SERIOUS INCIDENT

Aircraft Type and Registration:	Bombardier DHC-8-402 Dash 8, G-ECOF
No & Type of Engines:	2 Pratt & Whitney Canada PW150A turboprop engines
Year of Manufacture:	2008
Date & Time (UTC):	21 July 2011 at 1036 hrs
Location:	Approximately 25 nm south-west of Carlisle at FL240
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 4 Passengers - 47
Injuries:	Crew - None Passengers - None
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	55 years
Commander's Flying Experience:	8,010 hours (of which 1,960 were on type) Last 90 days - 141 hours Last 28 days - 48 hours
Information Source:	AAIB Field Investigation

Synopsis

In the cruise at FL240, the aircraft generated a spurious SMOKE warning from the forward baggage compartment. The crew assumed the warning was valid and carried out checklist actions designed to tackle fire or smoke from an unknown source. This resulted in power being removed from the co-pilot's flight displays, the autopilot, the Instrument Landing System (ILS), the transponder, the CVR and FDR, and caused the aircraft to begin to depressurise. The aircraft landed safely at Edinburgh following a Surveillance Radar Approach (SRA), vacated the runway and the passengers were evacuated onto a taxiway.

The investigation indicated that the spurious warning was probably caused by an intermittent short-circuit in a smoke detector connector as a result of moisture ingress.

History of the flight

G-ECOF was operating a commercial air transport flight from Newquay Airport to Edinburgh Airport and was cruising at FL240. At 1036 hrs, the aircraft was approximately 25 miles south-west of Carlisle when a MASTER WARNING light and an aural warning were triggered, and a SMOKE warning light illuminated on the Caution and Warning Panel (CWP) indicating that there was smoke in either the forward or aft baggage compartment. The crew confirmed from information on the overhead panel that the smoke warning was generated from the forward compartment.

The pilots put on their oxygen masks and smoke goggles, which were the first actions of the '*SMOKE (Warning light)'* drill in the Abnormal and Emergency Checklist. While they were doing so, the SMOKE warning light extinguished briefly before illuminating again accompanied by the MASTER WARNING light and the aural warning[1]. The crew carried out the remaining memory items of the checklist, which included pressing the SMOKE/EXTG switch for the forward compartment. This discharged fire suppressant into the compartment and, after the switch was pressed, the aural warning sounded, the CHECK FIRE DET warning light illuminated[2] and the SMOKE warning light extinguished.

The co-pilot asked the senior cabin crew member (SCCM) to look for smoke in "THE FORWARD BAGGAGE" and then declared a PAN to ATC who informed him that the aircraft was 90 nm from touchdown at Edinburgh airport. The pilots then took off their oxygen masks and smoke goggles because there were no signs of fire or smoke in the flight deck. The SCCM reported on the interphone that she could not smell any smoke. The commander told her that "WE HAD TO FIGHT THE FIRE" and that they would be making an emergency descent into Edinburgh. He instructed her to secure the cabin and said he would decide later whether or not an evacuation would be required after landing. The commander told the co-pilot that no smoke had been seen but they agreed that the situation would have to be treated "AS REAL".

The crew consulted the '*FUSELAGE FIRE or SMOKE*' checklist and decided to carry out actions associated with a fuselage fire or smoke from an unknown source[3]. The checklist required the pilots to degrade the aircraft electrical systems by turning off the DC and AC generators, and the Main, Auxiliary and Standby batteries. After they had finished their checklist actions, the commander was required to fly the aircraft from the left seat because power had been removed from the co-pilot's flight displays. Power had also been removed from, amongst other systems, the autopilot, Instrument Landing System (ILS), transponder, CVR and FDR, and the aircraft had begun to depressurise.

At 1047 hrs ATC informed the pilots that the aircraft was 55 nm from touchdown and, two minutes later, estimated it would be about seven minutes until touchdown. The controller tried to calculate a more accurate estimate based on the aircraft's groundspeed but groundspeed information was not available from the de-powered transponder.

The co-pilot called the cabin crew on the interphone to give them a 'NITS' brief[4]. The cabin crew asked for confirmation when told there was to be an evacuation rather than a precautionary rapid disembarkation[5] and the co-pilot, having consulted with the commander, confirmed that it would be an evacuation. He said that the time until landing was expected to be seven minutes and asked whether this would be sufficient for the cabin crew to complete their passenger briefings; the SCCM said that it would not be. The co-pilot then gave an emergency PA to the passengers during which he told them to expect to evacuate the aircraft after landing.

The crew informed ATC that the aircraft would vacate the runway after landing and the passengers would be evacuated onto the taxiway. Following an uneventful

Footnotes

[1] Figure 8 shows the intermittent nature of the smoke warning at the start of this incident.

[2] See later section: Description of the aircraft.

[3] See later section: Aircraft Abnormal and Emergency Checklist.

Footnotes

[4] A formal emergency briefing to the cabin crew consisting of: Nature of the emergency; Intentions: Time to landing; Special considerations.

[5] See later section: Rapid Precautionary Disembarkation or Evacuation.

