AIRCRAFT ACCIDENT REPORT 1/2007

Air Accidents Investigation Branch

Department for Transport

Report on the serious incident to British Aerospace ATP, G-JEMC 10 nm southeast of Isle of Man (Ronaldsway) Airport on 23 May 2005

This investigation was carried out in accordance with
The Civil Aviation (Investigation of Air Accidents and Incidents) Regulations 1996

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This report contains facts which have been determined up to the time of publication. This information is published to inform the aviation industry and the public of the general circumstances of accidents and serious incidents.

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4/2004	Fokker F27 Mk 500 Friendship, G-CEXF at Jersey Airport, Channel Islands on 5 June 2001.	July 2004
5/2004	Bombardier CL600-2B16 Series 604, N90AG at Birmingham International Airport on 4 January 2002.	August 2004
1/2005	Sikorsky S-76A+, G-BJVX near the Leman 49/26 Foxtrot Platform, in the North Sea on 16 July 2002.	July 2002
2/2005	Pegasus Quik, G-STYX at Eastchurch, Isle of Sheppey, Kent on 21 August 2004.	November 2005
3/2005	Boeing 757-236, G-CPER on 7 September 2003.	December 2005
1/2006	Fairey Britten Norman BN2A Mk III-2 Trislander, G-BEVT at Guernsey Airport, Channel Islands on 23 July 2004.	January 2006
2/2006	Pilatus Britten-Norman BN2B-26 Islander, G-BOMG West-north-west of Campbeltown Airport, Scotland on 15 March 2005.	November 2006
3/2006	Boeing 737-86N, G-XLAG at Manchester Airport on 16 July 2003.	December 2006

Department for Transport
Air Accidents Investigation Branch
Farnborough House
Berkshire Copse Road
Aldershot
Hampshire GU11 2HH

December 2006

The Right Honourable Douglas Alexander
Secretary of State for Transport

Dear Secretary of State

I have the honour to submit the report by Mr P T Claiden, an Inspector of Air Accidents, on the circumstances of the serious incident to British Aerospace ATP, registration G-JEMC 10 nm southeast of Isle of Man (Ronaldsway) Airport on 23 May 2005.

Yours sincerley

David King
Chief Inspector of Air Accidents

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APPENDICES

GLOSSARY OF ABBREVIATIONS USED IN THIS REPORT

AAIB	Air Accidents Investigation Branch
AFM	Aircraft Flight Manual
AFRS	Aerodrome Fire & Rescue Service
AMM	Aircraft Maintenance Manual
AOC	Air Operator's Certificate
AOM	All Operator Message
ATC	Air Traffic Control
ATPL	Airline Transport Pilot's Licence
CAA	Civil Aviation Authority
CAP	Civil Air Publications
CG	centre of gravity
CVR	Cockpit Voice Recorder
CWP	Central Warning Panel
°C	Celsius
DC	Direct current
ECS	Environmental Conditioning System
EGPWS	Enhanced GPWS
FDR	Flight Deck Recorder
FL	flight level
FODCOM	Flight Operations Department Communication
ft	feet
GA	General Aviation
hrs	hours (clock time as in 12:00 hrs)
JAR	Joint Airworthiness Requirements
kg	kilogram(s)
km	kilometre(s)
kt	knot(s)
MAC	Mean aerodynamic chord
mb	millibar(s)
METAR	a timed aerodrome meteorological report
MHz	Megahertz
MOR	Mandatory Occurance Report
OM	Operations Manual
OPC	Operator proficiency check
PF	Pilot flying
PNF	pilot not flying
psi	pounds per square inch
v	volt
VMC	Visual Meteorological Conditions

Air Accidents Investigation Branch

Aircraft Accident Report No: 1/2007 (EW/C2005/05/05)

Registered Owner and Operator	Emerald Airways
Aircraft Type	British Aerospace ATP
Nationality	British
Registration	G-JEMC
Place of Accident	10 nm southeast of Isle of Man (Ronaldsway) Airport
Date and Time	23 May 2005 at 1740 hrs

Synopsis

This serious incident was notified to the Air Accidents Investigation Branch (AAIB) by ATC at the Isle of Man (Ronaldsway) Airport, at 1855 hrs on 23 May 2005. The following Inspectors participated in the investigation:

Mr P T Claiden	Investigator in Charge
Mr T Atkinson	Operations
Mr A H Robinson	Engineering
Mr P Wivell	Flight Recorders

Under the *Isle of Man Civil Aviation (Subordinate Legislation) (Application) Order 1992*, the *United Kingdom Civil Aviation (Investigation of Air Accidents) Regulations 1989* are applicable in the Isle of Man. Accordingly, Inspectors of Air Accidents from the AAIB carried out an investigation into this occurrence.

The aircraft was configured with 64 seats; 33 passengers were on board. Shortly after takeoff, a seal associated with the retraction line for the hydraulically operated integral airstairs at the front left cabin door, failed. This allowed hydraulic fluid to escape in the form of a fine mist, depleting the contents of the main hydraulic system. This misting was perceived by the cabin crew as smoke, and they informed the flight crew accordingly. In flight, this line is normally de-pressurised but, owing to a jammed airstairs UP selection switch and a stuck door safety microswitch, it had remained pressurised.

The intensity of the misting in the forward section of the cabin led the cabin crew to reposition the passengers towards the rear of the cabin. As a result, the aircraft's centre of gravity (CG) position moved beyond the operator's specified aft limit.

An emergency was declared to ATC and the aircraft returned to Ronaldsway. During the approach, the EGPWS system alerted the crew to an incorrect flap setting for landing.

After landing, the aircraft was taxied clear of the runway but difficulties encountered with the nosewheel steering system forced the commander to stop the aircraft short of the terminal buildings. One passenger, who was asthmatic, was taken to a local hospital but later discharged as medical treatment was not considered necessary.

The investigation identified the following causal factors:

1. A combination of a stuck door safety microswitch plunger and a jammed-on airstairs UP switch caused hydraulic pressure to remain applied to the airstairs retraction actuators in-flight.

2. The failure of the hydraulic seal associated with the airstairs operating mechanism occurred in-flight; this resulted in the fluid contents of the main hydraulic system being discharged as a fine mist into the passenger cabin.

3. At the time of the incident, there were no periodic inspection or maintenance checks required on the airstairs operating system.

4. The rearward movement of the aircraft's CG position beyond the aft limit as specified by the operator, was caused by the cabin crew moving passengers towards the rear of the cabin in an attempt to minimise their exposure to the 'smoke'.

5. There was no requirement for cabin crews to obtain agreement from the commander prior to moving passengers towards the rear of the cabin although, on this occasion, the commander was informed of their actions.

6. The flight crew's non-adherence to SOPs[1] and associated checklists put the aircraft and its occupants at unnecessary increased risk from potential handling problems as well as risk of fire and prolonged exposure to hydraulic fluid mist.

One safety recommendation is made.

[1] Standard Operating Procedures

1. Factual Information

1.1 History of the flight

The aircraft took off from Ronaldsway Airport in the Isle of Man at 1721 hrs, as Emerald Airways flight 311, a scheduled passenger flight bound for Liverpool. The crew consisted of a commander, co-pilot and two cabin crew. The senior cabin crew member, referred to in this report as the No 1, was seated on a forward-facing seat in the rear galley, with a view along the cabin aisle. The other cabin crew member, the No 2, was seated on a rearward-facing crew seat in the forward entrance vestibule, also with a view along the aisle. The aircraft was configured with 16 rows of seats, with four seats to a row. There were 33 passengers on board.

The flight crew were operating their fourth sector of a scheduled six-sector day (three return trips Ronaldsway/Liverpool), and had agreed at their briefing that the commander would be the pilot flying (PF) for the first three sectors and the co-pilot the PF for the remaining three. The preparation for the series of flights was routine, with the crew obtaining the necessary meteorological and operational information without difficulty. The aircraft was despatched with appropriate loading details by the operator's staff at Ronaldsway. This information required, amongst other things, that the passengers should be evenly distributed throughout the cabin, aft of row four.

Before departure, the commander informed the cabin crew that he might delay releasing them from their seats to begin the cabin service as turbulence was expected after takeoff. The flight proceeded normally until the aircraft was some 10 nm south-east of Ronaldsway. At this point, the No 2 heard sounds which she described as "a burst and then the sound of escaping gas" and saw what she assessed to be smoke emanating from the area of the forward passenger door. Simultaneously, she noticed an unfamiliar smell, later described as being like 'turps'[2]. The No 1 later described the conditions at the rear of the cabin as "not pleasant".

The No 2 attempted to contact the No 1 using the public address (PA) system to attract her attention, but was unsuccessful. As the cockpit door was closed and locked, she then used the interphone system to contact the commander, informing him that "I'VE GOT A BIT OF ….ERRM…. SMOKEY STUFF COMING THROUGH THE DOOR….". The commander asked her to clarify which door she was referring to and she replied that it was "THE FORWARD PASSENGER DOOR". The commander began to reply to the No 2, but was interrupted by

[2] Turpentine spirit.

the No 1, who had picked up her interphone handset and stated very clearly "[commander's forename] (brief pause) SMOKE IN THE CABIN".

Immediately these words had been spoken, and with the cabin crew both still listening on the interphone, the Hydraulic Low Level (HYD LO LEVEL) caption on the flight deck central warning panel (CWP) illuminated and an alert sounded. The commander stated that the problem was "HYDRAULIC LOW LEVEL", and then told the cabin crew that his intention was to return to the Isle of Man and that he would make an appropriate announcement to the passengers.

The aircraft was still in contact with ATC at Ronaldsway. At 1724 hrs the commander stated to the controller that the aircraft had "A MINOR PROBLEM" and requested to return to the airport. The controller asked whether they were in VMC. The commander confirmed that they were and then requested to stop the climb at flight level (FL) 45 to remain clear of cloud. The controller agreed to the request and instructed the aircraft to take up a heading towards the airport for a landing on Runway 26.

The commander suggested that the co-pilot should engage the autopilot, which she did, and then called ATC again stating:

> "WE'D JUST LIKE TO MAKE THIS A PAN……WE HAVE REPORTS OF A LITTLE BIT OF SMOKE IN THE CABIN….WE HAVE GOT A HYDRAULIC LOW LEVEL WARNING ON THE SYSTEM…"

The controller acknowledged this call and requested the number of souls on board the aircraft. The controller then informed the crew that the approach controller (Ronaldsway Radar) would contact them shortly on the same frequency.

At 1725 hrs the co-pilot remarked that conditions in the flight deck were "QUITE SMOKEY"; the commander agreed and said that he could smell something unusual.

At 1726 hrs the commander referred to the '*Hydraulic Reservoir Low Level'* drill in the Emergency and Abnormal Checklist, Figure 1. This required him to identify whether the alert related to low level in the main or auxiliary hydraulic systems, or in both. The hydraulic panel, situated by the commander's left knee, showed that the main system contents were depleted. The drill presents two alternative courses of action, according to whether the landing gear is up or down. With the landing gear up, the crew are directed to *'Go to Card 43'*, which is titled *'ABNORMAL AND EMERGENCY LOWERING OF LANDING GEAR',* Figure 2. However, the commander did not refer to Card 43, as instructed, but selected the landing gear down. After it deployed successfully, he then referred to the relevant gear down drill, which required no further action.

