SERIOUS INCIDENT

Aircraft Type and Registration:	British Aerospace (BAe) ATP, SE-MHF
No & Type of Engines:	2 Pratt & Whitney Canada PW126 turboprop engines
Year of Manufacture:	1989 (s/n 2013)
Date & Time (UTC):	3 May 2018 at 2210 hrs
Location:	8 nm west of Milton Keynes
Type of Flight:	Commercial Air Transport (Cargo)
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	54 years
Commander's Flying Experience:	4,277 hours (of which 2,169 were on type) Last 90 days - 54 hours Last 28 days - 19 hours
Information Source:	AAIB Field Investigation

Synopsis

The aircraft experienced a loss of DC electrical power during the cruise whilst operating a cargo flight from East Midlands Airport to Stansted Airport, resulting in the loss of a significant number of flight deck instruments and systems. The crew decided to return to East Midlands Airport where they made a normal landing, following which DC electrical power was restored without crew action. The loss of electrical power was consistent with a failure of the No 1 Transformer Rectifier Unit (TRU) or its contactor, followed by a subsequent failure of the DC essential busbar COUPLE function. Subsequent testing of the aircraft's electrical system did not identify the cause of either failure.

The investigation identified that the aircraft's FDR was recording intermittently due to corrosion caused by moisture ingress. Two Safety Recommendations are made, relating to the prevention of moisture entering the FDR on BAe ATP aircraft with the Large Freight Door (LFD) modification and for the replacement of flight recorders using magnetic tape.

History of the flight

The aircraft was operating a cargo flight from East Midlands Airport to Stansted Airport and was established in the cruise at FL110 with the No 2 autopilot engaged. The co-pilot was the pilot flying and the commander was the pilot monitoring. As the aircraft was approximately 8 nm west of Milton Keynes and, shortly before commencing the descent towards Stansted Airport, the master caution aural alert sounded and the TRU 1 and DC LO VOLTS central warning panel (CWP) lights illuminated. This indicated that the No 1 TRU was no longer supplying 28 VDC voltage to the No 1 essential DC busbar (Figure 2).

The crew carried out Emergency and Abnormal Checklist (EAC) Card 49 *'TRU failure or single DC busbar low voltage'* (Figure 1). The commander initially attempted to reset TRU 1, but this was not successful. He then switched the No 1 non-essential DC busbar OFF and selected the DC essential busbar couple to connect the No 1 and No 2 essential DC busbars together. Following these selections, the DC LO VOLTS warning message extinguished, and the crew observed that the No 1 battery voltage indicator was in the green arc, indicating that the battery voltage was between 23 and 29 V. During this period, the commander was recorded on the CVR stating that he considered it was a busbar relay fault, rather than a TRU fault.

The crew conducted a DODAR[1] decision-making exercise and decided to return to East Midlands Airport. Shortly after, the commander tried to reset the TRU 1 again but this was unsuccessful. En-route the crew confirmed that the load on the No 2 TRU was below 180 amperes (A) and that no circuit breakers in the cockpit had tripped.

Approximately 15 minutes after the initial loss of electrical power, the commander noticed that his flight director had failed. The crew confirmed that the DC essential busbars were coupled and the DC LO VOLTS CWP caption had re-illuminated. The commander subsequently recalled that the No 1 inverter had failed and the No 1 battery voltage had reduced to 12V.

Seven minutes later, a master caution alert sounded and the GPWS CWP caption illuminated. This was shortly followed by the commander's electronic flight instrumentation system (EFIS) primary flight display (PFD) and navigation display screens becoming corrupted and unreadable and the autopilot disconnecting; the quick access recorder (QAR) recording also stopped. The commander then declared a PAN.

A few minutes later, as the aircraft was descending to 5,000 ft amsl, the No 1 engine control FROZEN indication and standby controls FAIL CWP caption illuminated, the flight deck lights flickered and a pulsing was heard on the radio by both crew. As a precaution, the crew advised ATC that the radios might stop operating. The FDR stopped recording a few seconds later. The commander selected the emergency busbar for his radio (the co-pilot's was also supplied by the emergency busbar) but the pulsing sound continued.

The aircraft was on base leg for Runway 27 at East Midlands Airport when the flight management system (FMS) failed, along with the No 1 DME and the autopilot flight mode annunciator panel. When the aircraft was about 7 nm from the runway, the pulsing sound on the radios stopped. The aircraft was vectored to a visual approach to Runway 27, which was followed by an uneventful landing, flown by the co-pilot whose