Surveillance Radar Approach (SRA), the aircraft landed at 1104 hrs and, as it touched down, power was restored to the CVR and FDR. The aircraft was taxied from the runway onto Taxiway L, brought to a halt near the fire vehicles and shut down, following which the commander ordered the passengers to evacuate. The fire service found no signs of fire or smoke.

The evacuation

There were 47 passengers and 4 crew members on board and they exited the aircraft through the four cabin doors, two at the front and two at the back. Passengers used steps at the front left door but the remaining doors had neither steps nor slides. A number of passengers tried to put on coats and take belongings with them, and the rate at which passengers left the rear of the aircraft was slowed by passengers reluctant to jump down from the door sills, which were 1.6 m above the ground. One passenger refused to jump and was eventually helped down by a member of the rescue services. Although the paramedics examined one person who fell onto her hip when she jumped from the rear left door, there were no injuries.

Once clear of the aircraft, the cabin crew members ensured that the passengers gathered at the airport operations vehicle until a coach arrived. They were then required to get onto the coach with the passengers and, approximately one hour later, were taken to the airline's business lounge at the airport. They were able to leave the lounge approximately three hours after the evacuation.

Information from the pilots

The crew decided to continue to their destination, rather than divert to an alternative airport[6], because they had already briefed for the arrival at Edinburgh and to continue seemed the most expeditious solution.

After the SMOKE/EXTG switch was pressed, the smoke warning light went out, which suggested to the pilots that there had been smoke in the compartment. When the smoke warning light subsequently illuminated permanently, the pilots considered that the fire might have re-ignited through an electrical loom, or that the smoke detectors might have been wired incorrectly meaning that the source was actually in the rear cargo compartment. The commander did not want to "do nothing" and decided to look in the '*FUSELAGE FIRE or SMOKE*' checklist even though he knew the checklist was designed to remove smoke from the aircraft and that none had been reported. If there was a fire, the pilots thought it probably had an electrical source and so they began the checklist at the section that dealt with electrical systems. The commander was not prepared to assume that the warning was spurious.

The pilots discussed whether they should evacuate the aircraft or command a rapid disembarkation and decided that, because "fire was in the equation", an evacuation would be required "just in case".

On a recent flight to Edinburgh, the commander had participated in an airport emergency training exercise during which it was assumed that his aircraft had smoke in the cabin. On that occasion he taxied clear of the runway after landing and stopped near the fire vehicles. During the subject incident, he taxied clear of the runway believing it would help the emergency services.

Both crew members stated that they had been told during simulator training that it was good practice to vacate the runway if possible before evacuating the aircraft to allow the airport to continue operations.

Footnote

[6] Edinburgh was approximately 90 nm away and Newcastle, Durham Tees Valley and Isle of Man airports were approximately 60 to 65 nm away.

Information from the cabin crew

The SCCM, when asked to look for smoke, did not hear the reference to the forward baggage compartment and thought that the source of the smoke was simply towards the front of the cabin. Neither cabin crew member knew the supposed source of the smoke until the NITS brief was given to them, which was also the first time they realised the urgency of the situation.

Seven minutes would not have been enough time for the cabin crew to carry out all the duties required of them prior to an emergency landing. However, it actually took 15 minutes to land and they could have made better use of the time had they been given a more accurate estimate. Some passengers expressed concern that there were no slides at the rear exits.

The cabin crew expected to be segregated from the passengers following the evacuation. They felt unprepared to attend to the needs of the passengers once they had left the aircraft, a role for which they had not been trained.

Information from the operator's Ground Services Operations Manager

The operator's Ground Services Operations Manager at the airport expected the passengers to be moved to the gate identified in the airport's emergency response plan for use as a passenger reception centre. When he asked the Airport Duty Manager (ADM) to make this area available his request was refused because the scale of the incident did not warrant it. The ADM agreed that the passengers could be taken to the operator's business lounge.

Description of the aircraft

The aircraft was a Bombardier DHC-8-402, also known as the Q400 version of the Dash 8 (Figure 1). It had accumulated 6,067 flying hours and 6,568 cycles at the time of the incident.

Smoke detection and warning

The aircraft was equipped with a forward and an aft baggage compartment. The aft baggage compartment was fitted with two smoke detectors and was only

Figure 1

Incident aircraft

accessible from an external door at the rear of the aircraft. The smaller forward baggage compartment, located opposite the forward main entrance door, was accessible via an internal door and an external door – this compartment was fitted with one smoke detector (Figure 2).

A placard on the forward baggage compartment door stated: 'NO ACCESS DURING TAXI AND FLIGHT'. The aircraft manufacturer stated that this was a strict requirement in all situations, because if a fire were present then opening the door would make the fire extinguisher ineffective and would allow smoke and extinguishant to enter the cabin and potentially into the cockpit.

When a baggage compartment smoke detector senses smoke, an alarm signal is produced causing a SMOKE light to illuminate on the CWP in the flight deck. This is accompanied by an aural warning and a flashing Master Warning light on the main instrument panel. If smoke is detected by the forward baggage compartment smoke detector, a red SMOKE light illuminates on the 'BAGGAGE FWD' part of the Fire Protection Panel located on the overhead console (Figure 3). The forward fire extinguisher bottle EXTG light will also illuminate indicating that the bottle is armed for activation. A forward baggage compartment test button is located on the same panel for testing the forward baggage compartment smoke detector system.