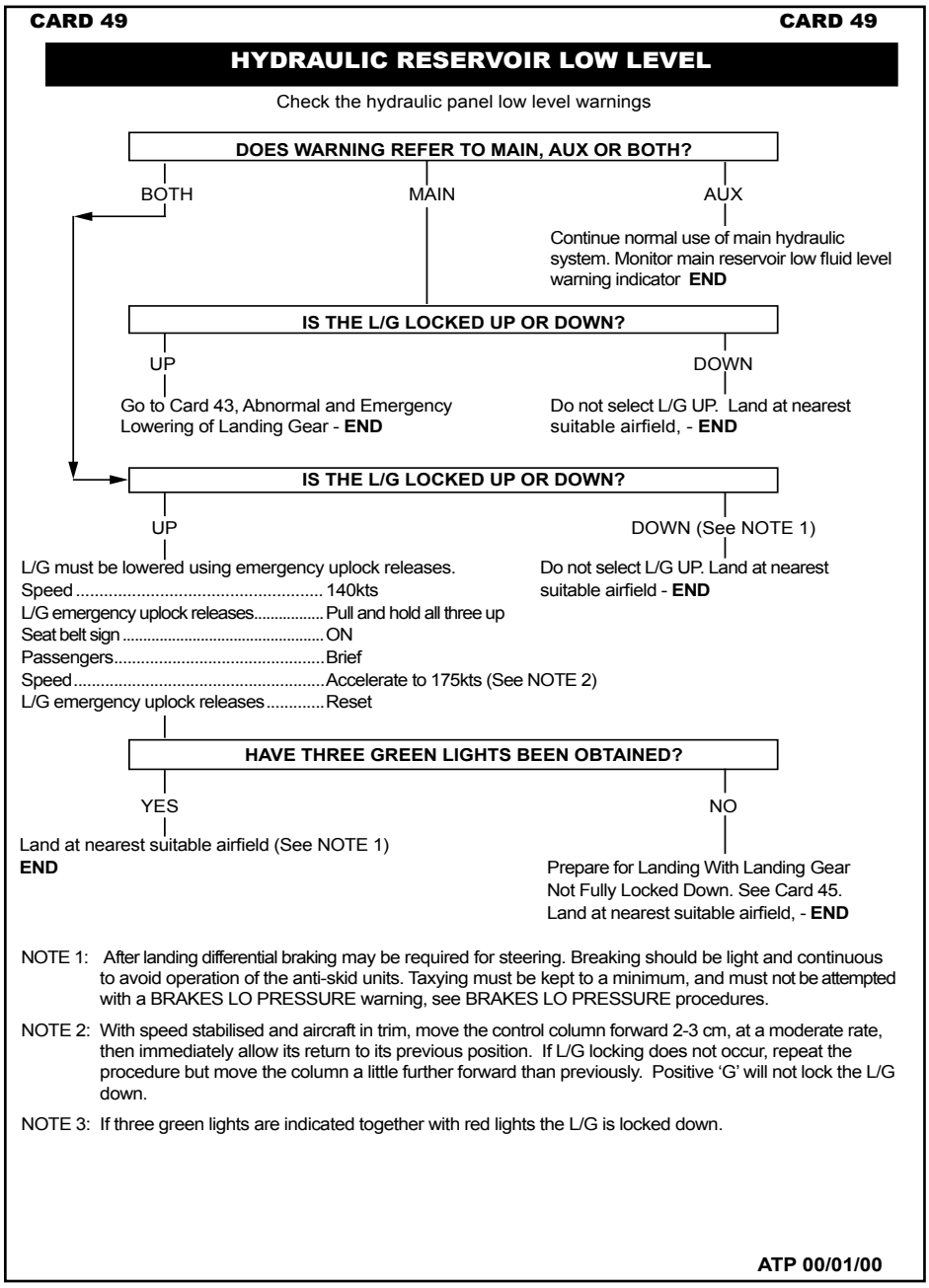
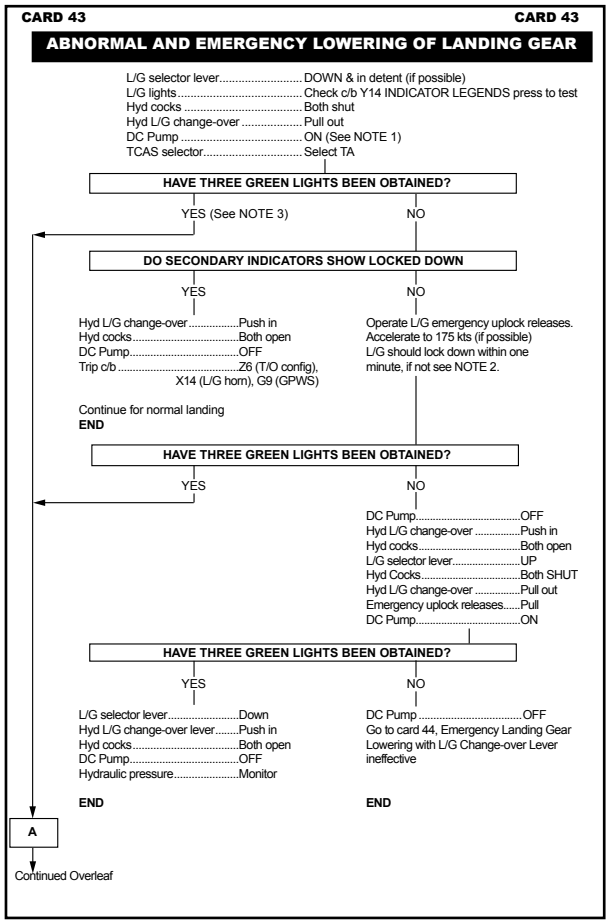


Figure 1

Hydraulic Reservoir Low Level Checklist

The commander advised the passengers over the public address system that there was a minor technical problem and that he intended to return to Ronaldsway. He also reassured them that there was no need for concern. Both cabin crew members moved along the cabin and personally reassured the passengers that they were not in danger. Some passengers were using sick bags and other available materials as improvised filters, to aid their breathing.



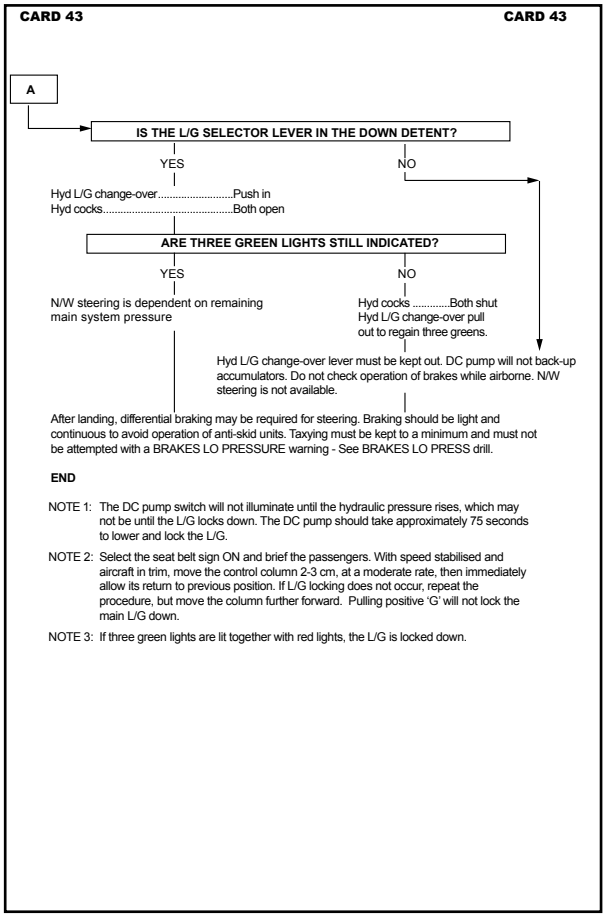


Figure 2

Abnormal and Emergency Lowering of Landing Gear Checklist

At 1727 hrs the No 1 contacted the commander by interphone and told him that the 'smoke' at the front of the cabin was so thick that the No 2 could not see anything if she sat in her normal seat. The commander instructed that she should sit further aft. At this point, without reference to the *'FIRE, SMOKE OR FUMES WITHIN FUSELAGE'* checklist, Figure 3, the commander selected the Environmental Conditioning System (ECS) packs off.

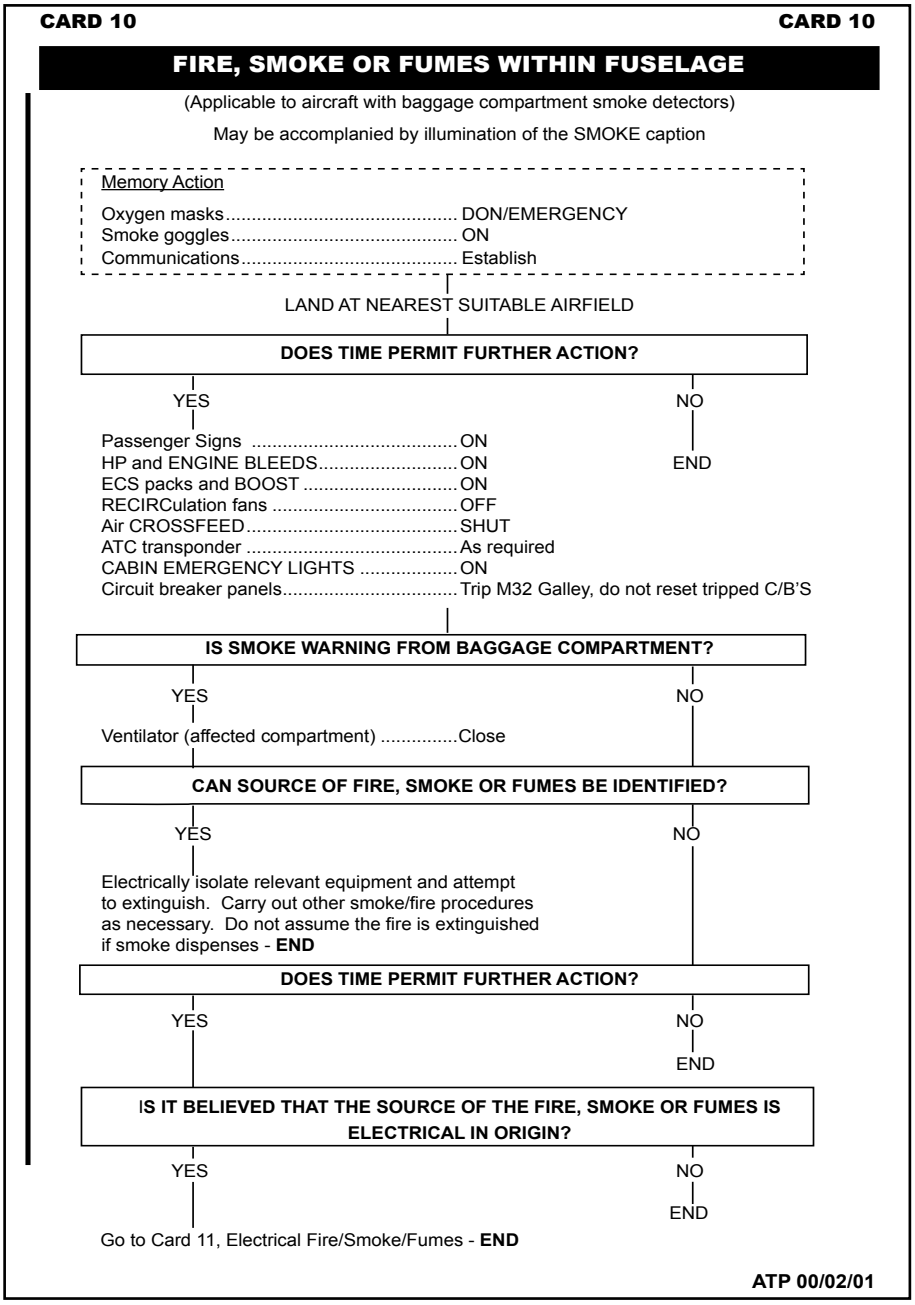


Figure 3

Fire, Smoke or Fumes within fuselage Checklist

At 1728 hrs the commander transmitted to ATC "WE'VE GOT SLIGHTLY MORE SMOKE IN THE COCKPIT NOW, SO WE'D LIKE TO MAKE THIS INTO A MAYDAY PLEASE"; the controller acknowledged this call. The flight crew then completed the descent checklist, one item of which required them to acknowledge that an approach briefing had been carried out. No briefing was given, but the commander asked the co-pilot if she was happy not to carry out a formal briefing, to which she agreed. He then calculated the approach speed for a Flap 20 landing. The co-pilot asked the commander to determine the speeds for landing, which he did before carrying out the approach checklist.

At 1730 hrs, with the aircraft approximately ten miles from touchdown, the No 1 called the commander and informed him that "ONE OF THE PASSENGERS CAN'T BREATHE" and was being given oxygen. The commander informed the No 1 that they would be landing in about four minutes and asked her whether she thought the situation would allow time for him to taxi the aircraft clear of the runway after landing. The No 1 replied that she hoped the emergency exit slides could be used at the rear of the aircraft, because the 'smoke' was nearly halfway along the cabin.

It seemed prudent to the cabin crew to move the passengers away from the worst of the 'smoke'. After doing so, the No 1 told the commander that "WE'VE HAD TO MOVE SOME PASSENGERS FURTHER DOWN". (The cabin crew had received no formal training concerning significant re-distribution of passengers in-flight, and the possible effect this might have on the handling qualities of the aircraft due, in this case, to the rearward movement of the aircraft's CG position.) The commander replied that he would see if he could clear the runway but added "IF IT LOOKS REALLY BAD", the No.1 should inform him. A short time later, the commander said to the No 1 that he planned to carry out "A NORMAL EVACUATION" on-stand, which she acknowledged.

The commander briefed the co-pilot that, although a go-around would be undesirable, there was no pressure to complete the approach and landing. The approach continued with the flight crew now in visual contact with the runway and the aircraft was configured with landing gear down and Flaps 7 set. ATC asked whether the intention was to evacuate the aircraft on the runway; the commander replied that he hoped to vacate the runway and park normally. The flight crew actioned the landing checklist and, at the item '*Flaps'*, the co-pilot requested Flaps 15, which was set by the commander[3]. The landing checklist also required that a 'cabin secure' report should have been received from the cabin crew. However, at this item, the commander said to the co-pilot "CABIN REPORT [pause] WE CAN ASSUME", which the co-pilot acknowledged.

[3] The checklist required that '*land flap'* (Flaps 20 or 29) be selected.

At 1733 hrs, with the aircraft established on the glideslope, the commander contacted the No 1 by interphone and asked about the 'smoke'. The No 1 informed him that the 'smoke' was only thin, not as bad as at the front and that, after landing, she hoped to be able to open the doors at the rear to allow air to circulate. The commander asked her again whether she thought that time would be available to taxi to stand. She replied that she thought there would be, but that she would contact him after landing.

As the approach continued, the co-pilot asked the commander whether he thought the 'smoke' might be related to the hydraulic problem; the commander replied that he did not know. The flight crew then briefly discussed the extra paperwork that would be necessary and whether there would be engineering staff available at Ronaldsway to address the problem. At the decision altitude the co-pilot confirmed that she had visual contact with the runway and disconnected the autopilot. At this point, the Enhanced Ground Proximity Warning System (EGPWS) sounded a "TOO LOW – TERRAIN" alert, which the commander dismissed as false, followed by a "TOO LOW – FLAPS" alert, which he also dismissed as false. However, he then realised that the flaps had not been set for landing, and that this latter warning was genuine. The warnings ceased after Flaps 20 was selected.

The co-pilot landed the aircraft at 1736 hrs. During the early part of the landing roll, the commander instructed the co-pilot to apply hard right rudder to maintain control. As the aircraft decelerated through 80 kt the co-pilot handed control to the commander who experienced difficulties in steering the aircraft using the tiller. He then realised that the nose wheel steering system was not functioning. ATC informed the flight crew that they could either vacate to the right onto the taxiway or shut down on the runway; the commander replied that he would try and vacate the runway. He reverted to steering the aircraft by applying differential braking and asymmetric thrust and was able to manoeuvre the aircraft onto Taxiway Bravo, Figure 4.

