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(ALL TIMES IN THIS BULLETIN ARE UTC)

SERIOUS INCIDENT

Aircraft Type and Registration:	Boeing 747-436, G-CIVB
No & Type of Engines:	4 Rolls-Royce RB211-524G2-T-19 turbofan engines
Year of Manufacture:	1993
Date & Time (UTC):	11 July 2009 at 0310 hrs
Location:	Pheonix, Arizona, USA
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 18 Passengers - 300
Injuries:	Crew - 1 (Minor) Passengers - some (Minor)
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	55 years
Commander's Flying Experience:	18,235 hours (of which 6,529 were on type) Last 90 days - 215 hours Last 28 days - 63 hours
Information Source:	AAIB Field Investigation and operator's internal investigation

Synopsis

The engines were being started during pushback when fumes and smoke were noticed in the cabin. The commander decided to return to the stand; however, there was some delay while the tug was reconnected. The intensity of the fumes increased and as the aircraft came to a halt on the stand an emergency evacuation was carried out. An extensive engineering investigation after the event was not able to provide any explanation for the origin of the fumes. The aircraft was returned to service and no further instances have occurred.

This serious incident occurred in the USA. In accordance with Annex 13 of the ICAO Convention on Civil Aviation, an investigation would normally be carried out by the State of Occurrence. On this occasion, it was agreed with the National Transportation Safety Board (NTSB) that it would be more appropriate for the State of the Operator, ie the UK, to conduct the investigation.

History of the flight

There were three pilots on the flight deck: the aircraft commander in the left seat, the co-pilot, nominated as pilot flying, in the right seat, and an additional pilot on the jump seat. There were 15 cabin crew members.

Pushback

The aircraft pushed back at 0244 hrs from stand B25 at Phoenix Sky Harbour Airport. The aircraft stand area and Taxiways Quebec and Romeo behind the aircraft were not visible from the Air Traffic Control Tower. The weather conditions at the time were: surface wind from 260º at 8 kt, CAVOK, temperature 41ºC, dewpoint 2ºC, pressure 1008 hPa, and the incident occured during the hours of darkness.

The engines were all started during the pushback; the No 4 engine was started first followed by the No 3. About a minute after the No 4 engine start, the additional pilot noticed an acrid burning smell. The cabin crew also noticed this smell and contacted the flight deck crew to advise them.

On the flight deck, the fumes intensified and the pilots put on their oxygen masks. The additional pilot then took off his mask in order to go back into the cabin to assess the situation outside the flight deck. The co-pilot asked the ground crew headset operator (who was a company maintenance engineer) if there was any unusual smell outside. He replied that there was only a smell of burning rubber from a recently landed aircraft. The flight crew opened the overhead emergency escape hatch in an attempt to clear the fumes from the cockpit, but this was ineffective.

Return to stand

At 0250 hrs, the commander decided to return to the stand and disembark the passengers. The engines were shut down and the headset operator was advised. A PAN call was made to ATC in which the commander requested that a set of steps be brought to the aircraft. He also notified the cabin crew and instructed them to return the doors to the 'manual' position.

At 0254 hrs the tug was reconnected, but as the aircraft had been pushed back through an angle of more than 90º, and then pulled forward, the tug had to manoeuvre several times to align the aircraft with the stand. This operation was accomplished by 0258 hrs.

Meanwhile in the cabin, the situation had deteriorated, particularly at the rear of the aircraft. Several passengers left their seats and moved forward wanting to get off the aircraft. One passenger called out that there was a fire. The two cabin crew members positioned at doors 3L and 4L, in the most intense area of fumes, left their doors to look for the source. They saw "whitish smoke" coming from the sidewall and discharged a fire extinguisher under the seats in the area. More passengers had now left their seats and one passenger then opened the now unattended door 3L; the cabin crew were unable to return to the opened door because of the number of passengers in the vicinity. The cabin evacuation alarm was triggered at door 3L, but it is not certain by whom. The crew member at 4R contacted the flight deck again and advised that there was smoke and possible fire in the cabin. The commander advised ATC that there was a fire on board and made a request for the emergency services to attend the aircraft. By now, many of the passengers had left their seats. Some with children were being assisted in the galley area by the crew and wet towels were handed out. The senior cabin crew member, who was by the exit/entry door 2L on the lower deck, was surrounded by anxious passengers and was not in a position to be able to control the situation in the cabin.

Evacuation

The commander realised the situation was deteriorating and decided to evacuate the aircraft. He made an announcement for the crew to put the doors to 'automatic' and then gave the evacuation command; because of the proximity of the airbridge, he instructed that evacuation should be from the right side of the aircraft.

The doors on the right side of the aircraft were opened and the slides all deployed successfully. The left upper deck door was opened in error and the slide deployed on top of the airbridge. The cabin crew member at this door had not heard the instruction to evacuate on the right, but when he saw the slide had not properly deployed he guarded the door and redirected the passengers. A member of ground handling staff who was on the airbridge realised the slide was deploying towards her and ran back into the terminal.

At 0258 hrs the passengers started evacuating down the slides onto the apron area. ATC were advised that an evacuation was in progress. A fire team subsequently entered the aircraft, but were unable to detect any heat sources or fire damage on the aircraft.

The passengers were on the apron for about 20 minutes before they were escorted back into the terminal building.

Engineering investigation

A detailed investigation was carried out over a four day period by the operator, in conjunction with the aircraft manufacturer, and no source of the fumes/smoke could be found. The aircraft was ferried back to the operator's main base where further examination and testing was carried out, but still no source or explanation of the fumes/smoke was found. The aircraft returned to revenue service on 21 July 2009 and has been operating with no recurrence of the problem since that date.

Recorded information

On this aircraft type, data is recorded on the Flight Data Recorder (FDR) and Quick Access Recorder (QAR). The start/stop logic is designed to capture data when at least one engine is running. The FDR records at least 25 hours of data and the QAR in excess of this. The data recorded that was relevant to this investigation did not offer any further insight into the events, other than corroborating the engine and pushback activity described in the History of the flight section of this report.

The Cockpit Voice Recorder (CVR) installation is designed to record audio information when the electrical power is selected on the aircraft, and the CVR fitted is designed to preserve at least the last 2 hours of audio information. Flight crew communications were considered important to this investigation and so the CVR should have provided further insight. However, the CVR continued to run during the maintenance activities carried out after the event, so all the audio information relating to the event was lost.

ICAO Annex 6, Part I, 11.6 states:

> *'An operator shall ensure, to the extent possible, in the event the aeroplane becomes involved in an accident or incident, the preservation of all related flight recorder records and, if necessary, the associated flight recorders, and their retention in safe custody pending their disposition as determined in accordance with Annex 13.'*

EU-OPS 1.160, '*Preservation, production and use of flight recorder recordings*', requires the following of the operator:

> *'(a) Preservation of recordings:*
>
> *(1) Following an accident, the operator of an aeroplane on which a flight recorder is carried shall, to the extent possible, preserve the original recorded data*

> *pertaining to that accident, as retained by the recorder for a period of 60 days unless otherwise directed by the investigating authority.*
>
> *(2) Unless prior permission has been granted by the Authority, following an incident that is subject to mandatory reporting, the operator of an aeroplane on which a flight recorder is carried shall, to the extent possible, preserve the original recorded data pertaining to that incident, as retained by the recorder for a period of 60 days unless otherwise directed by the investigating authority.'*

The operator provided the following extract from their '*Reporting of Air Safety Accidents and Incidents*' procedure.

> *'Outstation British Airways/British Airways Engineering Duty Staff*
>
> *(a) Ascertain as soon as is safely possible, that the Aircraft Cockpit Voice Recorder Circuit Breaker has been tripped by the departing cockpit crew in order that recordings stay intact. Ensure that this occurs if the disembarking flight crew were unable to, or did not complete this task.'*

A review of previous AAIB investigations showed that, out of 99 CVR replays, information was lost in 19 because the operator had not electrically isolated the recorder whilst the aircraft was on the ground. Seven of these events related to 'two-hour' recorders, with the remaining being 'half-hour' recorders. These occurrences were not specific to any one operator, or any particular nationality of operator.

Some operational procedures to preserve recordings are already in place, but the procedures are all too often ineffective. Any procedure that requires the crew to consult with a main base, or reference material not readily available in the flight deck in order to remove power from the CVR, will not be conducive to timely preservation of this evidence. It is considered that procedures should be put in place to ensure that, even if the flight crew successfully remove power from the CVR in a timely manner, subsequent maintenance activity does not include the re-application of electrical power to the recorder. One effective way of preserving CVR and FDR data is to pull and collar the relevant circuit breakers, and physically remove the recorders. Once permission has been granted by the investigating authority, they could then be reinstated.

Therefore, the following Safety Recommendations are made:

Safety Recommendation 2010-011

It is recommended that British Airways plc review their procedures and training of flight and maintenance crews to ensure the timely preservation of Cockpit Voice Recorder recordings in the event of a reportable occurrence, in accordance with ICAO Annex 6 Part I, 11.6 and EU-OPS 1.160. The procedures and training should provide the necessary information and skills to identify when reportable accidents and serious incidents occur, and implement the necessary tasks to preserve flight recordings in a timely manner.

Safety Recommendation 2010-012

It is recommended that the Civil Aviation Authority review the relevant procedures and training for UK operators, to ensure the timely preservation of Cockpit Voice Recorder recordings of a reportable occurrence is achieved in accordance with the requirements of ICAO Annex 6 Part I, 11.6 and EU- OPS 1.160.

Discussion

When the commander made the decision to return to the stand it was in the expectation that a normal disembarkation would be carried out by means of the airbridge, and by an extra set of steps which he had requested. There was a delay of several minutes while the tug was reattached and the aircraft was manoeuvred back onto stand. In this time, although the engines were shut down, the fumes seemed to increase and the situation in the cabin deteriorated.

The flight deck of the Boeing 747 aircraft is physically remote from the lower deck cabin and the commander had to rely on communications from the cabin crew to get "a picture" of the situation. The fumes in the flight deck were not severe initially and were barely noticeable in the upper deck cabin. He would have been reluctant to initiate an evacuation without being certain that it was necessary; the doors of the 747 aircraft are high above the ground and an emergency evacuation down the slides is likely to result in some injuries.

The source of the smoke/fumes in the cabin was not readily identifiable and it was, therefore, difficult for the cabin crew to locate and tackle the problem. Some confusion arose as passengers started to leave their seats and move away from the area. This confusion escalated when one of the passengers called out "fire". Once a fire extinguisher had been used, some passengers may have confused the discharged gas with smoke. Although trained in emergency procedures and in assertiveness, the cabin crew found it difficult to control the situation and keep the commander informed, particularly as the passengers became more distressed. The physical reality of the passengers' behaviour was unlike that experienced by the cabin crew during their training.

Door 3L was opened by a passenger but the slide did not deploy because at that time, prior to the evacuation command, the doors were at 'manual'; the slides deployed successfully on all the other doors that were opened. Some passengers collected hand baggage and carried it with them to the doors. The crew commented that if they took the bags away from these passengers, at some of the doors, there was nowhere to stow these items without possibly causing an obstruction.

The commander had reported that he was returning to stand. As the aircraft parked on the stand he requested the attendance of the emergency services and they arrived on the scene within three minutes.

An extensive investigation after the incident revealed no evidence of smoke or fire. From the description of the fumes by the crew, it seems unlikely that burning rubber from landing aircraft could have been the source.

Safety action

The operator carried out an internal safety investigation and identified some areas where training and procedures should be reviewed in light of experience gained from the incident. In particular, the cabin safety training will be reviewed, with extra consideration given to the management of passenger behaviour in stressful situations, to enable more realistic training to be devised.

ACCIDENT

Aircraft Type and Registration:	Cessna 401, VQ-TLG
No & Type of Engines:	Two Continental TSIO-520-E piston engines
Year of Manufacture:	1969
Date & Time (UTC):	24 July 2009 at 2226 hrs
Location:	Salt Cay, Turks & Caicos Islands
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 5
Injuries:	Crew - None Passengers - 2 (Minor)
Nature of Damage:	Propellers and underside of the fuselage
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	25 years
Commander's Flying Experience:	3,490 hours (of which 105 were on type) Last 90 days - 152 hours Last 28 days - 48 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

History of the flight

VQ-TLG took off from Grand Turk in the Turks and Caicos Islands for a flight to Salt Cay, which is approximately 8 nm to the south-west. The wind was from 110° at 10 kt, the visibility was over 10 km and there was no low-level cloud. As the aircraft descended through approximately 1,000 ft on its approach to Runway 08 at Salt Cay, the left engine failed. The commander feathered the propeller and selected full power on the remaining engine but the aircraft was unable to maintain altitude. He tried to re-start the left engine but was unsuccessful. The commander judged that the aircraft would not reach the airfield and decided to ditch in a large shallow lake that lay beneath the base leg for the runway. The ditching was successful and all the occupants were able to leave the aircraft through the usual cabin door. At the time of writing, the engines had not been inspected and the cause of the engine failure was unknown.

ACCIDENT

Aircraft Type and Registration:	Cessna 421C Golden Eagle, N1FY
No & Type of Engines:	2 Continental Motors Corp GTSIO-520 piston engines
Year of Manufacture:	1981
Date & Time (UTC):	25 January 2010 at 1358 hrs
Location:	Kemble Airfield, Gloucestershire
Type of Flight:	Private
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to the underside of the nose and to both propellers
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	47 years
Commander's Flying Experience:	7,000 hours (of which 500 were on type) Last 90 days - 70 hours Last 28 days - 25 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and subsequent enquiries by the AAIB

Synopsis

Following an uneventful approach into Kemble Airfield, the aircraft's nose gear collapsed on touchdown despite all three green 'down-and-locked' lights being illuminated in the cockpit. The aircraft suffered damage to the underside of the nose and to both propellers, but both occupants were uninjured and they exited the aircraft normally. Subsequent engineering analysis revealed a corroded downlock microswitch on the nose gear actuator.

History of the flight

The pilot was flying a visual circuit at Kemble Airfield. Upon selecting GEAR DOWN, the gear was felt to cycle and three green lights illuminated in the cockpit to indicate that the gear was 'down-and-locked'. The Kemble FISO (Flight Information Service Officer) on duty at the time was watching N1FY's approach, through Binoculars, and he observed that the aircraft's landing gears appeared to be in the down position before landing.

At touchdown, the nose gear collapsed causing the aircraft to slide along the runway on its nose until it came to a halt just to the left of the centre line. The pilot and passenger were not injured in the accident and they exited the aircraft through the rear door of the aircraft. The fire service were in attendance in less than one minute.

The pilot stated that even after the nose gear had collapsed, the three green 'down-and-locked' lights in the cockpit were still illuminated.

Landing gear operation description

The landing gear on the Cessna 421C is a fully retractable tricycle landing gear consisting of a nose gear and a main gear located aft of each engine nacelle.

The normal extension and retraction of the landing gear is by a hydraulic actuator at each gear. For normal extension of the gear, hydraulic pressure generated by engine driven hydraulic pumps is routed to a hydraulic unlock actuator at each gear uplock hook. When the hydraulic actuator has reached the full unlock position, fluid is routed to the gear actuator to extend the gear.

Downlock microswitches are located on each gear actuator and cut off the hydraulic pressure to the actuators when all three switches close to indicate that the gears are 'down-and-locked'. These switches also provide the status of the landing gear to several aircraft systems including the landing gear position indicators in the cockpit, the hydraulic gear extension/retraction system and the 'landing gear unsafe' aural alert warning system. Mounted in the instrument panel are three landing gear indicator lights that illuminate green when the respective gears are 'down-and-locked'. An 'in transit' light also illuminates when any gear is in an unlocked position.

The aircraft is equipped with an aural alert system to alert the pilot if the gear is unsafe when the throttles are retarded or the flaps are configured for landing. This system is disabled when all downlock microswitches are in a position that indicate all gears are 'down-and-locked'.

In the event of a loss of hydraulic pressure, emergency gear extension is available by means of an air bottle blow-down system actuated by an emergency control handle located in the cockpit.

Engineering examination

The repair agency for the aircraft conducted an engineering examination of the nose landing gear and ascertained that the landing gear failure occurred as a result of the nose gear downlock not being engaged. They also discovered that the nose landing gear downlock microswitch was stuck in the closed position due to corrosion.

In normal operation when GEAR DOWN is selected, the nose gear leg will usually lock down before the main gear legs. However, in certain circumstances, if the main gear legs lock down first, and the nose gear downlock microswitch has failed in the closed position, the hydraulic pressure will be removed and the system will give a nose gear 'down-and-locked' indication irrespective of the gear actuator position. The result would be an aeroplane configured for landing with the main gears 'down-and-locked', and the nose gear partially extended but not extended by a sufficient amount as to engage the mechanical downlock latch.