Figure 2

Forward baggage compartment with its internal door closed (left) and door open (right)

Figure 3

Fire Protection Panel on overhead console

The smoke signal from a baggage compartment smoke detector feeds into a Fire Control Amplifier, which arms the appropriate fire extinguisher bottle and triggers the flight deck warnings. Once the extinguishers have been armed, pressing the EXTG (extinguish) button on the Fire Protection Panel activates the appropriate fire extinguishers. When the fire extinguishers have been depleted the CHECK FIRE DET light illuminates on the CWP to indicate that the levels are low.

The forward baggage compartment smoke detector is mounted above the external door and is protected by a wire cage (Figures 2 and 4). The smoke detector contains a photo-electric sensor which detects a change in light beam intensity when smoke passes through it.

Aircraft exits

The aircraft is equipped with four exit doors. The main door at the front left side of the aircraft has an integrated air stair which lowers with the door. The right front door is made of two parts and consists of an upper removable hatch and a lower hinged door. The two doors at the rear of the aircraft are normal hinged doors and there is a stowable set of stairs aft of the rear left door which can be extended manually after opening the door. The steps are not designed to be used in the event of an evacuation but are intended for use in a

Figure 4

Forward baggage compartment smoke detector

rapid disembarkation[7]. There are no evacuation slides fitted to any of the doors. The distance to the ground from the base of the rear doors is 1.60 m (Figure 5) and it is 1.28 m from the right front door. The EASA certification requirements relevant to this aircraft type state than an emergency slide is required if the distance from the exit to the ground is greater than 1.80 m (Certification Specification CS 25.810).

Aircraft examination

No evidence of fire or smoke was found inside the forward baggage compartment or in any other part of the aircraft. The forward baggage compartment contained a step ladder, a tool box and a bag belonging to one of the cabin crew and there were no items in either the tool box or in the bag that could have generated smoke or other airborne particulate. The investigation therefore focussed on trying to determine the cause of a false and intermittent smoke warning.

An operational test of both the forward and aft baggage compartment smoke detectors was carried out by depressing the test switches on the Fire Protection Panel and these tests were passed. Insulation and resistance wiring checks were carried out between all the components of the baggage compartment smoke detection system but no faults were found. Some deposits were found on pin B (Figure 6) of the smoke detector plug and on socket B of the female connector. The female connector socket was also found to be missing blanking pins in unused holes. The smoke detector, fire control amplifier and smoke detector connector socket were removed for further examination. There were no further reports of false smoke warnings on G-ECOF between the time these components were removed and the completion of this report in November 2011.

The fire control amplifier and smoke detector were sent to the component manufacturer in the USA, where they

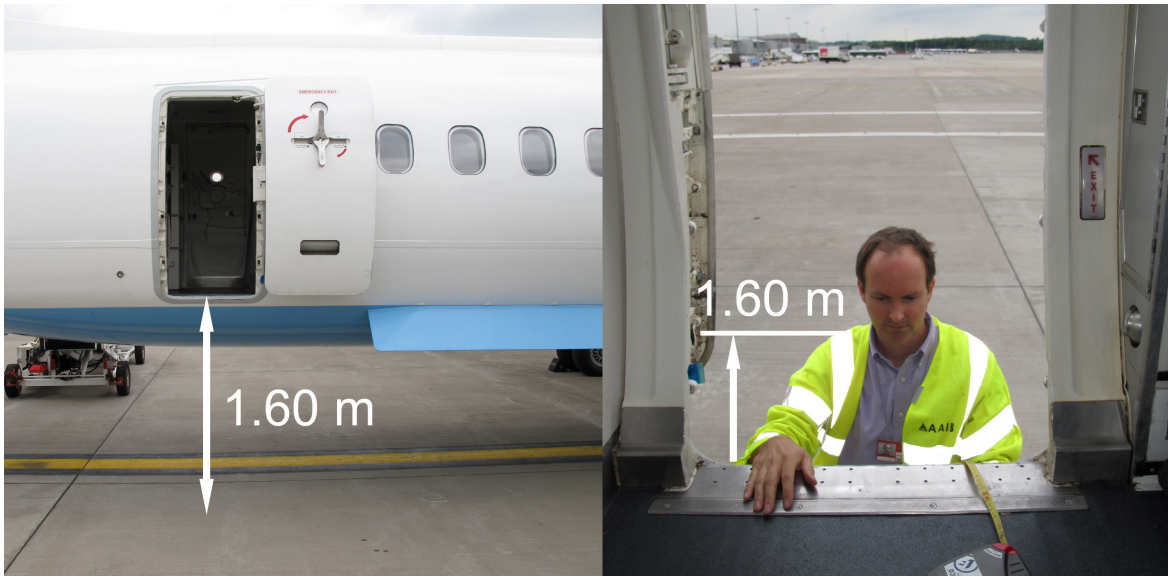

Figure 5

Height of rear exit doors

Footnote

[7] See later section: Precautionary rapid disembarkation or evacuation.

were tested and then strip-examined under the supervision of an investigator from the US National Transportation Safety Board.