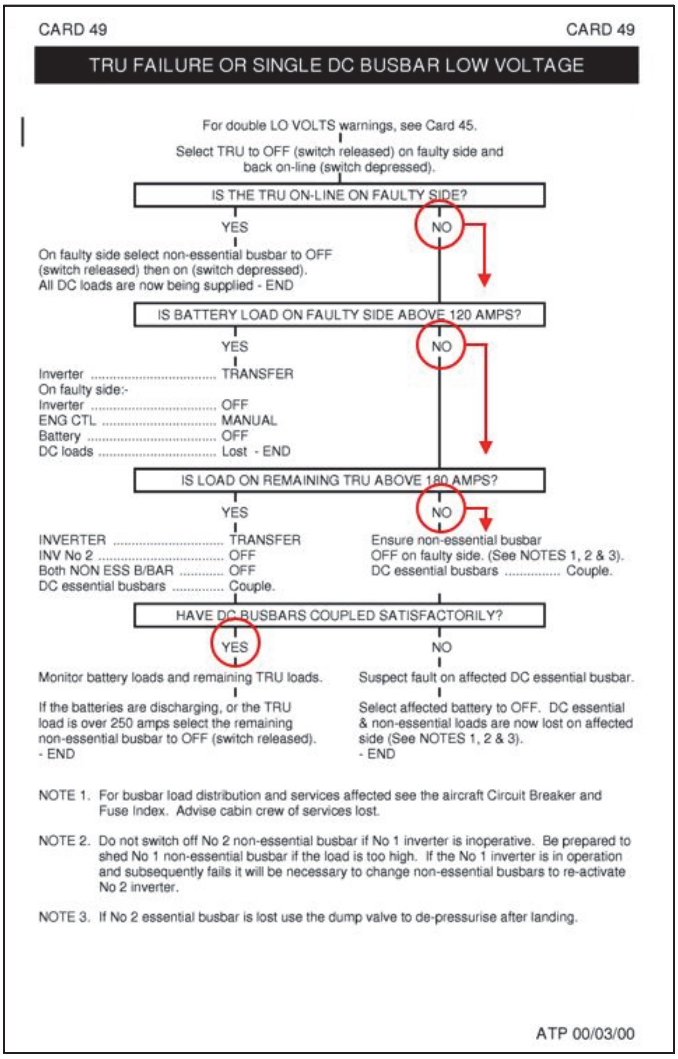
Footnote

[1] Diagnose, Options, Decide, Act or Assign, Review.

EFIS screens were operating normally. As the aircraft touched down, the pulsing sound on the radios briefly returned before stopping again.

As the aircraft vacated the runway, the DC LO VOLTS and TRU 1 CWP warning messages extinguished and power was restored to the flight deck lights, the commander's EFIS screens and flight director. The crew checked the electrical load on TRU 2 and noted that it was more than 180 A, so they followed QRH Card 49 again. The crew selected the inverter transfer ON and selected inverter No 2 and both non-essential DC busbars OFF, to reduce the electrical load, and the DC essential busbars were confirmed as being coupled.

After the aircraft was parked, the crew and two engineers from the operator's maintenance organisation discussed the event and began fault-finding. As the No 1 battery busbar was connected to DC power, the No 1 battery overheat CWP caption briefly illuminated and one engineer noted that the No 1 battery was drawing over 300 A. Both batteries were switched OFF prior to further functional testing of the electrical power system.


CARD 49 CARD 49

TRU FAILURE OR SINGLE DC BUSBAR LOW VOLTAGE

For double LO VOLTS warnings, see Card 45.

Select TRU to OFF (switch released) on faulty side and back on-line (switch depressed).

IS THE TRU ON-LINE ON FAULTY SIDE?

YES

On faulty side select non-essential busbar to OFF (switch released) then on (switch depressed).
All DC loads are now being supplied - END

NO

IS BATTERY LOAD ON FAULTY SIDE ABOVE 120 AMPS?

YES

Inverter .... TRANSFER
On faulty side:-
Inverter .... OFF
ENG CTL .... MANUAL
Battery .... OFF
DC loads .... Lost - END

NO

IS LOAD ON REMAINING TRU ABOVE 180 AMPS?

YES

INVERTER .... TRANSFER
INV No 2 .... OFF
Both NON ESS B/BAR .... OFF
DC essential busbars .... Couple.

NO

Ensure non-essential busbar OFF on faulty side. (See NOTES 1, 2 & 3).
DC essential busbars .... Couple.

HAVE DC BUSBARS COUPLED SATISFACTORILY?

YES

Monitor battery loads and remaining TRU loads.

If the batteries are discharging, or the TRU load is over 250 amps select the remaining non-essential busbar to OFF (switch released).
- END

NO

Suspect fault on affected DC essential busbar.

Select affected battery to OFF. DC essential & non-essential loads are now lost on affected side (See NOTES 1, 2 & 3).
- END

NOTE 1. For busbar load distribution and services affected see the aircraft Circuit Breaker and Fuse Index. Advise cabin crew of services lost.

NOTE 2. Do not switch off No 2 non-essential busbar if No 1 inverter is inoperative. Be prepared to shed No 1 non-essential busbar if the load is too high. If the No 1 inverter is in operation and subsequently fails it will be necessary to change non-essential busbars to re-activate No 2 inverter.

NOTE 3. If No 2 essential busbar is lost use the dump valve to de-pressurise after landing.

ATP 00/03/00

Figure 1

EAC Card 49, with actions followed by crew annotated

Aircraft information – electrical system

The electrical power system of the ATP aircraft, Figure 2, is supplied by two 200/115 volt 45 Kva AC frequency-wild engine-driven generators. TRUs convert the AC power supplies to 28 VDC. The internal battery supply consists of two 24 V 37 Ah nickel-cadmium batteries capable of providing emergency power. Two solid-state inverters provide 200/115 VAC 400 Hz supplies.