The No 1 called the flight crew on the interphone and informed the co-pilot that there was panic in the cabin and reminded her that one passenger, who was asthmatic, was being given oxygen. The No 1 then asked whether the aircraft would stop on the taxiway so that she could open a door. The commander broke into the conversation and informed the No 1 that the nosewheel steering system was not functioning, that manoeuvrability was extremely limited and that he was doing well to keep the aircraft moving in a straight line. The No 1 then asked whether she could have an ambulance or paramedic to attend the aircraft; the commander replied that this would be arranged.

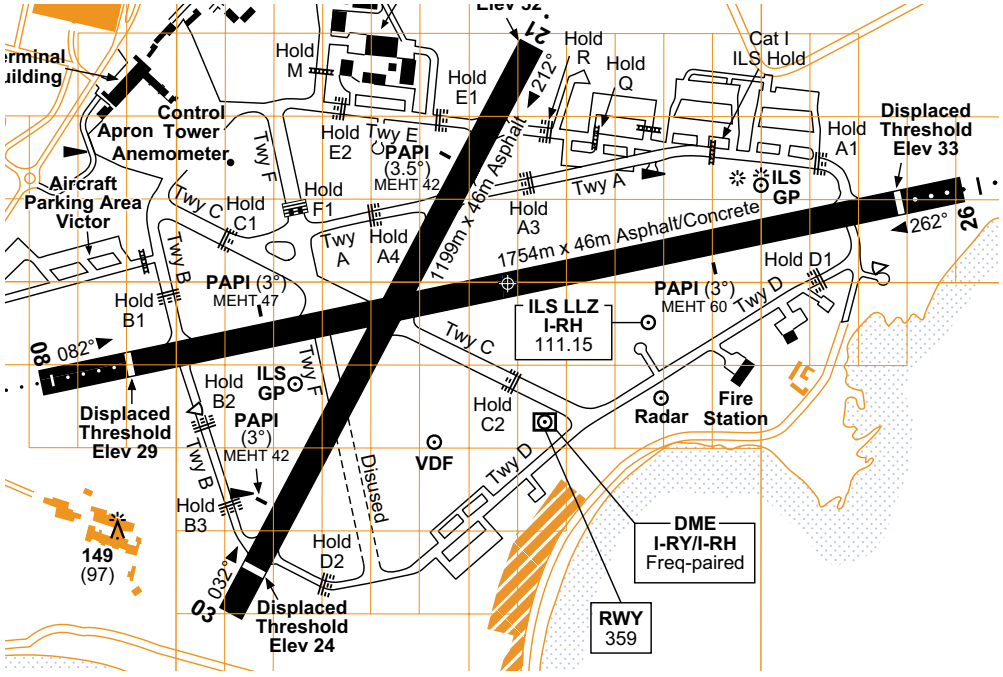


Figure 4

Layout of Ronaldsway Airport

ATC instructed the flight crew to bring the aircraft to a halt in its present position to permit access by the Airport Fire and Rescue Service (AFRS) vehicles. The commander acknowledged this instruction and informed the controller that he required an ambulance or paramedic to attend the aircraft, adding that a passenger had been slightly overcome by 'smoke'. The controller acknowledged this request and then spoke by radio with the Fire Leader[4] and asked him whether he had 'copied' the conversation with the flight crew concerning their request for medical support to attend the aircraft. The Fire Leader acknowledged that he had.

At about this time, the co-pilot asked the commander whether they should shut down the engines. The commander replied that he did not want to as he intended to taxi the aircraft further to avoid having to use the escape slides to evacuate the passengers. At 1738 hrs, he contacted the No 1 by interphone and asked whether the 'smoke' was getting any worse, adding that fire vehicles were coming to escort the aircraft. The No 1 replied that some passengers had sick bags over their mouths and that the smell was "AWFUL". She began to say "I REALLY WANT…", but the commander interrupted her, saying that he was going to start moving the aircraft again and would figure out how

[4] The Airport Fire Service officer in charge.

far the aircraft could go; he added that they would be no more than about another two minutes. The No 1 acknowledged this. The co-pilot then said to the commander that she thought that they should stop the aircraft in its present position. Immediately after this, ATC informed the flight crew "YOU MIGHT JUST AS WELL SHUT DOWN IN THAT POSITION THERE" and that a bus would be sent to disembark the passengers.

At 1739 hrs the commander contacted the No 1 again and told her that he now intended to shut the aircraft down in its present position and that a bus would be sent to the aircraft. The No 1 asked the commander whether he wanted the No 2 to open the forward passenger door in manual mode as soon as the propellers had stopped. The commander agreed to this. Accordingly, the No 1 then contacted the No 2 and instructed her to set the door to manual mode which, once done, was confirmed back to the No 1.

The commander then asked the co-pilot to go through the shutdown checklist. With the checklist partly completed, and after the engines had been shut down, ATC requested the flight crew to contact the AFRS on a dedicated frequency[5]. They were asked by a Fire Officer to open the forward door, deploy the steps and to describe the conditions in the cabin. The commander replied that one passenger was using oxygen and others were breathing through sick bags and feeling fairly nauseous. The Fire Officer acknowledged this and the conversation concluded. At 1740 hrs, the No 1 contacted the No 2 by interphone and instructed her to open the forward passenger door.

The flight crew completed the remaining items of the shutdown checklist. The No 1 made an announcement to the passengers telling them that they would soon be able to leave the aircraft by the forward passenger door. The commander then realised there was a slippery substance on the flight deck floor and deduced that it was hydraulic fluid. He inspected the area around the airstairs, concluding that the fluid had come from this region and that this was associated with the hydraulic fluid low level warning. The passengers left the aircraft via the forward vestibule and the airstairs, passing through the contaminated area.

The crew continued with their rostered duty using a similar aircraft belonging to the operator, taking with them the passengers from the incident flight.

[5] 121.6MHz is promulgated within the United Kingdom for use between aircraft and fire and rescue services.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	-	-	-
Serious	-	-	-
Minor/none	4	33	None

1.3 Damage to aircraft

Failure of a hydraulic seal and contamination of the passenger cabin and flight deck by hydraulic fluid.

1.4 Other damage

None

1.5 Personnel information

1.5.1 Commander: Male, aged 56 years

Licence:	Airline Transport Pilot's Licence (ATPL)
Medical certificate:	Class One, expiry date 9 March 2006
Flying experience:	6,193 hours total
	1,677 hours on type
	148 hours in the last 90 days
	44 hours in the last 28 days
Previous rest period:	More than 12 hours

The commander had been employed by the operator for approximately one year before the incident. His previous airline experience was gained as a commander on the ATP aircraft over a three-year period with another UK airline. He had also worked in general aviation (GA) flying piston, turboprop and small turbojet aircraft.

He had completed an Operator Proficiency Check (OPC) on 9 November 2004. The check had not included the item 'Smoke Control and Removal' as this was only required to be done once in every three checks. However, he had completed a 'Fire and Smoke' training course on 12 November 2004, including a module entitled *'Effects of Smoke in an Enclosed Area'*.

1.5.2 Co-pilot: Female, aged 30 years

Licence:	Commercial Pilot's Licence (Frozen ATPL)
Medical certificate:	Class One, issued 19 November 2004
Flying experience:	368 hours total
	120 hours on type
	N/K hours in the last 90 days
	N/K hours in the last 28 days
Previous rest period:	Off Duty: 12 hours

The co-pilot held a rating on the British Aerospace ATP aircraft. She had satisfactorily completed an OPC on 1 December 2004. This check had not included the item 'Smoke Control and Removal'. She also had completed a 'Fire and Smoke' training course on 18 May 2005, including the module *'Effects of Smoke in an Enclosed Area'*.

1.5.3 Senior Cabin Crew member (No 1)

The No 1 had flown as a member of cabin crew for a number of years, attaining a position as Senior Cabin Crew Member on long-haul widebody aircraft. She had undertaken the 'Fire and Smoke' training course on 2 April 2005.

1.5.4 Second cabin crew member (No 2)

The No 2 had only recently joined the company and had no previous experience as cabin crew. She had also undertaken the 'Fire and Smoke' training course, on 19 April 2005.

1.6 Aircraft information

1.6.1 Leading particulars.

Type:	British Aerospace ATP
Constructor's number:	2032
Date of manufacture:	1990
Registered owner:	Emerald Airways Ltd
Certificate of airworthiness:	Public Transport (Passenger) category, issued on 16 April 2004, expiry date 15 April 2007
Total airframe hours:	16,368 hours
Engines:	2 Pratt & Whitney Canada PW126A Turboshaft Engines

The aircraft documentation indicated that the most recent maintenance inspection was Part 2 of Checks 1A and 3A, which had been completed on 25 January 2005, at 16,126 airframe hours. The next inspection, a Check 2A, was due at 16,403 airframe hours.

1.6.2 General description

The ATP is a derivative of the HS 748 aircraft. It is a low wing all-metal monoplane, with maximum seating capacity of 72 passengers and powered by two turboprop engines. The aircraft's primary flight controls are manually operated, with a single main hydraulic system providing power for the landing gear and braking systems. The hydraulic fluid used is OM-15, a mineral based fluid which is not 'fire resistant', and which is now not generally used on larger commercial transport aircraft. An auxiliary hydraulic system, which has its own fluid reservoir and DC pump, is used to back up the main system, Figure 5.

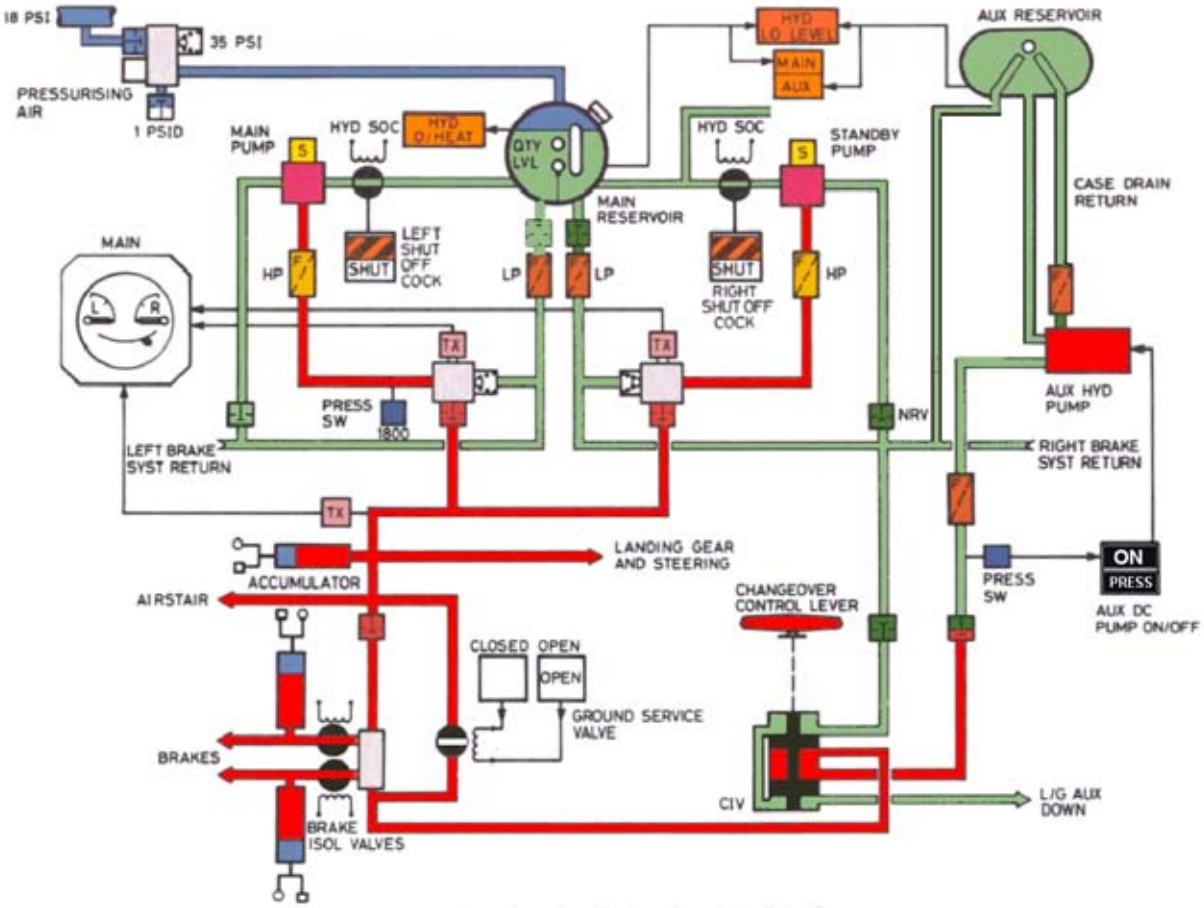


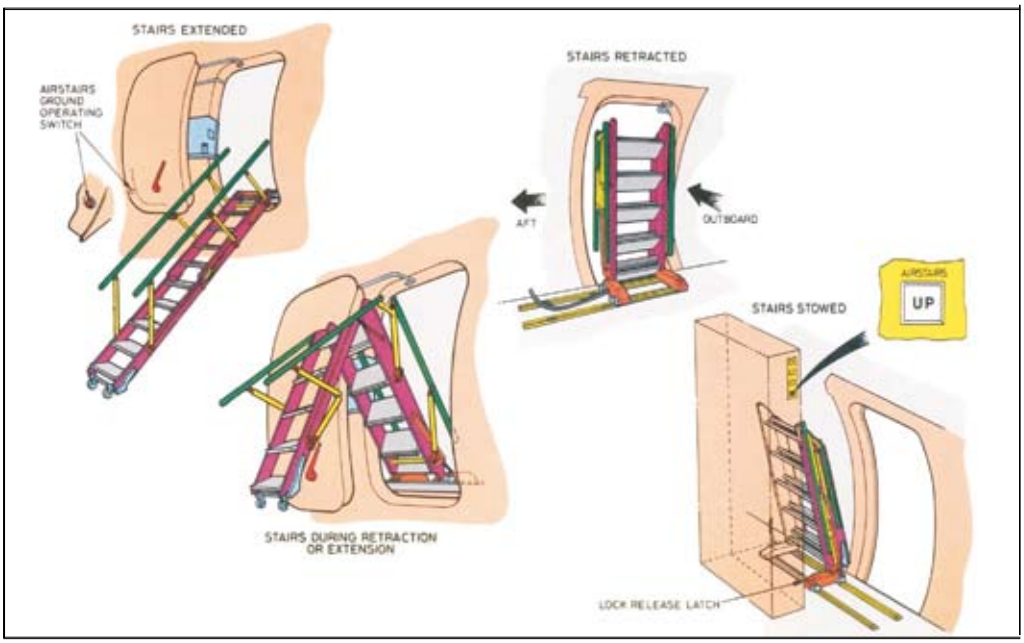
Figure 5

Schematic diagram of the ATP hydraulic system

With the aircraft on the ground, it may also be used to top-up the brake accumulators and to retract the airstairs via the main system accumulator. The flaps are electrically powered.