Related service information

In 1989, following identification of a potential problem with the landing gear downlock microswitches, the aircraft manufacturer issued a Service Newsletter (SNL 89-3), which was subsequently mandated by a CAA Airworthiness Directive (AD 002-02-90). The Service Newsletter instructions were to seal the downlock microswitches on affected aircraft to prevent moisture ingress and possible corrosion, with subsequent repetitive inspections and the reapplication of sealant when necessary. AD 002-02-90 was cancelled in 2003 when the European Aviation Safety Agency took over responsibility for Airworthiness Directives from the National Airworthiness Authorities.

Maintenance history

The maintenance organisation for the aircraft confirmed that the sealant and regular inspection of the gear actuators and downlock microswitches on N1FY had been conducted in accordance with SNL 89-3. The maintenance organisation stated that due to previous experience with problems associated with the corrosion of the gear actuator components on other similar aircraft types, gear actuator inspections on N1FY were carried out annually and the associated sealant replaced every two years as a precautionary measure.

Previous accidents

According to CAA records, there have been several similar accidents that have involved Cessna 400 series aircraft nose gears collapsing on landing. In a number of these accidents it was confirmed that the three green 'down-and-locked' lights in the cockpit were erroneously indicating that the nose gear was 'down-and-locked', even after the nose gear had collapsed. In most of these previous accidents, the downlock microswitch attached to the nose gear actuator was found to have failed due to corrosion.

Discussion

The gear position microswitch on the nose gear actuator was found to be stuck in the closed position due to corrosion and thus it provided a false indication to the pilot, and to other aircraft systems, that the nose gear was locked down. Although the microswitch had been sealed against the ingress of moisture in accordance with SNL 89-3, any disturbance of the sealant during service would have reduced its effectiveness and allowed moisture to penetrate into the switch leading to corrosion.

The failure of the switch would have resulted in the premature disconnection of hydraulic pressure to the nose gear actuator, thus preventing the nose gear from locking into place. Furthermore, the direction of travel of the nose landing gear leg would have been hindered by the oncoming airflow, preventing the gear from locking down under its own weight. N1FY was equipped with a blow-down emergency landing gear extension system, but it was not used as there was no indication to the pilot that the nose landing gear had not locked down prior to touchdown.

INCIDENT

Aircraft Type and Registration:	DHC-8-402 Dash 8 Q400, G-JEDM
No & Type of Engines:	2 Pratt & Whitney Canada PW150A turboprop engines
Year of Manufacture:	2003
Date & Time (UTC):	3 March 2009 at 1820 hrs
Location:	10 nm north-east of Southampton Airport, Hampshire
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 4 Passengers - 61
Injuries:	Crew - None Passengers - None
Nature of Damage:	None
Commander's Licence:	Air Transport Pilot's Licence
Commander's Age:	38 years
Commander's Flying Experience:	4,100 hours (of which 413 were on type) Last 90 days - 100 hours Last 28 days - 27 hours
Information Source:	AAIB Field Investigation

Synopsis

During an approach to Southampton in moderate turbulence the aircraft decelerated below its minimum manoeuvring speed and the flight crew received a momentary stick shake warning, indicating a low speed condition. The autopilot disengaged automatically and the aircraft reached 12.5° nose-up and rolled 43.5° to the left, albeit not concurrently, before the flight crew regained full control.

Background to the investigation

The aircraft operator became aware of the incident on 6 March 2009 through its flight data monitoring programme. Since the event was classified as an incident reportable to the Civil Aviation Authority (CAA)[1], the aircraft commander submitted an air safety report, which was received by the CAA on 25 March 2009.

The Civil Aviation (Investigation of Accidents and Incidents) Regulations 1996 empower the Chief Inspector of Air Accidents (CIAA) to determine whether or not an investigation is to be carried out into an occurrence, whether or not it qualifies for reporting to the AAIB. The CIAA ordered such an investigation to be conducted into this incident.

Footnote

1 As described in the CAA's Civil Aviation Publication (CAP) 382 – '*The Mandatory Occurrence Reporting Scheme*'.

History of the flight

The aircraft was operating a scheduled passenger service from Edinburgh to Southampton, with four crew and 61 passengers on board. The flight was the second of a four sector duty for the crew. The duty originated at Southampton and involved a planned aircraft change to G-JEDM at Edinburgh after the first sector. The aircraft departed stand at Edinburgh at 1701 hrs for the flight to Southampton, with the co-pilot handling the aircraft.

The weather at Southampton was wet and blustery and, although the aircraft's descent would be through an area of potential icing, icing conditions were not expected during the final approach. Therefore, when the co-pilot gave her approach and landing briefing, she briefed that 'non-icing' (ie non-adjusted) reference speeds would be used for the final approach.

As the aircraft descended, it was routed overhead Southampton Airport before being turned left onto a downwind heading for Runway 20. The aircraft entered cloud at about 8,000 ft, and information from the flight data recorder (FDR) showed that it encountered some airframe icing. The aircraft was in an 'icing configuration' at this point, in which activation speeds for the stall warning and protection systems were increased to allow for the possible adverse aerodynamic effects of ice on the airframe.

There was a strong wind blowing from the south and considerable turbulence at lower levels. As the aircraft turned downwind under instructions from Southampton Air Traffic Control (ATC), its groundspeed increased rapidly due to a 50 kt tailwind, prompting the controller to instruct the crew to slow the aircraft to 160 kt in order to ensure separation from an aircraft ahead. As it neared the end of the downwind leg, G-JEDM had slowed to about 174 kt IAS. The autopilot remained engaged in the heading and vertical speed modes.

The aircraft then commenced a turn to the left towards a base leg. Shortly after being established in the turn, it entered an area of increased turbulence and the stall warning stick shaker activated for a brief period, at a recorded aircraft speed of 161 kt. This caused the autopilot to disconnect automatically. Almost coincident with this, the trailing edge flaps were selected from 0° to the intermediate approach setting of 5º. The aircraft then pitched up slowly, reaching a maximum of 12.5º pitch angle and a minimum speed of 147 kt. It rolled further left and, with increasing bank angle, the pitch attitude started to reduce. The aircraft reached a recorded 43.5º of left bank before the co-pilot made any significant control inputs. Normal control was then regained. The speed subsequently increased to about 175 kt and the autopilot was re-engaged.

According to crew accounts, the commander was unaware that the stick shaker had activated, and the co-pilot was unsure whether she had mentioned it at the time. As the surface wind for landing was in excess of the company limits for a co-pilot to land, the commander assumed control for the final approach. Turbulence and windshear were also encountered during this period, and at one point the autopilot again disconnected, but there were no further stick shaker activations.

Meteorological information

A cold front crossed the south of England during the day, giving rise to a band of heavy rain which continued into the evening as wintry showers. For the approach into Southampton, the airport was reporting a surface wind from 170°M at 16 to 47 kt, a visibility of 6,000 m in rain, and broken cloud cover at 1,200 ft aal. The flight crew reported that the aircraft was in cloud and rain at the time of the incident, with moderate to severe turbulence. The aircraft's FDR recorded an outside air temperature of +2°C at the moment the stall warning stick shaker activated and the autopilot disengaged.

Crew information

The commander joined the operator from the RAF in May 2008, having previously flown the Lockheed Martin C130J Hercules. At that time he had about 3,800 flying hours, including about 1,100 hours in command on the C130J. He completed all the required aircraft conversion training and testing and had been flying the Dash 8-Q400 as commander since 30 July 2008. The duty period in which the incident occurred was the commander's first period at work after 10 days leave.

The co-pilot commenced her commercial flying career in 2001. She joined the operator in 2008 after a two year break from flying. She completed a final line check on 6 January 2009 and at the time of the incident had a total of about 3,500 flying hours, with 88 hours on type. Her commercial flying prior to joining the operator was mainly on the Dash 8-300, on which she had about 570 hours, and the Embraer 145. The co-pilot worked a part-time roster and had also just taken annual leave. The duty period in which the incident occurred was her first period at work after 18 days off.

Aircraft information

The Dash 8-Q400 is a high wing, two pilot, transport category aeroplane, with seating for up to 78 passengers. It is powered by two turboprop engines, each driving a six bladed propeller, and is approved for flight into known icing conditions.

Ice detection system

An automatic ice detection system provides early indication of aeroplane icing conditions. The flight crew are alerted to the presence of airframe icing by an ICE DETECTED message which appears on their engine display.

Stall protection

A stall protection system warns the crew when the aircraft is in a near stall condition. It calculates when to start and cancel stick shaker and stick pusher operation. Operation of one or both stick shakers causes the control columns to vibrate. In addition to this tactile warning, the stick shaker motor and the rattling of the mechanism on the control column creates a loud noise. If only one stick shaker is operating, its vibration is transmitted through the control linkage to the other column. When the stall protection system signals a stick shaker to operate, it also sends a signal to the automatic flight control system to disengage the autopilot.

Activation of stick shaker and stick pusher systems is triggered at a relatively lower angle of attack when in icing conditions, because of the reduced performance limits of the aircraft. This change is signalled to the system by the flight crew setting a REF SPEEDS switch on the ice protection panel from OFF to INCR. The minimum operating speed, depicted on the speed tape of each pilot's primary flight display (PFD), is increased accordingly.

Aircraft performance

The calculated mass of the aircraft at the time of the incident was 26,200 kg; maximum landing mass was 28,009 kg. Reference stall speeds (Vsr) from the manufacturer's Aircraft Operating Manual (AOM) were given as: 122 kt in Flap 0 configuration and 113 kt in

Flap 5 configuration. The operator's in-flight data card for 26,500 kg gave minimum manoeuvring speeds[2] for Flap 0 and Flap 5 configurations as 150 kt and 138 kt respectively.

Icing procedures

Icing procedures were contained in the AOM and the operator's Operations Manual (OM). The AOM instructed that the REF SPEEDS switch should be set to INCR either before entering icing conditions or when an ICE DETECTED message appeared on the engine display. With the REF SPEEDS switch at INCR, the minimum clean speed (Flap 0) was to be increased by 25 kt, equivalent to 175 kt for G-JEDM at the time of the incident. This advice was reproduced in the OM. To ensure limiting speeds were not exceeded, the OM recommended selecting Flap 5 at 180 kt when decelerating, irrespective of icing conditions. It also listed an icing increment of 20 kt to the Flap 5 minimum speed, giving a minimum Flap 5 speed of 158 kt at the time of the incident.

Stall recovery

Stall entry and recovery procedures were also contained in the AOM and reproduced in the OM, although the procedures were oriented towards the training environment rather than inadvertent stall encounters during line operations. In summary, the required crew response was for the handling pilot to announce the stall and set the power levers forward to the normal takeoff power setting, while relaxing control back pressure and levelling the wings. The monitoring pilot would set the condition levers to maximum. The OM stated:

'Once stick shaker has ceased and aircraft is safely established in a recovery, climb to and maintain the altitude at which the stall was entered or as briefed. Adjust power so as not to exceed 160 KIAS. Stall recovery is complete and the aircraft should be configured as required for continued flight.'

Automatic flight indications and displays

The autopilot couples the flight director commands to the flight control surfaces using pitch and roll servos for automatic control of the aircraft's flight path. Autopilot engagement is indicated by two lit arrows on the flight guidance control panel, which is mounted centrally on the glareshield. Engagement is also indicated by a green A/P legend on each pilot's PFD.

Automatic autopilot disengagement is signalled to the crew by a flashing red warning light on the glareshield in front of each pilot and by a flashing amber AP DISENGAGED legend on each PFD. It is also accompanied by an aural tone which sounds continuously until acknowledged by the flight crew by pressing either of two disengage switches mounted on the control wheels.

Operational notices to crew

In 2005, the operator had identified that a number of recorded low speed events had been due to the REF SPEEDS switch being at an incorrect setting (ie at INCR) when 'non-icing' speeds were being used, resulting in an increased stick shaker activation speed. A notice to flight crews stressed the importance of having the switch in the correct position for the prevailing conditions. It also stressed that crews must respond to any stick shaker warning by carrying out the stall recovery actions; they were not to react by setting the REF SPEEDS switch OFF in an assumption that the switch must be incorrectly set.

Footnote

2 Minimum manoeuvring speed in this case equates to Vsr, in the relevant configuration, multiplied by a factor of 1.23.

The stalling information in the AOM and OM, together with the minimum operating speeds in icing conditions, was reiterated to the operator's flight crews in an operational notice dated 16 February 2009, shortly before the incident.

Recorded flight data

FDR information for the whole flight had been downloaded by the aircraft operator and was available for analysis. Figure 1 shows relevant flight data from the time of the incident.

Initial manoeuvring

As the aircraft passed 6,000 ft, descending through cloud with an outside air temperature of -0.25°C, the ice detection system generated an ICE DETECTED message, which lasted one minute. The REF SPEEDS switch was already at INCR, having been selected to that position during the climb after the aircraft departed from Edinburgh. The aircraft continued to descend on the downwind leg for Runway 20, towards a cleared altitude of 3,000 ft. The autopilot was engaged in vertical speed mode, with a rate of descent of 500 ft/min selected. The power levers were retarded and the engines were developing approximately zero torque. Airspeed, which had been decreasing steadily, was about 200 kt and the wind, as sensed by the aircraft, was from 210°M at 50 to 55 kt.

When the aircraft turned left towards base leg, the airspeed was 174 kt and the engine power lever positions were unchanged, giving zero to -3% torque. The aircraft was descending at 500 ft/min through 4,300 ft. The bank angle subsequently stabilised at 23°, with the same power setting and steadily reducing airspeed.

Stick shaker activation and attitude excursion

About five seconds after the turn was established, there was an increase in the level of turbulence, indicated by increasingly large normal 'g' spikes. Near the peak of one such fluctuation, which recorded 1.36 'g', both stick shakers activated and the autopilot disengaged. Airspeed was 161 kt and the angle of attack, which had been at about 7° immediately beforehand, rose to between 10 and 12° for between one and two seconds. The aircraft's pitch attitude was 6° nose up.

The power levers had been advanced to a mid-range setting just before the stick shakers activated but the engine torques had not increased before the warning was triggered. The engine torques then rose momentarily to about 40%, reduced to between 25 and 30%, before increasing again to 56.5%, where they remained for the remainder of the event. Flap 5 was selected within about a second of stick shaker activation.

The angle of bank remained unchanged for about five seconds, as the aircraft began to pitch further nose up at a rate of approximately one degree/second. Bank angle then began to increase, and was increasing through 34° as a maximum pitch of 12.5° was reached. The angle of bank reached a recorded maximum of 43.6°, coincident with the lowest recorded airspeed of 147 kt. The REF SPEEDS switch was selected OFF at between 153 kt and 147 kt[3], shortly before the minimum speed was reached and approximately 10 seconds after the stick shaker had activated.

The exact moment and duration of stick shaker activation could not be determined precisely because the data sampling rate was once every four seconds.

Footnote

[3] The recorded data update rate for this item was relatively slow, at once per four seconds.

