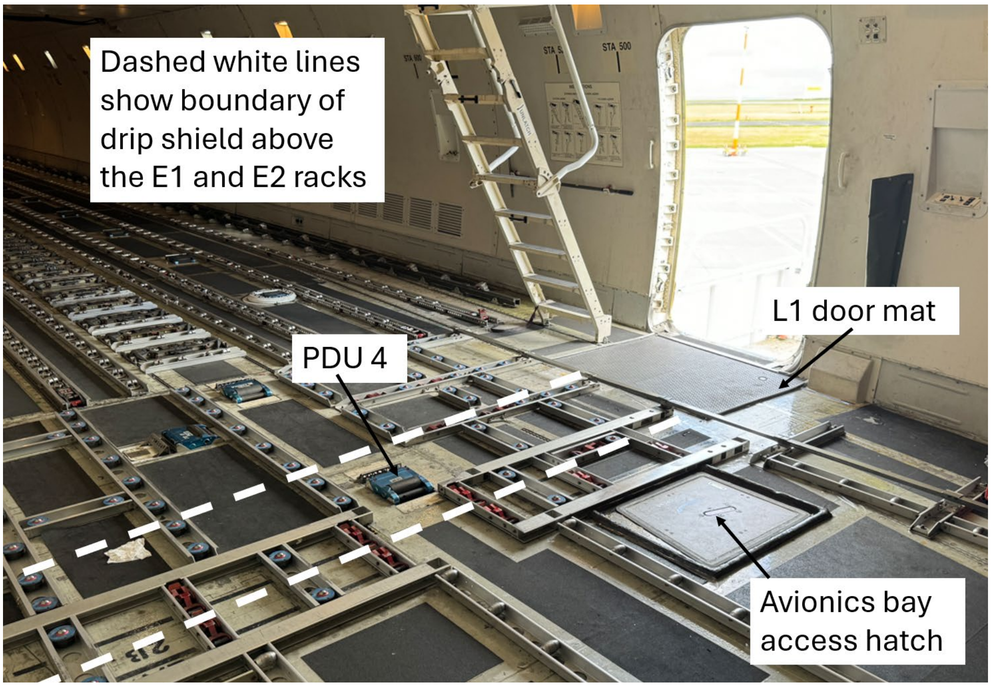

Figure 13

Location of L1 door mat and PDU 4 relative to the E1 and E2 racks beneath the cargo deck floor

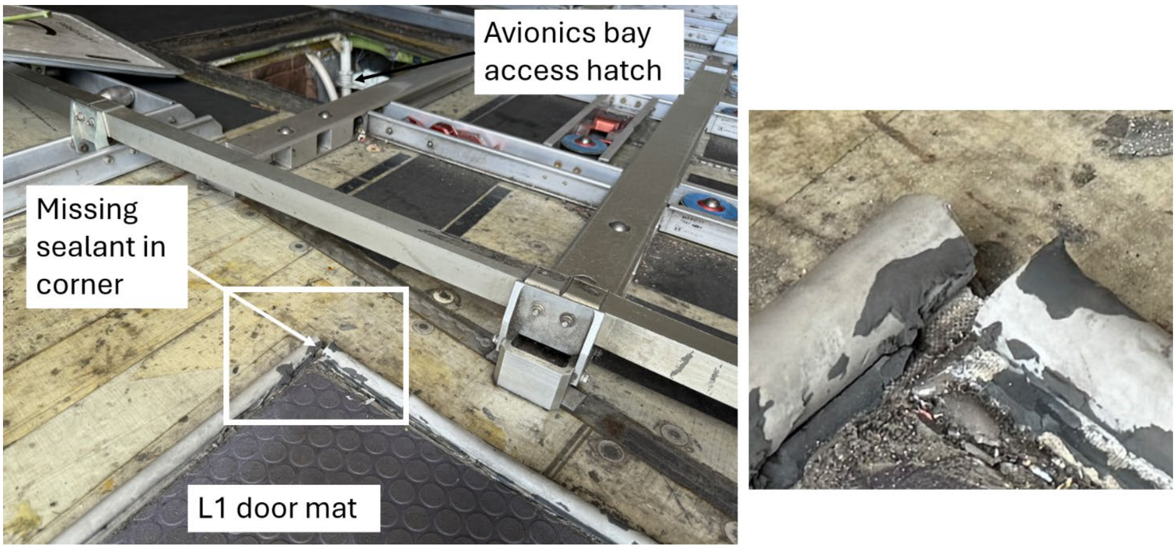

Figure 14

L1 door mat showing missing sealant in forward right corner

PDU 4, which is located directly above the E1/E2 racks, was examined by pulling and pivoting it upwards on its aft hinge. Beneath it were drain holes and a missing screw on the right side (Figure 15). Subsequent tests showed that the drain hole was clear and did not leak. The missing screw created a hole that could have allowed water to pass down directly on top of the drip shield above the E1/E2 racks.

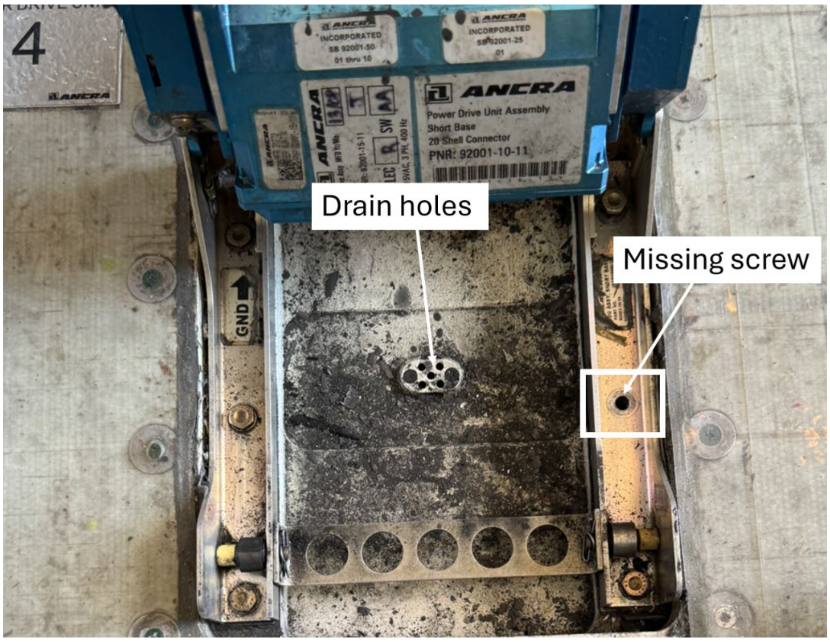

Figure 15

Missing screw beneath PDU 4

Despite the rectification work that had been carried out during the A-check, sections of the cargo deck floor near the L1 door were found to have cracked and missing polyurethane tape (Figure 16). These findings were all rectified by the aircraft operator.

Figure 16

Cracked and missing polyurethane tape in cargo deck floor area near L1 door

Aircraft examination during C-check

The drip shield cannot be examined without removing all the floor panels which is an extensive job, so this was planned for the aircraft's C-check which was carried out at a maintenance organisation in Germany in August 2024. An investigator from the German Federal Bureau of Aircraft Accident Investigation (BFU[15]) attended the examination.

The fibreglass reinforced overcoat[16] on the drip shield appeared to be undamaged, but there were cracks in some sealant at the edge of an L-shaped bracket on the right side of PDU 4 (Figure 17), and on the left side of PDU 4. When the bracket was removed to repair the sealant, the drip shield was found to be damaged and had holes which could have been a potential path for water. Similar damage and holes were found in the drip shield when the bracket on the left side of PDU 4 was removed.

There are four drains, one in each corner of the drip shield. The flexible hose attached to the forward right drain was excessively crimped with a plastic tie wrap but would not have prevented water draining.

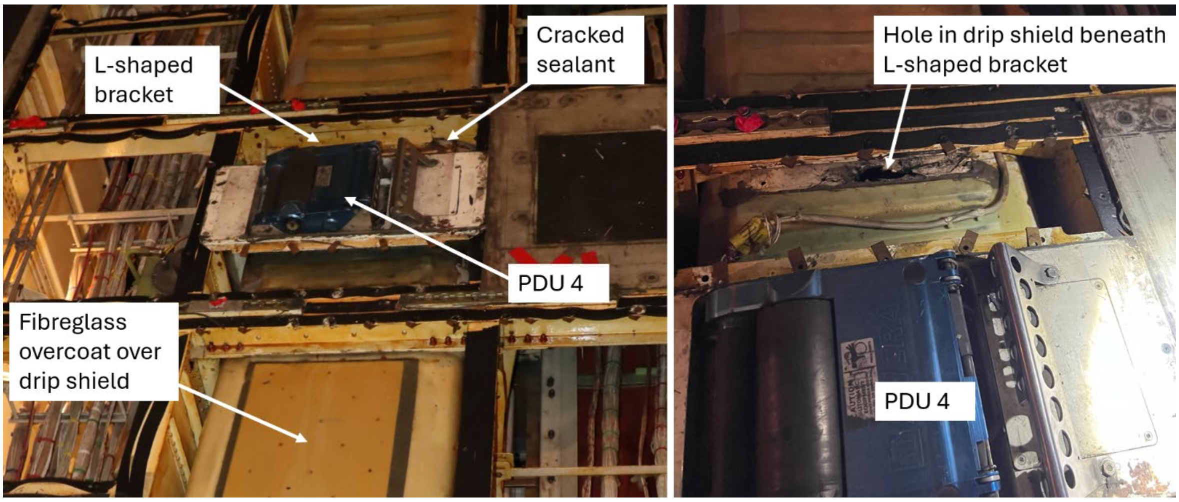

Figure 17

Hole in top of drip shield near PDU 4

Overspeed event

The aircraft reached a maximum 383 KIAS during the overspeed event. The aircraft operator stated that at the altitude of the overspeed the V_{MO} was 365 KIAS, so the speed exceedance was 18 kt. They stated that an aircraft overspeed inspection was only required if the V_{MO} was exceeded by 20 kt, so no inspection was carried out.

Footnote

15 Bundesstelle für Flugunfalluntersuchung (BFU).
16 The fibreglass reinforced overcoat is explained in report section 'Service Bulletins and Airworthiness Directives to address water ingress into MEC'.

Meteorology

The Met Office provided a comprehensive summary of the weather over the UK and North Sea for the time of the flight. The report contained information regarding specific airfields and a general synopsis for the region including icing and turbulence areas (Figure 18), and weather radar (Figure 19).