The two AC generators and their respective control units are connected to separate frequency-wild busbars and via TRUs to the essential busbars. The battery supplies also connect to the essential busbars and separately to the emergency busbar. Each battery also has its own busbar that remains permanently 'live' when the battery power cables are connected to the installed batteries. Non-essential busbars are supplied from the essential busbars. The DC supply to the No 1 inverter is from the No 1 essential busbar and the No 2 inverter DC supply is from the No 2 non-essential busbar. The inverters supply two separate 400 Hz AC essential busbars.

The control and indication panels for the electrical system are located on the left roof panel (Figure 3) and a failure caution and warning system is provided for the management of fault conditions. The DC LO VOLTS CWP caption is illuminated when the power on either DC essential busbar falls below 24.5 V, after a five-second delay. If this occurs the non-essential DC busbar on the affected side is automatically disconnected.

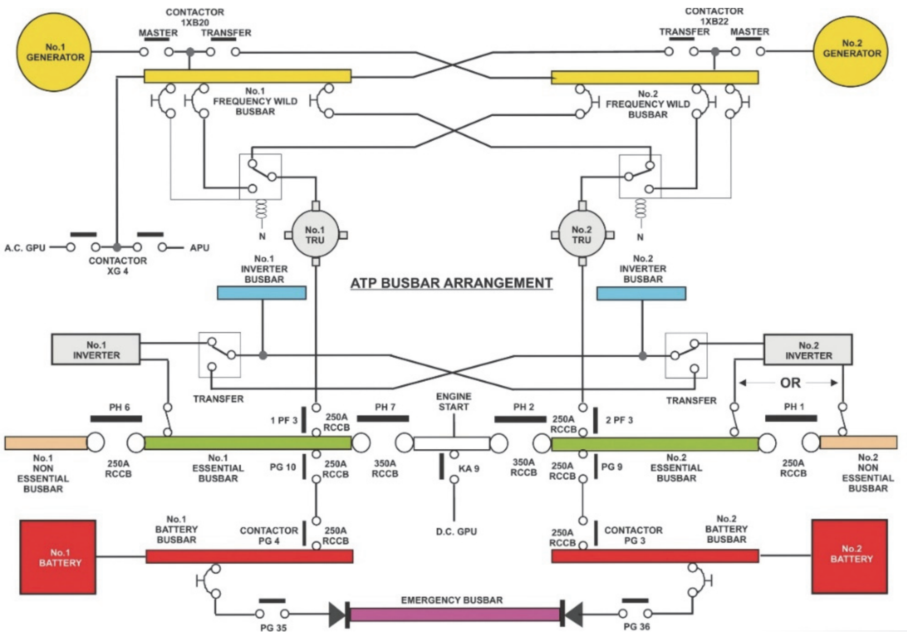


Figure 2

BAe ATP electrical power system (courtesy BAE SYSTEMS)

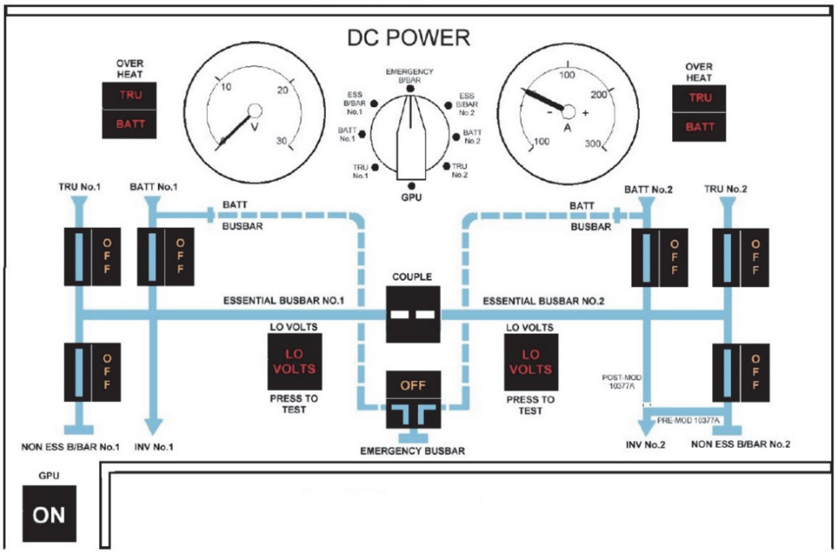


Figure 3

BAe ATP DC electrical power control panel (courtesy BAE SYSTEMS)

Aircraft examination – electrical system

Following the incident to SE-MHF, the operator's maintenance organisation conducted a visual inspection and electrical continuity tests of the aircraft's No 1 and No 2 TRUs, DC essential busbars and associated wiring harnesses, without detecting any abnormalities. The DC electrical system was then tested at high electrical loads of up to 230 A supplied from a single TRU, again without producing any abnormalities or failures.

The aircraft's No 1 and No 2 batteries, No 1 TRU and the No 1 and No 2 TRU contactors were removed from the aircraft for examination and functional testing, and no defects were identified. The aircraft was returned to service and no further failures were experienced with the DC electrical power system.

Recorded information – CVR, FDR and QAR

The aircraft was equipped with a two-hour CVR, a 25-hour FDR and a QAR. The QAR was routinely downloaded by the operator to support its Flight Data Monitoring (FDM) programme.

The CVR recorded the incident flight, which was 49 minutes duration. Both FDR and QAR recordings ended prior to the aircraft landing and an intermittent recording fault was identified with the FDR.