1.6.3 Airstairs system description

All passenger versions of the ATP are equipped with 'single-fold' airstairs, complete with folding handrails, located at the forward left side passenger door entrance. The unit is mounted on two roller tracks, fitted flush with the aircraft floor, which permits the whole assembly, when folded, to slide aft into a stowage area. This allows the entrance to remain clear to be used both as an emergency exit and for normal access via external steps. In normal operation, once the door is in the fully open position, the airstairs are manually slid forwards towards the front of the aircraft. They are then locked and pushed outward allowing them to extend under the influence of gravity. Figure 6 illustrates the principle of operation of the airstairs, Figure 7 shows a schematic diagram of the operating system.



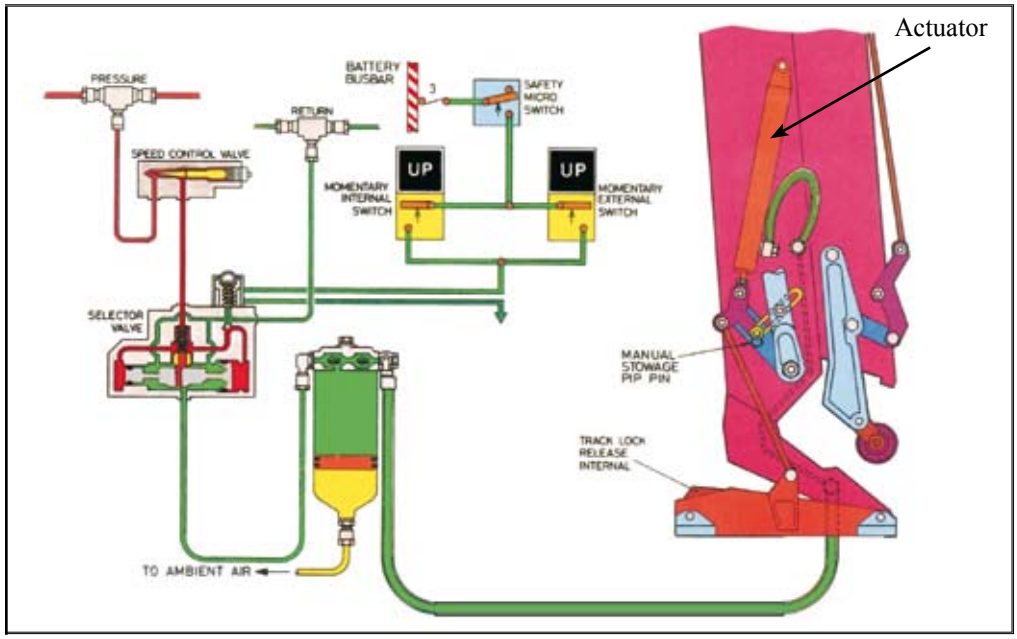
AIRSTAIRS SYSTEM OPERATION

Figure 6

Principle of airstairs operation

Retraction is achieved by the aircraft hydraulic system and is electrically activated from the 28V DC battery bus by means of a solenoid-operated hydraulic selector valve. Two single-acting hydraulic actuators are attached to the airstairs, one on either side of their structure. They are retracted by pressing either of two spring-loaded, non-latching switches; one switch is located on the door, and is accessible by ground crew outside the aircraft, the other is mounted on a

panel at the cabin attendant's call station adjacent to the airstairs stowage area. This switch is provided with a transparent plastic 'flip-guard', hinged along its upper edge, designed to prevent inadvertent operation. When the retraction is complete, the switch is released, allowing its internal spring to return it to the off position. This de-energises the solenoid on the selector valve, isolating the hydraulic pressure supply from the airstairs retraction system.



AIRSTAIRS HYDRAULIC SYSTEM OPERATION

Figure 7

Airstairs hydraulic system operation

A safety microswitch, operated by a spring-loaded plunger, is attached to the door hinge mechanism. The operation of the microswitch is achieved by movement of a plunger, which is in contact with a roller mounted on the switch actuating arm, Figure 8. The plunger is depressed by fully opening the door, bringing the roller into contact with the larger diameter parallel section. This pushes down on the actuating arm, placing the switch in its 'made' state; electrical continuity is achieved, enabling power to be supplied to the airstairs retraction system.

1.6.4 Enhanced Ground Proximity Warning System (EGPWS)

The aircraft had been fitted with an EGPWS installation some months prior to the incident. However, regular false or nuisance alerts and warnings had been experienced. Typically, these occurred during the approach phase of flight at about 200 ft above touchdown.

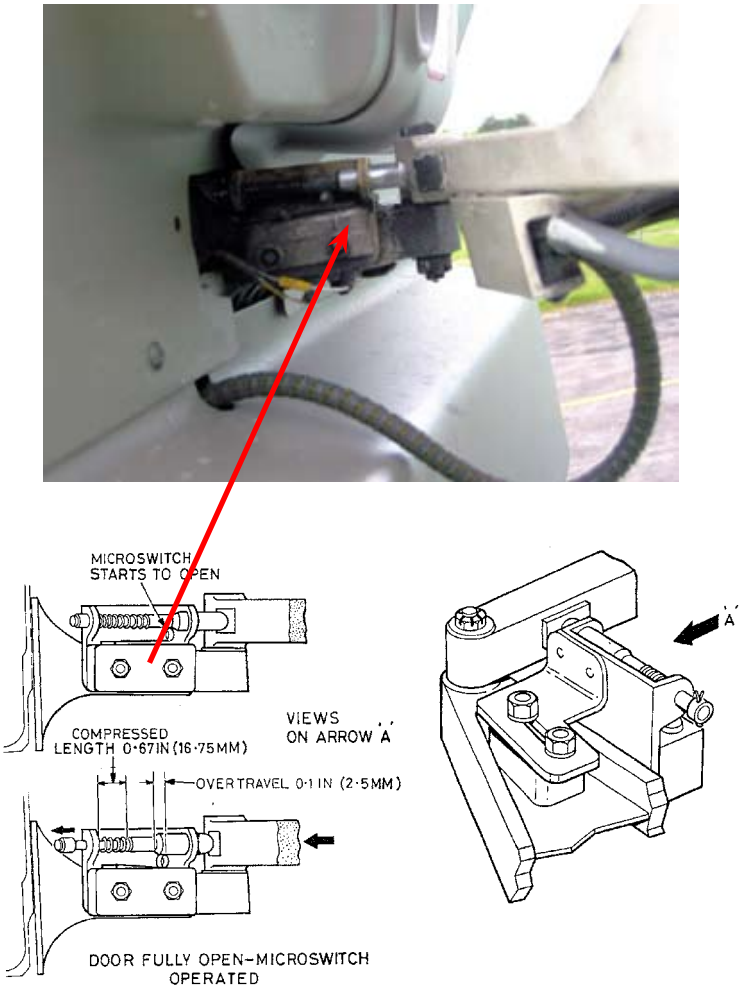


Figure 8

Operation of door safety microswitch

1.6.5 Aircraft weight and centre of gravity (CG) position

The aircraft was loaded for departure in accordance with the loadsheet; its mass was within limits and the CG position was determined to have been 24% Mean Aerodynamic Chord (MAC). At the aircraft's takeoff weight of 20,241 kg, the limits were 21% to 29 % MAC. During flight, as the 'smoke' intensified in the front of the cabin, the cabin crew moved some passengers towards the rear. No specific note was taken of the seats that passengers occupied at the time but the cabin crew recalled that they were all seated aft of row seven or eight. Calculations determined that the aircraft's CG position, after the passengers had moved, was between 30% and 31% of MAC, in a region marked on the company's loadsheet as *'UNSAFE FOR FLIGHT'*[6].

[6] The weight and CG position limits shown on the Operating Company's loadsheets were more restrictive, than those presented in the Aircraft Flight Manual (AFM) produced by the aircraft manufacturer. The best estimate of G-JEMC's actual CG position, made by the manufacturer, suggested that it had been within the AFM specified limits.

The company's Operations Manual states, in section 7.2.1:

> *'Responsibility of the Aeroplane Commander:*
>
> *At all times, the Commander is to ensure that the aeroplane is loaded in accordance with Company procedures and requirements. He must ensure that no mass limitation is exceeded and that he must ensure that the C.of G. will remain inside the envelope at all times during the flight.'*

There is no specific responsibility placed on the cabin crew with regard to mass and balance.

1.7 Meteorological information

The incident occurred in daylight.

The Meteorological Actual Report (METAR) at 1720 hrs stated that the wind was 220°/24 kt, visibility was greater than 10 km, there was a slight shower of rain, cloud was FEW cumulonimbus cloud at 1,800 ft, SCATTERED at 3,000 ft, and BROKEN at 4,500 ft above the aerodrome, the temperature was +11ºC, the dewpoint +8ºC, and the sea level pressure was 1006 mb.

The METAR at 1750 hrs stated that the wind was 230º/21 kt, visibility was greater than 10 km, there was a slight shower of rain, cloud was FEW cumulonimbus cloud at 1,800 ft and BROKEN at 4,000 ft above the aerodrome, the temperature was +11ºC, the dewpoint +8ºC, and the sea level pressure was 1006 mb.

1.8 Aids to Navigation

Not relevant

1.9 Communications

1.9.1 All communications between G-JEMC and ATC at Ronaldsway, including that on 121.6 MHz between the Airport Fire Service and the flight crew, were recorded in the control tower and on the aircraft's CVR, and used to assist in generating the '*History of the flight*' section of this report.

1.10 Aerodrome information

A plan of the airfield is presented at Figure 4.

1.11 Flight Recorders

The aircraft was fitted with a half-hour duration Cockpit Voice Recorder (CVR), part number 93-A100-83, and a 25-hour duration Flight Data Recorder (FDR), part number PV1584F1. The CVR recordings were of a good quality and covered the period from before takeoff to when electrical power was switched off during the shutdown checks. Information from the FDR was also used to assist in generating the '*History of the flight*' description at the beginning of this report.

As well as the verbal communication, the CVR recorded the sounds associated with various system alerts. One sound was recorded that was neither recalled by the crew nor identifiable to the airframe manufacturer. Analysis has ruled out an association with any crew alerting systems, including the stick-shaker. The sound is presumed to have been associated with a normal aircraft function but propagated through the airframe to the microphone. Consequently, it would have been inaudible to the flight crew.

The FDR was successfully downloaded, yielding 30 parameters over a period of nearly 28 hours. This covered 46 flights, including the incident flight, for which the recording covered the 23 minutes from engines start to shut down. There were no recorded parameters relating to the landing gear status or the hydraulic systems. The FDR documentation for the aircraft indicated that autopilot status and GPWS alert parameters were recorded.

No engineering records were produced relating to the calibration of the FDR recorded parameters; the information presented is uncalibrated, resulting in reduced confidence in the accuracy of some parameters due to possible sensor drift.

The pertinent FDR recorded parameters are shown in Figure 9, together with relevant extracts from the CVR. The CVR recorded the autopilot disconnect alert, approximately 30 seconds before touchdown, with selection of landing flap occurring shortly thereafter.

A comparison of pitch-related parameters towards the end of the flight is made with those from other landings, in Figure 10. Of note, the aircraft pitch trim setting was significantly more nose-down, the (left) elevator angle was deflected significantly more in the aircraft nose-down sense, and the aircraft's pitch attitude

during the final descent, was amongst the highest recorded of the preceding 46 flights. Also, there was an apparent change in the aircraft's pitch stability at the end of the flight, following selection of Flap 15 in preparation for landing. Had landing flap been selected at the appropriate time on approach, additional nose-up pitch forces would have occurred over a longer period.