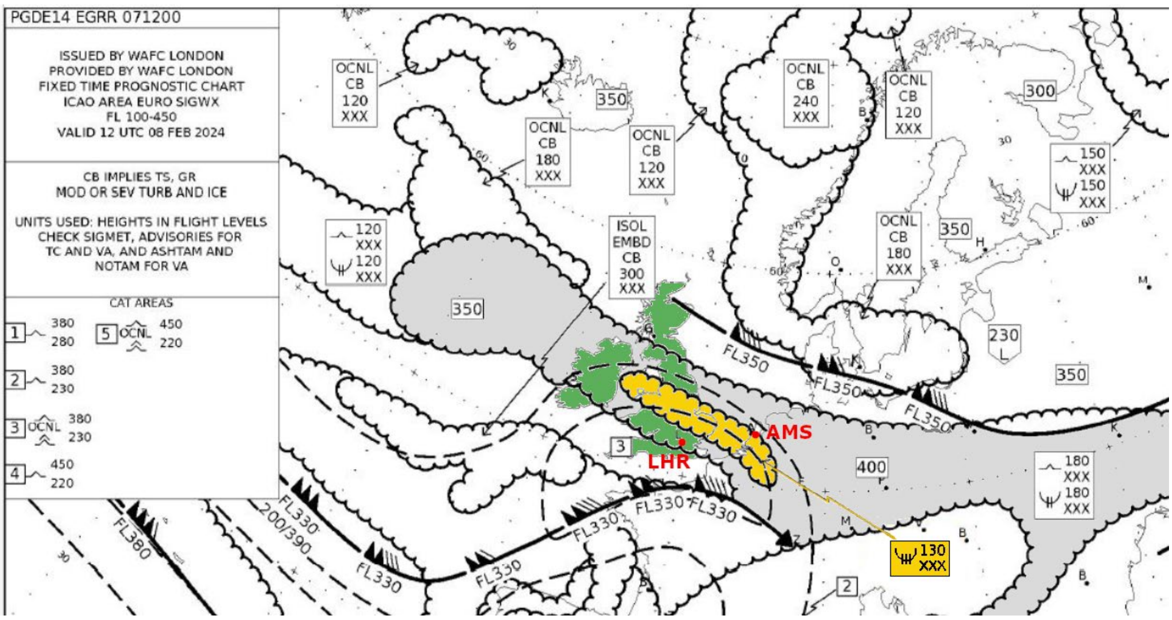

Figure 18

SIGMET chart provided by the Met Office (with colour added for clarity)

The SIGMET chart showed a band of severe icing below FL130 between London Heathrow Airport (LHR) and Amsterdam Schiphol Airport (AMS) (yellow area in Figure 18).

Extracts from the report are included for the relevant airfields:

> *'On the morning of the 8th February 2024, the southern North Sea and Dover Straits area were under the influence of an active warm front, which brought persistent rainfall, occasionally moderate to heavy. This frontal system also affected northern France, The Netherlands and Belgium.*
>
> *Thick layers of cloud extended through the atmosphere, with a risk of Severe icing to 13000 FT and moderate icing to 18000 FT.*
>
> *The rainfall initially reached Heathrow around 0420 UTC, turning moderate for a time, with a total accumulation of 9.4mm by 1000 UTC.'*
>
> LHR
>
> *'All three London airports were reporting easterly winds of around 7 to 11 knots, with light occasionally moderate rain throughout the period. Visibilities were*

generally around 6 to 8 KM, although lowered to 3000 M to 5000 M in heavier precipitation. With Heathrow reporting visibility at 2500 M in moderate drizzle at 1020 UTC.'

The cloud base at Heathrow during the event was overcast between 500 ft and 600 ft agl.

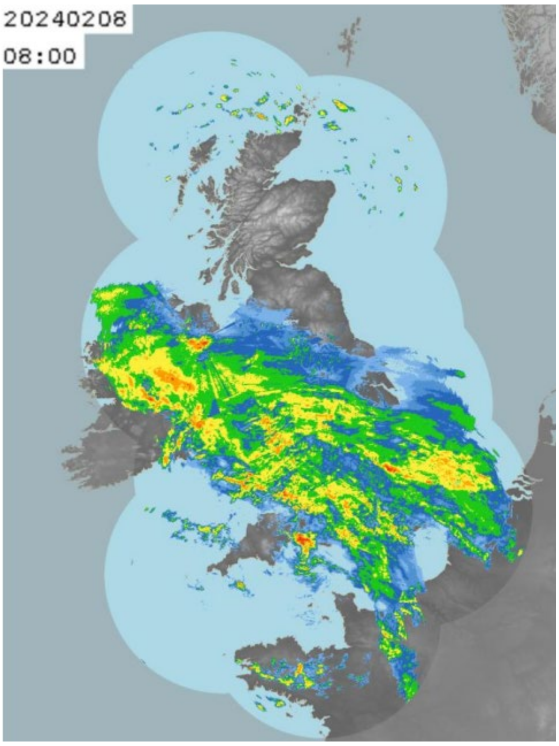

Figure 19

Met Office radar image of the UK at 0800 hrs on 8 February 2024

AMS

'Amsterdam were initially reporting light easterly winds with CAVOK conditions. A few patches of cloud at 4800 FT started to be reported 0925 UTC. Cloud cover then started to increase to become broken at 4500 to 5000 FT, with light rain reported at 1055 UTC.'

Other information

Workload management

Aviate, Navigate, Communicate (ANC)

The FAASTeam publication *'Fly the Aircraft First! It's as Easy as ANC'* [17] reiterates the well-established aviation principle of **Aviate, Navigate, Communicate**, and highlights its

Footnote

[17] FAA Safety Briefing / FAASTeam publication: https://www.faa.gov/sites/faa.gov/files/2022-01/Fly%20the%20Aircraft%20First.pdf [accessed 6 May 2026].

relevance to accident prevention. The publication notes that loss of aircraft control frequently remains a causal or contributory factor in serious incidents and accidents, particularly during periods of increased workload. It identifies distraction and task fixation as mechanisms by which flight crews may divert attention from fundamental flight path control. The FAASTeam publication emphasises that the effective management of abnormal or emergency situations is dependent upon the maintenance of positive aircraft control as the primary task, with navigation and communication undertaken only when the aircraft is under control.'

During any abnormal or confusing event, crews must first stabilise the situation:

- Aviate – Fly the aircraft, control pitch/power, maintain attitude and airspeed.
- Navigate – Ensure you're heading somewhere safe (terrain separation, safe altitude, known position).
- Communicate – Tell ATC or company only after you've stabilised the first two.

ANC prevents crews from jumping straight into troubleshooting or discussing problems while the aircraft is not controlled.

TDODAR (Appendix) is a structured aeronautical decision-making tool, widely used by airlines in the UK, that helps individuals or teams make effective decisions under time pressure. It is an iterative process that encourages situational awareness, communication and continuous reassessment.

Accident to Airbus A330 (F-GZCP) involving unreliable airspeed

In 2009, there was a fatal accident to an Airbus A330 (F-GZCP), operated by Air France, over the Atlantic Ocean. The investigation by the French Safety Investigation Authority (BEA[18]) identified a temporary loss of reliable airspeed information associated with pitot probe icing as a significant event in the accident sequence. The accident led to extensive international review of flight crew training, aircraft systems, unreliable airspeed procedures and the operational challenges associated with the loss of valid air data. The investigation resulted in numerous safety recommendations, which are detailed in the BEA investigation report[19].

This accident investigation is referenced because it illustrates how the combination of unreliable airspeed and high workload can challenge flight crews, even when the initiating technical failure is temporary.

Footnote

[18] Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation Civile (BEA).
[19] Final Report on the accident on 1st June 2009 to the Airbus A330-203 registered F-GZCP operated by Air France flight AF 447 Rio de Janeiro – Paris, July 2012. https://bea.aero/fileadmin/documents/docspa/2009/f-cp090601.en/pdf/f-cp090601.en.pdf [accessed 6 April 2026].

Previous incidents of water ingress into the MEC of Boeing 747-400 aircraft

The Australian Transportation Safety Board (ATSB) published a report on an electrical failure event involving a passenger variant of the Boeing 747-400 that occurred on 7 January 2008[20] (registration VH-OJM). During the descent and approach into Bangkok International Airport, power was lost from AC buses 1, 2 and 3 and the power was not recovered. The aircraft suffered multiple system failures, but the flight crew were able to land safely under VMC conditions. Prior to the failures the cabin crew had reported a substantial water leak in the forward galley, which is located above the MEC. The investigation revealed that the cause of the failures was water ingress into GCUs 1, 2 and 3. The path the water took from the galley floor into the top of the GCUs was not identified but a number of possible paths were identified as shown in Figure 20 (extracted from the ATSB report).

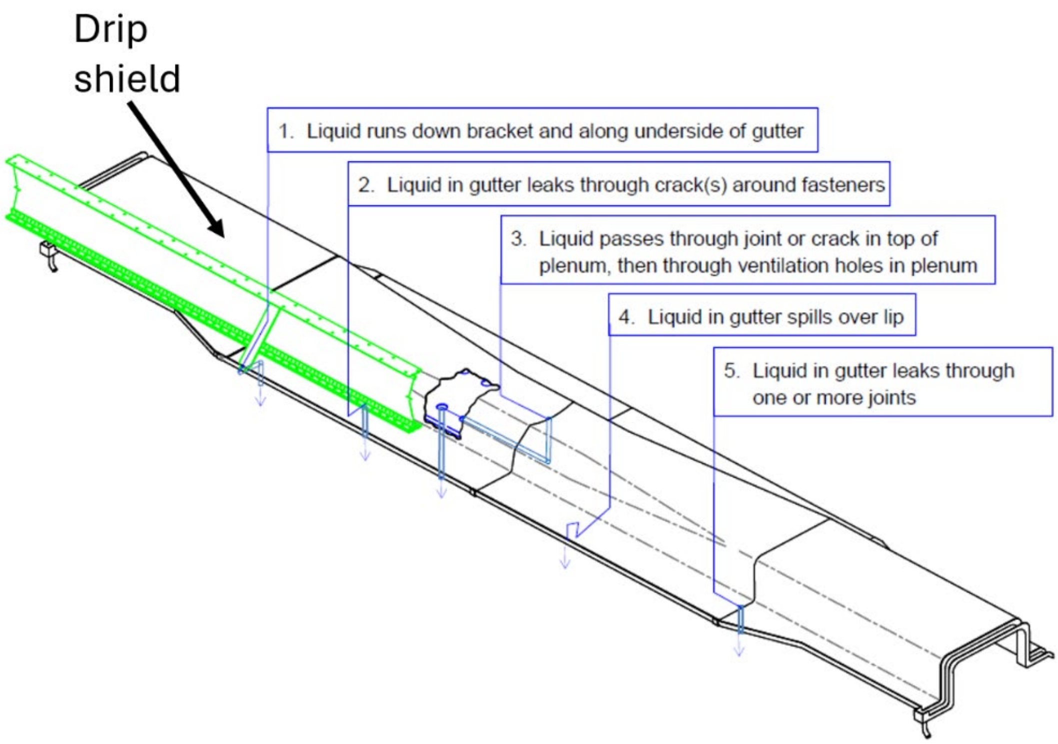

Figure 20

Potential water paths identified by ATSB in report on VH-OJM electrical failure event (image courtesy of ATSB)

The investigation also revealed that the aircraft manufacturer had received a number of reports of damaged drip shields on other 747-400 aircraft (example shown in Figure 21). At the time the ATSB's report was drafted in 2010, the manufacturer had received 52 reports of damage to the drip shield or gutter.

Footnote

[20] ATSB Transport Safety Report AO-2008-003: https://www.atsb.gov.au/sites/default/files/media/3440510/ao2008003.pdf [accessed 27 March 2026].

Figure 21

Cracks in the top of a drip shield from an unidentified Boeing 747-400 aircraft – prior to fibreglass re-enforcement overcoat
(image courtesy of ATSB)

One of the engineers who had conducted maintenance on G-ONEE during the night before the incident flight, reported that when he worked for a different freighter operator, one of their 747-400s had "lost GCU 3 and GCU 4" and this had been attributed to water ingress from snow on the cargo that had melted.

Service Bulletins and Airworthiness Directives to address water ingress into MEC

As a result of the VH-OJM event and findings of cracked drip shields, the aircraft manufacturer published Service Bulletin SB-747-25A3555 in November 2009, which stated:

> *'This service bulletin will reduce the possibility of water penetration into the main equipment center (MEC). Cracking of the MEC drip shield gutters has allowed water to drip past the MEC drip shield and through the exhaust plenum into the MEC. Water penetration into the MEC could result in loss of flight critical systems.'*

It recommended:

- Installing aluminium gutter reinforcing brackets to correct cracking drip shield gutters.
- Installing flanged sleeves and drain tubes in lower surface of plenum as interim action.
- Installing a fibreglass reinforcing overcoat on the drip shield as a terminating action.