CVR, FDR and QAR system description

In SE-MHF, the QAR and FDR were installed in the rear equipment bay, located below the cabin floor within the pressurised area of the aircraft. The bay was accessed by a hatch on the underside of the fuselage (Figure 4). The aircraft was fitted with a LFD, which slides aft to its open position. The FDR and QAR were located below the LFD opening.

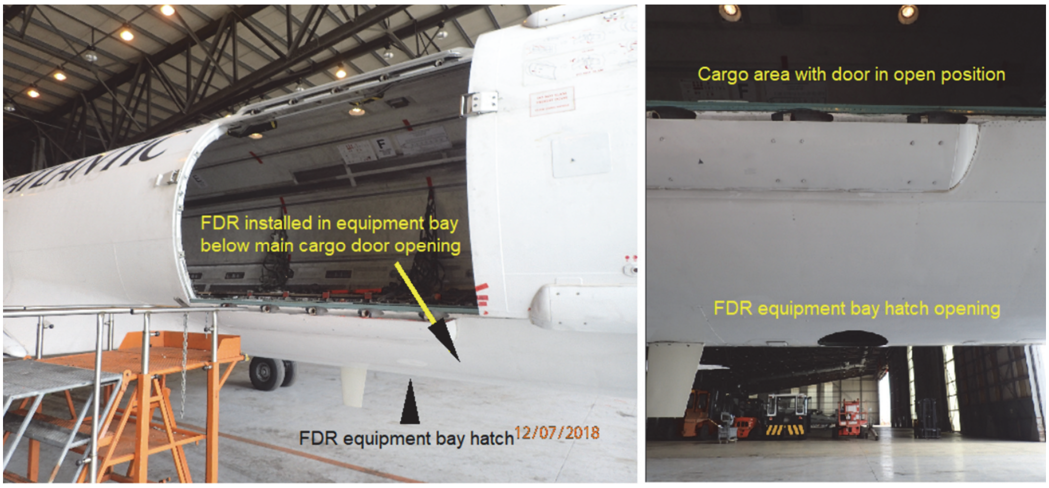


Figure 4
Location of FDR relative to LFD opening

The FDR and QAR were electrically powered from the No1 inverter 115 VAC 400 Hz busbar with the FDR starting to record as soon as electrical power was available. The CVR was electrically powered from the DC emergency busbar. The FDR provides the QAR with digital flight data[2], which the QAR records onto a removeable solid-state memory card, and the delay between receiving the data and it being recorded by the QAR is no more than 0.5 second. The QAR stops recording when electrical power is removed or the digital flight data signal from the FDR stops.

The FDR[3] (model PV1584) fitted to SE-MHF and other BAe ATP aircraft, was developed in the 1980s. It is a single-box design that incorporates both parameter acquisition and recording function, with digital flight data recorded onto magnetic tape. The FDR's electronics module contains 19 circuit boards, of which 17 connect to a main circuit board using push-fit connectors. The circuit boards are held in position by a metal panel that also forms part of the external cover of the FDR. The PV1584 is no longer manufactured.

The circuit boards and associated electrical components are covered with a conformal-coating that provides protection against moisture. However, the coating was not applied to the circuit board connectors or their solder connections as the FDR manufacturer[4] stated that it could cause reliability problems if the coating entered the connectors.

During certification, the PV1584 FDR was tested for the effects of moisture. However, it was not required to be tested for waterproofness and the effects of dripping water; this requirement was introduced for later generation FDRs that use solid-state memory. Solid-state memory recorders also undergo more extensive testing for crash survivability. The PV1584 FDR is not hermetically sealed and therefore moisture and liquids can enter the unit.

Footnote

2 The data is from electronic circuits prior to the signal being recorded onto the FDR magnetic tape.
3 Part number 650/1/14040/005, model PV1584F. Several variants of the PV1584 were manufactured, but each retained the basic design.
4 Meggitt Avionics purchased the original type design.

The PV1584 FDR incorporates a built-in test equipment (BITE) function that detects if the electrical signal at the tape-recording heads is lost, or a recorded signal is not present on the magnetic tape. This latter function does not perform a 'read-after-write' check so there is no validation that data has been correctly recorded. A fault must remain present for a period of at least 12 seconds before the BITE indicates a fault and if the fault clears, the BITE turns the fault signal off.

On the BAe ATP, an FDR fault is presented to the crew by illuminating a light on the Flight Data Entry Panel (FDEP), installed behind the co-pilot's seat. The crew are required to test the FDR fault light prior to the first flight of each day and check that the fault light is not illuminated as part of the pre-flight checks. The FDEP is not positioned in the direct line of site of either crew, so there is a possibility that an intermittent fault could go unnoticed. However, the operator of SE-MHF predominantly operated its fleet of BAe ATP aircraft at night and stated that the brightness of the fault light was sufficient to attract the crew's attention.

Comparison of SE-MHF FDR and QAR data

The FDR was removed from SE-MHF shortly after the incident and downloaded by the AAIB. QAR data for the incident flight, and approximately 40 hours of previous flight data, was provided by the operator.

Analysis of the flight data indicated that an intermittent fault within the FDR had resulted in a combination of partial recording of several flights and just over nine hours of historical data that should have been overwritten. Figure 5 provides an example of the partial flight recording and Figure 6 a time sequence of the FDR and QAR data. The time sequence coloured green in Figure 6 represents data that was correct, and the area coloured red (six flights) that should have been overwritten by more recent data coloured yellow (nine flights).