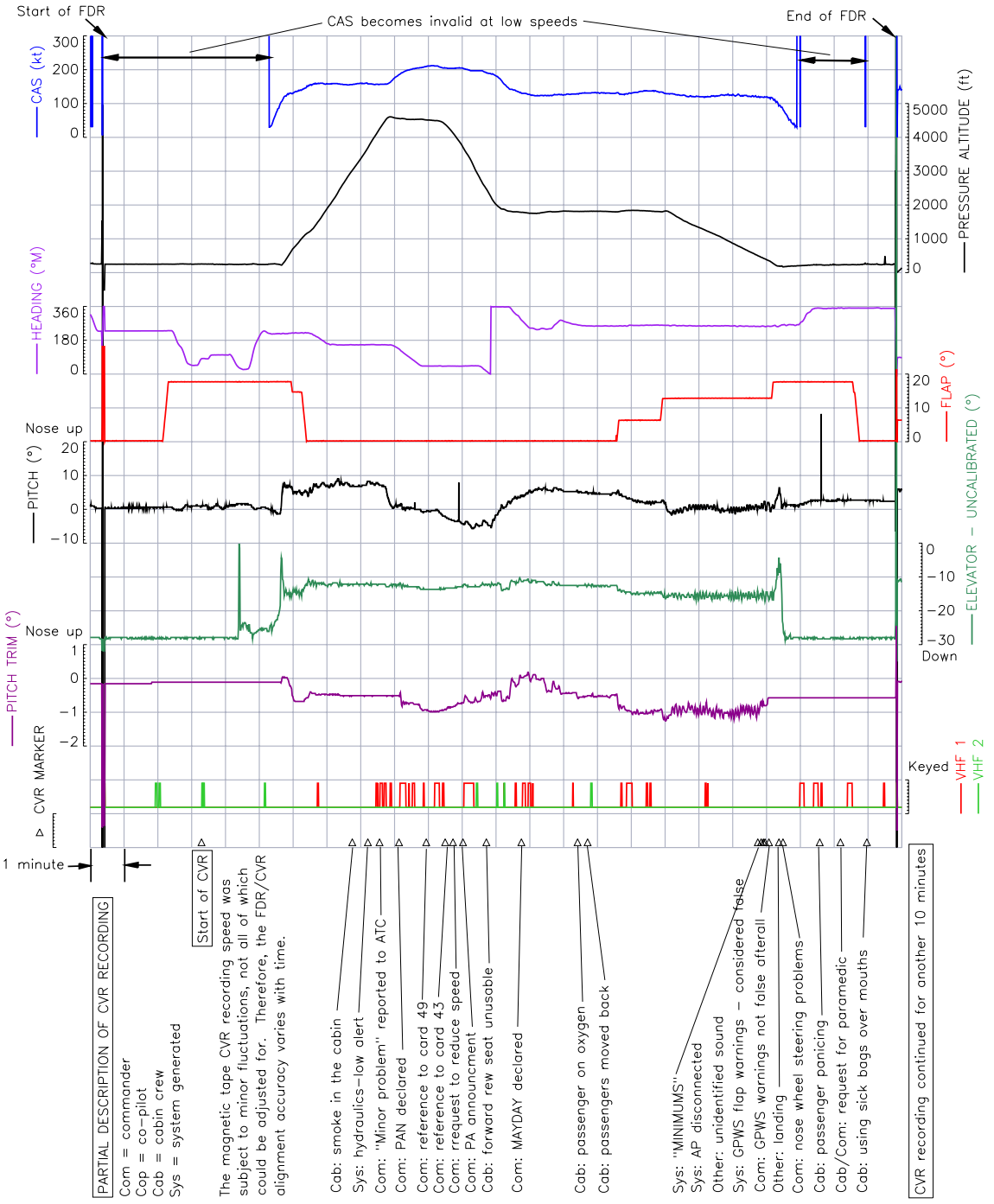


Figure 9

Selected FDR recorded parameters shown against pertinent CVR extracts

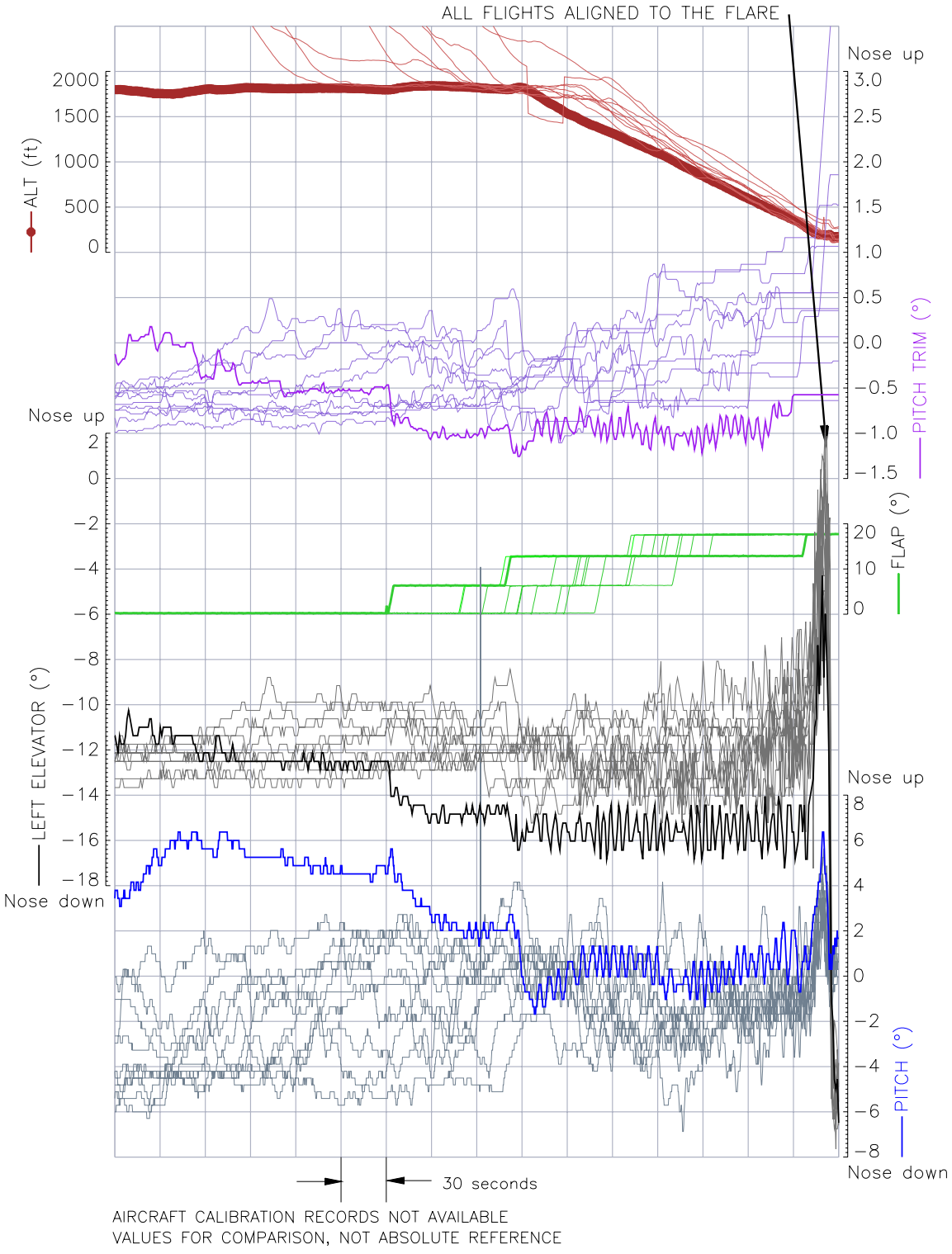


Figure 10

Comparison of pitch related parameters against those of previous flights.
The bold lines relate to the event flight and the rest relate to previous flights recorded on the FDR

1.12 Wreckage and impact information

1.12.1 Examination of the aircraft

1.12.1.1 General

The floor in the vestibule area of the cabin had been heavily contaminated with hydraulic fluid. This extended into the flight deck and the main cabin area, although this was most probably the result of being carried on the feet of AFRS personnel following the deplaning of the passengers. A large quantity of fluid had leaked through the floor and had formed pools in the bottom of the equipment bay beneath the vestibule. Subsequent inspection of the hydraulic reservoir for the main system revealed that it was virtually empty; the auxiliary system reservoir remained full.

The auxiliary hydraulic system was activated by switching on the DC pump, following which the airstairs UP switch was briefly pressed. This immediately produced a hydraulic fluid spray, emanating from a 'banjo' type connection to a rigid hydraulic pipe on the airstairs frame. Whilst the auxiliary hydraulic system was operating, the opportunity was taken to check the operation of the nosewheel steering system. Operation of the steering tiller produced a corresponding movement of the nosewheel.

1.12.1.2 Airstairs UP switch

On inspection of the switch panel at the Flight Attendant's call station, it was immediately apparent that the airstairs UP switch was being held in the depressed position by the plastic flip-guard. This had been lifted beyond its usual 90° position such that it was lying against the switch panel, Figure 11. Lying thus, the switch button had become trapped behind the upper edge of the guard, preventing the switch spring from returning the switch to the OFF position.

Examination of the guard on a similar aircraft revealed the presence of a baulk strip, bonded to the outer face of the guard, close to its upper edge. Rotation of the guard significantly beyond the 90º position caused the baulk strip to make contact with the surface of the switch panel and this served to discourage attempts to rotate it further, Figure 12. The presence of the baulk strip identified the flip-guard as a 'Korry' type, which was introduced following an earlier incident (see Section 1.18.1). Additional examination of the flip-guard from G-JEMC revealed traces of adhesive, showing that a baulk strip had been present at some stage, and that this had most probably been broken off as a result of the guard being forced beyond the 90º position.

Figure 11

'As-found' position of airstairs retraction switch flip-guard, holding switch in

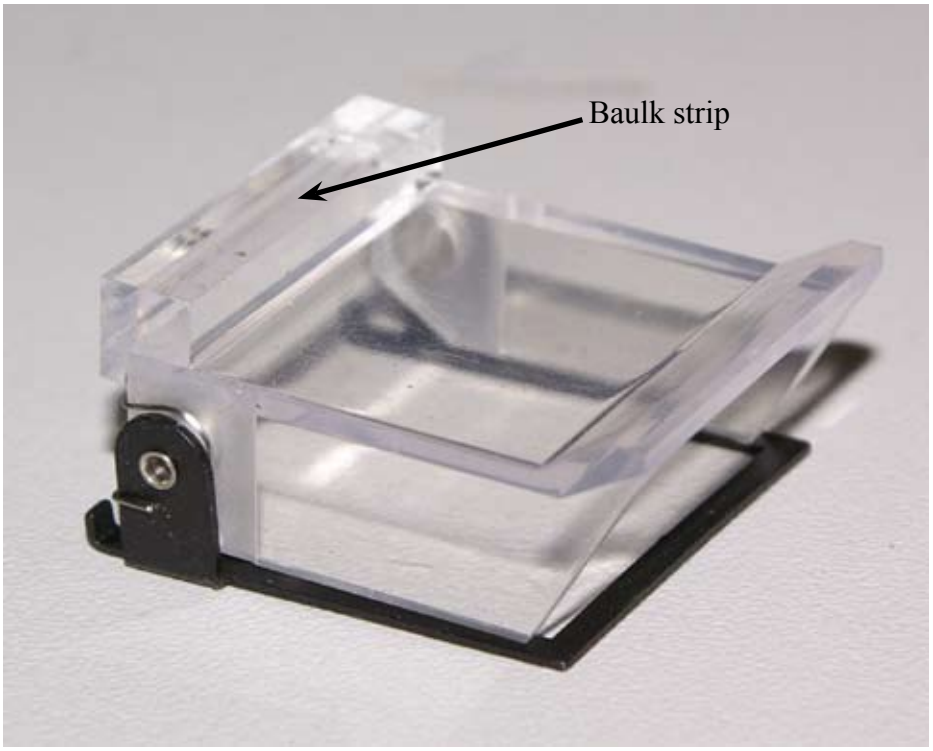


Figure 12

New flip-guard showing baulk strip, which prevents guard from being rotated beyond 90º position

1.12.1.3 Door safety microswitch

Figure 13 shows a photograph of the safety microswitch and its associated plunger, as it was found immediately after the incident. The plunger had remained in its depressed state, despite the fact that the door had been moved away from its fully open position[7]. The reason for this was not clear: it appeared that the contact force between the roller and plunger may have exceeded the ability of the spring to move the plunger. This in turn implied that the axis of the plunger may not have been exactly parallel to its line of travel, so that the contact force between the roller and plunger increased with distance travelled. When finger pressure was applied to the end of the plunger, it was found that it could be encouraged to stick in the depressed position if it was pushed, against spring pressure, to its full limit of travel. This raised the possibility that the door may have over-travelled at some stage, which would have had the effect of extending the plunger travel beyond normal.

Figure 13

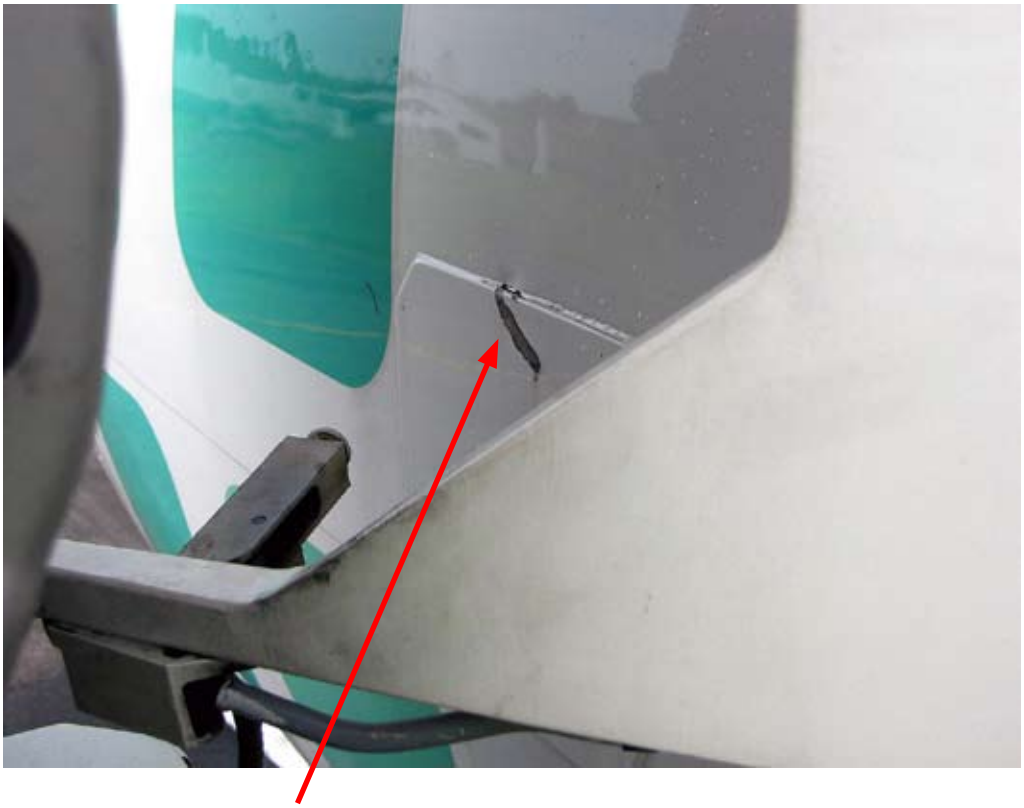
'As found' stuck switch condition of the door safety switch

The general appearance of the microswitch and plunger assembly was slightly grimy, with a sheen of grease, although the latter may have originated from nearby hinge components. The microswitch was subsequently cleaned and adjusted in accordance with the Aircraft Maintenance Manual (AMM), following which it operated normally; it could not be encouraged to stick. It was noted that

[7] Unless the door is in the fully open and locked position, this switch should be 'open circuit', thereby isolating electrical power from the airstairs system.

the Aircraft Maintenance Manual did not specify any lubrication to be applied, and neither the operator nor the aircraft manufacturer specified any periodic inspection of the microswitch and plunger assembly. No record was found of the last time that this component had been inspected, adjusted or refitted.