This was later accompanied by a US Federal Aviation Administration (FAA) Airworthiness Directive (AD) 2012-15-10 which mandated the actions in the Service Bulletin (SB). This AD was applicable to G-ONEE and had been embodied on that aircraft.

Other SBs and ADs were published with similar requirements for different variants of the 747-400 aircraft.

In 2005 the aircraft manufacturer published SB 747-25-3387 to address water ingress into the MEC on cargo versions of the 747-400. The recommendation was to install a moisture barrier (curtain) to protect the electrical/electronics units in the E1/E2 rack from water contamination from the PDUs in the cargo floor above. It stated that '*Three operators have reported water contamination of the electrical/electronic units in the rack'*. The change involved attaching a top curtain to the upper part of the rack, and a lower curtain to the bottom part of the rack, using Velcro hooks and loop tie downs. These moisture barriers were recommended by SB but were not mandated by an FAA AD.

When the freighter manufacturer of G-ONEE created the requirements for the conversion of the passenger aircraft to a cargo aircraft, they installed their own version of a moisture barrier (right image in Figure 11). This was part of the standard equipment on delivery and therefore there was no accompanying SB for it. When the operator of G-ONEE took delivery of the aircraft from another operator, the moisture barrier was not fitted, and their post-delivery checks did not reveal that it was required standard equipment. They were under the impression that it was optional as per the Boeing SB.

Aircraft maintenance requirements

Main deck floor inspection

The aircraft manufacturer's 747-400 Maintenance Planning Document (MPD)[21] contains a task for 'Main Deck Cargo Container Compartment' which states '*Perform an external inspection of the interior of main deck cargo container compartment*'. This is a general 'zonal inspection' of the entire cargo deck (an area about 56 m by 6 m, Figure 22), which is carried out at each A-check (every 1,000 flight hours), usually from a standing height. The MPD does not contain a maintenance task for a specific visual inspection of the condition of the floor, the floor seals, or the protective tape over the MEC area, or the condition of the rubber dam around the door mat.

Footnote

[21] Boeing 747-400 Maintenance Planning Document, D621U400, published 15 March 2026.

Figure 22
G-ONEE main cargo deck floor

Drip shield inspection

Once AD 2012-15-10 had been complied with, which included installing a fibreglass reinforcing overcoat on the drip shield, there was no requirement for a subsequent inspection of the drip shield.

Maintenance information from a different Boeing 747-400 freighter operator

The AAIB spoke to a different Boeing 747-400 freighter operator which had experienced a number of events of water ingress into the MEC, one of which resulted in an air turn back and one of which resulted in an emergency landing. As a result of these events the operator created a new maintenance procedure titled '*Inspection of drip shields; drain line and floor boards*', to be carried out at every C-check. The inspection covers the main deck floor over the MEC, including checks for loose fasteners and missing sealant. It covers inspecting the moisture barriers and drain lines on the E1 and E2 racks. Similar inspections are included for the E-31 rack. In addition, they added an inspection of the floor tape above the MEC to be carried out at every fourth A-check.

Aircraft manufacturer information

The aircraft manufacturer analysed the data from this event and concluded that all the symptoms, including the pressurisation and flap selection issues, were consistent with the loss of power from AC Bus 1 and 4.

Prior to the G-ONEE incident, as a result of a 747 event in September 2021 where water leaked from the main deck cargo floor into the MEC and affected an FMC, the aircraft manufacturer initiated a review of MEC water ingress. This review, which was completed in April 2023, assessed the potential for water ingress and its impact on equipment in which loss of function could affect continued safe flight and landing. This included an assessment of the E1 and E2 racks, since these would be the most susceptible to water ingress as all six of the Electrical Power Generating System (EPGS) controllers (GCUs 1 to 4 and BCUs 1 and 2) were on the top shelf, and failure of all would result in the loss of all main AC and main DC electrical power buses, and associated systems.

The assessment considered that water could travel through the already existing water ingress protection features, and through the EPGS power supplies which would affect the functionality of multiple units, including the GCUs and BCUs simultaneously.

It was found that previous mitigation actions did not terminate the water ingress issue into the MEC, due to the moisture protection features being degraded over time. It concluded that not addressing the water ingress issue may result in loss of critical systems resulting in increased pilot workload which can impact continued safe flight and landing.

At that time the aircraft manufacturer did not recommend any specific in-service actions to be taken, but it was the beginning of a process to develop potential solutions.

The findings from the G-ONEE examinations were presented to the aircraft manufacturer in October 2024. The aircraft manufacturer was asked why there were no repetitive inspections of the fibreglass overcoat, or detailed inspections of the floor and water ingress protection measures above the MEC. The aircraft manufacturer stated that these questions would be considered as part of the process to develop potential solutions.

After discovering in 2025 that a US-based 747-400 freighter operator was conducting additional inspections to address water ingress issues into the MEC, and after a meeting with the AAIB and FAA in August 2025, the aircraft manufacturer decided that periodic and repeated inspection of the cargo deck floor for proper sealing, as well as the drip trays and drains, would help to ensure the equipment in the MEC rack was protected from water ingress. They stated that these additional inspections would be considered at the next meeting of the Boeing 747-400 Maintenance Steering Group; this group includes participants from aircraft operators. The group was expected to meet in the second quarter of 2026, but at the time of writing no meeting date had been scheduled.

The aircraft manufacturer did not believe that the presence of the moisture barriers would have made a significant difference in this incident as they were designed to protect from moisture ingress from the PDUs forward of the E1 and E2 racks.

The aircraft manufacturer stated that the rise in the cabin altitude while level at FL250 was probably due to a combination of one outflow valve being stuck open in its last position (following the loss of AC Bus 1), and the packs changing mode from high flow to normal flow. There was insufficient data to determine the reason for the change in flow mode.

Freighter manufacturer information

The freighter manufacturer responded to this incident by sending their operators the following message on 6 May 2024:

'Following an incident of water dripping into the MEC on an IAI converted 747-400SF (L1 door was left open during a rainy night), we would like to remind all operators of the attached IAI Service Bulletins providing instructions for improving the leakage protections at the MEC & E1/E2 area.

We recommend incorporating these IAI SBs, if not already incorporated, at your earliest convenience.'

The SBs attached were as follows:

- SB 366-25-122 (dated July 2012) to install a new drip shield over the M826 cardfile rack (this is a rack located forward of the E1 and E2 rack).
- SB 366-25-150 (dated March 2018) to install a different moisture barrier that is longer and wider than the original supplied post conversion.
- SB 366-25-094 (dated November 2017) to install an additional moisture barrier to cover wire bundles and the exposed upper corner of racks E1 and E2.

The findings from the G-ONEE examinations were presented to the freighter manufacturer in October 2024. The freighter manufacturer was asked why there were no repetitive inspections of the fibreglass overcoat, or detailed inspections of the floor and water ingress protection measures above the MEC. They stated that they would consider adding such additional inspections.

At the time of writing the freighter manufacturer was working on the wording for new inspections and deciding on the repetitive interval. They stated that the new maintenance tasks for a general visual inspection of the main deck cargo floor, in the area above the MEC, would cover:

- Checking the floor panel seals and waterproof tape for condition.
- Checking the L1 door floor mat (entryway water barrier) condition and security.
- Checking the drip shield above the electronic equipment bay for condition and security.
- Checking the Power Drive Unit number 4 attachment bolts and screws for condition and security.

Location of GCUs on Boeing 747-8

The upgraded Boeing 747-8 entered service in 2011. At the time this report was drafted there were about 150 747-8 aircraft in service, the majority of which were cargo aircraft.

In the E1 and E2 racks on the 747-8 the GCUs are no longer on the top shelf, but are on different shelves lower down, and spaced further apart (Figure 23). The moisture barriers are also fitted as standard equipment.

Figure 23

Location of GCUs highlighted in red in E1 and E2 racks on Boeing 747-8 aircraft

Second electrical failure incident on G-ONEE

After this report was drafted another electrical failure incident occurred on G-ONEE during departure from Ezhou Huahu International Airport in China on 22 May 2026. During taxi a number of electrical faults appeared on the EICAS indicating a failure of GCU 2 and 3. The aircraft returned to stand. Some moisture was identified on a circuit breaker panel on the right side of the MEC, but no moisture was found on the E1 or E2 racks. GCUs 1 and 2 were swapped, and GCUs 3 and 4 were swapped. Subsequent ground operation checks were successful and the aircraft departed. Shortly after takeoff AC Bus 4 lost power consistent with a failure of GCU 4 so the aircraft returned to land. The subsequent maintenance examinations revealed that in the main cargo deck area above the MEC there was water in some of the seat tracks beneath the moisture barrier tape over these tracks. There were also areas of poor sealant between floorboards and some damaged moisture barrier tape. A floor drain was also found to be taped over. Before the flight the cargo had been loaded during a period of heavy rain. Prior to loading, the ground handling team lifted the top layer of plastic on each pallet to remove pooled water. The operator reported that after this process there was some sheeting of water on the pallet base and heavy droplets on the plastic covering, but this was not unusual for a wet cargo operation.

The aircraft operator is investigating the prior maintenance of the cargo deck floor area and has initiated an inspection of this area on their fleet of 747 freighter aircraft. The aircraft operator also plans to introduce a General Visual Inspection of the main deck moisture barrier integrity and door threshold drain function at Weekly Check and A-Check intervals.

Analysis

Cause of the electrical failures

The electrical failure symptoms experienced by the flight crew were caused by a loss of AC Bus 4, followed by a loss of AC Bus 1. The evidence from the GCU 1 and GCU 4 NVM data showed that AC Bus 1 and 4 had been isolated from all sources of power by the GCUs commanding the opening of their respective BTB and GCB contactors. This meant that their respective IDG, although still operational, could not supply power to its AC Bus. It also meant that neither AC Bus 2 nor 3 could supply power via the Synchronous bus. The reason GCU 1 and GCU 4 commanded the BTB and GCB contactors to open is because they sensed electrical faults, such as short circuits, which needed to be contained. However, the sensed electrical faults did not exist. This was demonstrated when GCU 4 was replaced on the aircraft, and with GCU 1 then probably dry, the aircraft powered up with no system faults.

The internal examinations of both GCU 1 and 4 showed evidence of corrosion and moisture residue which indicated that water had been present inside. And in the case of GCU 4, water was seen to drip out of its cooling holes when it was removed from the E2 rack after the incident. The GCU component manufacturer stated that the sensed external electrical faults could have been triggered by water ingress in the GCUs causing internal short circuits. Since the moisture was no longer present this explained why GCU 1 passed its acceptance test, and GCU 4 passed almost all its tests. In the absence of any evidence of hard faults in the GCUs or on the aircraft itself, it was concluded that water ingress in GCU 1 and 4 caused the loss of power to AC Bus 1 and 4. The cause of the water ingress is discussed in section '*Maintenance of the water ingress protection measures'*.

The reason AC Bus 4 regained power and lost it again three times is because the flight crew pressed the GCS twice (which recloses the GCB) and later the BTS (which recloses the BTB) on that bus. The faults sensed by GCU 4 allowed resets of these contactors, but each time the sensed fault recurred it re-tripped the GCB or BTB. In the case of AC Bus 1, a different fault was sensed by GCU 1 which prevented any reset of the GCB or BTB. If the flight crew had pressed the GCS or BTS for AC Bus 1, it would not have had any effect.