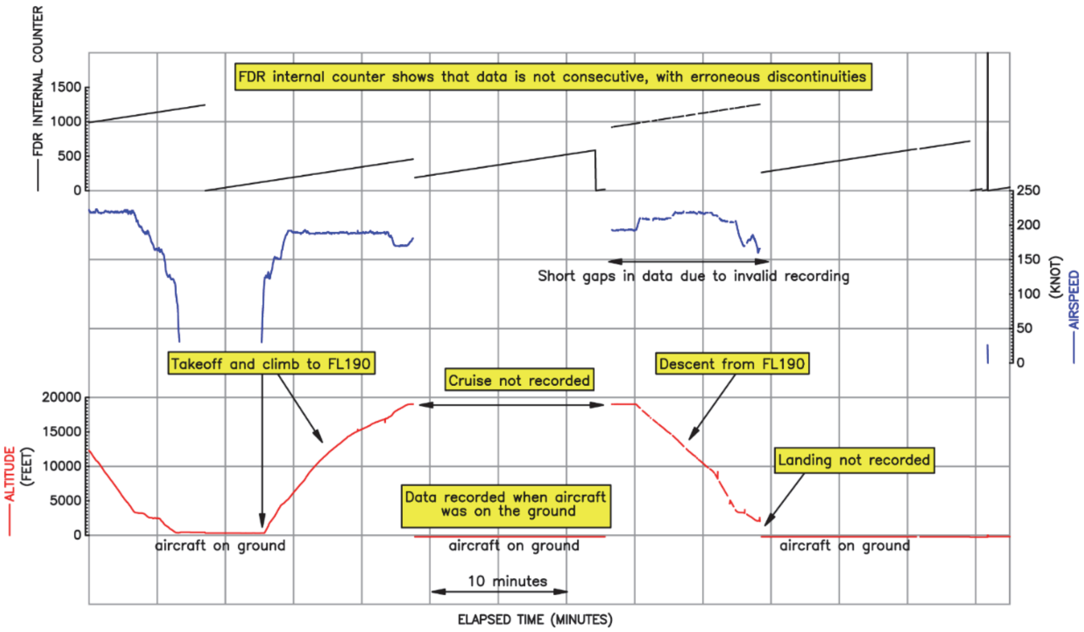


Figure 5

Example of SE-MHF erroneous FDR recording

This data showed that the electronics in the FDR that provide the QAR with data had continued to operate correctly, but an intermittent fault had prevented data from being written to the FDR's magnetic tape.

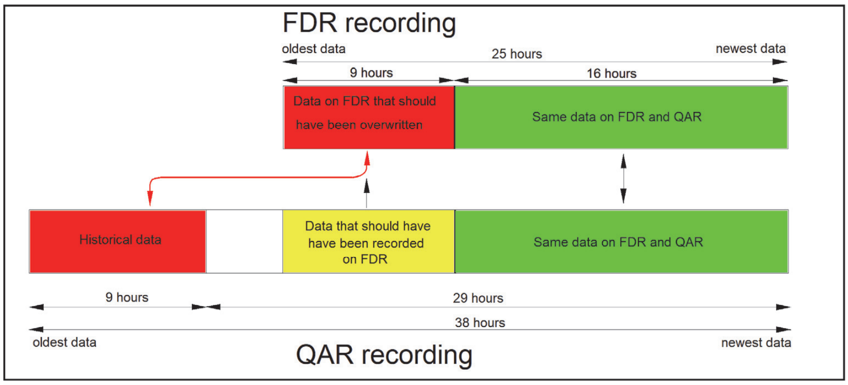


Figure 6

Pictorial time sequence of FDR recording

History of FDR serial number 10031

The FDR in this incident, serial number 10031, was fitted to SE-MHF on 11 January 2018 and removed shortly after the incident. The operator stated that between this period no defects with the FDR system were raised.

The operator purchased FDR serial number 10031 in March 2016. Records indicate that it was unserviceable but in November 2016 it was briefly fitted to one the operator's BAe ATP aircraft, SE-LGZ. During ground test the unit failed and was sent for repair to a Maintenance Repair Overhaul (MRO) facility. During repair, evidence of moisture ingress and damage was found that required replacement of a circuit board connector. A recording head had also failed, which had most likely caused the unit to fail. Serial number 10031 was returned to the operator in May 2017, where it was stored[5] prior to its fitment to SE-MHF.

Testing

During the AAIB investigation the FDR was tested for several days by the MRO facility that had previously serviced it. However, the intermittent recording fault could not be replicated. It was then disassembled and inspected. This identified:

- The inner face of the metal panel that secured the circuit boards was stained with moisture residue (Figure 7).
- An analogue to digital (A/D) converter circuit board (Figure 8) had an area of several cm^2 of staining that was attributed to moisture.
- Moisture residue and small areas of corrosion was apparent on the solder connections of two power-supply circuit board connectors (PSU1 and

Footnote

5 The FDR was stored in area that was monitored for temperature and humidity.

PSU2, Figure 8 and 9) and corresponding connectors on the main chassis interconnect.

- Corrosion was present on the chassis where the tape transport attached to the electronics module (Figure 10).