The door was fitted with a stop, comprising a plastic strut with an adjustable pad at its end. With the door fully open, the pad came in to contact with a reinforcing plate attached to the fuselage but, when the door was forced further open, the strut could be made to deflect, causing the pad to slide off the edge of the reinforcing plate. This had caused a significant dent in the fuselage skin. The presence of a scar on the surface of the plate indicated that this had occurred in the recent past, Figure 14. Examination of another aircraft revealed no evidence of such a scar and that the strut appeared to be more rigidly attached than on G-JEMC. However, it was noted that the reinforcing plate on the other aircraft was positioned lower on the side of the fuselage than on G-JEMC, resulting in a significant dent being made in the fuselage skin.

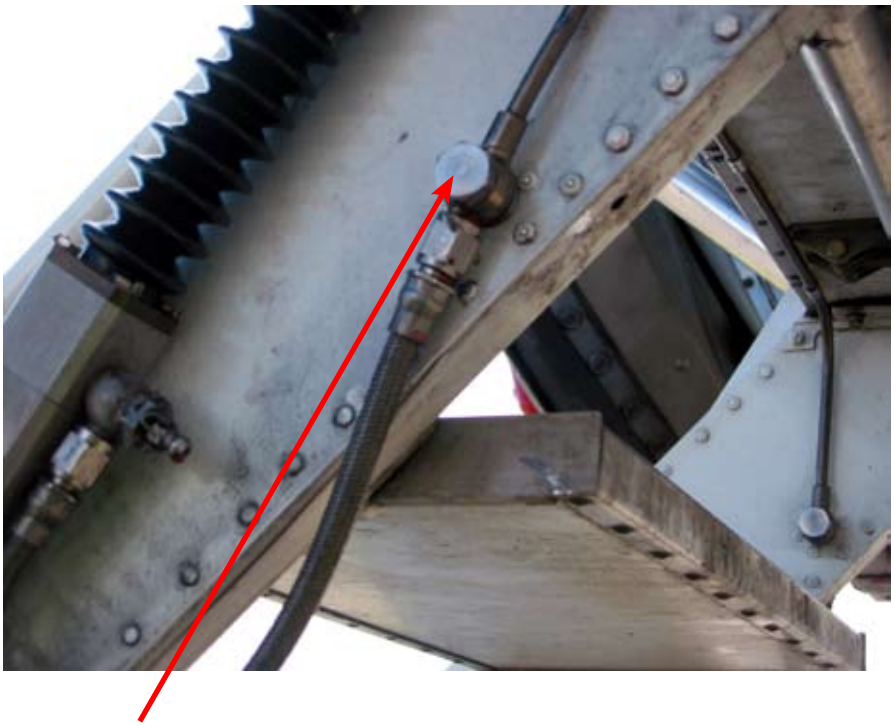


Scar on fuselage reinforcing plate caused by door stop deflection

Figure 14

1.12.1.4 Hydraulic leak

Hydraulic fluid was found to be leaking from the banjo fitting on the right side of the airstairs, when viewed from outside the aircraft. The fitting marked the point where the hydraulic pressure supply pipe bifurcated, with one (flexible) pipe leading to the actuator mounted nearby, the other routing underneath one of the airstairs rungs to the actuator on the opposite side, Figure 15.



Banjo fitting associated with the hydraulic fluid leak

Figure 15

The part number of the seal from the banjo fitting associated with the leak was 300-202-1911-02, with the last two numerical groups referring to the rubber material from which the seal was made and the metal outer ring respectively. According to the manufacturer's data sheet, the seal burst pressure is 1,270 bar, or approximately 18,500 psi, ie well in excess of the aircraft's main hydraulic system operating pressure of 2,450 psi. The seals had not burst and appeared intact, Figure 16.

Figure 16

Banjo bolt with 'intact' seals

1.13 Medical and pathological information

1.13.1 Effects of hydraulic fluid mist

The hydraulic fluid used in the ATP is a mineral-based fluid to the specification DS9l-48 (US alternative MIL-H5606-E). It is used extensively in aircraft operated by the Royal Air Force, where it is known as OM-15. The relevant UK Ministry of Defence Safety Data Sheet states, '*...inhalation of mist and vapour may cause irritation to nose and respiratory tract.*' Although the fluid contains ingredients classified as hazardous, they are not present in sufficient quantities to warrant classifying the product as hazardous.

1.14 Fire

Despite the cabin crew's belief that the hydraulic fluid misting was smoke, there was no fire on board the aircraft.

1.15 Survival aspects

There were no direct survival issues resulting from the flight, the landing or disembarkation.

However, there were potential problems associated with the hydraulic fluid leak. OM-15 hydraulic oil is a petroleum based 'mineral' oil and is inherently flammable, particularly when in the form of a mist. Its flash point[8] is in the region of 90ºC to 110ºC. The cabin systems and equipment in this aircraft, eg, lighting and galleys, in common with most commercial transport aircraft, are not designed to be 'intrinsically safe'[9]. Therefore, while the mist or 'smoke' was present in the cabin, a risk of fire existed. There was also a risk of overpressure within the fuselage, should an ignition source with sufficient energy have ignited the oil/air cloud.

1.16 Tests and Research

None

[8] The minimium temperature at which the oil vapour will ignite, under test conditions.

[9] Intrinsically safe items are designed not to produce sparks or have exposed surfaces at elevated temperatures, so that they may be used in atmospheres containing flammable vapours.

1.17 Organisational and management information

1.17.1 The Operations Manual

Extracts from the operator's Operations Manual (OM) Part B4 11.5.4.h, are reproduced at Appendix A. These include information on likely sources of fire and high-risk areas on-board aircraft, and procedures for cabin crew in a 'smoke filled cabin' situation. In particular, the OM states the following:

> *'Smoke-filled Cabin*
>
> *No visual sign of fire is a dangerous situation as it could indicate smouldering wires/cables in the concealed electrical systems within the aeroplane.*
>
> *Smoke will filter into the cabin through the air conditioning system, or will seep through joins in the cabin side wall trim panels if a fire is concealed between the outer and inner skins of the aeroplane.*
>
> *i) Inform the Commander IMMEDIATELY, so that he may take whatever action is necessary, ie, ventilate the cabin'*

and

> *'v) If any passengers are having breathing difficulties they should be moved as far away from the source of the smoke and oxygen should be administered.'*

1.17.2 Crew scheduling and duty

The flight crew had been rostered for a six sector duty day, commencing at Ronaldsway, consisting of three round trips to Liverpool. The commander had spent the night in hotel accommodation near Ronaldsway, and the co-pilot had spent the night at her home, also nearby. Two cabin crew members worked the first three sectors, and two other cabin crew members, the No 1 and No 2, joined the aircraft for the remaining three sectors.

1.17.3 Crew co-ordination

The operator's Operations Manual contained the following with respect to Crew Co-ordination:

'CREW CO-ORDINATION

The concept of operation is that the PF (Pilot Flying) flies the aeroplane and the PNF (Pilot Not Flying) operates the systems at the behest of the PF.

Checks are called for by the PF and normally conducted by using the 'CHALLENGE AND RESPONSE' method: the PNF challenging. Exceptions are airborne Check Lists, Emergency Check Lists and After Landing Checklists, which are mostly PNF to "read and do", Whenever the PF requires the PNF to make a power change or operate a system, he must identify the system first…'

1.18 Additional information

1.18.1 Previous incidents

A search of the CAA Mandatory Occurrence Report (MOR) database revealed the following three incidents, on separate ATP aircraft, involving the airstairs:

- *'June 1989. During pre-flight checks, there was an uncommanded retraction of the airstairs following selection of the DC hydraulic pump. It was found that the airstairs selector switch had stuck in the IN position'*

It was this incident that led to the modification of the 'Korry' flip-guard on the switch.

- *'March 1994. An uncommanded retraction of the airstairs occurred during passenger boarding when the hydraulic system was pressurised. The selector switch was found seized in the active position'*

- *'May 1997. During the climb, a smell of hydraulic fluid became evident in the vicinity of the airstairs, followed by a Main Hydraulic System Low Level Warning. The aircraft returned for an uneventful landing. The subsequent investigation revealed that the flexible hose attaching to the airstairs actuator had split'*

The door safety microswitch and its associated plunger were not mentioned in any of the above Occurrence Reports. In the first two incidents, the door was open; thus there would have been electrical continuity through the microswitch

in any case. In the 1997 incident the door was closed, so the microswitch should have been open circuit, thus preventing hydraulic pressure being applied to the hose. This being the case, the leak would have to have occurred during airstairs retraction. However, it would seem unlikely that the amount of fluid released from the ruptured hose during the airstairs retraction process would be sufficient to cause a fluid low level warning, yet remain unnoticed by the cabin crew until after takeoff. It therefore seems likely that the door microswitch was stuck in the closed position, in the same manner as occurred in the incident to G-JEMC. In this incident, the narrative noted that the CAA considered it to be an isolated incident and that both the manufacturer and operator had taken 'appropriate action'.

1.18.2 Action by the aircraft manufacturer

Following the incident to G-JEMC, the manufacturer issued an All Operator Message (AOM), Reference 05/015J, dated 15 July 2005. This provided factual information on the incident and listed the following manufacturer's recommendations:

- During any smoke/fumes event it is vital that flight deck crew follow the appropriate emergency checklist in its entirety.

- On any guarded switch throughout the aircraft, check the integrity of the guards for wear and also for missing parts such as guard baulk strips.

- Check the integrity of the airstairs safety microswitch door hinge plunger to ensure it is operating satisfactorily. Refer to AMM Task 52-60-00-820-830.

1.18.3 Certification requirements

The ATP was certificated to Joint Airworthiness Requirements (JAR) Part 25 at Change 8. These requirements did not (and currently do not) preclude the location of hydraulic components within the passenger cabin. The relevant regulation is JAR 25.1435, within Sub-part 'F' - Equipment, and is primarily concerned with the design, operation and testing of the system. Requirement 25.1435(b)(3) states that the hydraulic system must have:

'…….means to minimise the release of harmful or hazardous concentrations of hydraulic fluid or vapours into the crew and passenger compartments during flight.'

The majority of the hydraulic system components in the ATP are located outside the pressure shell. The main reservoir, filters, ground connections, shut-off cocks, etc, are grouped in the hydraulic bay in the right wing root fillet with additional components, such as the auxiliary reservoir and brake system accumulators, located in the nose landing gear bay. A hydraulic conduit runs along the fuselage keel, between the wing and the nose landing gear bay. The only hydraulic components within the cabin are the airstairs retraction actuators and their associated hoses and pipe-work. These, however, remain unpressurised in normal circumstances, whenever the door is not fully open and the airstairs UP switch is not depressed.

1.18.4 Centre of gravity effect on nosewheel steering

The manufacturer was asked to provide their assessment of the position of the aircraft's centre of gravity and its likely effect on the ability of the nosewheel to steer the aircraft. The nose landing gear leg on the ATP is equipped with a microswitch that enables the steering mechanism when the strut is compressed by approximately 15 mm. According to the landing gear manufacturer, this would occur with a load on the wheels of around 1,043 kg with the oleo pressurised within normal limits. At the aircraft's estimated landing weight and passenger distribution, the calculated load on the nose leg would have been approximately 1,434 kg. The calculations were for static conditions only and took no account of braking action or aerodynamic effects.

1.18.5 Abnormal and emergency lowering of landing gear checklist

This checklist (Figure 2) provides flight crews with the following information:

> *'N/W steering is dependent on remaining main system pressure'*

and

> *'After landing, differential braking may be required for steering. Braking should be light and continuous to avoid operation of anti-skid units. Taxying must be kept to a minimum…'*

1.18.5 Declaration of an emergency, Appendix B

'The Radiotelephony Manual (CAP 413)' details the information to be passed (circumstances permitting) and the manner of the declaration, whenever an aircraft commander considers it necessary to notify ATC of an urgent or emergency situation.

In particular, the nature of the emergency (either a PAN or a MAYDAY) should be transmitted first, with the word MAYDAY being repeated as a single group of three words, and PAN as three groups of two words, ie, 'MAYDAY MAYDAY MAYDAY' or 'PAN PAN, PAN PAN, PAN PAN'.

1.18.6 CAA FODCOMs

The CAA publish Flight Operations Department Communications (FODCOMs) as a means of informing holders of Air Operator's Certificates (AOCs) of various matters of relevance. FODCOMs 17/2000, 14/2001, 21/2002, and 22/2002 give guidance and instruction regarding smoke and fire on-board aircraft. Appendix C details relevant extracts from these FODCOMs. Of note, FODCOM 17/2000 states the following:

> *'The first action in the event of smoke or fumes in the flight deck should be for the flight crew to don oxygen masks and establish communications.'*

All of these documents include the statement:

> *'Recipients of new FODCOMs are asked to ensure that these are copied to their 'in house' or contracted maintenance organization, to relevant outside contractors, and all members of their staff who could have an interest in the information or who need to take appropriate action in response to this Communication.'*

No record could be found that the operator had informed their flight crew members of the contents of FODCOMs 17/2000, 14/2001, 21/2002 and 22/2002.