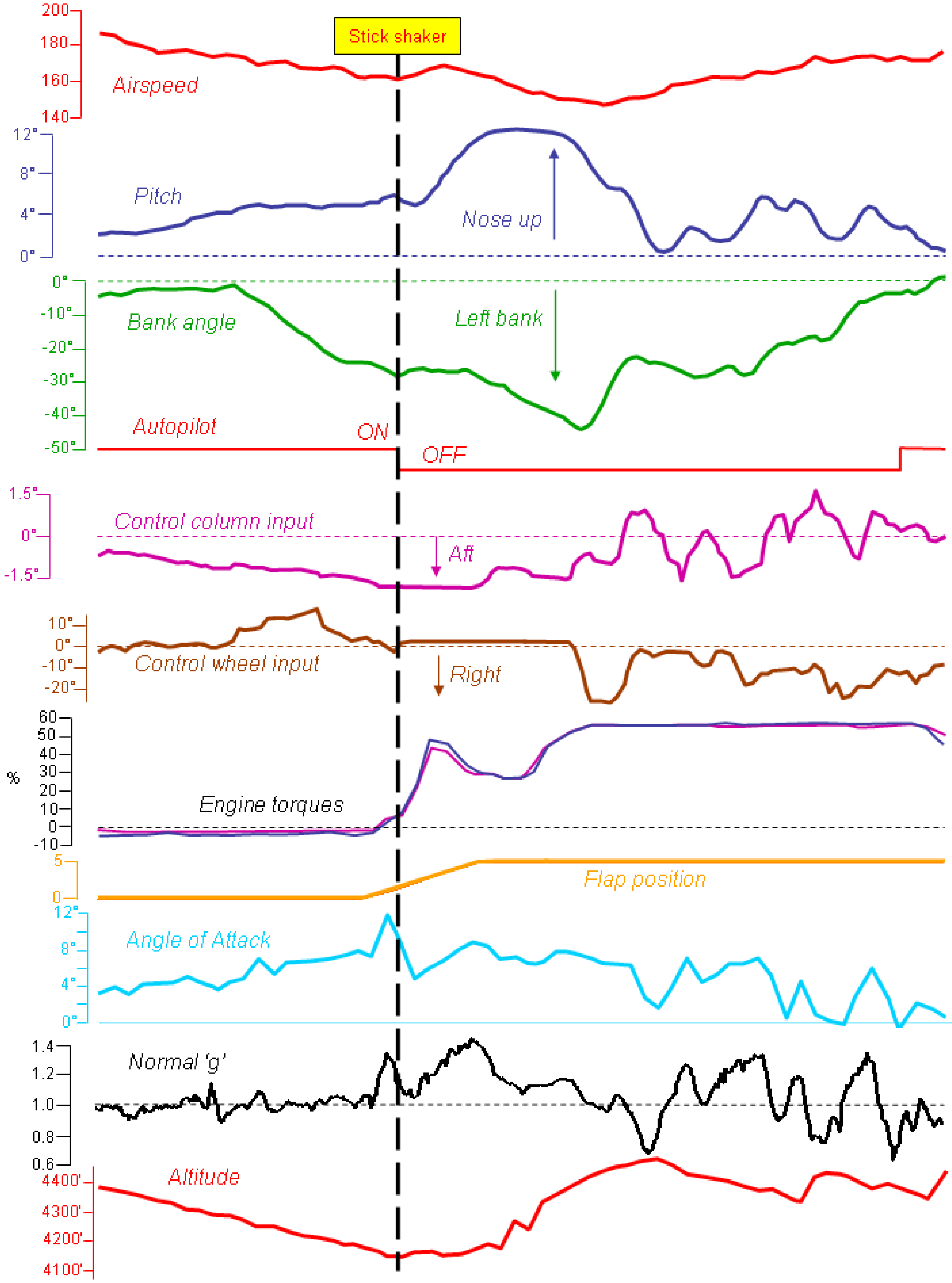

Figure 1

Relevant FDR parameters over a 65 second period surrounding the stick shaker event (simplified)

However, from the angle of attack and other data with a higher sampling rate, it is likely the stick shaker was active for only about one second, possibly less. The airspeed continued to reduce below that at which the stick shakers activated but, by then, the flaps had travelled to 5° and the angle of attack, although still fluctuating, was less.

Flight control inputs

Lateral control wheel displacements of up to 17° were recorded as the aircraft rolled left, in response to autopilot commands, returning to almost zero as the aircraft was stabilised in the turn. The control columns gradually moved aft as the speed reduced but this movement ceased when the autopilot disengaged, although the aircraft continued to pitch up and roll further left. Pitch trim, which had been increasing under autopilot control, remained unchanged after the autopilot was disengaged.

As the pitch approached its maximum value, about four seconds after autopilot disengagement, there was a small forward movement of the control column, which was soon removed, with no wheel displacement. Only when the bank angle increased beyond 40° was a large lateral control wheel input made, which corrected the overbanked condition. This was about 13 seconds after autopilot disengagement.

The aircraft returned to a steady turn condition, banked left at about 25° with a pitch attitude near 0°. It completed its turn onto a westerly heading and the airspeed recovered to 175 kt. Having gained about 350 ft during the event, the aircraft was established in a descent, once again, and the autopilot was re-engaged in the heading and vertical speed modes.

Flight crew accounts

The incident was initially investigated by the aircraft operator under its existing flight safety scheme. Consequently, both pilots had discussed the event at some length with company management and were aware of the FDR data. Thus, when they were interviewed as part of the AAIB investigation, nearly a month after the incident, it is probable that their recall of the event was influenced somewhat by the earlier investigation process.

The aircraft commander said that the flight crew had been expecting icing conditions during the descent, but the reported conditions at Southampton allowed for the final approach and landing to be made using normal speeds, ie without icing increments. Neither pilot recalled receiving an ICE DETECTED message at any stage of the flight. Both reported that cockpit conditions became difficult as the aircraft descended and encountered cloud, with heavy rain and turbulence causing considerably raised noise levels in the flight deck.

The commander recalled the ATC instruction to reduce speed to 160 kt. Although the REF SPEEDS switch was set to INCR, and he knew that non-icing speeds would be used for the final approach, he was undecided as to when he would or should put the switch to OFF. He was aware of the Flap 5 minimum manoeuvring speed of 138 kt and the 20 kt icing increment with the REF SPEEDS switch at INCR. He thought that the speed had reduced to 160 kt and the co-pilot had called for Flap 5 when the autopilot disengaged, although he did not recall the stick shaker activating. The co-pilot had her hands clear of the controls but placed them on the controls at that time.

The commander considered that he may have been partly distracted by the radio and imminent flap selection at about the time that the stick shaker went off. However, he recalled seeing the airspeed just above the point on the speed tape at which stick shaker activation was predicted. He called something like "CAUTION, SPEED – REFS GOING OFF" and set the REF SPEEDS switch to OFF. This immediately increased the speed margin above stick shaker activation.

The co-pilot recalled thinking that the 160 kt instruction was achievable with Flap 5 and, essentially, conformed to a normal speed profile. She reported being aware that the autopilot had disconnected, which she attributed to the turbulence. As it did so, she placed her hands on the control wheel and felt the stick shaker for a brief moment. She attributed the subsequent attitude excursions to the severity of the turbulence. She did not recall the commander mentioning the REF SPEEDS switch but was aware that he set it to OFF.

During interview, both pilots expressed some reservations about the complexity of the icing procedures, as they appeared in their company's documentation, and felt that simulator training in this regard tended not to reflect real world situations in which changes from icing to non-icing procedures often entailed changing the REF SPEEDS switch during speed transitions.

Safety actions

Following the incident, the aircraft operator introduced or planned a number of safety measures:

1. A further notice to flight crews on the subject of low speed events was issued, incorporating information gleaned from a company analysis of such events over the preceding two years. The notice further stressed to crews the importance of the correct operation of the REF SPEEDS switch and of awareness of its position, particularly during the approach phase when a transition from 'icing' to 'non-icing' speeds was planned. The analysis identified a number of cases in which the REF SPEEDS switch had been set to OFF as an early action on encountering stick shaker, so it was again stressed that crews were to carry out standard stall recovery actions before making any attempt to identify the reason for a stick shake warning.

2. A standard speed profile was introduced. Using this profile, the aircraft would reduce to a Flap 0 speed of 210 kt by 12 nm to touchdown, thence to 180 kt with Flap 5 by 8 nm to touchdown. Further speed reduction, initially to 160 kt, would normally only occur within 8 nm of touchdown.

3. An evaluation would be made of the quality of the initial type rating training given to company pilots regarding the correct use of the REF SPEEDS switch, with a view to amending the training if deemed necessary.

4. Further amendments to winter operations documents were planned, to reinforce the correct procedures in icing conditions.

5. A review would be made of the stall recovery training given during initial type rating training to ensure such training reinforced the correct initial response to a stick shake warning.

6. Low speed awareness training was to be included in recurrent simulator training programmes.

7. Takeoff and landing data cards were to be introduced, to provide reference speeds for flight crews on the flight deck.

8. In a subsequent revision to the OM, the operator removed the requirement not to exceed 160 kt during stall recovery, replacing it with the phrase *"not to exceed any airframe limitations."*

In May 2009 a meeting was held between the AAIB and the CAA, at which the operator's response to the incident was discussed. The CAA was satisfied that appropriate and measured steps were being taken by the operator and undertook to monitor the areas of concern at future audits. No further actions or recommendations were deemed necessary.

Analysis

Stick shake encounter

The aircraft was descending with the autopilot engaged in vertical speed mode, with a low rate of descent and at low power. Although this configuration suited the planned descent path and resulted in a desired reduction in airspeed, it required that the crew closely monitor airspeed to ensure it did not fall below the minimum for the configuration, particularly given the turbulent conditions.

Had the aircraft been flying in smooth, straight and level flight, there would have been a margin above the stick shaker speed, even with the REF SPEEDS switch at INCR. However, the aircraft was in a decelerating turn at low power, and in moderate turbulence. In this case, the reduction below the minimum Flap 0 speed, together with these other factors, reduced the margin to zero for a brief time, causing the stick shaker to activate.

Both pilots were apparently aware of the minimum Flap 5 speed of 158 kt, but on this occasion seem to have regarded this as a target speed with Flap 5 rather than a minimum speed. This may have been influenced by the knowledge that the REF SPEEDS switch was soon to be set OFF, or may be indicative of a less than full understanding of the speed schedule in icing conditions. The late flap selection resulted in a significant excursion below the minimum Flap 0 speed of 175 kt which, with the aircraft in a turn and in moderate turbulence, caused the stick shakers to activate.

Attitude excursion

FDR data showed that no effective control inputs were made after the autopilot had disengaged, although the co-pilot had placed her hands on the controls at that point. As the aircraft subsequently reached exaggerated attitudes in both pitch and roll, it appears that the co-pilot did not in fact realise that the autopilot had disengaged until the increasing roll attitude had become a concern. Her belief at interview that the attitude excursion was brought on by turbulence supports this supposition. The commander saw the co-pilot put her hands on the control wheel and probably thought she had assumed manual control.

Flight crew performance

Each pilot was correctly trained and qualified, and had demonstrated their competence to the required standards. However, on this occasion they did not operate effectively, either individually or as a crew, in that they first allowed the aircraft to reach an undesirable situation and then did not deal with the situation in an entirely appropriate manner.

Neither pilot had flown for a period of time due to annual leave and their normal roster patterns. Although this did not contravene any regulation, it was not an ideal situation. Early in their first duty period after leave, they were required to fly an approach at night in difficult circumstances, albeit the approach was at their home airfield and not procedurally demanding.

The presence of a significant tailwind on the downwind leg may have combined with the pilots' relative lack of currency and difficult cockpit conditions to produce a situation where they were not thinking as far ahead as they normally would. The tailwind necessitated ATC's instruction to reduce speed to 160 kt at an unusually early stage in the approach and was followed quickly, again because of the tailwind, by the instruction to turn left onto base leg. As this coincided with the aircraft speed reducing to the point that flap extension was required, the crew's workload would have increased rapidly and probably unexpectedly, which would have increased the likelihood of them making procedural and cognitive errors.

The lack of a positive reaction by the co-pilot to the stick shaker, and the commander's response to the low speed situation of putting the REF SPEEDS switch to OFF, shows that neither pilot considered the aircraft to be in immediate danger of an actual stall. This was an accurate assessment, but one which is difficult to make at a time of increased stress and workload, hence the requirement to carry out positive stall recovery actions upon stick shaker activation.

The co-pilot was faced with an unusual situation, in which her procedures and training required a definite response (the stall recovery actions). Yet the aircraft had effectively recovered itself and already met most of the criteria for recovery: speed was in excess of (or not far below) 160 kt, the altitude was about that at entry, and the aircraft was by now configured for continued flight. Crucially though, the aircraft was not wings level, and positive action from the co-pilot on the controls at this stage to level the wings, or at least reduce the existing bank angle, would have prevented the subsequent attitude excursion.

SERIOUS INCIDENT

Aircraft Type and Registration:	Embraer ERJ 190-200 LR (Embraer 195), G-FBEH
No & Type of Engines:	2 General Electric Co CF34-10E7 turbofan engines
Year of Manufacture:	2007
Date & Time (UTC):	1 August 2008 at 1220 hrs
Location:	40 nm NW of Wallesey, en route from Manchester to Belfast City
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 5 Passengers - 90
Injuries:	Crew - 1 (Minor) Passengers - 4 (Minor)
Nature of Damage:	No 1 air cycle machine failure
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	48 years
Commander's Flying Experience:	6,500 hours (of which 410 were on type) Last 90 days - 147 hours Last 28 days - 65 hours
Information Source:	AAIB Field Investigation

Synopsis

The aircraft was operating a scheduled passenger transport flight with the No 2 air conditioning pack inoperative, as permitted by the Minimum Equipment List (MEL). Whilst en route, a failure of the No 1 Air Cycle Machine (ACM) occurred, releasing smoke and fumes into the aircraft. A MAYDAY was declared and an expeditious diversion was carried out. After donning oxygen masks the pilots had great difficulty communicating with each other, ATC and cabin crew, because of technical problems with the masks. During the emergency evacuation the right overwing emergency exit door became jammed and unusable. Passengers who evacuated via the left overwing exit were unaware of how to get from the wing down to the ground. Two Safety Recommendations are made as a result of this investigation.

History of the flight

The crew reported for duty at Belfast City Airport at 0445 hrs for a four-sector day. The first sector was to London Gatwick, where the crew made a planned aircraft change onto G-FBEH for the return flight to Belfast. This aircraft had experienced a fault with the No 2 air conditioning pack on 28 July 2008. The pack had remained unserviceable since then and the defect was recorded in the aircraft technical log as an Acceptable Deferred Defect (ADD). The flight crew confirmed from the MEL that dispatch with this defect was allowed for up to 10 days; with the limitation that the maximum altitude be restricted to FL310. After returning to Belfast they then flew the aircraft to Manchester. All three sectors were without incident.

The final sector of the day was scheduled to be from Manchester to Belfast City. The aircraft took off at 1150 hrs, with the commander operating as handling pilot. Approximately 10 minutes after takeoff, during the climb to the final cruising level of FL240, both pilots smelt a sulphurous burning smell, similar to that of a match being struck. They contacted the Senior Cabin Crew Member (SCCM) by interphone to ask if he could smell it in the cabin and asked him to check the forward toilet, which is close to the flight deck, as they considered the smell might have been due to a passenger smoking in the toilet. The SCCM and a cabin crew member from the rear of the aircraft reported that there was no evidence of anyone smoking in the toilet, but they could smell something in the cabin and a haze was visible from the rear of the cabin. When interviewed after the incident, the crew commented that the smell was unfamiliar to them, which heightened their concern.

The smell became sufficiently strong on the flight deck that the pilots decided to don their oxygen masks. The aircraft was approximately midway between Manchester and the Isle of Man and the wind direction of approximately 210° at about 15 kt made a straight-in approach to Runway 26 at Ronaldsway Airport (Isle of Man) favourable. The commander was familiar with the airport and, concerned that the smell might have been due to a fire, decided to divert there.

The co-pilot requested a descent from Manchester ATC and clearance was given to descend to FL200. He then declared a MAYDAY and informed ATC of their decision to divert to Ronaldsway. An expeditious descent was performed, during which the co-pilot reviewed the emergency descent checklist and selected the emergency code, 7700, on the transponder. Given the absence of any flight deck warnings or visible smoke and the limited time available for planning the approach, the flight crew did not refer to any other emergency checklist.

Communication whilst wearing the oxygen masks proved very difficult due to technical problems with the masks. The co-pilot had to repeat calls to ATC to make himself understood and communications between the two pilots were rendered so poor that they had to resort to shouting.

The SCCM had tried to contact the pilots by interphone during the descent to inform them that the smell in the cabin was getting worse and that the haze was now also visible in the front of the cabin. Although both pilots could hear him, he could not hear them and the pilots activated the cabin emergency call bell. The SCCM, still unable to communicate with them by interphone, initiated the emergency access procedure and gained entry to the flight deck. The commander told the SCCM that he intended to land as soon as possible and ordered him to secure the cabin. The SCCM was advised to expect a normal landing, but was not told that they would be landing at Ronaldsway. The commander did not make an announcement to the passengers because of the communication problems experienced whilst wearing his oxygen mask and the limited time available to prepare for the approach.

Manchester ATC transferred the aircraft to Ronaldsway ATC who offered them either a Surveillance Radar Approach (SRA) or an NDB approach to Runway 26. The flight crew accepted the SRA and requested that the fire services be in attendance for the landing.

The cabin crew stated that the smell came and went during the flight. The SCCM reported that whilst on the approach to Ronaldsway the smell intensified again, becoming stronger than before and smoke was now visible in the cabin. He advised the commander, who considered that he would probably conduct an evacuation on landing. He did not communicate his intent to the SCCM or ATC as he thought that to tell them anything at this late stage of the flight might cause confusion should he decide not to order an evacuation.

The pilots continued with the SRA and became visual with the runway at an altitude of about 700 ft. The commander completed a visual approach and landing on Runway 26 and brought the aircraft to a halt at a runway intersection, turning it into wind as he did so. He then ordered the cabin crew over the Passenger Address (PA) system to stand by, and a few seconds later, gave the order to evacuate.