The MRO considered the intermittent recording fault had most likely been caused by moisture ingress. The MRO also added that other PV1584 FDRs received from the same operator's fleet of BAe ATP aircraft had been found with evidence of moisture ingress and damage. On occasion, staining from moisture residue has also been observed on the outside of the unit, indicating that water might have been dripping onto the unit. The FDR removed from SE-MHF did not show evidence of this.

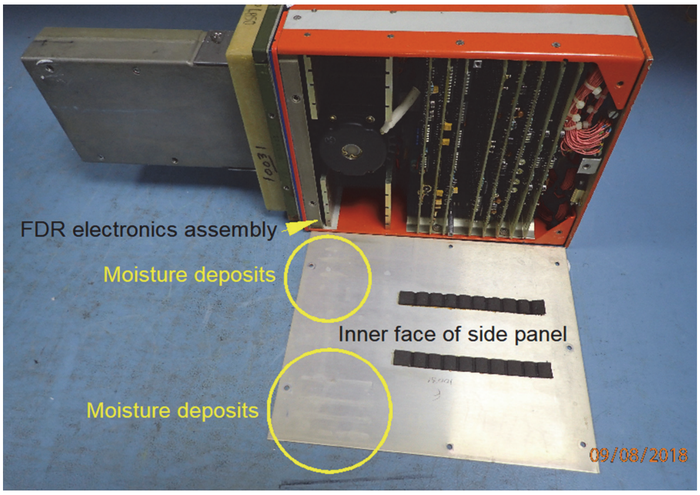


Figure 7

Inside of FDR electronics assembly side panel showing areas of moisture residue

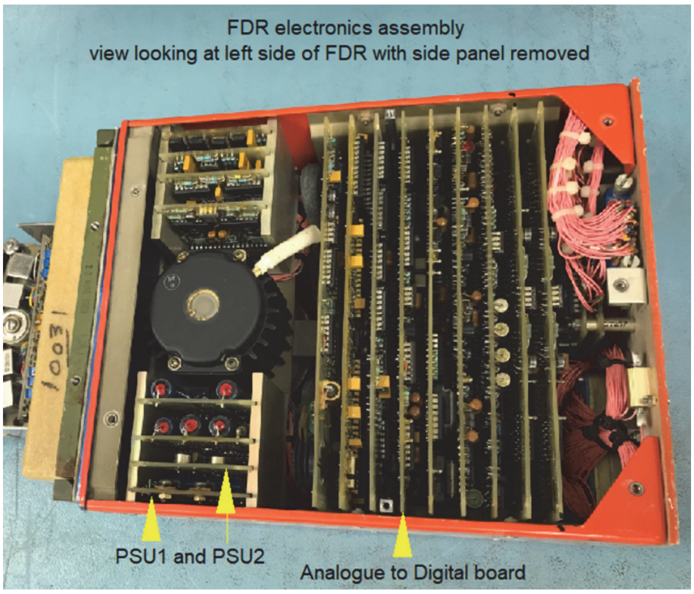


Figure 8

Position of PSU1, PSU2 and A/D circuits boards damaged by moisture

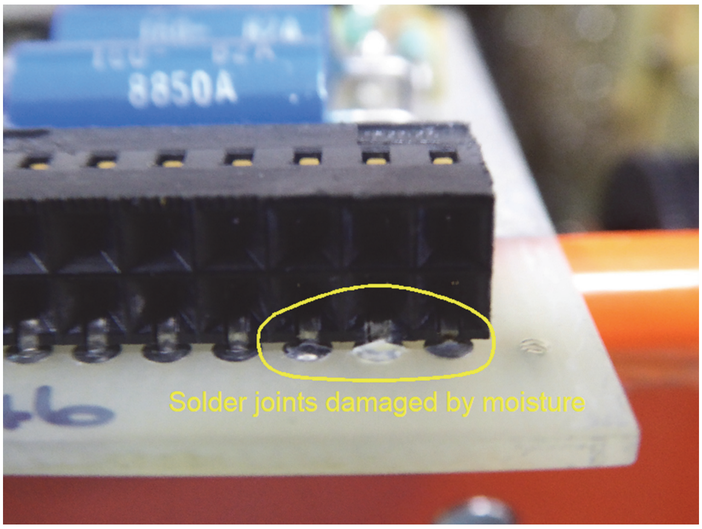


Figure 9

PSU1 connector solder joints damaged by moisture

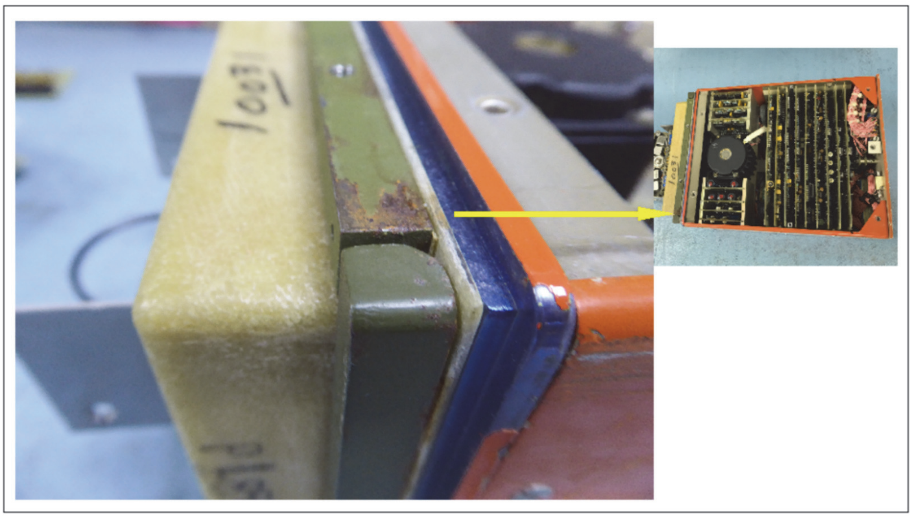


Figure 10

Corrosion on FDR chassis adjacent to electronics assembly

Effects of moisture on electronic devices

Moisture from rainwater contains dissolved electrolytes that can conduct electricity. Moisture entering electrical systems can cause equipment failures, intermittent operation and corrosion of solder joints and connectors that can affect long-term reliability.

BAe ATP LFD cargo door modification.

A total of 20 BAe ATP aircraft had been modified to cargo transport with the installation of the LFD that replaced the rear passenger door. Of these LFD aircraft, the operator of SE-MHF had operated 16. It had also operated a further 13 BAe ATP aircraft that used the rear passenger door for cargo loading (Figure 11), referred to as Small Freight Door (SFD) aircraft in this report.

At the time of this report, 12 LFD aircraft were in operation with the operator of SE-MHF, one operating in Indonesia, three in storage and four scrapped.

Figure 11
LFD and SFD cargo doors

Aircraft inspection – moisture ingress

The operator stated that during loading and unloading activities of LFD aircraft, rainwater and snow could easily enter the cargo area. Similar ingress on SFD aircraft was much less of a problem due to the smaller door aperture.

An inspection of the rear equipment bay of SE-MHF found that seals between the floor and supporting structure had degraded and there was evidence of light surface corrosion on several components. Discussions with the operator's engineering staff indicated that water had occasionally been found on the inside of the rear equipment bay hatch, but they could not recall whether this was more common on some aircraft in the fleet than others.

History of moisture ingress within FDRs fitted to the BAe ATP

The MRO facility provided 102 repair records for 37 PV1584 FDRs that had been fitted to a combination of LFD and SFD equipped BAe ATP aircraft between December 2010 and May 2018.

Analysis of these records indicated:

- Evidence of moisture ingress was found within 35% of the units serviced. Of these, the majority required replacement of damaged circuit board connectors.