1.19 New investigation techniques

None.

2.0 Analysis

2.1 Crew handling of the emergency

2.1.1 Crew actions following the notification of 'smoke'

From analysis of the CVR recording it is clear that, throughout the flight, the co-pilot was primarily concerned with her duties as Pilot Flying (PF) and the commander, who remained in overall charge of the situation, the duties of the Pilot Not Flying (PNF). It was apparent from the conversation between the flight crew on final approach, during which the co-pilot asked the commander if he thought that the hydraulic problem was the cause of the 'smoke', that he had at that time not made the connection between the onset of the 'smoke' and the near co-incident low hydraulic fluid quantity warning. However, after the 'smoke' had been reported, the commander informed ATC that the aircraft had "A MINOR PROBLEM" and requested to return to the airport.

The presence of 'smoke' was noticed on the flight deck shortly after the HYD LO LEVEL alert. Without knowledge of its origin or the severity of any potential 'fire', the commander decided, initially, to action the checklist appropriate for low hydraulic fluid quantity. Having determined that the alert related to the main system, the checklist presented alternative drills, depending on whether the landing gear was UP or DOWN. The landing gear was UP, but the commander decided to select it to down, although this was not called for in the drill. With the gear locked down, no further action was called for in the checklist. However, the drill for the landing gear UP case directs the reader to the *'ABNORMAL AND EMERGENCY LOWERING OF LANDING GEAR'* checklist. Of significance, this checklist provides flight crews with the following information:

> *'N/W steering is dependent on remaining main system pressure'*

and

> *'After landing, differential braking may be required for steering. Braking should be light and continuous to avoid operation of anti-skid units. Taxying must be kept to a minimum…'*

Had the commander read this information, it might be expected that he would have stopped the aircraft and shut down the engines as soon as possible after landing, rather than attempt to taxi the aircraft to a stand, especially as this would not have been a problem for ATC. However, he expressed his concern over the use of the escape slides to evacuate the passengers and stated his intention to carry out a "NORMAL EVACUATION" on stand.

The reports of 'smoke' were received simultaneously with the low hydraulic fluid contents warning. Although these reports of 'smoke' made no mention of fire, it would seem prudent for the commander to have assumed that there was indeed a fire in the cabin or at least to have considered the possible hazardous consequences of fumes. Handling the aircraft at this stage of flight was not dependant on hydraulic pressure as the flight controls are manually operated. It might, therefore, have been expected for the commander to have actioned the *'FIRE, SMOKE OR FUMES WITHIN FUSELAGE'* emergency checklist as a matter of priority, as he was aware of 'smoke' in the cabin and on the flight deck, and considered the situation serious enough to transmit to ATC "WE HAVE REPORTS OF A LITTLE BIT OF SMOKE IN THE CABIN" and "WE'VE GOT SLIGHTLY MORE SMOKE IN THE COCKPIT NOW, SO WE'D LIKE TO MAKE THIS INTO A MAYDAY PLEASE". Although this checklist was not actioned, the commander, without reference to the co-pilot or the checklist, turned the ECS packs to OFF, the opposite action to that called for in the checklist.

The first items on the checklist require the flight crew to don their oxygen masks and smoke goggles and establish communications. The reason for this is to isolate the flight crew from the potential harmful effects of smoke or fumes within the flight deck and thereby minimise the possibility of their partial or full incapacitation. The checklist then instructs the flight crew to land the aircraft at the nearest suitable airfield, but includes further actions to be taken if time permits. These actions are intended to purge smoke or fumes from the fuselage and identify and isolate their source. By not actioning this checklist, and understanding that there was 'smoke' in the cabin (and hence the possibility of a 'fire'), the commander did not follow the most appropriate course of action, as stated in FODCOM 17/2000.

It is not considered reasonable to expect pilots to retain detailed knowledge and the consequences of the actions required for every foreseeable malfunction on a complex aircraft, other than vital actions required to be carried out without delay in some emergencies[10]. This is one reason why emergency checklists are provided. Such checklists are designed to guide crews through the required actions, with the minimum of delay, and also may provide information on the consequences of failures. Nevertheless, having decided to action the '*LOW HYDRAULIC QUANTITY CHECKLIST*', which leads to the *'ABNORMAL AND EMERGENCY LOWERING OF LANDING GEAR'* checklist, it was not followed correctly, resulting in the crew overlooking information concerning the loss of services. Had the checklist been followed correctly, they would have been forewarned about the loss of the nosewheel steering system and the requirement

[10] Memory recall items.

that taxiing must be kept to a minimum. This information was also available in the Operations Manual.

2.1.2 The approach and landing

Shortly after the declaration of a MAYDAY, when the crew began to action the descent checklist, the commander asked the co-pilot whether she was content not to carry out a formal approach briefing; she agreed with this suggestion. Despite the fact that they were about to land at Ronaldsway for the third time in their day's duty, and that both pilots were very familiar with the airport, the checklist required the flight crew to acknowledge that an approach briefing had been carried out. Had this been done, given the unusual manner in which the aircraft was configured for landing and the early lowering of the landing gear, it may have prevented the very late selection of landing flap and associated EGPWS warnings. Analysis of the CVR recording suggested the commander's dismissal of the first warning ("TOO LOW – TERRAIN") may have been influenced by repeated false alerts which had been experienced since the installation of EGPWS on the aircraft. His dismissal of the second warning ("TOO LOW – FLAPS") was clearly followed by the realization that the flaps had not been set for landing. This was immediately corrected by moving the flap selector to the Flaps 20 position.

As the aircraft made its short final approach, the commander was assessing whether to attempt to taxi to a parking position or stop on the runway and evacuate the passengers. He was unaware of the information relating to the loss of nosewheel steering and braking contained in the *'ABNORMAL AND EMERGENCY LOWERING OF LANDING* GEAR' checklist, and made his decision to continue to attempt to taxi the aircraft to a stand based on, or with knowledge of, the following factors:

- the aircraft had a hydraulic system problem
- 'smoke' of unknown origin was present in the cabin and flight deck
- at least one passenger was experiencing breathing difficulties and a paramedic had been requested to attend the aircraft
- there had been a report of 'panic' in the cabin
- the cabin crew had asked whether the aircraft would stop on the taxiway so that doors could be opened and the cabin ventilated.

It was only when ATC asked the aircraft to stop (co-incidentally with a similar suggestion from the co-pilot), to allow the AFRS vehicles to catch up and inspect the aircraft, that the commander stopped the aircraft and shut down

the engines. The flight crew members were separated from the cabin by the closed flight deck door and would have experienced more benign conditions than those affecting the passengers and cabin crew. This may have affected their perception of the urgency of the situation being conveyed by the cabin crew, resulting in the commander's decision to attempt to continue to taxi the aircraft.

2.1.3 Emergency radio communication

During the emergency, the commander declared both a 'PAN' and a 'MAYDAY'. Although both communications were made in a conversational style and standard phraseology was not used, the emergency messages were understood by ATC.

2.1.4 Crew co-ordination

The co-pilot was young and relatively inexperienced; the commander was more mature but a substantial part of his flying experience had been gained during single-pilot operations on aircraft other than the ATP. Analysis of the CVR recording confirmed this relatively steep 'cockpit experience gradient', with the commander firmly 'in charge'. There was little discussion between the pilots and although, in general, the commander informed the co-pilot of his actions, he did not at any stage enquire of the co-pilot as to her understanding or diagnosis of the situation. However, although she did not contradict any of the commander's actions, after landing, she did suggest to him that the aircraft should be stopped in their present position. The operator's Operations Manual contained details on how the company required the crew to co-ordinate (Appendix C), the concept of which is that the PF flies the aircraft and the PNF operates the systems at the behest of the PF. Checks are called for by the PF and normally conducted by using the 'challenge and response' method: in this case, the PNF challenging. Exceptions are Airborne checklists, Emergency checklists and After Landing checklists, which are mostly PNF to 'read and do'.

Analysis of the CVR recording showed that this procedure was not adhered to by the flight crew, and it is considered that this played a part in the late selection of landing flap and the associated EGPWS alerts.

2.1.5 CG position considerations

When the aircraft was approximately 10 miles from touchdown, the commander was informed by the No 1 that the cabin crew had been forced to move some of the passengers towards the rear of the cabin, away from the 'smoke'. Had

the aircraft been full, or nearly so, then there would have been little scope for the cabin crew to move significant numbers of passengers rearwards. In this case, there were 33 passengers out of a potential maximum of 64. With the majority being moved, this resulted in a rearwards shift of the aircraft's CG position to beyond the aft limit as specified in the Operator's Loading Instructions. However, it probably remained within the limit published in the AFM. Although the cabin crew informed the flight deck of the movement of the passengers, there was no evidence that its potential effect on the handling qualities of the aircraft was given any consideration by the flight crew, possibly as they were in a high workload situation at the time.

The result was that an approach and landing were conducted with the centre of gravity beyond the aft limit specified by the company, which would have reduced the longitudinal stability of the aircraft. Although, demonstrably, the aircraft could be controlled by both the autopilot and the flight crew when being flown manually, the FDR parameters clearly indicated that it was being operated towards the extremes of the effectiveness of the elevator and pitch trim systems. The subsequent two flap selections would have exacerbated any handling problems.

It was apparent that the cabin crew were not aware of the potential problems associated with moving the passengers to the rear of the aircraft, and that they had not been trained to seek permission from the flight crew before doing so. Although it remained the responsibility of the commander to ensure that the CG remained '….*inside the envelope at all times*….', he was informed of the redistribution of the passengers at a time when his focus was on dealing with the emergency.

Therefore, the following safety recommendation is made:

> It is recommended that the Civil Aviation Authority advises all operators of Commercial Air Transport aircraft on the UK register of the need to ensure that the training of cabin crew members includes an awareness that handling problems may result from the movement of the aircraft's CG position, should a significant redistribution of passengers be required in flight. This awareness training should include the necessity to both inform and seek the approval of the flight crew prior to such a redistribution taking place and should be reflected in the appropriate Cabin Crew Safety Manuals. (Safety Recommendation 2006-069)

The rearwards movement of the aircraft's CG position would also have affected the contact force exerted by the nosewheel on the runway. Calculations made by the aircraft manufacturer suggested that the likely weight on the nosewheel, due to the position of the CG, would have exceeded the minimum required to compress the nose landing gear microswitch, and thus enable the nosewheel steering system. In this condition, sufficient friction would have been present between the tyres and ground to steer the aircraft. This led to the conclusion that hydraulic fluid exhaustion of the main hydraulic system was the cause of the inability of the flight crew to steer the aircraft by the nosewheel steering system.

2.2 The technical failures

The hydraulic fluid mist in the cabin was the product of three independent factors which, individually, were relatively minor in nature. These were: the faulty door microswitch, the jammed flip-guard on the airstairs switch and the leaking seal. The incident was compounded by the subsequent movement of some of the passengers to the rear of the cabin, leading to the CG of the aircraft moving beyond the company's specified aft limit. This in turn exposed the aircraft to a risk of a potentially more serious outcome from handling problems.

2.2.1 The door safety microswitch

The sticking door microswitch plunger represented a dormant failure; it could not be established how long this condition had existed or whether it was intermittent in nature. Previous incidents involving the airstairs hydraulic system suggest that a similar situation had occurred on at least one other occasion. In the absence of any requirement for a periodic inspection or maintenance of the plunger mechanism, it is possible that other aircraft in the fleet could be similarly affected due to the accumulation of grease and dirt. It would therefore seem logical for the Maintenance Schedule to be amended to introduce periodic checks and maintenance of the microswitch asembly.

2.2.1.1 Safety action taken by the manufacturer

In March 2006, following a Maintenance Review Board, the manufacturer issued a *Letter of Transmittal – MRB ATP-01 Issue 3 – Revision No.4,* in which they identified new maintenance tasks associated with the airstairs fitted to the ATP aircraft, as follows:

Item No. 52-30B	New task	Do an operational check of the door open safety microswitch assembly (4,000 hr intervals)
Item No. 52-30C	New task	Do a general visual inspection of the door open safety microswitch assembly (2,000 hr intervals)
Item No. 52-30D	New task	Do a detailed visual inspection of the airstairs structure, including the handrails, attachment fittings and tread (2,000 hr intervals)
Item No. 52-30E	New task	Perform lubrication of the door open safety microswitch (2,000 hr intervals)

In consideration of this action, is not thought necessary to make any formal safety recommendations to the manufacturer.

2.2.2 The airstairs switch flip-guard

The missing baulk strip on the flip-guard had enabled it to be rotated into a position such that it had trapped the airstairs UP switch in its depressed position. Whilst it is possible that this had occurred on previous occasions, a concomitant sticking door microswitch plunger would not have presented a problem so long as the hydraulic seals remained intact. If cabin crews have at any time noticed the absence of the baulk strip on the flip-guard, it is possible that they could have considered it a trivial matter and unworthy of a report. Moreover, the UP switch has to be fully depressed before the flip-guard can be moved to a position to jam the switch, and thus be immediately apparent to the attendant on releasing the switch.

It is therefore possible that jamming of the switch could arise as a result of a deliberate action by a cabin attendant, in order to spend a few moments doing other things in the busy period prior to departure, whilst the airstairs retract. The risk in this, of course, is that the switch could remain in the depressed position during flight. However, if this were so, it seems unreasonable to expect cabin crew to have the depth of system knowledge required to appreciate the potential consequences of leaving the guard in such a position.