Fire control amplifier examination

The fire control amplifier was connected to the manufacturer's test set and passed 15 of the 17 test items: the two failures were resistance checks which were slightly out of tolerance. The amplifier was disassembled and inspected but no anomalies were found. During temperature stress testing, it was found that cooling certain parts of the circuit board with a cooling spray, followed by heating them with the heat gun, generated a CHECK FIRE DET warning and occasionally a SMOKE warning. The manufacturer stated that the false warnings were abnormal and had been triggered only after the circuit board had been subjected to more moisture than would normally be encountered in service. The amplifier functioned normally and did not trigger any warnings in an environmental chamber where the temperature was cycled between -40°C and +85°C.

Smoke detector examination

Before function testing the smoke detector the manufacturer measured the resistance from pin B, where the foreign deposits were located, to the connector shell; the resistance was found to be normal (open circuit). The detector was then connected to the manufacturer's test set and function tested – all tests were passed. The detector was then subjected to the same thermal cycling as the amplifier and all tests were passed. No warnings were generated at any point.

The manufacturer stated that if the deposits surrounding pin B were products of corrosion then this would indicate that moisture had been present, and if moisture caused a short circuit between pin B and the connector shell it would trigger a self-test. This would create the same effect as pressing the forward test button on the Fire Protection Panel, and would trigger the smoke warnings and arm the extinguishers.

The smoke detector was taken to an independent company specialising in electrical failure investigation. Using a scanning electron microscope with elemental x-ray analysis they determined that the deposits surrounding pin B on the smoke detector and on the corresponding hole B of the socket were products of corrosion. There was also evidence of corrosion deposits in several of the other socket holes.

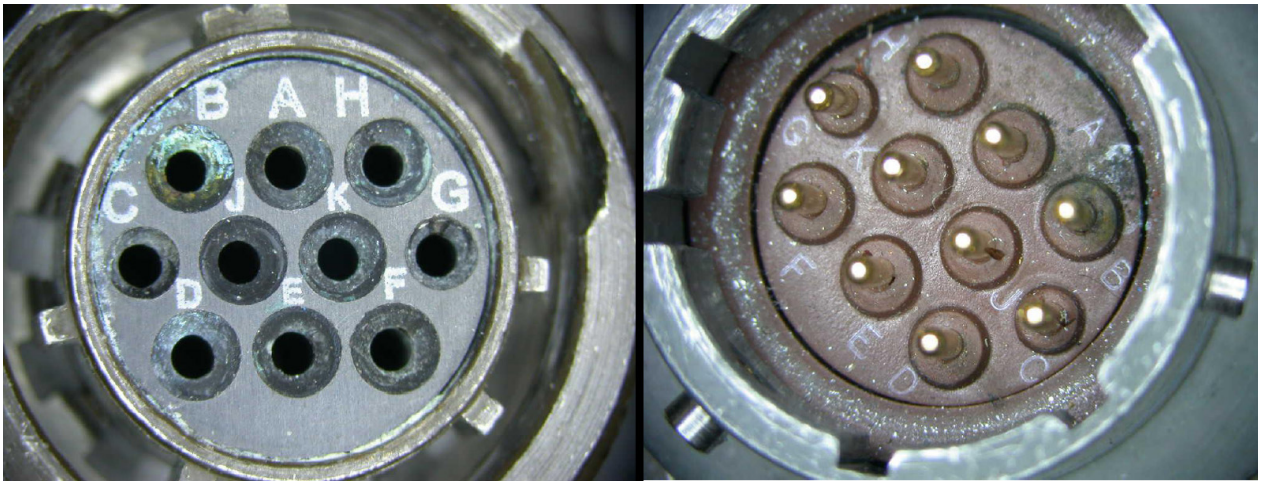

Figure 6

Smoke detector socket (left) and plug (right) – corrosion deposits visible at hole B and pin B

Using a sensitive high-resistance meter, the resistance between pin B and the connector shell was measured while blowing humid air at it, allowing it to dry and then repeating. The initial resistance was measured at 400,000 MΩ, but it reduced to as low as 4 MΩ after blowing humid air at it. For reference, pin A was measured at 200,000 MΩ and this value did not change with humidity.

The smoke detector connector is a MIL-standard connector, designed to MIL-C-26482 which, if used correctly, has a high degree of environmental resistance. However, this only applies if all holes in the socket are filled with either a wire or a blanking pin. The blanking pins were found to be missing from the socket connected to the forward smoke detector on G-ECOF. Figure 7 shows the back of another socket revealing the four wires and red plastic blanking pins fitted in the unused holes. With open holes airborne moisture would have been able to enter the socket and reach the pins. The forward smoke detector is installed upside down at about a 45° angle which results in pin B being located at the bottom where any moisture is likely to collect.

Inspections for missing blanking pins

The aircraft manufacturer stated that blanking pins are inserted in all unused sockets of electrical connectors fitted to their aircraft. According to the aircraft operator's records the forward smoke detector socket on G-ECOF had not been replaced and was therefore probably the one fitted during manufacture in 2008. The aircraft manufacturer carried out a 'line check' of seven aircraft at their manufacturing facility and all the smoke detector sockets were found to contain blanking pins. The aircraft operator also inspected three aircraft at its base maintenance facility and blanking pins were found to be in place.