- 22% of the units had failed due to moisture related damage; of these, 16% were removed because the FDR BITE had detected a fault, 4% were for readout and 2% for overhaul.
- 31 of 35 units with moisture ingress were fitted to LFD aircraft at the time of their removal.

- 3 of the 35 units found with moisture ingress were removed from SFD aircraft. All these units had been previously fitted to LFD aircraft.

Obsolete recording technologies

In 2010, the International Civil Aviation Organisation (ICAO) recommended[6] that the use of obsolete recording technologies for CVR and FDR, which included magnetic tape, should be discontinued by 1 January 2016. In response, EASA carried out a review in 2013 and their resulting '*Notice of Proposed Amendment (NPA) 2013-26*' contained the following statements:

> *'The unreliability of magnetic tape, magnetic wire and frequency modulation translate into causal factors of accidents and serious incidents being missed or not timely identified. As flight recorders using these technologies are not produced anymore, their average age is increasing, so that their failure rate is expected to increase as well.*
>
> *There is no easy way to check regularly the quality of the recorded data: a reliable self-monitoring of the recording medium condition is not in place with these kinds of recording technologies.*
>
> *Around one third of magnetic tape FDRs are found to have an insufficient recording quality.'*

EASA subsequently required that all magnetic-tape CVRs should be replaced by a two-hour solid-state memory CVR, with a compliance date of 1 January 2019. For FDRs, however, EASA conducted a rulemaking impact assessment, reflected in the EASA NPA 2013-26. This assessment indicated that, based on an aircraft service life of 30 years, by 2019 there would be only a very few magnetic-tape FDRs still in service ('*close to 0%')*. EASA did not, therefore, set a requirement for replacement of magnetic-tape FDRs.

In 2018, the AAIB contacted UK operators to establish CVR and FDR aircraft fitment. This showed that there were still a small number (fewer than 20) of aircraft operating with magnetic-tape FDRs. The operator of SE-MHF has also indicated that it intends to operate its fleet of BAe ATP aircraft beyond 2019.

The type design holder no longer provides a repair facility for the PV1584 FDR, but two MRO facilities in the UK do. One of these MROs advised that it was shortly to cease offering a repair service and the second MRO estimated that it might run out of spare parts to service the PV1584 model by approximately mid-2020. The two MROs also indicated that they were considering ceasing to offer a repair service for other models of FDRs using magnetic tape.

Footnote

6 ICAO Annex 6 Part 1 (Aeroplanes) and Part III (Helicopters).

Analysis

Electrical system failure

The initial loss of DC electrical power was caused by a failure of either the No 1 TRU or its contactor providing connection of the TRU's output to the No 1 DC essential busbar. This fault condition persisted until the aircraft landed, when the dc lo volts and TRU1 warning captions extinguished.