Aircraft evacuation

The aircraft was equipped with six emergency exits: four doors fitted with inflatable slides, two at either end of the cabin, and two 'Type III' emergency exits located approximately midway up the cabin, over the wings. On hearing the order to evacuate, the cabin crew opened their allocated doors, the escape slides inflating automatically. The SCCM initially prevented passengers using Door 1 Left (D1L) as the slide had not fully inflated by the time the first passenger arrived there. Once it was fully inflated, the SCCM had to push himself past the flow of passengers to reach Door 1 Right (D1R) to open it. He commented that had he opened this door first, given the layout of the cabin, he would not have been able to push past passengers to get to D1L (Figure 1).

Passengers commented that they found the slides very steep and were surprised by the speed at which they slid down them. The slides also ended without any round-out at the bottom, causing passengers to slide straight onto the ground at speed. This, and attempts by passengers to slow themselves on the slides, were the principal causes of injury reported. The cabin crew became aware of the problems and tried to reduce injuries by instructing passengers to sit down as they got onto the slide and by controlling the flow of passengers down the slides. Particular attention was paid to the older and more infirm passengers.

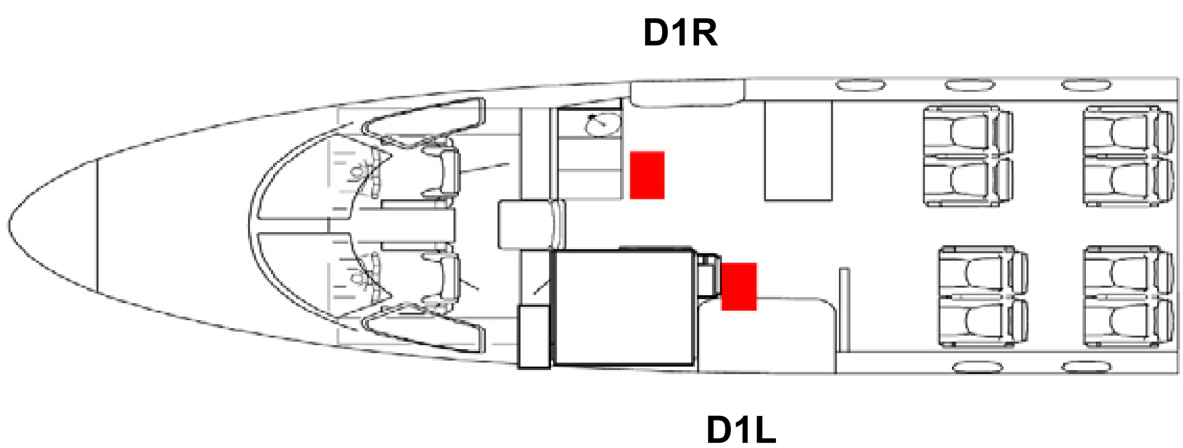

Figure 1

Forward cabin layout, showing forward exits (Doors 1 Left and Right)

When the order to evacuate was made, passengers were able to open the left overwing exit door and evacuate onto the wing. Attempts to open the right overwing exit door proved unsuccessful, as the forward upper part of the door trim had become jammed under the ceiling edge trim panel, preventing the exit from being opened (Figure 2).

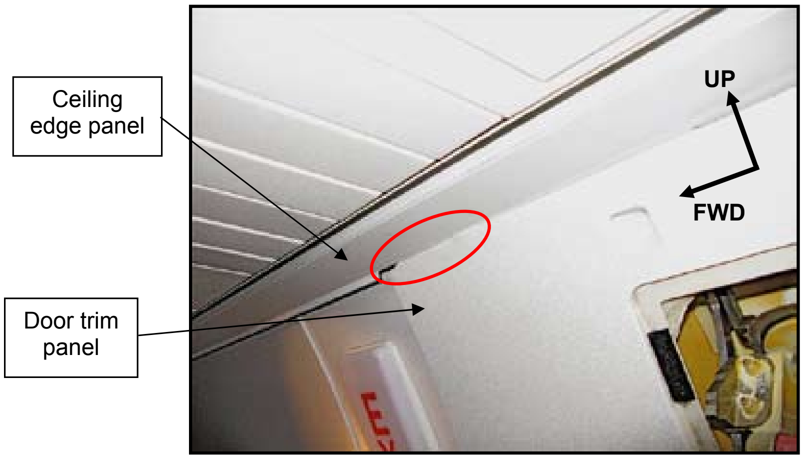

Figure 2

Right overwing emergency exit showing door trim partially jammed (circled) under ceiling edge panel

Passengers evacuating via the left overwing exit reported that once out on the wing, there was confusion as to how they should get off the wing down to the ground. A 61 cm-wide walkway was demarcated at the wing root in black paint, with arrows pointing towards the trailing edge (Figure 3). This was not noticed by some passengers; one passenger thought that the markings denoted an engineers' walkway, rather than an escape route. The overriding comment from passengers who evacuated onto the wing was that it was not obvious to them that they were meant to climb off the wing via the trailing edge. Although the wing flaps were lowered in accordance with the emergency evacuation checklist, there remained a considerable drop to the ground of about 1.7 metres.

Two male passengers who evacuated via the overwing exit were able to jump down from the rear of the wing and assist other passengers to the ground. This included a mother carrying a baby. They believed that had they not been able to offer such assistance, it is likely that some of the passengers might have received serious injuries in attempting to climb off the wing. Passengers believed that the situation would have been worse had it either been raining or dark at the time of the evacuation.

Figure 4 illustrates the exits used by the passengers, correlated by seat position. It shows that no passengers used D1R, despite this door being open with the slide deployed. Some passengers had been queuing to use the overwing exit when they were called to the rear of the aircraft by the cabin crew to use the rear exits, once they were clear of other passengers. This included a passenger seated one seat away from the left overwing exit, who stood in the aisle and assisted passengers evacuating via that exit.

Figure 3

Overwing exit evacuation route markings
(left wing shown, view towards wing trailing edge)

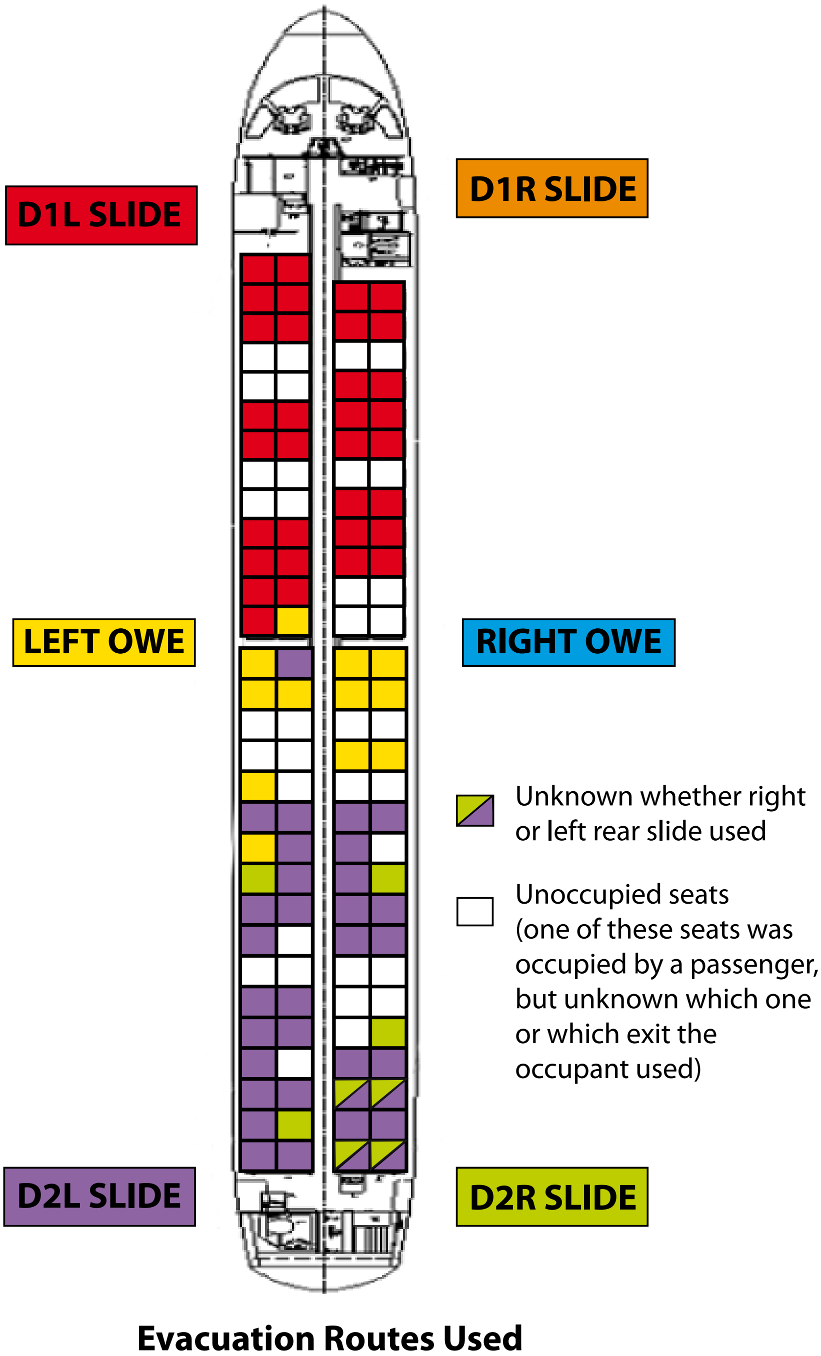

Figure 4

Evacuation routes used by passengers, correlated by seat position

The cabin crew estimated that all the passengers had exited the aircraft within one minute, following which the two cabin crew from the rear of the cabin checked that no one was still on board. They reported to the SCCM that the cabin and toilets were clear before returning to the rear, collecting their high visibility vests and a megaphone and evacuating via Door 2 Left (D2L).

The pilots attempted to communicate with ATC and the attendant fire services by radio, but this proved difficult because of the continuing technical problems with their oxygen masks. They eventually removed the masks and opened the window to speak to the fire services directly. On completing the emergency evacuation checklist the pilots entered the cabin, by which time only the SCCM was present. The latter had been concerned that the crew had not emerged earlier and, with no peephole to see into the flight deck, had resorted to banging on the door to attract their attention. The commander conducted a final search of the cabin and both pilots and the SCCM then evacuated via D1L.

Once outside, one of the cabin crew used the megaphone to assemble the passengers on an area of grass at the side of the runway. They also assisted passengers who were distressed or injured.

Pre-flight emergency briefing

Prior to departure, passengers seated next to the overwing exits were briefed by the cabin crew on how to operate the exit. There were also instructions attached to the seatback in front of these passengers, included in which is the depiction of an arrow apparently guiding passengers towards the trailing edge of the wing. Safety cards, provided for all passengers, included diagrams depicting passengers climbing off the trailing edge of the wing onto the ground.

Following this incident the operator revised its briefing to passengers seated next to the overwing exits to make them aware that the arrows on the wing indicate direction of evacuation, ie aft over trailing edge of the wing.

Voice and data recorders

Recorders

The aircraft was equipped with two identical Digital Voice and Data Recorders (DVDR), each recording flight and cockpit voice data. The voice recordings were sourced from a number of microphones including each flight crew member's (headset) boom microphone, both flight crew oxygen masks, the PA system, and the Cockpit Area Microphone (CAM).

Voice and flight data

Each recorder was successfully downloaded. The data show that while climbing through FL156, the co-pilot identified a burning smell similar to that of a lit match. Around three minutes later, the commander said to the co-pilot, "OXYGEN ON MATE, OXYGEN ON". The DVDR then automatically switched to record crew speech from the microphones in the oxygen masks.

The co-pilot declared a MAYDAY and requested a further descent to FL100. This request was not acknowledged initially by ATC, and only fragmented speech was audible on the recording from the co-pilot's oxygen mask microphone.

At around the time the oxygen masks were donned, the FDR data show an unusual drop in the 'Pack 1' flow rate and compressor outlet temperature. Prior to this, the flow rate was variable about a mean value of around 70 pounds per minute (lb/min) initially, rising to 75 lb/min with peaks of 90 to 91 lb/min. (Other data provided by the operator for the same aircraft with both packs operating showed that the pack outlet temperatures and flow rates were generally lower than under single-pack operation. The mean dual-pack flow rates were generally around 50 lb/min, with transients seldom exceeding 75 lb/min during dual-pack operation).

During the descent, recorded speech from the co-pilot's microphone continued to be fragmented and was described by ATC during their communications with the aircraft as "QUITE BROKEN". Recorded speech from the commander was also fragmented, and at times could be heard on the area microphone but not through his oxygen mask microphone. Intercom communication was also affected and the cabin crew had great difficulty understanding the flight crew. On occasions, the cockpit door had to be opened for face-to-face communication.

The aircraft landed 20 minutes after the flight crew first identified the smell. The recordings stopped when electrical power was lost after engine shutdown, so the evacuation sequence was not recorded.

Aircraft examination

Right overwing emergency exit

The right overwing emergency exit door was unlatched, but the forward upper corner of the door trim panel was partially jammed behind the outer edge of the ceiling-edge panel (Figure 2), preventing the exit from being opened.

Door retention and opening (Figure 5)

The overwing exit door is retained at its lower edge by spigots which engage in recesses in the bottom edge of the door aperture. Its top edge incorporates a locking mechanism operated by a handle at the top of the door, covered by a removable panel secured by Velcro strips. Pulling the operating handle disengages the lock at the top of the door and allows the door to pivot inwards about its lower edge. The spigots remain engaged until the door has pivoted inwards sufficiently for its top edge to clear the aperture, after which it is lifted clear of the aperture using a fixed handle near its base to support its weight. The door must then be thrown out of the aperture so that it does not cause an obstruction in the cabin to evacuating passengers. A compressible rubber bumper block limits the vertical displacement of the door during the initial phase of opening.

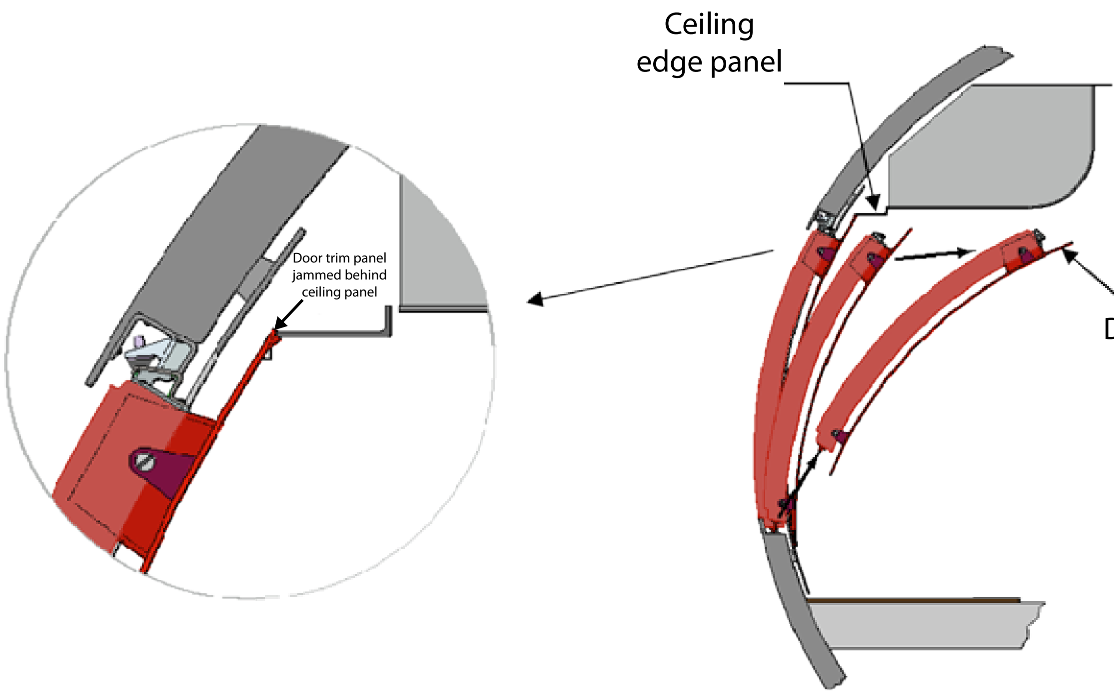

Figure 5

Overwing emergency exit opening, showing location of jam

Door opening clearances

Although the edge of the ceiling panel was cut back around the top edge of the overwing exit door, the resulting clearance between the door trim and ceiling edge panel was insufficient. Measurements of the right overwing exit showed that over most of its length the clearance was just sufficient to accommodate insertion of a credit card, but near the forward corner of the door, where the door trim had jammed, the clearance was only 0.003 inch.