Maintenance history

An inspection of G-ECOF's maintenance records revealed nine other smoke detector related problems since the aircraft entered service in July 2008. However, all these problems concerned faults that were found on the ground and usually during the smoke detector self-test prior to the first flight of the day. The forward smoke detector on G-ECOF

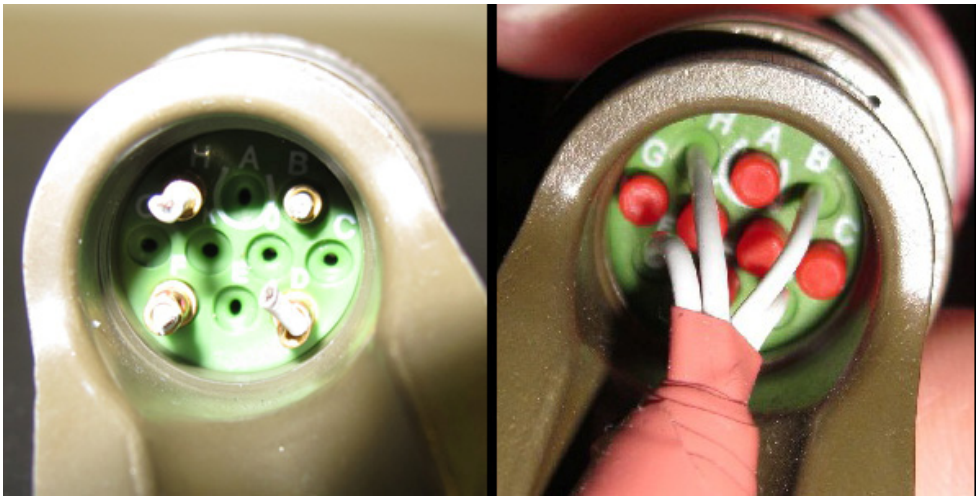

Figure 7

G-ECOF smoke detector socket (left) with blanking pins missing; another socket (right) showing installation of red blanking pins

was a refurbished unit and had been installed on 7 June 2011; the aircraft had flown 278 hours since it was fitted.

The smoke detector was of a new type that was not affected by interference from mobile phones[8].

Flight recorders

The aircraft was fitted with a Flight Data Recorder (FDR) and a Cockpit Voice recorder (CVR), which were successfully downloaded.

System power

In this aircraft the FDR and CVR were powered from the main DC busbars. During the incident flight on 21 July the crew procedurally switched off the DC and AC generators, leaving the aircraft in what the Maintenance Manual refers to as an '*Emergency Mode*' electrical state, powered only by the batteries through the Essential DC busbars. The emergency mode maximises the time that battery power will be available for essential equipment but also results in the FDR and CVR being de-powered. While airborne, the emergency mode state is achieved by disconnecting the batteries from the main DC busbars. On the ground, the lack of active generators does not require the aircraft to be in an emergency mode electrical state. Consequently, the auxiliary and main batteries are allowed to power the left and right main DC busbars respectively unless the AUX BATT and MAIN BATT, or the BATTERY MASTER switches have been selected OFF by the crew on the overhead DC control panel.

The FDR and CVR recordings stopped at 1045 hrs when the crew procedurally switched off the generators. The fact that the recordings restarted at 1104 hrs, as the aircraft came out of the '*Emergency Mode'* condition on touchdown, indicated that the AUX BATT and MAIN BATT switches on the DC control panel were ON at that stage.

FDR parameters

The salient FDR parameters (Figure 8) show that the SMOKE light on the CWP illuminated at 1036 hrs and went off approximately 33 seconds later. The light came on and went off again a further three times before coming on and staying on at 1041 hrs. The end of the second period of the SMOKE light being on was marked by the CHECK FIRE DET light illuminating and staying on. The MASTER WARNING light illuminated briefly every time either the SMOKE or CHECK FIRE DET light illuminated. The MASTER CAUTION light illuminated just before the generators were shut down.

The latest build standard for this aircraft uses the essential DC busbars to power the FDR and CVR, which ensures that they will continue recording even with the aircraft in the emergency mode electrical state. The build standard made no change to battery capacity and the aircraft still meets battery endurance requirements with no AC or DC generators on line.

Aircraft Abnormal and Emergency Checklist

The first checklist actions carried out from memory by the crew were from the '*SMOKE (Warning light)'* checklist. The second checklist to which the crew referred was the '*FUSELAGE FIRE or SMOKE'* checklist, which is a systematic method of isolating the source of fire or smoke and minimising any effects. The relevant parts of the checklist are shown below:

Footnote

[8] When the Dash 8 Q400 first entered service in 2000 the aircraft suffered from a number of spurious in-flight smoke warnings, which were attributed to mobile phone interference. The smoke detectors were modified and the problem did not recur. The smoke detectors fitted to G-ECOF were of the newer standard.