Cause of the unreliable airspeed

The loss of AC Bus 1 and 4 resulted in the loss of heating to all four pitot-static probes and both TAT probes. The recorded data showing one of the TAT probes reducing to 0°C and then staying at 0°C indicated that it was likely frozen. This evidence combined with the IAS DISAGREE being triggered around the same time, and the subsequent diverging of the captain's IAS and groundspeed indicated that the pitot probes were likely freezing too. Although only the captain's IAS was recorded, the flight crew reported that the IAS on the co-pilot's display and the standby instrument also reduced at around the same time.

If a pitot tube freezes in a descent, then the trapped pressure will cause the airspeed to under-read, so it was concluded that all three pitot tubes had frozen in the descent. The captain's IAS then jumped up suddenly from 260 to 345 kt in four seconds, at the same time as the TAT started to increase from 0°C, which indicated that the captain's pitot tube had unfrozen, resulting in a correct airspeed indication.

Cause of the increase in cabin altitude

Normal operating range for the cabin altitude is between 6,000 and 8,000 ft. When it exceeds 8,500 ft the primary EICAS changes to display the current cabin altitude in amber. There are no other alerts until it reaches 10,000 ft when a CABIN ALTITUDE warning is generated. Approximately 10 minutes after the aircraft reached FL250 the cabin altitude began to climb from 3,000 ft to a maximum of 9,246 ft. This was probably due to one outflow valve being stuck open in its last position (due to the loss of AC Bus 1) and the packs changing from high flow to normal flow mode. Manual control of the stuck outflow valve using DC power would have been available, but none of the events that direct the crew to carry out this procedure were triggered before they started the descent, so this was not attempted.

Cockpit voice recorder (CVR)

The CVR ceased recording approximately 19 minutes after departure following the loss of both power supplies. The absence of CVR recordings for the subsequent period limited the investigation's ability to establish an objective sequence of events, particularly as the flight crew were operating under a high workload and were unable to recall with certainty the precise order of system failures and actions taken. Had the CVR remained available, it would have provided an objective record to support the investigation; in the event of a nonsurvivable accident, such information may be critical to understanding the circumstances and identifying safety lessons.

Operating outside the normal scope during multiple complex failures

During the flight, the crew were faced with multiple, complex procedures taking them outside the scope of normal operations. For example, there was no defined QRH procedure for the loss of both AC Bus 1 and AC Bus 4, so the crew were required to manage multiple, concurrent checklists.

The FCTM states *'It is rare to encounter in-flight events which are beyond the scope of the Boeing recommended NNCs… In these situations the flight crew may be required to accomplish multiple NNCs, selected elements of several different NNCs applied as necessary to fit the situation, or be faced with little or no specific guidance except their own judgment and experience.'*

The QRH checklist instruction '*Use of Captain's Discretion'* states *'The flight crew must be aware that checklists cannot be created for all conceivable situations and are not intended to replace good judgment. In some situations, at the captain's discretion, deviation from a checklist may be needed.'*

This supports the flight crew's decision to alter the processes in this event.

Planning for unreliable airspeed

The crew reported that they were aware that they would transition through icing conditions to complete an arrival at an airport, and with the pitot heater systems unserviceable, this could lead to the airspeed becoming unreliable. Whilst in the cruise at FL250, they began planning for this potential event. They discussed the checklist and decided that, although it contained memory items which required the disconnection of the autopilot and autothrottle, and manually setting a pitch of 4° nose-up and 80% N1 power setting (flaps up), the objective of the checklist was to prompt the crew to fly the aircraft using the '*Flight With Unreliable Airspeed*' table in the '*Performance Inflight*' chapter of the QRH. The pitch and power required by the memory items would probably have produced near level flight, or a slight climb, and would have prolonged the time that the aircraft was subjected to icing conditions. With that in mind, they stated that they pre-emptively checked the table to work out the datum pitch and power settings needed to continue the descent and agreed to disconnect the autopilot and use idle thrust and 0° pitch in the event of having to action the checklist. Further planning time was curtailed by the increasing cabin altitude prompting the crew to commence an early descent, with the unreliable airspeed discussion not completed due to time constraints.

Handling of the unreliable airspeed and overspeed events

When the aircraft entered icing conditions, blockage of the pitot probes led to an erroneous reduction in IAS and the triggering of an IAS DISAGREE caption. With the autopilot engaged in FLCH mode, the system responded by commanding increasing nose-down pitch to maintain the selected airspeed. Although the crew added thrust, the frozen probes meant the indicated airspeed continued to reduce, resulting in further nose-down pitch commands and a rapidly increasing rate of descent, reaching 7.6° nose-down and 6,240 ft/min. The event coincided with a handover of control between the PF and PM, and it is possible that this distraction delayed their recognition of the initial onset of unreliable airspeed indications. While the decreasing pitch attitude was recognised and corrective action was initiated by increasing thrust, the crew allowed time to assess its effect; however, the aircraft pitch attitude only steepened. The crew were about to intervene further when the aircraft exited the icing conditions, at which point the probes cleared and the IAS rapidly increased, triggering an OVERSPEED warning. The autopilot then responded appropriately by pitching up to recover the target speed, coincident with the crew selecting idle thrust, effectively stabilising the aircraft and, with the decision to leave the autopilot engaged, reducing crew workload at a critical stage of the event.

Having seen the IAS decrease and then rapidly increase the crew lacked confidence in the indications so did not use the speedbrake to help slow the aircraft down, opting to monitor the autopilot performance while it corrected the pitch. In recognition of the deteriorating reliability of the instruments and the associated hazard to the aircraft, the crew declared a MAYDAY. The speed decreased below V_{MO} with the overspeed event lasting 55 seconds. Had the aircraft continued in icing conditions, disconnection of the autopilot and manual selection of the datum pitch and power settings, that the crew had derived from the table, would have been sufficient to maintain a stable descent into clear air.

When varying from a procedure, it can be useful to set and communicate acceptable parameters and what actions would be carried out should the aircraft deviate beyond these. In this case, if the crew had selected an upper and lower pitch boundary around 0° and agreed to disconnect the autopilot and manually intervene at that point, this could have possibly reduced the pitch exceedance and prevented the overspeed.

Cause of the water ingress into the GCUs

On the 747-400 all four GCUs are located on the top shelf of the E1 and E2 racks leaving them the most exposed to potential water ingress from the cargo deck floor above. The aircraft examination did not reveal any blocked drains that could have been the source of water ingress, and there was no moisture or dampness in the intake of the air duct fan that provided cooling to the E1/E2 racks. No cargo had been present on the main deck. The only source of water that could be identified was from rain when the L1 door was left open during maintenance prior to the flight.

The cargo deck floor is designed to be a wet area, because it is difficult to ensure that cargo is dry when it is loaded. Cargo containers and pallets can be left out in rain or snow prior to loading. It would have been better if the L1 door had been closed while it was raining (see *Safety Actions* section to see action taken by the aircraft operator to address this), but the amount of water on the floor reported by the engineers should not have caused an issue to the equipment in the MEC if the water ingress protection measures had been in place.

The mat at the L1 door, with integral drain, was surrounded by a rubber dam, but the sealant in the forward right corner of the dam was missing so water could flow beyond the mat to the floor area above the MEC. A screw was missing from PDU 4 which provided a hole for water to pass from the floor onto the top of the drip shield above the E1/E2 racks. Some of the waterproofing tape on the floor above the MEC was also found compromised which could have provided potential water paths. The drip shield contained cracks and holes on either side of the location of PDU 4. These had been covered by L-shaped brackets, but the sealant around these brackets was compromised providing a potential path for water to pass through into the plenum chamber between the drip shield and the GCUs. The drip shield end cover plates, near GCU 1 and 4, were also found to have compromised sealant, providing an additional path for water to enter the plenum chamber above these GCUs. The top surfaces of the GCUs contain multiple holes for cooling air to pass through from below but could also allow water to pass in from above.

The moisture barrier curtains which should have been fitted to the front of the E1/E2 racks were not fitted as the aircraft operator was not aware they were required equipment by the freighter manufacturer. However, the curtains do not cover the cooling holes in the top of the GCUs so would not prevent water ingress via that path.

The investigation was unable to determine the exact path that water took from the cargo deck floor to the GCUs, but a number of weaknesses in the water ingress protection measures were found that could have caused or contributed to water ingress into the GCUs.

Maintenance of the water ingress protection measures

There have been previous events of water ingress into GCUs and other events of water contamination of the electrical/electronic units in the E1/E2 rack on the 747-400. This has led to SBs and ADs to introduce measures such as installing a fibreglass reinforcing overcoat on the drip shield and attaching moisture barrier 'curtains' to the front of the E1/E2 racks.

The installation of the fibreglass reinforcing overcoat on the drip shield was specified as the 'terminating action'. There was no subsequent requirement to inspect it to check that no further cracks had formed. In the case of G-ONEE, cracks in the drip shield were found in two areas beneath an L-bracket on either side of PDU 4. These cracks were only discovered because the aircraft operator decided to inspect it following this incident. The aircraft manufacturer stated that water ingress into the MEC could result in loss of flight critical systems, and in the G-ONEE incident it resulted in multiple failures, multiple EICAS messages, high flight crew workload, a pressurisation issue and unreliable airspeed on all three airspeed indicators, the combination of which could have led to an accident. Therefore, the following safety recommendations are made:

Safety Recommendation 2026-013

It is recommended that Boeing Commercial Airplanes introduce a maintenance requirement on the Boeing 747-400 freighter variants to repetitively inspect the condition of the drip shield over the E1 and E2 racks in the Main Equipment Centre, to reduce the likelihood of water ingress that could cause the loss of flight critical systems.

Safety Recommendation 2026-014

It is recommended that Israel Aerospace Industries introduce a maintenance requirement on the Boeing 747-400 SF to repetitively inspect the condition of the drip shield over the E1 and E2 racks in the Main Equipment Centre, to reduce the likelihood of water ingress that could cause the loss of flight critical systems.

The drip shield over the E1 and E2 racks is the final barrier to water ingress into the top of electrical and electronic equipment located on the top row of the racks. Above the drip shield lies the main deck floor which is designed to be a wet area, and which should prevent water from reaching the drip shield. This first line of defence relies on the condition of the sealant between the floor panels, polyurethane tape over this sealant, in addition to wide moisture barrier tape over the entire deck area, combined with effective drainage. In the case of G-ONEE some of the tape on the floor above and near the MEC was in poor condition, and the sealant was missing from the corner of the dam around the L1 door mat. The only maintenance requirement for this area was to perform a general zonal inspection of the entire cargo deck area at each A-check (every 1,000 flight hours), with no focus on the area directly above or near the MEC. This inspection is usually carried out from a standing height which could miss sealant and tape issues and would not detect missing PDU screws as the PDU needs to be manually pivoted upwards to see the screws underneath. As the main deck floor over the MEC is the first line of defence to prevent water ingress into electrical and electronic components that could result in the loss of flight critical systems, the following safety recommendations are made:

Safety Recommendation 2026-015

It is recommended that Boeing Commercial Airplanes introduce a maintenance requirement on the Boeing 747-400 freighter variants to repetitively inspect in detail the condition of the floor panel seals, waterproof tape, power drive units and L1 door floor mat in the area above and near the Main Equipment Centre, to reduce the likelihood of water ingress that could cause the loss of flight critical systems.

Safety Recommendation 2026-016

It is recommended that Israel Aerospace Industries introduce a maintenance requirement on the Boeing 747-400 SF to repetitively inspect in detail the condition of the floor panel seals, waterproof tape, power drive units and L1 door floor mat in the area above and near the Main Equipment Centre, to reduce the likelihood of water ingress that could cause the loss of flight critical systems.