Prior to this investigation, no clearance was specified at any location on or around the overwing exit door. After being alerted of this incident by the AAIB, the aircraft manufacturer issued Service Bulletin (SB) 190-25-0092. This required an inspection of the clearance between the overwing exit door trim and the ceiling edge panel, and replacement of the latter if the clearance was less than 2 mm. Additionally, a check was introduced during aircraft production to verify a minimum clearance of 2 mm between the door trim panel and the ceiling edge panel.

The efficacy of SB 190-25-0092 was subsequently assessed by the AAIB, with a representative from the aircraft manufacturer in attendance. This assessment was made on another aircraft from the operator's fleet on which the SB had just been implemented, with the rubber bumper at the top of the door correctly adjusted. It was found that the specified 2 mm clearance was insufficient to prevent the door liner from becoming jammed behind the ceiling edge panel if the door was lifted during the initial stages of opening, or if it was opened energetically, such as might be the case in an actual emergency. It was concluded that whilst the SB reduced the probability of a jam, the potential for a jam had not been eliminated.

Aircraft certification aspects

The Embraer 190 and its later derivative model the Embraer 195 were both certificated by EASA, the latter in July 2006. According to the aircraft manufacturer, the Embraer 195 was largely certified on the basis of its similarity to the Embraer 190; this approach was adopted for the overwing exits. However, during Embraer 195 development, the ceiling edge panel manufacturer introduced changes to the configuration and dimensions of the cut-outs around the overwing exit aperture, reducing the clearance between the ceiling panel and the door trim. These changes were not notified to the aircraft manufacturer.

The current aircraft certification requirements for overwing exits primarily address the issues of capacity, positioning, size and profile, but not that of potential jamming, except that there must be provisions

> *'to minimise the probability of jamming of emergency exits resulting from fuselage deformation in a minor crash landing.'*

Source of the smoke and fumes

Background

At the time of this incident, only the No 1 air conditioning pack was operative. The No 2 pack had been declared unserviceable after an investigation by the operator into the cause of a separate smoke in the cabin event that had occurred four days previously. It was established that the No 2 ACM rotor had seized. Examination of the No 1 pack ACM following this incident revealed that its rotor had also seized. It was later confirmed that both ACMs had suffered Stage 2 turbine blade failures. The resultant imbalance had resulted in contact between the turbine blade tips and the ACM casings, producing hot, finely divided, metallic particles that were released into the cabin air system, creating the reported symptoms of smoke and fumes inside the aircraft.

ACM failure investigation

Both ACMs were returned to the manufacturer for disassembly and preliminary examination; the failed Stage 2 turbine wheels were then returned to the AAIB for independent metallurgical investigation. The manufacturer established that both units had suffered turbine blade fatigue failures close to the blade root in a location of high stresses associated with a known failure mode caused by turbine blade resonance.

The independent metallurgical examination confirmed this finding. No evidence of any fatigue initiating features was found near the crack origins.

Previous ACM turbine failures

Previous failures of the Stage 2 turbine have occurred and were attributed by the ACM manufacturer to fatigue failure caused by blade resonance resulting from an overspeed condition. Of those turbine failures investigated, 40% of the cases were found to have been caused by component or control system failures that could cause an overspeed. In the remaining 60% of cases, no reason for an overspeed, or any other cause of the fatigue failure, was found.

Metallurgical examination by the manufacturer of a turbine failure which occurred in 2005, after 1,279 hrs and 868 cycles, established that one blade had separated from the wheel as a result of a fatigue crack, and a further two blades exhibited partial fatigue cracks. This mode of failure was very similar to that of the failed turbine from the No 2 ACM on G-FBEH. The positions of the crack origins corresponded with a known location of high stresses induced by full-blade third-mode resonance, which the manufacturer stated occurs at 51,574 RPM +/ 3% (50,072 RPM to 53,121 RPM).

During single-pack operation, the nominal turbine speed is predicted to range from 42,500 RPM (25,000ft climb, standard conditions) to a maximum of 51,100 RPM (sea level climb, hot conditions), with an absolute maximum, taking into account sensor tolerances, of 52,100 RPM.

The manufacturer stated that an analysis of ACM removals suggested no relation between ACM failure (of any type) and single-pack operation. Following this incident the aircraft manufacturer conducted a reliability analysis of the ACM, concluding that a reduction in the current single-pack MEL operating period limit of 10 days was not warranted.

A modification to reduce the probability of Stage 2 turbine blade resonance, introducing a new Stage 2 turbine nozzle design with an increased vane count to move the blade pass frequency outside the critical range, was being developed when this incident occurred.

Crew oxygen masks

Overview

The crew oxygen masks are equipped with selector valves which give the option of 'mixed' (air/oxygen), '100%' (oxygen) and 'force-feed' (purge) modes of supply.

The microphone system installed in the masks incorporates a cut-out device that electrically isolates the microphone during the inhalation phase of breathing, and reconnects it again during exhalation. This is to prevent the 'wind-rush' sound caused by the in-flow of air/oxygen across the microphone.

The cut-out device comprises a small plastic balance beam supported on trunnion bearings in the manner of a 'seesaw', carrying a magnet that moves in proximity to a reed switch mounted beside it. The balance beam is positioned in the gas path and is biased towards the 'microphone live' position by residual attraction between the magnet and an adjacent screw head. An asymmetry in the area presented to the gas flow on either side of the pivot creates a net force on the beam, tending to tilt it towards the 'cut-out' position in opposition to magnetic bias-force. At in-flow velocities below a certain threshold, ie during exhalation, the magnetic bias moves the beam back to its original position, restoring microphone function.

On-aircraft checks

Checks of the crew oxygen mask microphones on G-FBEH suggested that the captain's microphone was defective, but it could be made to operate by lightly tapping the face of the microphone casing.

Similar checks of the crew oxygen masks were performed on another of the operator's aircraft. The microphone on the captain's mask, like that on G-FBEH, was also initially inoperative, but became live after the mouthpiece was tapped sharply. A consistent pattern of malfunction was observed: during inhalation, the cut-out system (correctly) isolated the microphone and, thereafter, it remained isolated during the exhalation phase. Tapping the mouthpiece then restored microphone function until the cut-out mechanism isolated it again during the next inhalation phase.

During these checks it was noted that with the oxygen supply set to purge mode, the microphone cut-out mechanism tended to hunt between live and cut-out modes during speech, producing a sound similar to the garbled radio transmissions heard from the aircraft during the incident.

Oxygen mask examination and tests

The captain's and co-pilot's masks from G-FBEH, and the defective captain's mask from the other aircraft were tested and strip-examined at the manufacturer's facility in the United States, under AAIB supervision. The captain's mask from G-FBEH was found to be non-functional and could not be tested. The co-pilot's mask passed all of the test criteria. The other captain's mask operated intermittently, displaying the same characteristics as seen during the on-aircraft checks.

When demonstrated by someone who routinely performed the production acceptance tests, the microphone on a serviceable mask produced clear speech with the oxygen flow setting in all modes. However, when tried by people less familiar with mask operation, the audio output in the purge flow mode was garbled. With practice, once accustomed to speaking against the (significant) positive gas pressure in this mode, good clarity of speech was achieved. The tendency to produce garbled output when set to purge was evidently a feature of the system that required practice to overcome. The operator of G-FBEH was advised of this finding.

Strip-examination

Strip-examination of the microphone and cut-out assembly from the captain's mask from G-FBEH revealed that the magnet was fouling slightly against the side of the cut-out switch body, causing the balance beam to become stuck in the cut-out position. The cause of the foul was the incorrect positioning of the reed switch body.

Disassembly of the captain's mask from the other aircraft identified a spurious whisker projecting from the plastic housing of the cut-out switch, the free end of which contacted the underside of the flow sensor pivot. The whisker acted as a ratchet, tending to inhibit movement of the sensor vane in the direction required to reactivate the microphone, whilst leaving its motion in the direction required to cut out the microphone unaffected. Consequently, the mechanism tended to stick in the cut-out position, leaving the microphone open circuit. The whisker or spurious material appeared to be a 'curl' of the switch casing material (Figure 6), probably created either in the production of the switch itself, or during its assembly into the mask.

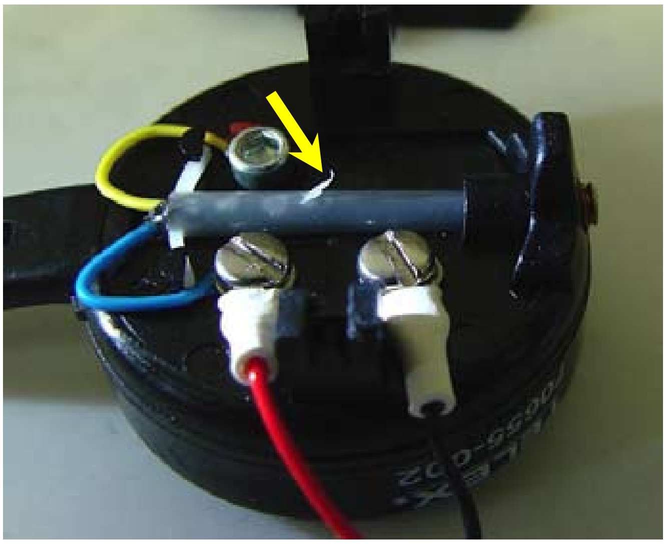

Figure 6

Whisker of plastic material on cut-out switch

In the light of these findings, the mask manufacturer undertook a detailed review of its design and manufacturing processes. This resulted in an improved physical location of the magnet at its attachment to the flow sensor vane, the use of adhesive to prevent movement of the switch body once its position has been adjusted to provide the required change-point, and the addition of quality checks to ensure that switch casings supplied to the company are free of burrs.

Additional information

Previous evacuation incident

The AAIB investigated an incident on 1 April 2002 (EW/C2002/4/1), in which the cabin of a Fokker F28 filled with smoke. An emergency evacuation was carried out, during which passengers using the overwing exits experienced similar problems getting from the wing to the ground. The report stated:

> *'Having climbed out of the cabin, passengers disembarking from the left overwing exit were unsure of how to descend from the wing to the ground. A number congregated on the wing looking for a way down. Cabin crew eventually noticed the confusion and urged the passengers to get off the wing. Some passengers slid or jumped from the wing tip and leading edge (a drop of some 7 to 8 feet) instead of sliding off the wing trailing edge down the extended flaps.'*

Of the report's three recommendations, one is relevant to the incident involving G-FBEH:

> **Safety Recommendation 2002-42**
>
> The CAA and the JAA should review the design, contrast and conspicuity of wing surface markings associated with emergency exits on Public Transport aircraft, with the aim of ensuring that the route to be taken from wing to ground is marked unambiguously.

The Civil Aviation Authority accepted the recommendation, but no response was received from the Joint Aviation Authority. The responsibility for aircraft certification within Europe is now held by the European Aviation Safety Agency (EASA).

Analysis

Crew decision making

The commander's decision to divert to the Isle of Man was based on his concern that there might have been a fire on the aircraft. The sulphurous smell experienced by both pilots was something that they had never encountered on an aircraft before, but one which they uniquely associated with burning. Having made the decision to divert, the commander had limited time in which to achieve a straight-in approach and landing. This task was made more difficult by the communication difficulties experienced once the pilots had donned their oxygen masks. Consequently, the commander omitted to inform the SCCM that they were diverting and it also led to his decision not to attempt to speak to the passengers over the PA.

The fluctuating intensity of the smell meant that the commander did not decide to perform an emergency evacuation until late in the flight. His intentions were not communicated to the cabin crew and passengers and they were therefore surprised by the command to evacuate. However, despite the unexpected nature of the order to evacuate, this did not delay its commencement.

Door 1R & 1L configurations & passenger flow issues

None of the passengers evacuated the aircraft via D1R. This, it is considered, was influenced by the staggered layout of the front two emergency exits. In addition, there was only one crew member situated in this part of the cabin to direct and assist passengers during the evacuation and he was standing next to D1L. Passengers would have therefore had to find and use D1R at their own initiative.

Overwing escape route markings

It is apparent from this incident that the issue of ambiguous overwing escape route markings that resulted in AAIB Safety Recommendation 2002-42 still exists. It is therefore appropriate that this matter is re-examined. As responsibility for aircraft certification now lies with the EASA, the previous Safety Recommendation is therefore re-issued as follows:

Safety Recommendation 2010-007

It is recommended that the European Aviation Safety Agency review the design, contrast and conspicuity of wing surface markings associated with emergency exits on Public Transport aircraft, with the aim of ensuring that the route to be taken from wing to ground is marked unambiguously.

Overwing exit jam

The jamming of the right overwing exit door occurred because of insufficient clearance between the top edge of the door trim and the ceiling edge panel. To prevent fouling at this location, adequate clearance must be available in the initial stages of door movement until the door trim panel has passed fully beyond the ceiling panel. In the case of the right overwing exit on G-FBEH, there was effectively no clearance, such that the exit immediately jammed on attempting to open it.

The AAIB checks demonstrated that, whilst improving the situation, the 2 mm minimum clearance specified in SB 190-25-0092 was insufficient to prevent the door liner from fouling the ceiling edge panel if the door was lifted firmly as it was unlocked, or if the door was jerked open, as might occur in an emergency. The 2 mm clearance requirement is not entirely effective in eliminating the possibility of a jam. The following Safety Recommendation is therefore made:

Safety Recommendation 2010-008

It is recommended that Embraer modify the overwing emergency exits on Embraer 195 aircraft, to eliminate the possibility of the exit door jamming due to interference between the door trim panel and the ceiling edge panel.

ACM turbine failures

Examinations of the failed turbine wheels from G-FBEH showed that they had failed due to fatigue cracking originating in a location of high stresses associated with a known blade resonance condition. A new Stage 2 turbine housing was under development to address the problem.

The failure of the Stage 2 turbine on the No 1 ACM occurred after only four days out of the 10 days of single-pack operation permitted by the MEL. This suggests that the turbine speed had encroached into the resonance range during this period. It is possible that other units could be similarly vulnerable during single-pack operation. However, the aircraft manufacturer stated that this event was the only known case of the failure of an ACM Stage 2 turbine during single-pack operation on the Embraer 190/195 fleet. They also reported that the reliability of the air conditioning pack had been significantly improved through various modifications and maintenance actions, significantly reducing the probability of Stage 2 turbine failures. Therefore no Safety Recommendation is considered necessary.

INCIDENT

Aircraft Type and Registration:	SAAB-Scania SF340A, G-GNTF
No & Type of Engines:	2 General Electric CO CT7-5A2 turboprop engines
Year of Manufacture:	1988
Date & Time (UTC):	8 October 2009 at 0232 hrs
Location:	RAF Kinloss, Scotland
Type of Flight:	Commercial Air Transport (Cargo)
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to right propeller and fuselage side
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	33 years
Commander's Flying Experience:	3,250 hours (of which 2,250 were on type) Last 90 days - 164 hours Last 28 days - 45 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The aircraft landed on Runway 26 at RAF Kinloss, after an uneventful flight from Edinburgh. At about 40 to 50 kt during the ground roll, two deer were seen to run in front of the aircraft from left to right, a short distance ahead. The commander applied maximum braking and steered the aircraft to the left as far as he was able without risking a loss of directional control. The deer passed down the right side of the fuselage and struck the right hand propeller. The crew brought the aircraft to a stop and, with vibration from the right engine apparent, both engines were shut down. Upon inspection, a propeller tip was found to have sheared off and made contact with the fuselage side.

ACCIDENT

Aircraft Type and Registration:	Aviat A-1B Husky, G-HSKI
No & Type of Engines:	1 Lycoming IO-360-A1D6 piston engine
Year of Manufacture:	2005
Date & Time (UTC):	3 January 2010 at 1030 hrs
Location:	Llandegla Airfield, North Wales
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to propeller, right wing and tail
Commander's Licence:	Private Pilot's Licence
Commander's Age:	57 years
Commander's Flying Experience:	915 hours (of which 330 were on type) Last 90 days - 16 hours Last 28 days - 8 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Shortly after touching down on a private airstrip, the aircraft (a tailwheel type) nosed over and came to rest on its back. The occupants, who reported that they were both wearing full harnesses, exited the aircraft through the right door, uninjured. The weather was fine, with no wind, but the landing surface was snow-covered. The pilot reported that he had landed on snow-covered surfaces in the same area in the preceding two weeks, but on those occasions the surface had been of compacted snow about four inches deep.

Prior to the accident flight, the pilot was advised that the snow on the airstrip was about 12 inches deep, but he thought the surface would have compacted because snow had been lying on it for about 10 days. It subsequently became apparent that the airstrip was covered in about 10 inches of uncompacted snow.