'If known source of fire or smoke:

[Checklist items not relevant to this discussion]

If unknown source of fire or smoke:

[Checklist items relating to engine bleed air and air conditioning]

If source of fire or smoke still cannot be identified:

Caution: Following completion of this drill, fly the aircraft from the left-hand seat in order to read active instruments; PFD 1 will be lost so revert MFD 1 to PFD[9]. 45 min battery duration.

Battery..... Confirm ON
DC and AC Gens 1 and 2.....OFF
Storm/dome .....ON (if reqd)
Main, Aux and Standby.....OFF
Emergency.....OFF
Land immediately at the nearest suitable airport

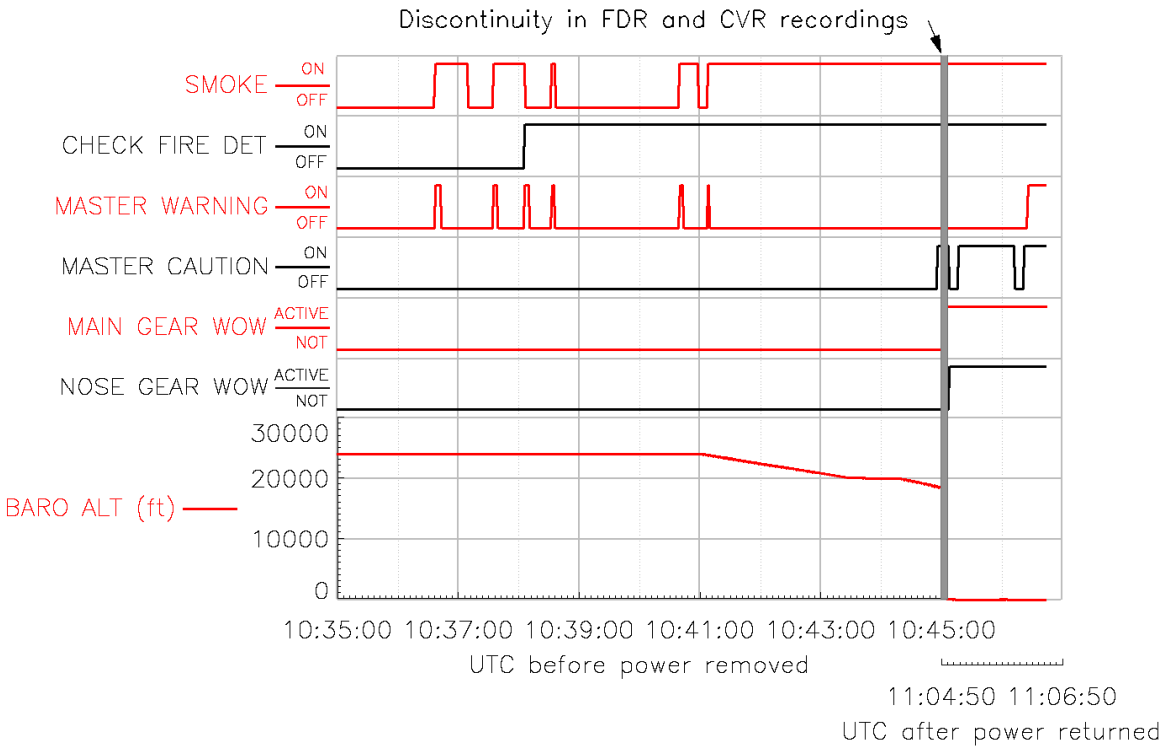

Figure 8

Salient FDR parameters

Footnote [9] PFD is a Primary Flight Display; MFD is a Multifunction Display.

Decisions on 'Precautionary rapid disembarkation' or 'Evacuation'

The operator's procedures include a '*Precautionary rapid disembarkation*' to be used in circumstances that require passengers to vacate the aircraft rapidly but not so rapidly that it justifies an '*Evacuation'* with its attendant risk of injury. A rapid disembarkation requires passengers to leave the aircraft quickly down steps at the front and rear left doors of the aircraft. An evacuation, however, requires passengers to leave the aircraft through any of the four doors, and requires them to jump down from all doors except the front left, which has integral steps.

The operator's Operations Manual gives guidance to aircraft commanders on how to decide which option, evacuation or rapid disembarkation, is appropriate in the circumstances. Figure 9, taken from the Operations Manual, shows how the decision should be made and it is amplified in the manual by the following guidance:

> *'The assessment of the cabin environment can be carried out from the cockpit by visual inspection by either flight crew or interphone contact with the cabin crew. Commanders are to remember that if there is any doubt, a full evacuation should be initiated.'*