2.2.3 The hydraulic leak

The reason for the failure of the seal was not established, but could have been the result of, for example, insufficient assembly torque or degradation of the seal material. Should the banjo connector seal have failed as the retraction sequence was initiated, in the absence of the other failure events, any hydraulic mist/spray would largely have occurred outside the aircraft during retraction of the airstairs after the passengers had boarded. This would not have presented a significant operating hazard and would have afforded an opportunity for detection and rectification prior to flight. The combination of the stuck door safety switch and defective seal resulted in the continued pressurisation of the only part of the aircraft's hydraulic system that was contained within the cabin. The result of the seal failure, apart from producing the mist which was perceived as smoke, was a rapid exhaustion of the contents of the main system hydraulic reservoir. However, the ATP has no hydraulically operated primary flight controls - it has electrically powered flaps - and the braking system is protected by accumulators. Thus the ability of the crew to operate the flight controls normally was not compromised.

2.2.4 Survivability issues

Following the onset of the hydraulic fluid leak and the notification of 'smoke' to the commander, the appropriate emergency checklists were not actioned or carried out correctly. The fluid used in the hydraulic system is inherently flammable, particularly when in the form of a mist, with a relatively low flash point. Therefore, while the mist was present in the cabin, it is considered that a risk of fire existed. Also there was the possibility that an overpressure within the fuselage could have occurred, should an ignition source with sufficient energy have ignited the oil/air cloud.

The aircraft's CG position had moved beyond the company's specified aft limit as a result of the passengers being relocated towards the rear of the aircraft. However, the aircraft landed safely and none of the occupants sustained any direct injury as a result of this incident and the manner in which it was handled. One passenger, who suffered from asthma, became affected by the hydraulic fluid mist and was given oxygen to help relieve their symptoms. By turning off the ECS packs in flight, despite the instruction in the '*FIRE, SMOKE OR FUMES WITHIN FUSELAGE*' checklist to turn to *ON* the '*ECS packs and BOOST*', the contamination in the cabin was likely to dissipate only slowly. In such circumstances, it would seem reasonable that the commander should have minimised any delay in clearing the atmosphere and providing medical attention by stopping, rather than attempting to taxi an unserviceable

aircraft with a contaminated cabin atmosphere to the stand. Fortunately, after attention by hospital staff, this passenger was released as treatment was not considered necessary.

The forward vestibule was heavily contaminated with oil and, as such, the floor was known to be slippery. Hence, there was a risk of passengers slipping and possibly being injured as they passed through this area and down the stairs. However, as the airstairs could be deployed without the use of the hydraulic system, the crew took the view that it was expedient to evacuate the passengers and clear the cabin quickly. The alternatives were to wait for mobile steps to reach the aircraft and evacuate the passengers through the rear door, or use the escape slides, with their own attendant risk of injury.

3.0 Conclusions

(a) Findings

1. The crew was properly licensed and qualified to conduct the flight, and the flight crew held valid medical certificates.

2. The crew had rested adequately before commencing duty.

3. The aircraft's documentation was in order and there were no outstanding defects recorded in the log.

4. Shortly after takeoff, a hydraulic connection associated with the forward left door airstairs sprang a leak and caused the forward part of the passenger cabin to fill with hydraulic fluid mist.

5. The cabin crew diagnosed the mist as 'smoke'.

6. The mist mostly affected the forward part of the cabin, but also entered the flight deck.

7. The cabin crew reported the 'smoke' promptly and clearly to the commander via the interphone.

8. Immediately after the report of 'smoke' had been passed to the commander, the aircraft's warning system alerted the flight crew to a HYDRAULIC LOW LEVEL condition.

9. The commander elected to return to Ronaldsway, which was the nearest available airport.

10. The flight crew did not comply with Standard Operating Procedures regarding checklist use and crew co-ordination.

11. The commander did not action the HYDRAULIC LOW LEVEL checklist correctly, and did not comply with its instructions.

12. The commander declared to ATC a state of urgency (PAN) and, later, emergency (MAYDAY), but did not use the standard radiotelephony phrases.

13. Following depletion of the hydraulic system's contents, the flight crew did not follow correctly the '*EMERGENCY AND ABNORMAL LOWERING OF LANDING GEAR CHECKLIST*'.

14. The crew did not associate the near-simultaneous low hydraulic fluid quantity warning with reports of 'smoke' from the cabin.

15. No review of available information was carried out by the flight crew, and they did not endeavour to establish whether the hydraulic system problem and the onset of 'smoke' were related.

16. The flight crew did not follow the actions proscribed in the company's Operating Manual with regard to smoke on board the aircraft.

17. The flight crew did not action any checklists referring to smoke on board the aircraft.

18. After the onset of the 'smoke', the cabin crew moved a number of passengers to seats towards the rear of the cabin.

19. At takeoff, the aircraft's loadsheet indicated that the aircraft's CG position was at about 24% MAC; the limits were 21% to 29%.

20. The cabin crew could not recall with precision where the passengers were seated after they had been moved.

21. The best estimate of the new CG position suggested that it had moved to between 30% and 31% MAC, beyond the company's specified aft limit.

22. The cabin crew did not inform the commander that most of the passengers had been re-located in the rear section of the cabin.

23. The commander did not seek amplification of the information regarding the movement of the passengers nor take action to address the implications associated with the rearward movement of the aircraft's CG position.

24. The commander selected the Environmental Conditioning System packs to OFF, without reference to a checklist, and contrary to the instruction contained in the '*FIRE, SMOKE AND FUMES WITHIN FUSELAGE CHECKLIST*'.

25. An alert from the EGPWS drew the flight crew's attention to the incorrect flap setting as the aircraft passed below the Decision Height; the flaps were then set correctly.

26. Prior to landing, the flight crew were not aware that the nose wheel steering system was inoperative.

27. The flight crew experienced difficulty in controlling the aircraft on the ground whilst manoeuvring the aircraft by using differential thrust and brakes.

28. The commander's decision to continue to taxi the aircraft after landing was not in accordance with the checklist requirement to keep taxiing to a minimum.

29. The commander's decision to attempt to continue to taxi the aircraft to the stand after landing did not minimise the occupants' exposure to the 'smoke' or the risk of a serious fire.

30. The operator had not brought to the attention of their flight crews the information contained within the CAA FODCOMs on the topic of fire and smoke.

31. The cause of the hydraulic leak was not identified by the investigation; the seal appeared to be undamaged but had been installed for a considerable period of time.

32. Prior to this incident, there were no periodic inspections or maintenance requirements covering the forward left door safety microswitch.

(b) Causal factors

The following causal factors were identified:

1. A combination of a stuck door safety microswitch plunger and a jammed on airstairs UP switch caused hydraulic pressure to remain applied to the airstairs retraction actuators in-flight.

2. The failure of the hydraulic seal associated with the airstairs operating mechanism occurred in-flight; this resulted in the fluid contents of the main hydraulic system being discharged as a fine mist into the passenger cabin.

3. At the time of the incident, there were no periodic inspection or maintenance checks required on the airstairs operating system.

4. The rearward movement of the aircraft's CG position beyond the aft limit as specified by the operator, resulted from the cabin crew moving passengers towards the rear of the cabin in an attempt to minimise their exposure to the 'smoke'.

5. There was no requirement for cabin crews to obtain agreement from the commander prior to moving passengers towards the rear of the cabin although, on this occasion, the commander was informed of their actions.

6. The flight crew's non-adherence to SOPs and associated checklists put the aircraft and its occupants at unnecessary increased risk from potential handling problems as well as risk of a fire and exposure to a hydraulic fluid mist.

4.0 Safety Recommendations

4.1 **Safety Recommendation 2006-069**: It is recommended that the Civil Aviation Authority advises all operators of Commercial Air Transport aircraft on the UK register of the need to ensure that the training of cabin crew members includes an awareness that handling problems may result from the movement of the aircraft's CG position, should a significant redistribution of passengers be required in flight. This awareness training should include the necessity to both inform and seek the approval of the flight crew prior to such a redistribution taking place and should be reflected in the appropriate Cabin Crew Safety Manuals.

5.0 Safety actions

On 4 May 2006, the CAA suspended the operator's Air Operator's Certificate (AOC). The company has effectively ceased trading and, therefore, no further safety recommendations are made to the Civil Aviation Authority or Emerald Airways.

P T Claiden
Inspector of Air Accidents
Air Accidents Investigation Branch
Department for Transport
December 2006

Appendix A

Operations Manual extract relating to likely sources of fire on-board an aeroplane

'LIKELY SOURCES AND HIGH RISK AREA'S (sic)

Sources of fire onboard an aeroplane include:

a. faulty electrical wiring

b. oven or hot cups/boilers

c. passenger items that have been brought onto the aeroplane without being spotted i.e. matches, gas or petrol lighters

d. incorrectly packed or manifested cargo

Fires involving items under a. could appear anywhere in the aeroplane but normally are very rare. Items under b. are in a very defined location, which should be under constant cabin crew surveillance. Items under c. would probably occur in the overhead lockers, although it is possible that an event could take place in the toilet if the passenger ignored all the announcements regarding the prohibition of smoking on the aeroplane. Items under d. will be stored in the cargo holds which are not normally accessible in flight. Indication systems on the flight deck will alert the flight deck crew to any incidents and they will advise the cabin crew on the required course of action.'

And:

'Smoke-filled Cabin

No visual sign of fire is a dangerous situation as it could indicate smouldering wires/cables in the concealed electrical systems installed in the aeroplane.

Smoke will filter into the cabin through the air conditioning system, or will seep through joins in the cabin side-wall trim panels if a fire is concealed between the outer and inner skins of the aeroplane.

i) Inform the Commander IMMEDIATELY, so that he may take whatever action is necessary, i.e. ventilate the cabin.

ii) Switch off electric's (sic) which may be located in the vicinity.

iii) Check for signs of fire, armed with a BCF fire extinguisher.

iv) Instruct passengers to breath through wetted handkerchiefs or other suitable material, using water from the galley or toilet sink.

v) If any passengers are having breathing problems they should be moved far away from the source of the smoke and oxygen should be administered.

'Searching' crew members should carry a smoke hood unit which can be utilised if smoke density increases or if situation dictates when fighting the fire.

NOTE: Oxygen bottles should be moved away from the source of the fire as oxygen is highly inflammable.'

Appendix B

Extract from Civil Aviation Publication '*The Radiotelephony Manual (CAP 413)*, regarding the transmission of emergency messages

'1.5 Emergency Message

The emergency message shall contain the following information (time and circumstance permitting) and, whenever possible, should be passed in the order given:

a) 'MAYDAY/MAYDAY/MAYDAY' (or 'PAN PAN/PAN PAN/PAN PAN');

b) Name of the station addressed (when appropriate and time and circumstances permitting);

c) Callsign;

d) Type of aircraft;

e) Nature of the emergency;

f) Intention of the person-in-command;

g) Present or last known position, flight level/altitude and heading;

h) Pilot qualifications (See Note 1);

i) Student pilots (see Note 2);

ii) No Instrument Qualification;

iii) IMC Rating;

iv) Full Instrument Rating.

i) Any other useful information e.g. endurance remaining, number of people on board (POB) etc.

Appendix C

CAA FODCOMs and the operator's actions on receipt

The CAA published Flight Operations Department Communications (FODCOMs), as a means of informing holders of Air Operator's Certificates of various matters of relevance. FODCOMs 17/2000, 14/2001, 21/2002 and 22/2002 gave guidance and instruction regarding smoke and fire on board aircraft.

FODCOM 17/2000 included the instruction:

'The first action in the event of smoke or fumes in the flight deck should be for the flight crew to don oxygen masks and establish communications.'

FODCOM 14/2001 included the instruction:

'Operators are further reminded that Operations Manual procedures should contain detailed instructions to crews on such procedures. These should at least include the necessity to use oxygen masks at 100% whenever contamination is present or suspected and the need to establish communications by the appropriate switch selections.'

FODCOM 21/2002 included the instructions:

'Operators should ensure that flight crews are aware that the first action in the event of smoke or fumes in the flight deck should be for the flight crew to don oxygen masks and establish communications.

Operators should ensure that flight and cabin crew are advised as to the post-flight actions required following a smoke/fumes incident. These actions should include:

a) A Commander's review of the in-flight incident. This should include consultation with the flight and cabin crew;

b) A determination as to whether any crew member felt unwell, or whether their performance was adversely affected; and

c) The requirement for a crew member who felt unwell, or felt their performance was affected, not to operate as a member of the crew until he/she has been assessed as fit by a medical practitioner and the crew member feels fit to operate.

The instructions to flight and cabin crew should be detailed in the Operations Manual.'

Appendix C

FODCOM 22/2002 referred to a report by the National Transportation Safety Board (NTSB) and included the instructions:

'Enhancement of In-Flight Fire Fighting Procedures

A summary of the operational NTSB recommendations is detailed below. These recommendations are designed to further enhance in-flight fire-fighting procedures.

a) Aircraft crew members should be trained to take immediate and aggressive action in response to signs of an in-flight fire.

b) Procedures should stress that fires are often hidden behind interior panels. Therefore an aircraft crew member may need to remove or otherwise gain access to the area behind interior panels in order to effectively apply extinguishing agents to the source of the fire.

c) Practical fire-fighting training drills should include realistic scenarios recognising potential signs of fire, locating the source of the fire and fighting hidden fires.

d) Training should include information on the properties of halon extinguishant including the negligible harmful effects on passengers and crew compared to the safety benefits achieved by fighting in-flight fires aggressively and, where appropriate, the effectiveness of halon compared to the use of CO_2 as an extinguishant.

Recommendation

Operators should review their Operations Manual procedures for in-flight fire-fighting and training syllabi to ensure the relevant CAP and JAR-OPS 1 requirements are in place. If not already included, procedures should be updated to take into account the summary of operational recommendations arising from the NTSB report.'

All the FODCOMs included the statement:

'Recipients of new FODCOMs are asked to ensure that these are copied to their 'in-house' or contracted maintenance organisation, to relevant outside contractors, and to all members of their staff who could have an interest in the information or who need to take appropriate action in response to this Communication.'

The CAA explained that Flight Operations Inspectors examine the Operations Manuals of AOC-holding organisations every year, with a more thorough audit of the manuals every three years.

The operator had not informed crew members of the contents of FODCOMs 17/2000, 14/2001, 21/2002 and 22/2002.