ACCIDENT

Aircraft Type and Registration:	Avid Flyer C, G-IMPY
No & Type of Engines:	1 Rotax 532 piston engine
Year of Manufacture:	1990
Date & Time (UTC):	1 March 2010 at 1600 hrs
Location:	Gadairwen Farm, Pontyclun, near Cardiff
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Right landing gear bent back into fuselage, right wing bent, propeller damaged
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	77 years
Commander's Flying Experience:	543 hours (of which 438 were on type) Last 90 days - 2 hours Last 28 days - 0 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Whilst on final approach in light winds with about 50 m to go to the private grass strip, the pilot encountered "rapid sink". He added power, but too late to prevent contact with the top of the low boundary hedge at the start of the strip, causing the aircraft to land heavily, with little forward speed, just beyond the hedge. Although the aircraft was extensively damaged, the pilot, who was wearing a three-point lap strap and shoulder harness, was uninjured and vacated the aircraft without difficulty.

ACCIDENT

Aircraft Type and Registration:	Europa XS, G-BYFG
No & Type of Engines:	1 Jabiru Aircraft Pty 3300A piston engine
Year of Manufacture:	2003
Date & Time (UTC):	29 May 2009 at 1419 hrs
Location:	South of Carsington Water, north-east of Ashbourne, Derby
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Minor) Passengers - N/A
Nature of Damage:	Substantial
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	59 years
Commander's Flying Experience:	2,150 hours (of which 110 were on type) Last 90 days - 8 hours Last 28 days - 2 hours
Information Source:	AAIB Field Investigation

Synopsis

The engine suffered a sudden and significant loss of power in flight. The pilot, who was unable to restore power, carried out a forced landing in a field, during which the aircraft collided with a hedge and was substantially damaged. He received minor injuries and was able to vacate the aircraft unaided. The investigation could not positively determine the cause of the power loss, but an unapproved modification to the fuel system may have been a contributory factor.

History of the flight

The purpose of the flight was to ferry the aircraft from Fishburn Airfield, near Durham, to its base at Tatenhill, near Burton-on-Trent. The aircraft had been at Fishburn for repair work following a landing accident in February 2008 (AAIB report EW/G2008/02/05 refers). After completion of the work, various taxi trials and a test flight were successfully undertaken. The inspection and test flight for the renewal of its Permit to Fly were completed in March 2009.

The pilot, an instructor with over 100 hours on type, had been asked to conduct the flight by the owners as they were not in current flying practice on the aircraft. One of the co-owners had flown the pilot to Fishburn in another aircraft and assisted with the preparations for the return flight.

Prior to the flight, the pilot taxied the aircraft to the fuel bowser for refuelling, during which he remained in his seat. The fuel sight tube is located on the centre tunnel near the front of the pilot's footwell and was difficult to see from his seated position, so he engaged the help of the co-owner, who stood beside the cockpit with his head positioned so that he could see the top of the sight tube. Fuel was added by an assistant and the co-owner instructed him to stop when the level approached the top of the sight tube, to avoid fuel overflowing out of the filler neck. Fuel was then carefully added until the fuel level was at the top of the sight tube, which the pilot and co-owner took to signify that the tank was full. A total of 26 litres of Avgas were uplifted.

The pre-flight and pre-takeoff checks were completed satisfactorily. Prior to the power checks the pilot selected the fuel selector to the other tank outlet to check the fuel supply from that part of the fuel tank. During the power checks, operation of the carburettor heat control only produced a small reduction in engine rpm, but a temperature rise was observed on the carburettor temperature gauge, confirming that the system was operational.

Once established in the cruise the pilot elected to fly at a reduced power setting in order to arrive at Tatenhill at a similar time to a slower aircraft that was following. The pilot obtained the weather from the East Midlands Airport ATIS; this gave a temperature of 24°C and dewpoint of 12°C. The flight had progressed normally for about 90 minutes when there was a sudden and significant loss of engine power. The pilot carried out his standard actions: applying carburettor heat, selecting the electric fuel boost pump ON and selecting the other fuel source. None of these actions had any effect on the engine performance, so he adjusted the throttle position to give the maximum power that was available.

The pilot then declared a MAYDAY to East Midlands Radar and stated his intention to land at nearby Ashbourne airfield. Within a few minutes the engine had lost all power and he was left with no option but to select a field and conduct a forced landing. As the aircraft descended, it became apparent that the chosen field was unsuitable because it was crossed by power cables and he decided to land in another field. However, no suitable fields were within the remaining gliding range. During the landing the aircraft floated above the down-sloping field, towards a tall hedge at the far end. He decided to try to fly through the hedge rather than risk a potential stall by attempting to climb over it. This rapidly slowed the aircraft and it came to rest, upright, in the field on the other side of the hedge.

The pilot received minor injuries and was able to exit the aircraft unaided. The aircraft had sustained substantial damage, including the detachment of the engine. After vacating the aircraft, he selected the electrical master switch and the fuel selector to OFF, before contacting East Midlands Radar using his mobile telephone. The emergency services were quickly on the scene and the pilot was taken to hospital.

The aircraft was recovered to Tatenhill the following day. It was later taken to the AAIB facilities for detailed examination.

Aircraft description

The Europa is a side-by-side two-seat homebuilt aircraft. Over 1,000 kits have been delivered to date and several hundred have been completed and are now flying. The aircraft is often fitted with a Rotax engine, but installation of the Jabiru engine is approved by the Light Aircraft Association (LAA).

Fuel system

General

The fuel system on the Europa incorporates a single saddle-shaped tank located behind the seats. G-BYFG was placarded as having a total useable capacity of 65 litres (56 main and 9 reserve). The main fuel supply is drawn from the upper part and one side of the tank. The other side of the 'saddle' is used as a small reserve fuel supply. A schematic of the fuel system is provided in Figure 1. According to the engine manufacturer the fuel consumption of this engine type at 75% power is 26 litres per hour, with the caveat that: *'actual consumption will vary depending on installation, propeller and power settings'*.

There were no records available of fuel uplifts on the aircraft, nor were any required to be kept.

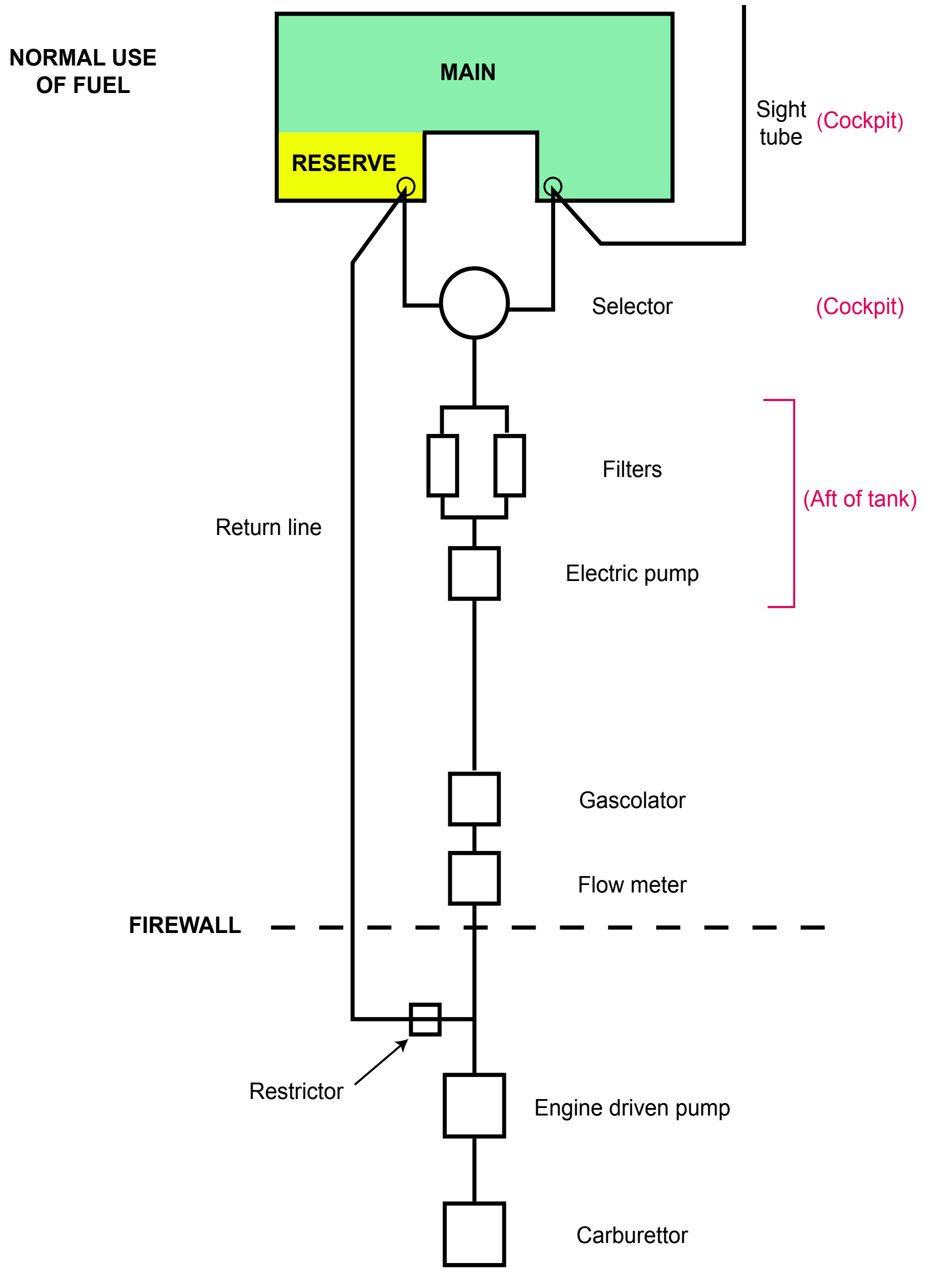

Figure 1

G-BYFG fuel system schematic

Fuel system modification

Under the direction of an LAA inspector, the fuel lines were replaced in June 2007 and a worksheet, signed by another LAA inspector, certified the satisfactory completion of this task. The entry also states that an additional return line *'required for MOGAS usage'* had been installed at the same time. This modification was not approved by the LAA. Examination of the aircraft showed that the bleed return line was connected between the main fuel line, immediately upstream of the engine-driven fuel pump, and the reserve side of the fuel tank. A restrictor was soldered into the 'T-piece' connecting the bleed return line to the main fuel line. Placards were fitted to the aircraft indicating that unleaded Mogas could be used. The co-owner stated that the aircraft was being prepared for the use of Mogas but further testing needed to be completed before modification approval could be applied for.

Fuel quantity indication

Fuel quantity indication was provided by means of a clear plastic sight tube mounted on the centre tunnel, close to the pilot's right lower leg (Figure 2). The sight tube must be calibrated during aircraft construction. The kit manufacturer's build manual suggests adding a card with dark and light stripes behind the tube to make the fuel level in the sight more visible; however, this was not used on this aircraft. Due to its location forward of the tank, the indicated fuel level is sensitive to changes in pitch attitude.

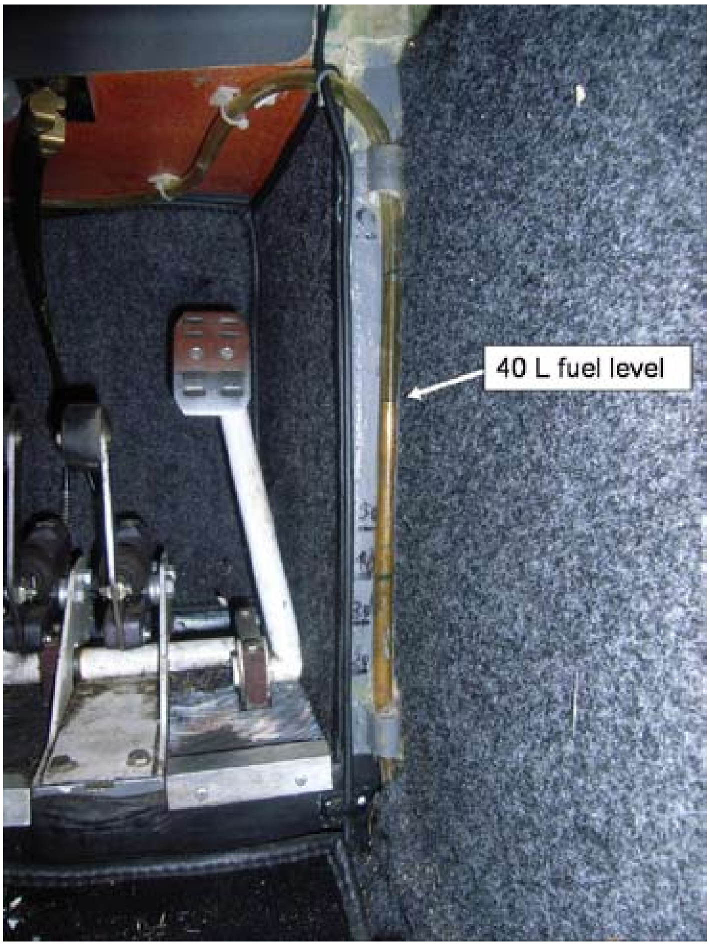

Figure 2

Fuel sight tube

The fuel sight tube on G-BYFG was discoloured and it was therefore difficult to read the fuel level in the tube. Graduation markings (20, 30, 40 and 50) were visible on the structure behind the sight tube (Figure 2), but it was not clear what these markings represented. Close examination of the sight tube revealed a line marked on the sight tube next to the '40' graduation. The significance of this line was not established. During the wreckage examination by the AAIB, water was poured into the fuel tank with the aircraft in its normal ground attitude, until the level in the sight tube reached the '40' graduation. This corresponded to an actual quantity in the tank of only 20 litres. When 40 litres were added to the tank, the level in the sight tube was well above all the graduations. With the level at the top of the sight tube, the total quantity in the tank was in excess of 60 litres.

Discussions with the co-owner revealed that the fuel sight tube had been calibrated following replacement of the fuel lines. These calibrations had been marked on an additional strip of metal that had been affixed beside the sight tube, on top of the abovementioned graduations. The metal calibration strip was subsequently found tucked in the bottom corner of the centre tunnel stowage pocket. It is not known when the strip became detached nor how it came to be in the stowage. The accuracy of these calibration marks could not be verified as the position in which the strip had been attached was not known.

Fuel system examination

When the aircraft wreckage was examined by the AAIB, no fuel was found anywhere in the fuel system or its components. However, given the length of time that had elapsed since the accident, this was not taken to be indicative of the quantity of fuel remaining in the aircraft at the time of the accident.

Examination of the carburettor did not reveal the presence of any debris in the float bowl and the carburettor functioned normally during subsequent engine testing. The fuel filters contained small particles of debris, but this was not considered to be unusual or significant. Only one of the two fuel filters was fitted with the required safety spring, however the filter element remained properly located. Inspection of the disrupted fuel pipes forward of the firewall showed that they had been forcibly pulled from their fittings when the engine detached.

The fuel system, up to the point where the engine had detached, was found to be free from leaks and capable of supplying fuel to the engine. There was no evidence of fuel staining on the airframe, which might have been indicative of a leak. A flow rate test using the aircraft's electric fuel boost pump showed that there was sufficient flow to satisfy the engine's demand at all engine power settings.

A further test was performed using an electric fuel pump to simulate the engine-driven pump. This pump was run with the fuel selector in the RESERVE position until that side of the tank was depleted, whereupon the flow decreased and eventually stopped. The fuel selector was then selected to MAIN and the electric fuel boost pump was then selected ON. Although the flow recommenced, it was at a much lower rate than before, even with both pumps running. It was apparent that air was being drawn into the fuel system through the fuel bleed return line from the now empty reserve side of the tank. Blocking the bleed return line restored the flow to its previous level.

Engine testing

The engine was examined and no pre-existing defects were identified. It was taken to a maintenance organisation specialising in this type of engine and after some minor remedial action to correct accident damage, it was mounted in a test stand. The engine started on the first attempt and ran smoothly at various power settings, despite one ignition system being inoperative due to accident damage. Following this test, the fuel bleed return line was introduced into the fuel system to replicate the aircraft's fuel system. It was found that the engine would run normally with the bleed return line closed off, but as soon as it was opened to atmosphere, air was drawn into the engine-driven fuel pump in preference to fuel, resulting in a significant loss of engine power.

LAA advice on aircraft modifications

The LAA produces Technical Leaflets to advise owners of procedures to be followed to ensure the continued airworthiness of their aircraft; these are available on the LAA website. There are several references to the modification process including Technical Leaflets TL 2.01 and TL 3.01.