Conclusion

The aircraft suffered numerous electrical system failures that were caused by a loss of AC Bus 4, followed shortly thereafter by a loss of AC Bus 1. The loss of power was the result of water ingress into GCUs 1 and 4 which led to the GCUs commanding contactors to open to isolate AC Bus 1 and 4. Water had entered the main cargo deck prior to departure because the L1 door had been left open during rain, and sealant was missing from the corner of the L1 door mat. The investigation was unable to determine the exact path that water took from the cargo deck floor to the GCUs, but a number of weaknesses in the water ingress protection measures were found that could have caused or contributed to water ingress into the GCUs.

The system failures led to multiple EICAS messages and a highly complex situation, outside the scope of normal operations, creating a high workload for the flight crew. The crew managed these by using an effective TDODAR decision-making process supported by the presence of a third crew member. After the loss of the second AC bus, the crew appropriately declared a PAN and diverted to Schiphol Airport. There was no QRH procedure for the simultaneous loss of AC buses 1 and 4; however, the crew were aware that all pitot heating had been lost and that unreliable airspeed could occur in icing conditions. The rising cabin altitude led them to initiate a descent into icing conditions, and although they were aware of the IAS DISAGREE message, they decided to keep the autopilot engaged to reduce workload. This coincided with a temporary handover of flying control between the PF and PM for the crew to check correct routing in the FMC. They had a target pitch attitude of 0° in mind but allowed the autopilot to pitch the aircraft nose-down to -7.6° with an associated 6,240 ft/min descent rate. The crew were about to intervene when the autopilot began correcting the pitch as the aircraft exited icing conditions, and the correct IAS returned. The commander declared a MAYDAY, but the excessive descent rate led to an 18 kt overspeed. The flight crew were able to manage the subsequent flap issues and landed safely.

The incident demonstrated the challenges posed by an unreliable airspeed situation when it is combined with multiple other failures. The crew's training, structured decision-making, and use of all available crew resources were likely significant factors in preventing a more serious outcome.

There have been previous events of water ingress into GCUs and other events of water contamination of the electrical/electronic units in the E1/E2 rack on the 747-400, which can lead to the loss of flight critical systems. This has led to SBs and ADs to introduce measures such as installing a fibreglass reinforcing overcoat on the drip shield above the E1/E2 rack, but there was no requirement for a repetitive inspection of the drip shield. There was also no maintenance requirement to repetitively inspect in detail the condition of the floor panel seals, waterproof tape, power drive units and L1 door floor mat in the area above and near the Main Equipment Centre. Therefore, the AAIB has made four safety recommendations to address these maintenance concerns.

Safety actions

On the day after the incident, 9 February 2024, the aircraft operator published a Technical Notice, entitled 'Ground operations in inclement weather' which stated that:

> *'When carrying out maintenance activities or ground operations during periods of inclement weather (Light or Heavy Rain/Ice & Snow), regardless of the time on the ground, all Main entry doors, maintenance access doors & cargo doors must remain closed when possible. If the doors must be open for maintenance access or loading, then make provisions to reduce water ingress to the aircraft.*
>
> *If no activities are being carried out on the aircraft, then the exterior doors must remain closed at all times.*
>
> *If water ingress is unavoidable a suitable inspection must be carried out to confirm no excess water is present in the area surrounding the MEC hatch on the main deck floor and also the drip trays located above the main electrical racks and card file systems, and a maintenance entry made in the aircraft technical log.'*

The freighter manufacturer responded to this incident by sending their operators the following message on 6 May 2024:

> *'Following an incident of water dripping into the MEC on an IAI converted 747-400SF (L1 door was left open during a rainy night), we would like to remind all operators of the attached IAI Service Bulletins providing instructions for improving the leakage protections at the MEC & E1/E2 area.*
>
> *We recommend incorporating these IAI SBs, if not already incorporated, at your earliest convenience.'*

Safety Recommendations

Safety Recommendation 2026-013

It is recommended that Boeing Commercial Airplanes introduce a maintenance requirement on the Boeing 747-400 freighter variants to repetitively inspect the condition of the drip shield over the E1 and E2 racks in the Main Equipment Centre, to reduce the likelihood of water ingress that could cause the loss of flight critical systems.

Safety Recommendation 2026-014

It is recommended that Israel Aerospace Industries introduce a maintenance requirement on the Boeing 747-400 SF to repetitively inspect the condition of the drip shield over the E1 and E2 racks in the Main Equipment Centre, to reduce the likelihood of water ingress that could cause the loss of flight critical systems.

Safety Recommendation 2026-015

It is recommended that Boeing Commercial Airplanes introduce a maintenance requirement on the Boeing 747-400 freighter variants to repetitively inspect in detail the condition of the floor panel seals, waterproof tape, power drive units and L1 door floor mat in the area above and near the Main Equipment Centre, to reduce the likelihood of water ingress that could cause the loss of flight critical systems.

Safety Recommendation 2026-016

It is recommended that Israel Aerospace Industries introduce a maintenance requirement on the Boeing 747-400 SF to repetitively inspect in detail the condition of the floor panel seals, waterproof tape, power drive units and L1 door floor mat in the area above and near the Main Equipment Centre, to reduce the likelihood of water ingress that could cause the loss of flight critical systems.

Appendix

TDODAR is one of several recognised aeronautical decision-making (ADM) models used within the aviation industry to support structured crew decision-making in time-critical and non-routine situations. Although neither the CAA, EASA nor the FAA prescribe the use of a specific ADM mnemonic, their human factors and crew resource management guidance consistently emphasises the importance of systematic problem diagnosis, consideration of available time, evaluation of options and risks, task allocation, and continual review. In this respect, TDODAR reflects established regulatory best practice and aligns with alternative ADM frameworks such as FORDEC, DECIDE and Threat and Error Management (TEM), all of which provide structured means of supporting sound judgment under conditions of increased workload and operational uncertainty.

TDODAR was the ADM used by the aircraft operator in the G-ONEE event and it stands for:

T - Time

Assess how much time is available before a decision must be made.

Sets the urgency level and guides how detailed the rest of the process can be.

D - Diagnose

Identify what the actual problem is.

Gather the essential facts, symptoms, and indications.

Aim to avoid assumptions - focus on what you know.

O - Options

Generate possible courses of action.

Consider multiple solutions, even unconventional ones.

Avoid fixating on the first idea.

D - Decide

Select the best option based on safety, feasibility, and consequences.

Decision should be timely - avoid spending too much time on analysis.

A - Assign

Allocate tasks and responsibilities.

Ensure everyone knows who is doing what.

Enhances coordination and workload management.

R - Review

Monitor the outcome of the decision.

Ask: Is it working? Has anything changed? Do we need to reconsider?

Published: 3 September 2026.

Accident

Aircraft Type and Registration:	Eurofox 2K, G-CMAX
No & Type of Engines:	1 Rotax 915 iS piston engine
Year of Manufacture:	2021 (Serial no: 62421)
Date & Time (UTC):	27 December 2025 at 1130 hrs
Location:	Talgarth Airfield, Powys
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Serious) Passengers - N/A
Nature of Damage:	Damage to propeller, cockpit and wing disruption
Commander's Licence:	Private Pilot's Licence
Commander's Age:	81 years
Commander's Flying Experience:	2,249 hours (of which 54 were on type) Last 90 days - 1 hour Last 28 days - 0 hours
Information Source:	AAIB Field Investigation

Synopsis

Immediately after takeoff, the tug aircraft in a glider-tug launch combination rolled, uncommanded, to approximately 60° left wing down. The glider disconnected and landed safely ahead, but the tug aircraft turned left and touched down within the airfield boundary before becoming airborne again. Control of the aircraft was then lost and it struck the ground in an adjacent field. The sole pilot was seriously injured.

The wind at the time of the accident was fully across the runway in use and may have been above the crosswind limit of the aircraft. Turbulence encountered by the aircraft during the flight immediately before the accident indicated that the air mass over the runway was unstable and is likely to have been so during the accident flight, probably causing the initial roll and subsequent loss of control.

As a result of this accident the gliding club improved the weather reporting system to provide more accessible and accurate wind measurements to pilots and began work to improve the safety culture at the gliding club.

History of the flight

The pilot initially intended to take off to the east, into wind. However, it was discovered whilst setting up that the launch area was wet and too boggy to operate from. Following a conversation between the duty instructor and the tug pilot it was agreed to change runways and operate from the north-westerly runway[1], accepting a 90° crosswind from right to left. Whilst moving the glider to the new launch area, G-CMAX departed from the north-westerly runway without a glider attached to check the local flying conditions. It was common practice at the club for the tug aircraft to fly for about 10 to 15 minutes before the start of gliding operations to check for rotor turbulence from the mountains in the area in which the gliders were going to be flying. The aircraft was seen returning to the airfield and making an approach in the reciprocal direction to departure. As the wind was blowing at right-angles to the chosen runway, neither direction had a favourable headwind. On final the aircraft was observed being rocked considerably by turbulence. The amount of rocking was enough for a club member to comment on it to a fellow member. The aircraft was seen to climb away after which the pilot made a second approach to the same runway and landed.

The tug aircraft taxied over to the waiting ASK13 glider, and the glider was attached to the aircraft for launch. The glider had two experienced glider pilots onboard, both pilots being qualified gliding instructors. The pilot of the tug aircraft was also a qualified gliding instructor and had over 20 years of tug flying experience. The tug-glider combination was observed to accelerate slowly due to the boggy nature of the grass runway, but this had been anticipated and the launch had been commenced close to the boundary fence to leave as much takeoff distance as possible. Once the combination was airborne the tug aircraft was observed rocking from side to side and then to drop the left wing by approximately 60°. On seeing this the glider pilot released the tow and performed a safe landing within the airfield boundary. The tug aircraft turned approximately 60° to the left (downwind), increasing the tailwind component that it was experiencing. The main landing gear tyres touched the ground briefly, whilst the aircraft was tracking towards a line of trees. The aircraft became airborne again and was observed to be climbing "almost vertically" as viewed from the launch point. The aircraft passed over the trees and a small hangar, the left wing dropped, and the aircraft descended rapidly into a field just outside the airfield boundary.

Accident site

The aircraft came to rest in a field to the west of and adjacent to the gliding site (Figure 1). Damage to the aircraft's wings, a wire fence on the edge of the field and ground scars in the field indicated that the aircraft initially clipped the top of the fence with its left wingtip before striking the ground in a nose down attitude. It then turned horizontally through 270° before coming to rest on its wheels, facing in a northerly direction. The glider towing line remained attached to the aircraft and trailed over the boundary fence and foliage, indicating the direction from which the aircraft had come (Figure 2).

Footnote

[1] Runways at the airfield are named using words to represent the takeoff direction rather than °M.

Figure 1

Google Earth image of Talgarth Airfield with aerial image of G-CMAX accident site overlayed

Figure 2

G-CMAX final resting position – note tow rope trailing over foliage in the right of the image

Wheel marks in the soft ground between the runway and the accident location indicated that the aircraft touched down briefly and became airborne again before crossing the airfield boundary (Figure 3).