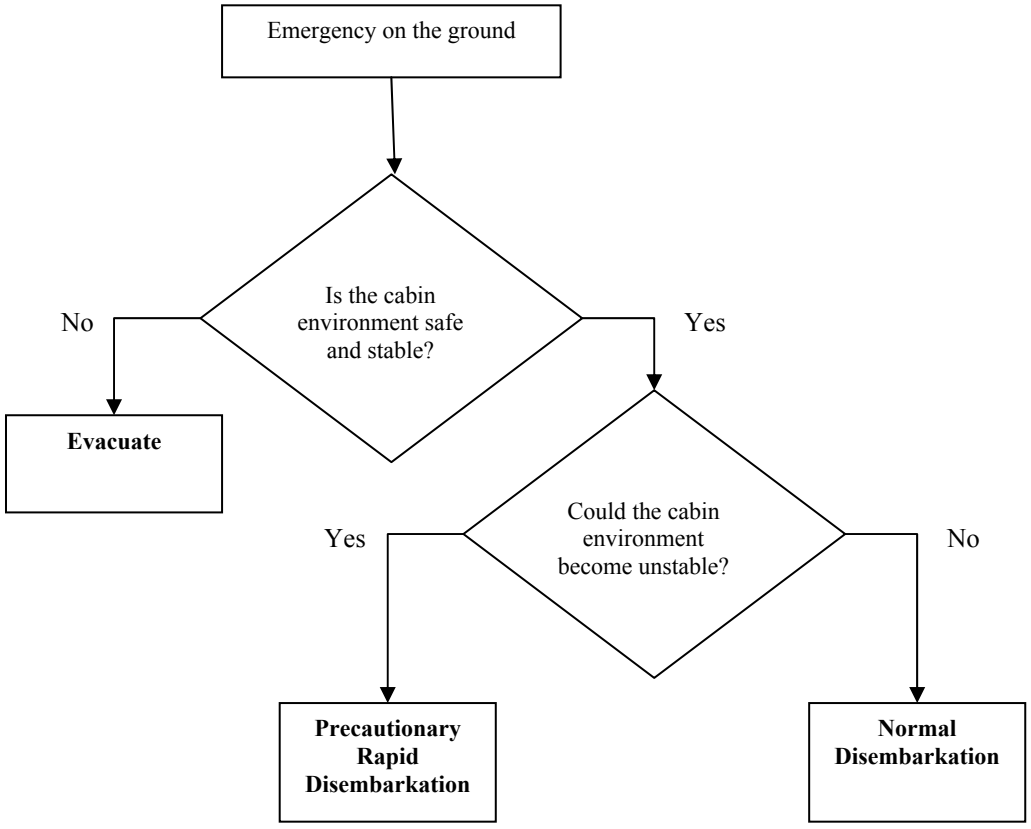

Figure 9

The Operator's decision tree for evacuation or rapid disembarkation

Comments from the aircraft operator

The aircraft operator stated that crews should not be encouraged by ATC or through training to vacate the runway before an evacuation. Airline policy in circumstances where an evacuation is possible after landing is for the aircraft to stop on the runway and, if necessary, for the passengers to be evacuated from the position at which it has stopped.

The operator noted the problems that had been encountered at the rear of the aircraft with passengers refusing to jump to the ground. Passengers are normally loaded onto this type of aircraft with a bias towards the rear for trim purposes although company guidance to handling agents is that passengers with reduced mobility should be seated towards the front of the cabin. However, many such passengers do not advise the airline of their requirements, and passengers are able to choose their own seats during online or self-service check-in.

Although the cabin crew were separated from the pilots for a considerable time after the evacuation, the operator did not wish to impose a requirement for all crew to remain together or for cabin crew to be segregated from the passengers. Rather, the operator expected each situation to be managed by the commander and SCCM according to the circumstances.

Review of the incident by the airport authority

The airport authority carried out a review into the incident and identified the following issues:

1. The airport used a Passenger Evacuation Management System (PEMS) mounted on a vehicle, which included lights and a recorded message to marshal passengers. The speaker system was unserviceable during this evacuation and a loudhailer was used instead. The airport authority considered the system suitable in this incident but decided that additional resources would be required to supplement its use in the event of a larger scale event.

2. The coach used to pick up the passengers was summoned by radio using a codeword that was not recognised and a phone call had to be made instead. This did not delay the bus significantly.

3. When he received the request to use the passenger reception centre, the ADM turned it down as he did not believe that the situation was serious enough.

4. There was a possible misunderstanding as to where or when responsibility for passenger welfare should pass between the emergency services, the airline or handling agent and the airport authority.

5. There should be a method of segregating crew from passengers following an evacuation.

Civil Aviation Publication (CAP) 168 – '*Licensing of Aerodromes'*

CAP 168 details the licensing requirements that must be met by aerodrome authorities. Chapter 9 considers emergency planning and paragraph 8.5 states:

> *'The post-accident arrangements for any survivors who are not injured…..is a joint responsibility between the aerodrome, the airline and/or its agents, and Category 1 Responders and should be set out in the Emergency Plan.'*

CAA Safety Notice: SN-2011/013 *'Rescue and Fire Fighting Service Response to Smoke/Fumes Incidents'*

In its introduction to Safety Notice SN-2011/013, dated 26 September 2011 (but not written in response to this incident), the CAA stated:

> *'There have recently been instances where the response of the aerodrome Rescue and Fire Fighting Service (RFFS) to reported incidents of smoke or fumes has resulted in evacuations or de-planing of passengers in inappropriate locations.'*

The notice commented that, if smoke or fumes are inside the aircraft, the flight crew are best placed to determine the course of action and recommended that:

> *'The RFFS should review its procedures for responding to such incidents to assure effective communication with the flight crew so that the need for any action is agreed and co-ordinated.'*

Analysis

Engineering analysis

The aircraft suffered a false and intermittent forward baggage compartment smoke warning. No faults with the aircraft wiring system were found and, after removal of the forward smoke detector and the fire control amplifier, there were no further reports of false smoke warnings on the aircraft. It is probable, therefore, that either the smoke detector or the amplifier generated the false warning. The amplifier could generate a false smoke warning but only when exposed to high levels of moisture not representative of normal operating conditions. It is therefore more likely that the spurious warning was caused by a short circuit at the smoke detector connector between pin B and the connector shell. The evidence of corrosion in this area indicated that moisture had been present, and sufficient moisture would have provided a conductive path from the pin to the shell. Grounding pin B triggers a self-test, which would have given the flight crew indications of a smoke warning and would have armed the fire extinguishers.