Technical Leaflet TL 2.01 explains the responsibilities of the aircraft owner. In Section 3 the requirement to ensure the aircraft conforms to a LAA-approved design standard is discussed and includes reference to:

> *'making sure that any modifications are approved by LAA Engineering (not just the local inspector).'*

Technical Leaflet TL 3.01 deals with the approval of prototype modifications and sets out the process to be followed. It includes a section on the process for approving a modification application, which includes the following note:

> *'Once an aircraft has been modified it may not be flown until it has been approved.'*

Mandatory Permit Directive

Mandatory Permit Directive MPD: 1998-019 R1, relates to flexible fuel tubing. The MPD states:

> *'Prior to the issue or the renewal of a Permit to Fly, inspect all tubing used in fuel systems, including fuel delivery tubes, vent tubes and fuel sight gauge tubes for discolouration, shrinkage, degradation or embrittlement.'*

Completion of this mandatory inspection should be recorded in the aircraft logbook, however no such record could be found for G-BYFG.

Analysis

Whilst no positive evidence for the power loss could be identified, a number of possible scenarios were explored.

Carburettor Icing

The temperature and dewpoint obtained from the East Midlands Airport ATIS by the pilot were plotted on the carburettor icing chart from CAA Safety Sense Leaflet 14, '*Piston Engine Icing*', along with an estimated temperature for the altitude at which the flight was conducted. This indicated that moderate carburettor icing could be expected at cruise power, becoming severe at descent power. Given that the aircraft was being flown at a low cruise power setting it is reasonable to assume that moderate to severe carburettor icing could have been experienced. However the pilot reported that his regular checks did not indicate any carburettor ice formation and his application of carburettor heat after the engine had faltered had no effect. Nevertheless, given the ambient conditions and low cruise power setting, carburettor icing cannot be discounted as a possible cause of the power loss.

Debris in the fuel system

Because of the position of the fuel bleed return line, unfiltered fuel could be fed directly to the carburettors irrespective of the position of the fuel selector. This could lead to debris causing a blockage within the carburettor. However as the orifice in the restrictor in the fuel bleed return line was relatively small, any significant debris passing along this line was more likely to be trapped by the restrictor before it could reach the carburettor. Although some debris was found in the fuel filters, none was found in the carburettor and it performed normally during the engine testing. Flow testing of the fuel system showed that it was capable of delivering sufficient fuel flow at all power settings. It is therefore unlikely that the power loss was the result of debris in the fuel system.

Fuel quantity

The fuel tank was filled to the top of the sight tube prior to departure, corresponding to a quantity in excess of 60 litres, which should have been adequate for the planned flight. Following the accident the pilot selected the fuel selector to OFF which should have prevented fuel leaking from the main supply pipe after the engine had detached, although fuel could still have leaked from the reserve side of the tank through the fuel bleed return line. Due to the tank design, this would have only emptied the top part and reserve side of the tank and any fuel remaining in the main side should have remained in the tank. However, none was present when it was examined by the AAIB. Given the amount of time that had elapsed between the accident and the examination of the wreckage, no conclusion could be reached regarding the amount of fuel remaining at the time of the accident.

Vapour locking

There was no history of vapour locking problems on this particular aircraft. Vapour locking generally occurs when slow-moving or stationary fuel is subjected to heat soak, causing it to vaporise in the fuel lines, interrupting the flow of fuel to the engine. The conditions at the time that the power loss occurred would not have been expected to have been particularly favourable for vapour locking, but vapour locking could not be entirely discounted as a possible cause.

The intention of fitting the bleed return line was to reduce the possibility of vapour locking. However, by connecting it upstream of the engine-driven fuel pump instead of downstream, it introduced the possibility of air or debris being drawn into the fuel system, with the potential for interrupting the fuel flow to the engine.

Conclusions

Despite extensive examination and testing, the cause of the power loss could not be positively determined. An unapproved modification to the fuel system may have been a contributory factor, but other possibilities could not be discounted.

There is always the possibility of an engine failure occurring, which, in a single-engined aircraft, necessitates a forced landing. There is therefore a need for pilots to be prepared for and well-practised in making forced landings.

The aircraft's fuel system had been modified without the approval of the LAA. The nature of the modification introduced the potential for fuel starvation to occur in certain circumstances. The importance of following the correct procedures when developing and installing modifications to Permit-to-Fly aircraft is emphasised in Technical Leaflets and other guidance material produced by the LAA.

ACCIDENT

Aircraft Type and Registration:	Falco F8L, G-REEC
No & Type of Engines:	1 Lycoming IO-320-B1A piston engine
Year of Manufacture:	1991
Date & Time (UTC):	9 August 2009 at 1200 hrs
Location:	Runway 08, Compton Abbas Airfield, Dorset
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Propeller, flaps and underside of aircraft
Commander's Licence:	Private Pilot's Licence
Commander's Age:	66 years
Commander's Flying Experience:	Not provided
Information Source:	Aircraft Accident Report Form submitted by the pilot

The pilot omitted to lower the landing gear and the aircraft landed gear-up on the grass runway, damaging the propeller, flaps and underside of the aircraft. There were no injuries.

ACCIDENT

Aircraft Type and Registration:	Morane Saulnier MS.894A Rallye Minerva, G-BKBF
No & Type of Engines:	1 Franklin 6A-350-C1 piston engine
Year of Manufacture:	1970
Date & Time (UTC):	13 March 2010 at 1616 hrs
Location:	Henstridge Airfield, Somerset
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to nose gear and propeller
Commander's Licence:	Private Pilot's Licence
Commander's Age:	55 years
Commander's Flying Experience:	204 hours (of which 83 were on type) Last 90 days - 5 hours Last 28 days - 4 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

During the landing roll-out the nosewheel started to shimmy and then detached from the nose gear. The aircraft came to a halt on its nose gear leg. The nosewheel axle was subsequently found to have failed close to where it meets the nose leg. The causes of the shimmy and axle failure were not established. There were no injuries.

ACCIDENT

Aircraft Type and Registration:	Siai Marchetti F260C, N61FD
No & Type of Engines:	1 Lycoming 0-540 series piston engine
Year of Manufacture:	1983
Date & Time (UTC):	21 March 2010 at 1250 hrs
Location:	Rettendon Common, Essex
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Substantial
Commander's Licence:	Private Pilot's Licence
Commander's Age:	49 years
Commander's Flying Experience:	498 hours (of which 133 were on type) Last 90 days - 12 hours Last 28 days - 8 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

As the aircraft climbed through 2,500 ft the pilot became aware that the rear of the canopy on the left side had lifted by approximately 25 mm from its normal position. He declared a MAYDAY to Farnborough Radar and stated his intention to divert to Southend Airport. He reduced the airspeed but this did not prevent the canopy from departing the aircraft and striking the fin and right side of the tailplane. The aircraft remained controllable, but the pilot felt that the elevator authority had been reduced. Given the possibility of structural damage, he decided to carry out a precautionary landing in a field. The reduced elevator authority made the approach more difficult and the landing on soft ground caused the nose gear to collapse, resulting in extensive damage to the aircraft. The pilot was uninjured and able to vacate the aircraft unaided.

The rearward-sliding canopy is mounted on rollers which run in rails. The rails are attached to each side of the fuselage by three sliding pins that locate into lugs on each rail. Operation of the canopy jettison handle causes the sliding pins to be withdrawn, allowing the canopy to be jettisoned in an emergency. The pilot reported that the jettison handle was still locked in the normal position and that the damage suggested that the sliding pins were not fully located in the lugs on the left hand rail. The aircraft had flown for four hours since refitment of the canopy following maintenance activity.

ACCIDENT

Aircraft Type and Registration:	Taylor Monoplane, G-BLDB
No & Type of Engines:	1 Volkswagen 1600 piston engine
Year of Manufacture:	1986
Date & Time (UTC):	25 March 2010 at 1420 hrs
Location:	Sandtoft Aerodrome, Humberside
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Propeller, right wing and right landing gear
Commander's Licence:	Private Pilot's Licence
Commander's Age:	24 years
Commander's Flying Experience:	77 hours (of which 1 was on type) Last 90 days - 6 hours Last 28 days - 5 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The aircraft is a monoplane having a conventional tailwheel undercarriage. Making his first flight in G-BLDB, the pilot flew a series of circuits and go-arounds at Sandtoft Aerodrome, before positioning for a full-stop landing on Runway 23. The reported surface wind was 160º at 15 kt.

The pilot stated that the touchdown appeared normal, but the aircraft had then veered towards the left side of the runway. He applied corrective rudder and the aircraft then started to drift to the right of the runway. As the aircraft's speed had reduced to the point where rudder authority had diminished, the pilot applied the left brake. The aircraft ground looped to the left, left the paved surface of the runway and entered an area of rough grass. It came to a stop as it tipped onto its nose and right wing. The engine stopped as the propeller struck the ground. The right undercarriage was also damaged. The uninjured pilot was assisted from the aircraft by the AFRS.

The pilot considered that the ground loop had been a result of excessive application of the left brake. He had flown a total of 77 hours on fixed wing aircraft of which six hours were on aircraft equipped with a conventional tailwheel undercarriage.

ACCIDENT

Aircraft Type and Registration:	Flight Design CTSW, G-CERA
No & Type of Engines:	1 Rotax 912ULS piston engine
Year of Manufacture:	2007
Date & Time (UTC):	30 June 2009 at 1101 hrs
Location:	North-east of Barton Aerodrome, Manchester
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - 1 (Minor) Passengers - 1 (Minor)
Nature of Damage:	Damaged beyond economic repair
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	19 years
Commander's Flying Experience:	46 hours (of which 2 were on type) Last 90 days - 12 hours Last 28 days - 5 hours
Information Source:	AAIB Field Investigation

Synopsis

The aircraft suffered a loss of engine power shortly after takeoff and crashed in a built-up area. The two occupants received minor injuries, but no one on the ground was injured. No mechanical defects were found during strip-examination of the engine. There was insufficient evidence to establish the cause of the loss of power, but an interruption in the fuel supply is believed to be the most likely cause.

History of the flight

The pilot had intended to fly to Sherburn-in-Elmet. During his pre-flight inspection he confirmed that there was sufficient fuel on-board for the flight. The reported air temperature was 23ºC and there was a light breeze from the east.

The pre-flight and power checks were carried out satisfactorily, with the magneto drops within limits. The flaps were set to 15 degrees for the takeoff. The pilot carried out a rolling takeoff on Runway 09, which was initially normal. However, part-way into the takeoff roll the engine briefly shuddered and coughed, prompting the pilot to check the choke control, which was in the OFF position.

The shuddering then ceased and as the airspeed had reached 40 kt, the pilot elected to continue with the takeoff. The climb was normal until about 300 ft, when the engine once again began to shudder and then lose power. As the pilot was in the process of raising the flaps, he completed the action; this further reduced the climb rate. He confirmed that the throttle was fully open, the choke was OFF, the fuel was selected ON and the magneto switch was set to '1+2'.

The aircraft then began losing height, so the pilot turned it to the left, in the direction of a sports field. On realising that the aircraft would not reach the field, he headed towards a gap between two houses and transmitted a distress call. The aircraft struck telephone wires as the pilot attempted to manoeuvre it to avoid a house and it came to rest in a domestic garden with its forward section completely detached. The passenger escaped and then freed the semi-conscious pilot from the wreckage.

Powerplant description

The aircraft is of a high-wing layout. It has a fuel tank built into the leading edge of each of the inboard wing sections supplying fuel by gravity feed to a selector valve behind the engine. A mechanical fuel pump is mounted at the front of the engine crankcase. A fuel pipe is routed over the top of the engine to the pump, whilst a further pipe is routed from the pump to the rear-mounted carburettors. This second pipe also passes above the engine. On this aircraft type a fuel bleed return line is connected between the downstream side of the fuel pump and the fuel drain sump, such that a steady flow of fuel is maintained through the fuel pipes. This reduces the temperature of the fuel in the pipes in the hot areas, reducing the propensity for vapour lock to occur after extended periods of running at low power.

Previous power loss incidents on this aircraft type have been attributed by some to the fuel outlets in the tanks becoming uncovered due to fuel sloshing during uncoordinated turns with low fuel levels, resulting in fuel starvation. In this case the aircraft reportedly had significant fuel on board and was not manoeuvring.

Wreckage examination

The aircraft wreckage was examined by the AAIB. All the damage to the engine and fuel supply system was consistent with the effects of impact. A strip-examination of the engine was carried out in conjunction with the UK agent for the engine manufacturer. No evidence was found of any internal engine defects.

Discussion

The absence of any evidence of engine mechanical failure casts suspicion on the fuel supply. No other aircraft operating locally were reported to have had similar problems, so the possibility of contamination of the local bulk fuel supply is discounted. The possibility of vapour lock was considered, but the engine had not been run at low power for an extensive period; this therefore seems unlikely. Other possibilities include contamination of the fuel due to the presence of water, debris in the fuel system or carburettor icing. However, there was insufficient evidence to determine which of these scenarios was most likely.

ACCIDENT

Aircraft Type and Registration:	Jabiru UL-450, G-BYYT
No & Type of Engines:	1 Jabiru Aircraft PTY 2200A piston engine
Year of Manufacture:	1999
Date & Time (UTC):	13 June 2009 at 1805 hrs
Location:	Hayward Private Airstrip, Herefordshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Nose gear, left wingtip and propeller damaged
Commander's Licence:	Private Pilot's Licence
Commander's Age:	59 years
Commander's Flying Experience:	397 hours (of which 75 were on type) Last 90 days - 8 hours Last 28 days - 4 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The pilot was making an approach to Runway 22 in a light south-westerly wind. As the aircraft touched down on the grass runway, a gust of wind took it off the centreline. The pilot attempted to regain the centreline and to slow the aircraft with the brakes. The right brake proved more effective than the left, causing the aircraft to enter a skid, during which the nose gear detached and the left wingtip contacted the ground. The aircraft then departed the right side of the runway and collided with tree saplings; the pilot was uninjured.

Accident

Aircraft Type and Registration:	Pegasus Quik, G-TCNY
No & Type of Engines:	1 Rotax 912ULS piston engine
Year of Manufacture:	2004
Date & Time (UTC):	11 April 2010 at 1500 hrs
Location:	St Michael's Airfield, near Preston, Lancashire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - 1 (Minor) Passengers - 1 (Minor)
Nature of Damage:	Damage to wing, fuselage pod and propeller
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	39 years
Commander's Flying Experience:	190 hours (of which 50 were on type) Last 90 days - 15 hours Last 28 days - 9 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Whilst landing on a dry grass runway the pilot lost control as the nosewheel was lowered to the surface. The microlight tumbled, causing minor injuries to both occupants. Based upon a subsequent inspection of the aircraft, the pilot thought that the nosewheel tyre may have been under-inflated prior to landing.

ACCIDENT

Aircraft Type and Registration:	Skyranger Swift 912S(1), G-CEZE
No & Type of Engines:	1 Rotax 912 ULS piston engine
Year of Manufacture:	2007
Date & Time (UTC):	1 March 2010 at 1630 hrs
Location:	Northrepps Airfield, Norfolk
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Noseleg collapsed, propeller damaged and screen cracked
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	45 years
Commander's Flying Experience:	144 hours (of which 6 were on type) Last 90 days - 15 hours Last 28 days - 9 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The aircraft was returning to Northrepps Airfield after a local flight in fine weather. The wind was light from the west and the aircraft touched down after an uneventful approach to Runway 22. After touchdown, the aircraft began veering to the left and continued to do so despite attempts by the pilot to correct it. It departed the left edge of the runway and entered a soft, muddy ploughed field at low speed at which point the nosewheel dug in and the aircraft gently tipped over, ending up inverted.

Both pilot and passenger were wearing full harnesses and escaped injury. Subsequent inspection of the landing gear revealed a damaged and deflated left mainwheel tyre. Inspection of the grass runway showed a single gouge created by the left wheel and wheel spat, tracking from the runway centreline to where the aircraft left the runway. The pilot considered that the left mainwheel tyre had deflated at some point prior to touchdown and this had caused the aircraft to depart the left side of the runway.

BULLETIN ADDENDUM

AAIB File:	**EW/A2003/03/01**
Aircraft Type and Registration:	Airbus A320-231, G-MEDA
Date & Time (UTC):	31 March 2003 at 2338 hrs
Location:	On approach to Runway 25L, Addis Abeba Airport, Ethiopia

AAIB Report published on the AAIB website in January 2008, pages 60-61 refer

The investigation and subsequent report into the circumstances of this serious incident was the responsibility of the Ethiopian Civil Aviation Authority. The AAIB published the results of their own investigation, including six draft Safety Recommendations, on the internet with the expectation that the Ethiopian CAA, as the State of Occurrence, would include these Safety Recommendations as and when their official report was published.