The crew correctly followed EAC Card 49 resulting in the successful coupling of the No 1 and No 2 DC essential busbars. The further attempt to reset the No 1 TRU, following the busbar couple, deviated from the procedure contained in Card 49 although it did not affect the configuration of the DC electrical system at this stage as the No 1 TRU or its contactor remained in a failed condition.

The subsequent recurrence of the DC LO VOLTS CWP caption and resulting loss of electrical services is consistent with a reduction in voltage of the No 1 essential DC busbar, caused by the failure of the couple between the No 1 and No 2 DC essential busbars. The busbar couple failure was consistent with one of the busbar tie contactors (PH7 or PH2) failing open. The No 1 battery continued to provide DC electrical power to the No 1 essential busbar until it was sufficiently discharged for electrical services to be lost.

The COUPLE push button selector-indicator (PBSI) on the DC electrical control panel is unusual in that it has a two-part 'mimic' line[7], with the left and right halves illuminated by power from auxiliary connections to the PH7 and PH2 busbar tie contactors respectively. Therefore, should one contactor fail open, the busbar couple function will fail yet one half of the COUPLE PBSI mimic line will remain lit. This may have led the crew to believe that the No 1 and No 2 DC essential busbars remained coupled, when they were not.

The TRU1 CWP message extinguished after landing, coincident with the restoration of electrical power to those services that had been lost during the flight. It is possible that the airframe vibration from the landing was sufficient to clear the electrical fault that had caused the No 1 TRU to fail, and also to allow the DC busbars to couple once again, as confirmed by the crew after landing. Inspection of the aircraft's DC electrical system following the event did not reveal any component defects that would have caused the electrical failures experienced during the flight.

The transient No 1 battery overheat CWP caption noticed by ground staff during post-flight fault-finding was caused by the discharged No 1 battery receiving a charging current in excess of 300 A for a sufficient period of time to allow it to reach the 60°C temperature threshold required to trigger the CWP warning.

Footnote

[7] A mimic line is an illuminated segment of the switch denoting a connection between parts of a system that the switch controls when pressed.

Intermittent fault within the FDR system

The PV1584 FDR fitted to SE-MHF had an intermittent fault that caused nine hours of data not to be overwritten and the loss of data during several other flights. Inspection of the FDR found evidence of moisture within the electronics module. This most likely caused the intermittent operation of the magnetic-tape recording function. The moisture may have also prevented the correct operation of the BITE as no fault was noticed during the period of incorrect operation.

Records showed that between 2010 and 2018, 35% of the PV1584 FDRs removed from BAe ATP aircraft contained evidence of moisture within the unit's electronic module. The majority of these units required replacement of damaged connectors, with 22 FDRs confirmed as having failed due to moisture damage.

The majority of FDRs found with moisture ingress were those that had been fitted to BAe ATP aircraft with the LFD. Discussions with engineers, and inspection of SE-MHF, indicate that rainwater can enter the cargo bay area during loading, which may then find its way into the rear equipment bay and the FDR. There was also some evidence that rainwater had dripped onto the FDR. Over time this will increase the probability of moisture entering the FDR and cause it to fail as corrosive products develop. Although tested for resistance to moisture ingress at certification, the PV1584 is not hermetically sealed and therefore moisture and liquids can easily enter the unit. Unlike later generation solid-state recorders, the unit was not required to be tested for its waterproofness or the potential effects of dripping water.

Therefore, to minimise the effects of moisture ingress on the performance of the FDR fitted to the ATP, the following Safety Recommendation is made:

Safety Recommendation 2019-001

It is recommended that the European Union Aviation Safety Agency (EASA) require BAE SYSTEMS to protect the flight data recorder fitted to those ATP aircraft equipped with large freight doors from the effects of rainwater and other liquids.

In response to an ICAO recommendation to discontinue the use of magnetic-tape FDR and CVR technology, EASA required the replacement of all magnetic-tape CVRs with a solid-state CVR by 1 January 2019. However, although EASA acknowledged that magnetic tape is unreliable, obsolete and '*have an insufficient recording quality',* they did not require the replacement of magnetic tape FDRs.

In addition to the operator of SE-MHF, which has indicated that it intends operating their BAe ATP fleet for several more years, there are also a small number of UK-operated aircraft that are equipped with a magnetic-tape FDR. Discussions with UK based MROs indicate that long-term support for this obsolete technology is declining. However, it may still be several years before aircraft operating in Europe with magnetic-tape FDRs are finally retired from service, or a lack of spares require an operator to install an alternative solid-state FDR.

It is important that FDR systems are reliable and ensure high quality data is available to accident investigation authorities. Therefore, the following Safety Recommendation is made:

Safety Recommendation 2019-002

It is recommended that the European Union Aviation Safety Agency (EASA) set an end date to prohibit the use of flight data recorders that use magnetic tape as a recording medium, to ensure compliance with ICAO Annex 6 from that date.

Conclusion

The aircraft experienced two separate, independent failures within the DC electrical power system during a cargo flight from East Midlands Airport to Stansted Airport, resulting in the loss of multiple flight deck instruments, lighting, left engine control and standby flying controls. The crew were able to return to East Midlands Airport where a normal landing was made, following which the DC electrical power was restored. The loss of electrical power experienced during the flight was consistent with a failure of the No 1 TRU or its contactor, followed by a subsequent failure of the DC essential busbar COUPLE function. The cause of both failures, which could not be repeated during subsequent testing, was probably intermittent and transitory so could not determined.