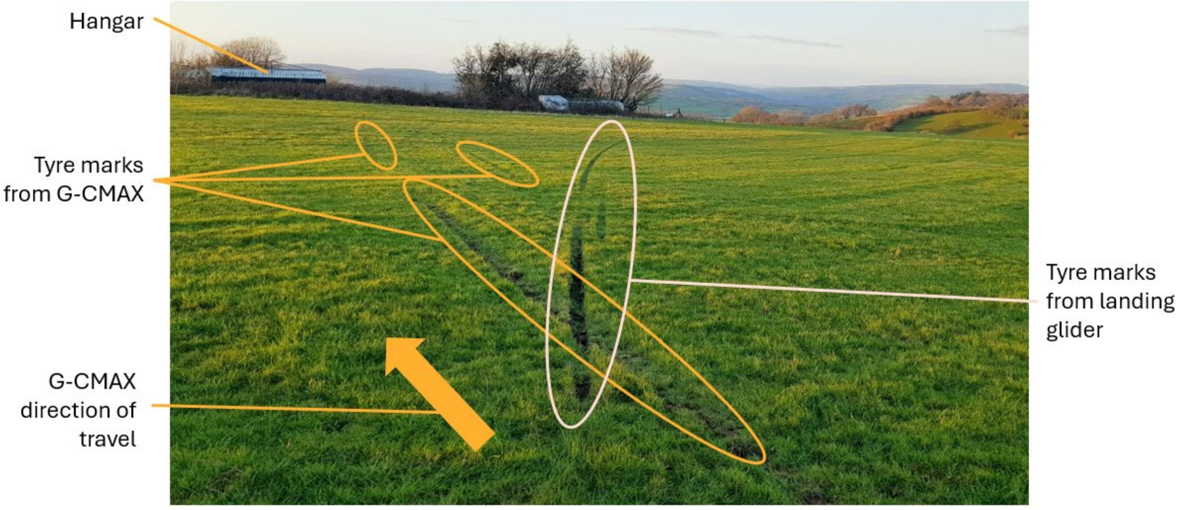

Figure 3
Tyre marks in airfield from G-CMAX and towed glider

Although the wings remained attached to the aircraft, the left wing had been displaced forwards and the right rearwards by approximately 45°. The cockpit had been severely disrupted.

The Rotax 915 iS engine was largely intact and one of the four propeller blades was missing from approximately 25% height. One of the remaining blades had also fractured at the hub but remained attached.

Examination of the aircraft found no pre-existing damage that would indicate a loss of continuity from the pilot's controls to the primary flying surfaces. The flap lever was found in the UP position and trim towards NOSE DOWN.

The aircraft had been tethered to the ground and de-fuelled by the first responders before the AAIB arrived.

Recorded information

The aircraft was fitted with an Engine Control Unit (ECU) which logged engine parameters for the last hour of operation. The ECU was downloaded and the accident flight was recorded at up to 10 samples per second. The data confirmed that the engine was responding and operating as expected. Figure 4 shows the throttle command and engine speed, showing a full power demand on takeoff with engine rpm maintaining approximately 5,000 rpm. Towards the end of the recording, the throttle command was reduced to 21% for approximately 2 seconds before being restored to 100%.

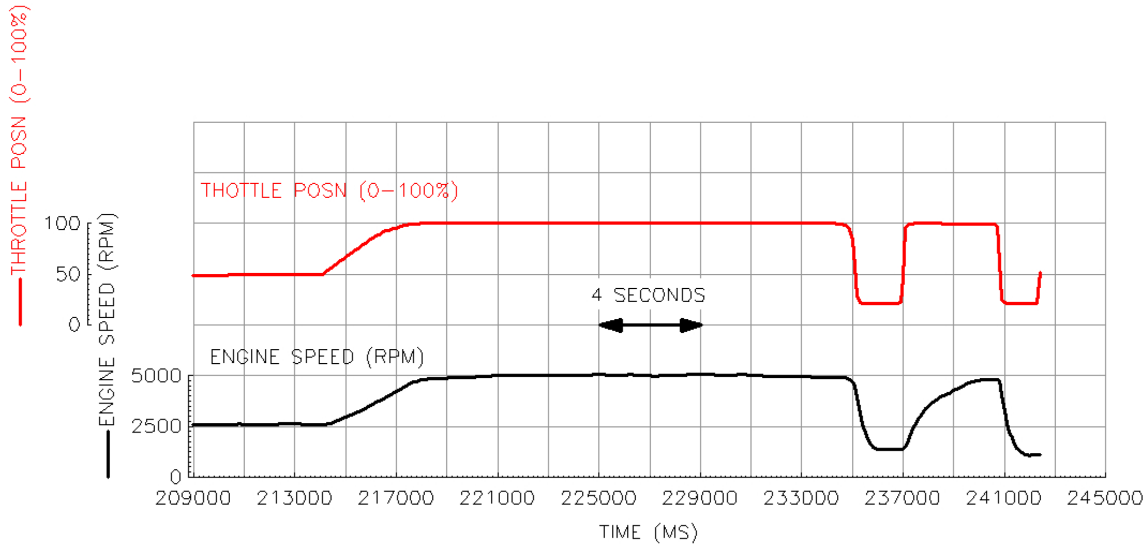

Figure 4
G-CMAX ECU data

Aircraft information

The Eurofox 2K aircraft is a conventional landing gear, two-seat, high-wing, tractor-engined, three-axis microlight aircraft with full span trailing edge flaperon roll/high lift devices. The welded steel tube fuselage structure is covered with painted poly-fibre fabric, as are the aluminium wing structures. The type can be powered by a range of engine and propeller combinations. G-CMAX was powered by a Rotax 915 iS engine with a DUC flash 3 four-bladed fixed pitch propeller.

G-CMAX was factory-built in 2021 and issued its Permit to Fly by the British Microlight Aircraft Association (BMAA) in May 2022, having been operated under a CAA flight test approval in the intervening time. At the time of the accident the aircraft had flown 482 hours and made 3,379 landings. The Permit had a current Certificate of Validity.

The aircraft was owned and operated by the gliding club and used solely as a glider towing aircraft. The Eurofox is a popular glider tug aircraft with over 50 operating in the UK for this purpose. The aircraft has a maximum crosswind limit for takeoff of 15 kt and a tailwind limit of 4 kt.

Weight and balance

At the time of the accident the aircraft had just the pilot on board and was within the published weight and balance limitations of the aircraft. The aircraft was towing an ASK13 two-seat glider with two pilots onboard, and the aircraft was approved by the manufacturer to tow this glider.

Aircraft performance

The manufacturer's approved pilot operating handbook gives a ground roll distance on a tarmac runway of 190 m when towing a ASK13 glider, Table 1. When corrected for a grass runway and an upslope on the initial ground run, the true ground run is 270 m with an additional 70 m distance to clear a 15 m obstacle. This means the total distance required to clear a 15 m obstacle is 340 m.

Ref nr	EuroFOX 915iS take off weight	Glider type, POB and MAUW	Ground roll distance tarmac	Time to 2000 feet from "all out" and start of ground roll	Best rate of climb towing speed	Distance to clear 15m obstacle
1	550kgs	Oly 2b Vintage One POB 304kg	170m	2.14 Mins	50 kts @ 1/2 flap	60m
2	540kgs	K13 2 POB 280kg	190m	2.43 Mins	60kts	70m

Table 1

Excerpt from Appendix 1 of the Eurofox POH

Meteorology

Talgarth Airfield is located close to the Black Mountains in Wales, and this affects the local weather. Conditions at the airfield are regarded as very changeable and can be challenging at times, due to the nature of the localised weather. There is no official source of weather information near the airfield, and so the club uses a variety of sources to determine weather conditions. These include websites providing forecasts primarily to mountain walkers, as well as Met Office aviation websites. The club has webcams looking east and west that are available for club members to view. To provide actual conditions at the club a weather station is situated at the clubhouse which feeds into a website, which also records the data. There is a windsock positioned north of the east/west runway that is visible from most locations on the airfield, including the starting position of G-CMAX takeoff roll. On any given day the flying conditions are assessed by the duty instructor using local knowledge and experience.

Weather station data from the day of the accident was recovered from the internet site which recorded parameters including wind speed, gust and direction every five minutes. Wind direction was recorded to the nearest 22.5° but the accuracy of the data could not be established. Figure 5 shows a time history of the recorded wind conditions on the day of the accident.

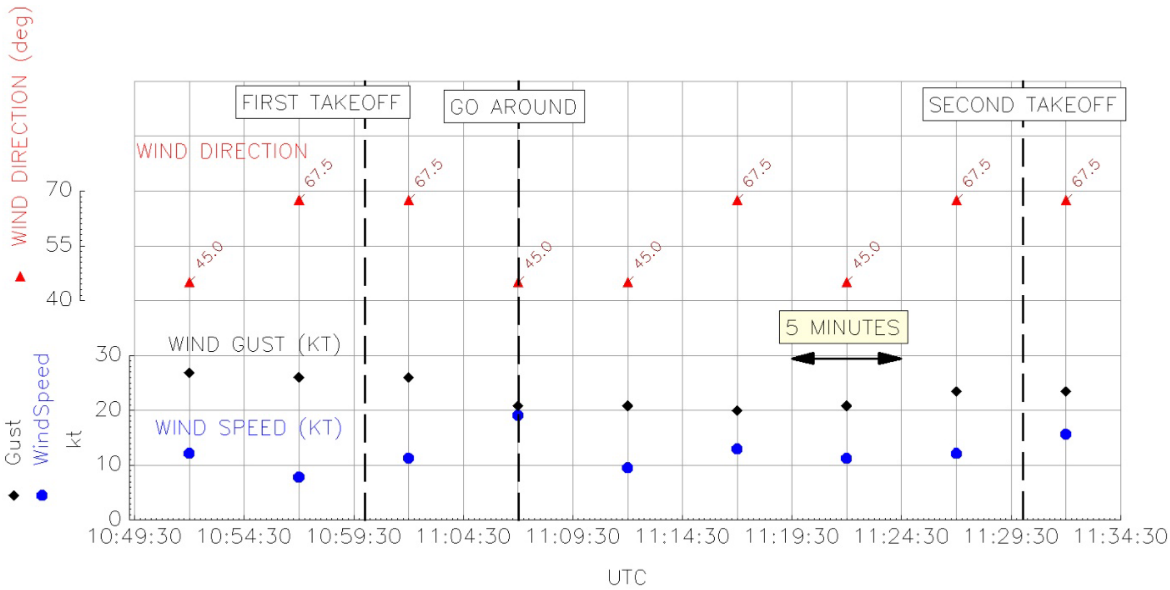

Figure 5

Weather data from airfield weather station (Credit: Weather Underground)

At the time of the accident the weather station at the clubhouse was reporting the instant windspeed as between 12 kt and 16 kt, gusting 23 kt from east-north-east. This wind was across the runway in use at the time. The temperature was 4°C with no precipitation and good visibility.

The pilot commented that local effects at the airfield meant that ground level winds along the runway were likely to be less than those recorded by the weather station when the wind was from the east.

Meteorological observations at aerodromes

For METAR reports, wind sensors are positioned to be representative of the wind at a height of 30 ± 3 ft above the ground. The weather station anemometer at Talgarth Airfield is situated on the hangar, approximately 25 ft above the ground.

Airfield information

Talgarth Airfield is located on the western slopes of the Black Mountains and is 970 ft amsl. The land slopes down from the centre of the strip, described on the gliding club website as being like an upturned saucer. When departing from the north-west runway, G-CMAX would have been starting its ground run with a slight upward incline after which it would have experienced a downward slope (Figure 6). The airfield is smaller than most typical gliding sites and can experience rotor turbulence from the nearby mountains. The north-westerly runway in use at the time of the accident has a length of 360 m. Challenges of operating from the airfield have been recognised by the gliding club, so a site briefing pack and video is available on the club's website to highlight these. It is compulsory for any pilot wanting to operate from the site to have reviewed this material. A briefing is conducted by the duty instructor every morning prior to the day's flying, and this briefing includes the prevailing weather conditions and threats for the day.

Figure 6
Talgarth Airfield runways published on Black Mountains Gliding Club website

Pilot information

The pilot of the tug aircraft was an experienced glider and powered aircraft pilot. He had held a PPL for 45 years and had completed over 12,000 aero-tow operations. He had been a gliding instructor since 1978 and had over 1,300 hours instructing on gliders.