The Ethiopian CAA final report has not yet been published and the AAIB has been given no timescales for this to take place. Therefore, as a number of safety deficiencies have been identified and require addressing, the AAIB is formally issuing these six Safety Recommendations.

Safety Recommendations

The systems which were fitted to the aircraft to provide a safety net against a CFIT[1] accident performed as they were designed but were ineffective in preventing this incident. Therefore, the safety of the aircraft during the ADS[2] VOR/DME approach procedure was entirely dependent on the correct operation of the ADS VOR and its monitoring systems. For as long as the ADS VOR continued to radiate incorrect bearing information there was a risk that another aircraft could suffer the same problem. The following Safety Recommendations are made:

Safety Recommendation 2010-020

It is recommended that the Ethiopian Civil Aviation Authority review the quality mechanisms that govern maintenance and monitoring of the ground station facilities to ensure that the correct procedures and correct parts are used.

Safety Recommendation 2010-021

It is recommended that the Ethiopian Civil Aviation Authority review their procedures for the issuing of NOTAMs and other safety related information to ensure a more robust process.

Safety Recommendation 2010-022

It is recommended that the International Civil Aviation Organization review the methods by which the effectiveness of radio navigation aid ground station monitors are assured.

Footnote

1 Controlled Flight Into Terrain.

2 Addia Abeba VHF Omni-Directional Radio Range beacon and Distance Measuring Equipment.

Since the original standards for TAWS[3] were set the industry has improved the performance and understanding of the TAWS capabilities significantly beyond the required minimum standard. Due to the significance of these improvements the major aircraft manufacturers have encompassed many of these improvements into their new deliveries. However, there are no retrofit requirements and as long as non-GPS systems are present on aircraft there is a significant potential for a CFIT accident due to a navigation error.

Safety Recommendation 2010-023

It is recommended that the European Aviation Safety Agency and the Federal Aviation Administration review and revise the existing TAWS certification requirements with a view to ensuring that they protect against common mode failures that could induce a CFIT accident. Furthermore the minimum requirements for the navigational accuracy of sources used for TAWS should be tightened to reflect the needs of the system to perform its function. These revised standards should then be applied retrospectively to all aircraft required to be fitted with TAWS.

Both the FMS[4] and TAWS had sufficient information to identify that there was a problem with the ADS VOR and the derived position information but there is no mechanism or requirement to communicate this effectively to the crew.

Safety Recommendation 2010-024

It is recommended that the European Aviation Safety Agency and the Federal Aviation Administration study the issues relating to the use of TAWS so that where data source problems are identified by the system the flight crew can be alerted.

Safety Recommendation 2010-025

It is recommended that the European Aviation Safety Agency and the Federal Aviation Administration consider whether the crew should be alerted when a FMS has identified a recurrent problem with a particular navigation aid and furthermore consider whether the subsequent use of that navigation aid for position information is desirable.

Footnote

3 Terrain Awareness Warning Systems.

Footnote

4 Flight Management System.

AIRCRAFT ACCIDENT REPORT No 2/2010

This report was published on 19 May 2010 and is available on the AAIB Website www.aaib.gov.uk

REPORT ON THE ACCIDENT TO BEECH 200C SUPER KING AIR, VQ-TIU AT 1 NM SOUTH-EAST OF NORTH CAICOS AIRPORT TURKS AND CAICOS ISLANDS, BRITISH WEST INDIES ON 6 FEBRUARY 2007

Registered Owner and Operator:	Air Turks and Caicos (2003) Limited
Aircraft Type:	Beech 200C Super King Air
Serial number:	BL-131
Nationality:	Turks and Caicos Islands
Registration:	VQ-TIU
Location of Accident:	1 nm south-east of North Caicos Airport, Turks and Caicos Islands, British West Indies (N21º 54.7′ W071º 55.0′)
Date and Time:	6 February 2007 at 1842 hours All times in this report are local (UTC-5)

Synopsis

The accident was reported to the Turks and Caicos Islands (TCI) Civil Aviation Department (CAD) on the evening of 6 February 2007. The same evening, a request for assistance was made to the United Kingdom Air Accidents Investigation Branch (AAIB), under the terms of a pre-existing Memorandum of Understanding; AAIB Inspectors arrived in the TCI on 8 February 2007. The TCI CAD appointed a TCI national as Investigator-in-Charge, tasked with conducting an investigation in accordance with the provisions of Annex 13 to the International Civil Aviation Organisation (ICAO) Convention. The investigation was conducted by: Mr P Forbes (Investigator-in-Charge), Mr K Fairbank (AAIB Operations), Mr P Thomas (Operations), Mr A Robinson (AAIB Engineering) and Mr K Malcolm (Engineering). The manufacturers of the aircraft, the engines and the propellers assisted during the later stages of the investigation.

VQ-TIU crashed soon after takeoff from North Caicos Airport, at the start of a flight bound for Grand Turk, TCI. On board were one pilot and five passengers. The pilot received fatal injuries in the accident; the passengers mostly suffered serious injuries, but all survived the accident. Weather conditions at the time were good, but it was after nightfall; the moon had not risen and there was little cultural lighting in the area.

The aircraft crashed into a shallow lagoon approximately one nautical mile south-east of North Caicos Airport. Wreckage was spread along a trail that extended in excess of 370 m along a track of 220°(M). The aircraft's fuselage had come to rest comparatively intact, although lying in an inverted attitude. Evidence from the accident site indicated that the aircraft had struck the water in a nominally upright attitude, with only a moderate rate of descent but at relatively high forward speed.

From a detailed examination of the wreckage and the circumstances of the accident, it was concluded that the aircraft was structurally intact and probably under control when it struck the surface. The evidence indicated that each engine was producing power throughout the short flight and at the time of impact. Although anomalies were found which suggested that a possible power asymmetry may have existed, this should not have been sufficient to cause the pilot serious control difficulties.

None of the passengers described an obvious problem with the aircraft during the flight, and most remained unaware of the impending crash. The circumstances of the accident suggested that the pilot became spatially disorientated, to the extent that the aircraft diverged from its intended flight path and reached an irrecoverable situation. The environmental conditions were conducive to a disorientation event, and a postmortem toxicological examination showed that the pilot had a level of blood alcohol which, although below the prescribed limit, was significant in terms of piloting an aircraft and would have made him more prone to disorientation.

The evidence indicated that the pilot had probably started a recovery to normal flight, but too late to prevent the accident. However, his actions had the effect of reducing the descent rate and placing the aircraft in a nearly level attitude at impact. This lessened the impact damage and helped preserve the fuselage structure relatively intact, increasing the passengers' chance of survival.

The investigation identified the following causal factors:

1. The aircraft adopted an excessive degree of right bank soon after takeoff. This led to a descending, turning flight path which persisted until the aircraft was too low to make a safe recovery.

2. The pilot probably became spatially disorientated and was unable to recognise or correct the situation in time to prevent the accident.

The investigation identified the following contributory factors:

1. The environmental conditions were conducive to a spatial disorientation event.

2. The pilot had probably consumed alcohol prior to the flight, which made him more prone to becoming disorientated.

3. The flight was operated single-pilot when two pilots were required under applicable regulations. The presence of a second pilot would have provided a significant measure of protection against the effects of the flying pilot becoming disorientated.

No Safety Recommendations are made.

Discussion

The available evidence, which shows that a significant change in aircraft attitude occurred late in the accident sequence, strongly suggests that the pilot was in control of the aircraft when it struck the surface, and was taking appropriate recovery action. Some conclusions may be drawn from this: the aircraft was controllable; the pilot was physically able to control it and was so doing; and he probably had sufficient information from the flight instruments, alone, to make correct control inputs.

The event which caused the actual and intended flight paths to diverge was not catastrophic. There were no unusual engine or other noises in the cabin, no particularly unusual forces were experienced by the aircraft occupants and there were probably no warning lights or sounds in the cockpit. Together with the lack of obvious concern on the part of the pilot as the flight path diverged, this indicates a subtle event or situation which developed unchecked until recognised by the pilot at a late stage, and even then possibly not fully.

It was not possible to rule out a subtle technical malfunction as a contributory factor, but the weight of evidence indicated that the pilot retained sufficient reliable information from his flight instruments to prevent or correct the attitude deviation which ultimately led to the accident. Similarly, it was not possible to rule out a subtle but transient medical condition which may have interfered with the pilot's normal functioning, although there was only circumstantial evidence to support the possibility.

The circumstances of the accident strongly suggest that the pilot became spatially disorientated. It was immediately after takeoff, it was dark with no reliable outside references and the pilot was operating as single crew. He had completed the after takeoff checks shortly before, which may have been an initiating distraction. It was probable that he had consumed alcohol at some time before the flight and his blood alcohol level, although not excessive, would have made him more prone to becoming disorientated. Although very experienced, the pilot had a potential weakness in his instrument scan technique. This and the turbulence the aircraft apparently encountered could also have contributed to any disorientation.

Spatial disorientation accidents are frequently fatal, as the pilot does not recognise the danger or is unable to effect a recovery. In this case the pilot did start a recovery and appears to have been taking appropriate recovery actions when the aircraft struck the surface. This had the effect of reducing the descent rate and placing the aircraft in an almost level attitude at impact. The pilot's actions, although initiated too late to avoid the accident, lessened the impact damage and helped preserve the fuselage structure relatively intact, which probably prevented greater loss of life.

Findings

1. The pilot was correctly licensed and qualified for the flight in accordance with existing regulations.

2. Aircraft maintenance records indicated that it was correctly equipped and maintained and that all required maintenance had been carried out.

3. The aircraft was within the applicable mass and balance limitations and carried sufficient fuel for the intended flight.

4. Weather conditions were generally favourable. Some turbulence was reported but this is unlikely to have been severe.

5. It was night, with little natural or cultural lighting. The pilot would not have had external visual references immediately after takeoff and would have been flying with reference to flight instruments.

6. Shortly after takeoff the aircraft rolled to the right, achieving an excessive bank angle. It descended in a banked attitude at an approximately constant descent angle, turning as it did so.

7. Passengers did not recall unusual noises, vibrations, accelerations or other significant events after takeoff, although some motions attributed to turbulence were reported.

8. The aircraft struck the surface with only a small amount of right bank and an approximately level pitch attitude, indicating that the pilot was probably attempting to recover from the situation.

9. The aircraft was intact at impact, with landing gear and wing flaps retracted.

10. There was no evidence of a pre-impact engine failure that would have prevented either engine from producing power.

11. A defect within the right engine FCU raised the possibility of a small power asymmetry, but would be unlikely to cause the pilot handling difficulties.

12. The propellers were operating in their governed range at impact. Damage to the propellers suggested that approximately symmetrical power was applied.

13. There was no evidence of a failure affecting the flying control systems.

14. The pilot was probably being presented with correct attitude information on his main attitude indicator.

15. The aircraft was probably under the control of the pilot at impact and was capable of controlled flight.

16. Impact was at a relatively high speed and there was no indication that the aircraft had stalled.

17. There was no pathological evidence to indicate that the pilot had become incapacitated in flight.

18. Conditions were conducive to spatial disorientation.

19. The pilot was operating as single crew, and there was some potential for distraction in the cockpit.

20. The pilot had probably consumed alcohol at some stage before the flight; the measured alcohol level in his system was below the applicable limit, but is likely to have increased his susceptibility to spatial disorientation.

21. The pilot's training records showed that he had demonstrated a satisfactory standard in handling in-flight emergencies such as engine failures, but a possible weakness in his instrument scan pattern had been identified.

22. Although the passengers had not paid for their seats, the flight should have been operated as a public transport flight.

23. The flight did not meet the regulatory requirements for public transport flights in respect of minimum flight crew and airport operating restrictions.

24. The presence of a second pilot on the flight deck would probably have lessened the chance of the accident occurring.

Safety Recommendations

No Safety Recommendations are made as a result of this investigation.

AIRCRAFT ACCIDENT REPORT No 3/2010

This report was published on 21 May 2010 and is available on the AAIB Website www.aaib.gov.uk

REPORT ON THE ACCIDENT TO CESSNA CITATION 500, VP-BGE 2NM NNE OF BIGGIN HILL AIRPORT 30 MARCH 2008

Operator:	Private flight
Aircraft Type and Model:	Cessna Citation 500
Registration:	VP-BGE
Location:	2 nm NNE of Biggin Hill Airport
Date and Time:	30 March 2008 1336 hrs All times in this report are UTC

Synopsis

Biggin Hill Airport notified the Air Accidents Investigation Branch (AAIB) of the accident on 30 March 2008 and the investigation began the same day. The following inspectors participated in the investigation:

Mr K Conradi	Investigator-in-Charge
Mr M Cook	Operations
Mr N Dann	Operations
Mr M Jarvis	Engineering
Mr A Burrows	Flight Recorders

The aircraft departed Biggin Hill for a private flight to Pau, France but shortly after takeoff initiated a return to Biggin Hill after reporting engine vibration. During the downwind leg for Runway 21, the aircraft descended. The flightcrew reported a major power problem just before it struck the side of a house. An intense fire developed. None of the two flight crew and three passengers survived.

The following contributory factors were identified:

1. It is probable that a mechanical failure within the air cycle machine caused the vibration which led to the crew attempting to return to the departure airfield.
2. A missing rivet head on the left engine fuel shut-off lever may have led to an inadvertent shutdown of that engine.
3. Approximately 70 seconds prior to impact, neither engine was producing any thrust.
4. A relight attempt on the second engine was probably started before the relit first engine had reached idle speed, resulting in insufficient time for enough thrust to be developed to arrest the aircraft's rate of descent before ground impact.

Three Safety Recommendations have been made.

Findings

1. Both the pilot and co-pilot were properly licensed and qualified to operate the aircraft for single pilot operation only.

2. The aircraft was certified, equipped and maintained in accordance with the regulations and approved procedures.

3. There is no specific routine inspection of the condition of the fuel cut-off levers or their attachment to the engine throttles.

4. There was no evidence of adverse wear in the flight controls and all the aircraft compartment and cabin doors were correctly secured and locked.

5. No pre-impact defects or distress were observed to either engine starter/ generator.

6. The rivet head securing the left engine fuel cut-off lever had become detached at some time prior to impact.

7. There was no evidence that either engine would not have been able to respond to flight crew control inputs.

8. There was no evidence of any pre-impact defects or distress in the rotating assemblies of either engine, nor was there any evidence of compressor stalling or surging.

9. The aircraft was structurally complete at the time of impact, the flaps were at, or close to, the take off/approach setting and the landing gear was retracted.

10. The engine cowlings were in place at the point of impact.

11. The rudder trim was found in the full nose-right position.

12. The damage observed on the fan blades of the left engine was consistent with the initial impact of the aircraft with the house.

13. Performance calculations suggest that approximately 70 seconds prior to impact neither engine was producing any thrust.

14. Both engines were operating when the aircraft struck the house.

15. A single engine relight could have produced sufficient thrust in the time available to prevent ground impact.

16. Both engines were relit prior to impact but with insufficient time to prevent ground impact.

17. The accident was not survivable.

18. The air cycle machine bearing distress is the most probable cause of the vibration described by the pilots as "ENGINE VIBRATION".

19. Having neither a flight data recorder nor a cockpit voice recorder installed on the aircraft meant that information critical to identifying the cause of the accident was not available to the investigation.

Safety Recommendations

The following Safety Recommendations have been made:

Safety Recommendation 2010-014

It is recommended that the Federal Aviation Administration require that Cessna Aircraft Inc introduce a scheduled inspection of the Cessna Citation 1 throttle quadrant assembly to ensure the integrity of the riveted joints securing the fuel shut-off levers to the throttle levers.

Safety Recommendation 2010-015

It is recommended that the Federal Aviation Administration require Cessna Aircraft Inc to amend the 'EMERGENCY RESTART –TWO ENGINE' checklist to emphasise the significance of only restarting one engine at a time.

Safety Recommendation 2010-016

It is recommended that the International Civil Aviation Organisation adopt the proposals of its Flight Recorder Panel for the requirement to install flight recorders on turbine-engine powered aeroplanes of a maximum certified takeoff mass of 5,700 kg or less.

FORMAL AIRCRAFT ACCIDENT REPORTS
ISSUED BY THE AIR ACCIDENTS INVESTIGATION BRANCH

2009

1/2009 Boeing 737-81Q, G-XLAC,
Avions de Transport Regional
ATR-72-202, G-BWDA, and
Embraer EMB-145EU, G-EMBO
at Runway 27, Bristol International Airport
on 29 December 2006 and
on 3 January 2007.

Published January 2009.

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

Published April 2009.

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

Published May 2009.

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

Published August 2009.

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

Published September 2009.

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

Published October 2009.

2010

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

Published February 2010.

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

Published May 2010.

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

Published May 2010.

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