The type of connector used on the smoke detector is normally resistant to moisture ingress but the lack of blanking pins in the unused sockets meant that moisture in the air could reach the pins. The fact that the corrosion was primarily present at pin B, the pin at the lowest point, was consistent with the theory that moisture had collected there.

Safety Action

At the end of this investigation the aircraft operator initiated an inspection programme of the forward and aft baggage compartment smoke detector connectors on all their Q400 aircraft to ensure that blanking pins were in place. As part of the inspection the condition of the connector pins would be assessed. The operator expected to have all aircraft inspected by mid-February 2012. A routine task to check for blanking pins would also be added to the aircraft's base maintenance 'C' check.

Operational analysis

The crew was presented with a smoke warning but there were no corroborating signs of smoke or fumes. The pilots were not prepared to proceed on the basis that the warning was spurious and assumed that it was valid. Subsequently, the continuing absence of corroborating evidence did not alter this assumption, and the crew proceeded on the basis that the continuous smoke warning meant that smoke or fumes were present

somewhere in the aircraft caused by an unknown electrical problem.

Having made their assumption, the pilots carried out checklist actions designed to remove smoke from the aircraft. The actions degraded the operational capability of the aircraft significantly because it depressurised, the commander had to fly manually (which reduced his ability to do other tasks) and the co-pilot's monitoring task was made more difficult because his flight displays were blank. Consequently, the crew's workload increased, which would have made managing the overall situation more difficult. In addition, the loss of its ILS system would have reduced the aircraft's approach capability in poor weather, although in this incident the weather was good and safety was not adversely affected.

The pilots made an early decision to evacuate the aircraft rather than use a rapid disembarkation because, with the possibility of a fire on board, they thought it was the safest course of action. By the time of the evacuation, 28 minutes had passed since the original warning during which there had been no reports of smoke within the cabin. Had the pilots assessed the cabin environment from the cockpit before commanding the evacuation, it is possible that the advice given in the Operations Manual would have led them to carry out a rapid disembarkation instead. However, that same advice recommends that commanders should evacuate an aircraft if they are in any doubt as to its safety, which was the course of action followed.

When the commander was asked to simulate having smoke in the cabin for a previous training exercise at the airport, he taxied clear of the runway to meet the emergency response vehicles. The CAA Safety Notice SN-2011/013 reinforces the fact that, if smoke or fumes are within the cabin, the commander is best placed to decide where any evacuation will take place but it is quite likely to be on the runway. An airport authority will not wish to close a runway for the purpose of an exercise but there is potential for negative learning if RFFS responders expect an aircraft in such circumstances to vacate the runway and evacuate passengers onto a taxiway. This negative learning probably extended to the commander who, in this incident, vacated the runway partly because he thought it would help the emergency services.

A number of passengers refused to jump from the rear doors, presumably because they thought they might injure themselves on landing. Had there actually been smoke or fire in the cabin, it is likely that the urgency of the situation would have convinced them that jumping involved a lower risk to their safety than remaining on board.

Safety Action by the aircraft operator

The operator reviewed its training of pilots for circumstances where an evacuation was possible after landing to ensure that the training was in accordance with its policy.

Safety Action by the airport authority

Following its review into the evacuation, the airport authority decided to:

1. Change its procedures for summoning a coach to ensure that the use of discrete radio codes would be effective in a future incident.

2. Update its ATC procedures to ensure that they were aligned with the airport's emergency orders on reportable incidents.

3. Brief all ADMs that the designated passenger reception area was to be used for all future evacuation incidents.

4. Discuss with airlines using the airport the division of responsibilities for passenger welfare following an evacuation.

5. Amend its procedures to ensure that crew would be segregated from passengers following an evacuation.

The RFFS at the airport reviewed its procedures in accordance with CAA Safety Notice SN-2011/013.

Summary

The aircraft generated a spurious smoke warning from the forward baggage compartment, which was probably caused by a short circuit in the smoke detector connector. The pilots decided to treat the warning as valid even though there was no evidence of smoke or fumes. The pilots decided that, with the possibility of a fire on board, an evacuation was required and, after landing, the aircraft vacated the runway and the passengers were evacuated onto a taxiway.

Safety action was taken by the aircraft operator to prevent a similar short circuit in other smoke detector connectors, and to ensure pilots received training with respect to aircraft evacuation that reflected company policy. Safety action was taken by the airport authority to address issues that arose during and after the evacuation.