The pilots in the glider were also experienced. Both pilots were instructors and had been flying for over 20 years, with one pilot having 2,400 hours gliding time and the other in excess of 4,000 hours.

British Gliding Association advice on safe aerotowing

The BGA have produced guidance on safe aerotowing of gliders, highlighting the dangers of tug upsets. The guidance explains that all tugs are vulnerable to upsets and that light tugs are more vulnerable. The Eurofox is considered a light tug. This guidance lists factors that could cumulatively contribute to a hazardous situation:

- *'Low experience of glider and/or tug pilot*
- *Gliders fitted with C of G hook only*
- *Glider's C of G towards the aft limit*
- *Turbulent air in the take-off area*
- *Rough ground in the take-off area*

- *Significant cross-wind component*
- *Short rope*
- *Light-weight glider, low wing loading.*'

A more comprehensive document on managing flying risk whilst operating tug aircraft, produced by the BGA, is available on its website[2]. Pertinent advice includes:

> *'Deciding enough is enough – Remember that however senior the glider pilot, the tug pilot is commander of the whole combination until release. It is the tug pilot's responsibility, after consultation with the person in charge, to terminate aero-tow operations if they are not happy to continue. Avoid towing in extreme conditions including weather where the aircraft handling on the ground or in the air becomes unreasonably difficult.'*

The BGA advice[3] is that certain hazards should be considered before takeoff. If three or more of the following factors are present, pilots should consider not launching the glider:

- *'Tow hook position*
- *Low-experience pilot*
- *Short tow rope*
- *All flying tailplane*
- *Lightweight glider pilot that might cause a rearward centre of gravity*
- *Turbulence and windshear*
- *Cross or slight tail wind.'*

A leaflet on aero-tow performance, available from the BGA, highlights that pilots make reasonable assumptions about takeoff performance based on many years of routine experience of the launch environment. However, this can lead to a situation where pilots adopt similar assumptions when the situation is not typical. The leaflet highlights factors affecting takeoff and climb performance, stating that even a slight tailwind will increase takeoff distance considerably, that a 90° crosswind will give no beneficial headwind, and that turning into a crosswind after takeoff adds energy and a better climb rate. It also cites turbulence, windshear and surrounding terrain as important factors to consider when aerotowing, pointing out that even a moderate wind may cause significant downdrafts.

CAA advice on operating from grass strip airfields

CAA Safety Sense Leaflet 12, *Strip Flying*[4], gives guidance on operating from grass airfields and highlights that a straightforward landing site can become challenging with low level turbulence on windy days.

Footnote

2 BGA Managing Flying Risk – Towing/Operating Tug Aircraft https://members.gliding.co.uk/safety/managing-flying-risk-index/managing-flying-risk-index-managing-flying-risk-towing/ [accessed 12 May 2026].
3 BGA Safe Aerotowing https://members.gliding.co.uk/safety/safe-aerotowing/ [accessed 12 May 2026].
4 CAA Safety Sense Leaflet 'Strip Flying' https://www.caa.co.uk/media/lpwhsrfn/safetysense12-strip-flying.pdf [accessed 12 May 2026].

Analysis

The loss of control

Shortly before the accident flight, the tug aircraft experienced severe turbulence on final approach, which was violent enough to be noticed and commented on by club members on the ground. It was only a short time after this that the tug-glider combination took off towards the area in which the tug had experienced the turbulence.

During the takeoff G-CMAX rolled left uncommanded and turned left by approximately 60°. During this time the glider under tow released from the tug and landed safely. G-CMAX briefly touched down within the airfield while tracking towards some trees and a single-story building. Recorded engine data confirmed that the throttle was closed, possibly in an attempt to land within the airfield perimeter, before full power was applied again. The aircraft was then seen to pull up into an almost vertical climb after which the left wing dropped, and the aircraft descended rapidly to the ground just outside the airfield perimeter. It is likely that after the initial touchdown the pilot pulled back on the control column to clear the obstacles and this reduced the airspeed of the aircraft leading to an aerodynamic stall and subsequent loss of control.

Assessment of the aircraft found no issues that could have caused an uncommanded roll during the takeoff. Review of the recorded data from the engine controller identified that the engine was operating normally during the takeoff and throughout the flight.

The decision to take off

The accident flight was conducted with an experienced tug pilot, and both pilots in the glider being towed were also experienced. All pilots had considerable time operating from Talgarth Airfield and were aware of the challenges of operating from this location. Initially the plan was to operate from an into-wind runway but it was too boggy, so following discussions between the tug pilot and duty instructor it was agreed to move to the north-westerly runway and accept a 90° crosswind.

The wind recorded around the time of the accident indicated a crosswind of 12-16 kt gusting to 23 kt. The published crosswind limit for the aircraft is 15 kt. Webcam images recorded from the club house confirmed the large variation in windspeed, but the wind direction remained constant. The pilot believed that at ground level along the runway the crosswind was likely to be less than the values recorded at the weather station, and so the decision was made to take off. There had been successful operations from the airfield many times previously in similar conditions and this might have supported a view that it would be no different on the day of the accident.

Pilots generally use reported surface wind to assess whether the wind exceeds an aircraft's crosswind limits, and the standard method of measuring surface wind requires the sensors to be representative of the wind at approximately 30 ft agl. Although the weather station at the airfield did not meet standard requirements for meteorological observations, the anemometer was at 25 ft agl and it is likely it would have given a reasonably valid value for comparison with the aircraft's crosswind limit. The crosswind at ground level during the takeoff could not be determined, but it is likely that as soon as the aircraft began to climb it encountered the wind that was being recorded at the weather station and that wind may have exceeded the aircraft's crosswind limit. The aircraft also encountered the severe turbulence it had encountered on landing only shortly beforehand, and it is likely that the combination of the crosswind and turbulence caused the wing drop that began the accident sequence.

The conditions for gliding were favourable that day and the focus on the goal of towing the glider for its flight might have prevented the pilot from pausing to reflect on the hazards, identified in the BGA and CAA guidance, caused by the crosswind and the turbulence.

After the accident the club began to instil a culture whereby pilots asked themselves:

> *'Should we fly, rather than can we fly;'*
>
> *and*
>
> *'What's trying to catch me out today, what mistakes would make that more likely, and what am I going to do about it before launch?'*

The club also introduced a live wind indicator on its website, accessible to all club members, which shows a mean two-minute wind and the maximum ten-minute gust. It also displays headwind, tailwind and crosswinds for all three runways.

Conclusion

G-CMAX took off with a glider under tow in gusty crosswind conditions and towards an area of turbulence. Immediately after liftoff the wing dropped, the aircraft began to turn left and the glider pilot disconnected from the tug. The tug touched down briefly but then began to climb steeply, probably in an attempt to clear obstacles ahead. The aircraft stalled, the wing dropped and the aircraft descended rapidly to the ground. It is likely that the gusty crosswind and turbulent conditions caused the rapid wing drop that led to the subsequent loss of control.

Safety actions

> As a result of this accident, the gliding club improved its weather reporting system to provide more accessible and accurate wind measurements to pilots and began work to improve its safety culture.

Published: 20 August 2026.

AAIB Correspondence Reports

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

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

The accuracy of the information provided cannot be assured.

Serious Incident

Aircraft Type and Registration:	Cessna Citation CJ2+, D-ISCV
No & Type of Engines:	2 Williams FJ44-3A-24 turbofan engines
Year of Manufacture:	2009
Date & Time (UTC):	6 January 2026 at 0910 hrs
Location:	London Biggin Hill Airport
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	None
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	50 years
Commander's Flying Experience:	10,500 hours (of which 4,000 were on type) Last 90 days - 41 hours Last 28 days - 9 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

D-ISCV was de-iced before departure. On rotation during the takeoff the pilot experienced what he thought was a control issue, with the aircraft not responding to aft pressure on the control column. A rejected takeoff (RTO) was performed during which the aircraft departed the runway at low speed. No mechanical reason was found to explain the perceived control issue. The aircraft manufacturer states in the aircraft's flight manual that heavier than normal elevator control forces might be experienced after de-icing, and this may have led to the perception that the aircraft was not responding to control inputs. During the RTO the pilot reported that he needed to apply heavy braking, but this may have been applied differentially, resulting in the aircraft departing the runway to the right.

History of the flight

The aircraft had been parked at Biggin Hill Airport for three days prior to the flight. The two pilots travelled to Biggin Hill two days before the flight to start their 14 days of duty. The pilots visited the aircraft the day before the incident flight and topped up the engine oil. On the day of the incident the aircraft was required to be positioned with just the two pilots onboard to Geneva, Switzerland, and departure was planned for 0800 hrs. The crew asked for the aircraft to be de-iced prior to the flight and stated subsequently that the aircraft only needed de-icing and not anti-icing due to the ambient conditions. The temperature dropped to -5°C the previous evening and the morning was clear and cold with no precipitation. De-icing was started at 0833 hrs using Type 2 fluid with a 75% fluid and 25% water mix, applied at a temperature of 60°C. This was completed at 0842 hrs and the commander performed a tactile test on the wing to ensure that any ice present had melted. It was noticed at the time by the pilots that the fluid had not "steamed" as much as normal when applied to the wing. The de-icing worksheet indicated that 84 l of fluid was applied with a holdover time[1] of five hours. The temperature at the time of applying the fluid was noted as -3.6°C, and there was no precipitation.

The flight time to Geneva was planned to be 1 hour 14 minutes and the aircraft had a fuel endurance of 2 hours 35 minutes. The co-pilot was in the right seat and conducting the flight as pilot flying and the commander under training, as part of their command line training. The commander was in the left seat and was a qualified company line trainer. After start, the crew "[paid] particular attention to the correct operation of the flight control surfaces following the de-icing procedure", and at 0905 hrs the aircraft taxied for departure from Runway 21.

At 0910 hrs the aircraft commenced its takeoff, which was reported by both pilots to be initially normal. At V_R of 102 kt the pilot flying (PF) applied back pressure on the control column to rotate, but he reported subsequently that the aircraft did not respond to this input. Further aft pressure was applied but there was still no response from the aircraft and the pilot called "abort, abort". The pilots reported that the takeoff was rejected at 110 kt around the midpoint of the runway. This aircraft type has differential braking on the main landing gear, which is applied by pressing on the top part of the rudder pedals, and the pilot flying reported that they had to apply higher than normal brake pedal pressure to stop the aircraft within the remaining runway available. At around 30 kt "the aircraft began to slide to the right of the runway" and it then ran onto the grass. The aircraft came to a stop about 15 m from the runway edge on the grass. The crew secured the aircraft and exited via the normal doors. The aircraft was subsequently recovered from its position to a maintenance hangar at the airport.

De-icing procedure

The de-icing service at Biggin Hill is provided by the handling agent. The fluid used for the procedure was Killfrost ABV K Plus Type 2, which was delivered premixed to a ratio of 75% fluid to 25% water. Type 2 de-icing fluid is designed to provide both de-icing and anti-icing capability. The fluid is viscous and remains attached to the aircraft surfaces during takeoff, until a speed of around 100 kt is reached after which its viscosity breaks down and it is shed from aircraft surfaces. A daily check of the fluid is performed every morning prior to the first application of the day. Before application, the operator checks for a green light on the machine, which indicates that the fluid is at the correct temperature for application; a red light illuminates if this is not the case.

The batch of fluid that was applied to D-ISCV had been applied to 19 aircraft in the proceeding three days, and a sample of the fluid had been sent to the manufacturer for routine testing two days before the incident, with no issues detected in the fluid. On completion of the

Footnote

1 Holdover time is the estimated period after the application of de-/anti-icing fluid during which the fluid is expected to prevent the formation or accumulation of ice, frost or snow on the protected surfaces.

procedure the commander signed the worksheet, confirming that the de-icing had been performed to his satisfaction.

Aircraft information

D-ISCV is a Cessna Citation CJ2+ aircraft, with a seating capacity of six passengers and two flight crew. It is approved for single pilot operations but is operated as a multicrew aircraft by the operator. The Citation CJ2+ is approved for operations in known icing conditions and is fitted with pneumatic de-icing boots on the leading edges of the wings and tail. Bleed air from the Williams FJ44 full FADEC engines is used for engine ice protection and windshield de-icing. Section VII of the aircraft flight manual contains the ground de-ice/anti-ice procedures. The manual states that takeoff performance is degraded when anti-ice fluid is applied to the aircraft. Takeoff is limited to flaps UP when Type 2 fluid is applied to the aircraft, in which case the takeoff field length must be increased by a factor of 1.3. The manual cautions that heavier than normal elevator forces may be experienced during rotation and the aircraft may be slower than normal to rotate; forces will return to normal shortly after rotation.

Aircraft examination

The aircraft was reported by the pilots to have more de-icing fluid remaining on its wings than they would have expected, given the high speed at which the rejected takeoff was initiated (Figure 1).

Figure 1

De-Icing fluid remaining on wing after rejected takeoff

On the subsequent maintenance examination there were no mechanical issues found with either the flight controls or the engines. Nothing was found that might have led to the inability of the pilot to increase the pitch of the aircraft on takeoff. It was noted that the right engine oil filler cap had not been fitted and was hanging on its chain to the side of the engine. However, there was no evidence of oil splatter inside the engine cowls, so it was suspected that this was only left off before this flight. This would not have had any significant impact on the control issue reported by the pilot on the incident flight.

Weight and balance

The aircraft had a crew of two pilots at the time of the incident with no passengers. A fuel load of 2,900 lb (1,315 kg) gave a takeoff mass of 11,255 lb (5,105 kg), and the maximum takeoff mass of the aircraft was 12,500 lb (5,669 kg). The aircraft was loaded within balance limits published by the manufacturer.

Meteorology

On the morning of the incident the weather was cold with a clear sky, and the temperature the night before the accident had fallen to -5°C. The runway was reported as being wet and had been chemically treated. The surface wind was reported as being from 240° at 7 kt and the temperature was -4°C. Just before the aircraft was cleared for takeoff the runway had been inspected but the runway surface conditions had not changed, so this was not reported to the pilot again.

Aerodrome information

London Biggin Hill (EGKB) is an airport to the south-east of London which serves both general aviation and business aviation. It has a single hard runway. The runway in use at the time of the incident was Runway 21 with a TODA of 5,919 ft.

Analysis

The aircraft had been left outside overnight in temperatures below freezing and the crew elected to de-ice the aircraft prior to departure. During the application process the crew noted that the fluid did not appear to steam as much as they had seen before, which might have suggested a lower temperature of fluid application. This appeared unlikely, however, because the checks performed by the operator and the design of the application equipment ensure that the application of fluid at a lower temperature is avoided. The pilots performed a tactile check following the procedure and were content that the aircraft was de-iced sufficiently.

The initial acceleration of the aircraft was reported as being normal and it was only when the pilot flying tried to rotate that he thought he had a problem because, when he pulled back on the control column, he felt no response from the aircraft. The crew had checked after start that the flight controls operated correctly, and subsequent checks on the aircraft did not find any mechanical issues with the controls or engines that would have caused such a lack of response from the aircraft. The manufacturer cautioned that following de-icing heavier than normal elevator forces may be experienced, and this may have contributed to the impression that the aircraft was not responding to normal inputs. The pilot reported that once the decision to reject the takeoff was made they needed to apply heavy braking to try to stop the aircraft within the remaining runway length available. This application of braking might have been applied with slightly different pressure on the differential brakes, and increased braking on the right brake may have contributed to the aircraft departing the runway to the right onto the grass. It was reported by the pilots that a considerable amount of de-icing fluid was still on the surfaces of the aircraft following the RTO but there was no evidence that this was excessive. The fluid had been applied in accordance with the manufacturer's recommendations and had been checked by the manufacturer two days before the incident.

Conclusion

The aircraft was de-iced prior to takeoff. During takeoff the pilot experienced what he thought was a control issue and so the takeoff was rejected. No mechanical issue was identified that could have contributed to a control issue. However, manufacturer guidance cautioned that heavier control forces should be anticipated following de-icing and the pilot may have experienced this on rotation and interpreted it as a control problem.

During the RTO, the aircraft departed the runway onto the grass. It is possible that this occurred because asymmetric pressure was applied to the brake pedals.

AAIB Record-Only Investigations

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

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

The accuracy of the information provided cannot be assured.

Record-only investigations reviewed: June - July 2026

1 May 2026 **UAS XAG P100 Pro** Near Beverley, East Riding of Yorkshire

Whilst operating the UAS to apply a shading product to a glasshouse roof, the real time kinematic (RTK) base station lost power and the operator chose to complete the task using a GNSS positioning autoflight mode. During approach to the landing site, the UA drifted towards the glasshouse. The operator attempted to manually take control of the UA but this was unsuccessful and the UA struck the glasshouse. Post-flight analysis of the flight log revealed that the operator had not completed the required flight control sequence to enter the manual control mode.

16 Jun 2026 **UAS Aurelia X6** Near Weybourne Airfield, Norfolk

The UA was being used for atmospheric measurements in a coastal location when it suddenly ascended and flew along the coast uncommanded. Maintaining visual line of sight, the remote pilot was able to land the UA despite compromised controllability, resulting in substantial damage.

24 Jun 2026 **UAS IONA Sonnet V2** Main Hall Farm Airfield, Cambridgeshire

During descent for landing within the defined operational area, the UAS flight controller and all four motors lost power simultaneously. The UA pitched nose-down and struck the ground resulting in major damage.

29 Jun 2026 **DJI Mini Pro 4** Pwll, Carmarthenshire

In its first flight after servicing, the UA took off as expected and flew normally for about "five to ten minutes". The UA then dropped to the ground from a height of approximately 20 to 30 ft.

10 Jul 2026 **DJI Agras T50** Near Martyr Worthy, Hampshire

The agricultural UA suffered a power loss and a rapid uncontrolled descent into a field resulting in extensive damage to the UA.

11 Jul 2026 **UAS XAG P100 Pro** Scawby, Lincolnshire

The UA collided with a low-voltage power line during an automated agricultural operation and fell to the ground resulting in its destruction. The remote pilot had assumed the orientation of the power lines based on the field geometry and had not verified the actual obstacle geometry at the location. The operator's obstacle avoidance procedures were not fully applied.

Miscellaneous

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

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

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

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

Published October 2015.

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

Published March 2016.

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

Published September 2016.

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

Published March 2017.

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

Published March 2018.

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

Published November 2018.

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

Published March 2020.

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

Published May 2021.

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

Published September 2023.

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

Published November 2023.

Unabridged versions of all AAIB Formal Reports, published back to and including 1971, are available in full on the AAIB Website

http://www.aaib.gov.uk

GLOSSARY OF ABBREVIATIONS

aal	above airfield level
ACAS	Airborne Collision Avoidance System
ACARS	Automatic Communications And Reporting System
ADF	Automatic Direction Finding equipment
AFIS(O)	Aerodrome Flight Information Service (Officer)
agl	above ground level
AIC	Aeronautical Information Circular
amsl	above mean sea level
AOM	Aerodrome Operating Minima
APU	Auxiliary Power Unit
ASI	airspeed indicator
ATC(C)(O)	Air Traffic Control (Centre)(Officer)
ATIS	Automatic Terminal Information Service
ATPL	Airline Transport Pilot's Licence
BMAA	British Microlight Aircraft Association
BGA	British Gliding Association
BBAC	British Balloon and Airship Club
BHPA	British Hang Gliding & Paragliding Association
CAA	Civil Aviation Authority
CAVOK	Ceiling And Visibility OK (for VFR flight)
CAS	calibrated airspeed
cc	cubic centimetres
CG	Centre of Gravity
cm	centimetre(s)
CPL	Commercial Pilot's Licence
°C,F,M,T	Celsius, Fahrenheit, magnetic, true
CVR	Cockpit Voice Recorder
DME	Distance Measuring Equipment
EAS	equivalent airspeed
EASA	European Union Aviation Safety Agency
ECAM	Electronic Centralised Aircraft Monitoring
EGPWS	Enhanced GPWS
EGT	Exhaust Gas Temperature
EICAS	Engine Indication and Crew Alerting System
EPR	Engine Pressure Ratio
ETA	Estimated Time of Arrival
ETD	Estimated Time of Departure
FAA	Federal Aviation Administration (USA)
FDR	Flight Data Recorder
FIR	Flight Information Region
FL	Flight Level
ft	feet
ft/min	feet per minute
g	acceleration due to Earth's gravity
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GPWS	Ground Proximity Warning System
hrs	hours (clock time as in 1200 hrs)
HP	high pressure
hPa	hectopascal (equivalent unit to mb)
IAS	indicated airspeed
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
IP	Intermediate Pressure
IR	Instrument Rating
ISA	International Standard Atmosphere
kg	kilogram(s)
KCAS	knots calibrated airspeed
KIAS	knots indicated airspeed
KTAS	knots true airspeed
km	kilometre(s)
kt	knot(s)
lb	pound(s)
LP	low pressure
LAA	Light Aircraft Association
LDA	Landing Distance Available
LPC	Licence Proficiency Check
m	metre(s)
mb	millibar(s)
MDA	Minimum Descent Altitude
METAR	a timed aerodrome meteorological report
min	minutes
mm	millimetre(s)
mph	miles per hour
MTWA	Maximum Total Weight Authorised
N	Newtons
N_R	Main rotor rotation speed (rotorcraft)
N_g	Gas generator rotation speed (rotorcraft)
N_1	engine fan or LP compressor speed
NDB	Non-Directional radio Beacon
nm	nautical mile(s)
NOTAM	Notice to Airmen
OAT	Outside Air Temperature
OPC	Operator Proficiency Check
PAPI	Precision Approach Path Indicator
PF	Pilot Flying
PIC	Pilot in Command
PM	Pilot Monitoring
POH	Pilot's Operating Handbook
PPL	Private Pilot's Licence
psi	pounds per square inch
QFE	altimeter pressure setting to indicate height above aerodrome
QNH	altimeter pressure setting to indicate elevation amsl
RA	Resolution Advisory
RFFS	Rescue and Fire Fighting Service
rpm	revolutions per minute
RTF	radiotelephony
RVR	Runway Visual Range
SAR	Search and Rescue
SB	Service Bulletin
SSR	Secondary Surveillance Radar
TA	Traffic Advisory
TAF	Terminal Aerodrome Forecast
TAS	true airspeed
TAWS	Terrain Awareness and Warning System
TCAS	Traffic Collision Avoidance System
TODA	Takeoff Distance Available
UA	Unmanned Aircraft
UAS	Unmanned Aircraft System
USG	US gallons
UTC	Co-ordinated Universal Time (GMT)
V	Volt(s)
V_1	Takeoff decision speed
V_2	Takeoff safety speed
V_R	Rotation speed
V_{REF}	Reference airspeed (approach)
V_{NE}	Never Exceed airspeed
VASI	Visual Approach Slope Indicator
VFR	Visual Flight Rules
VHF	Very High Frequency
VMC	Visual Meteorological Conditions
VOR	VHF Omnidirectional radio Range

Air Accidents Investigation Branch