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(ALL TIMES IN THIS BULLETIN ARE UTC)

INCIDENT

Aircraft Type and Registration:	Airbus A310, F-OJHH
No & Type of Engines:	2 General Electric CF6-80 C2A2 turbofan engines
Year of Manufacture:	1991
Date & Time (UTC):	24 November 2006 at 2043 hrs
Location:	On approach to Birmingham Airport
Type of Flight:	Public Transport (Passenger)
Persons on Board:	Crew - 11 Passengers - 84
Injuries:	Crew - None Passengers - None
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	59 years
Commander's Flying Experience:	9,748 hours (of which 2,950 were on type) Last 90 days - 278 hours Last 28 days - 91 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft was being radar vectored for an ILS approach to Runway 15 at Birmingham Airport. The radar controller had cleared the crew to descend to an altitude of 2,500 ft, but noticed that the aircraft continued to descend below the cleared altitude. He instructed the crew to climb and repeated the QNH, which the crew had not set. With the correct QNH set the aircraft climbed and levelled at 2,000 ft, as instructed by the controller. Having intercepted the localiser they were cleared to descend with the ILS and a normal landing was completed.

History of the flight

The aircraft was on a scheduled flight from Tehran to Birmingham Airport. The commander was the Pilot Flying (PF) and the co-pilot was the Pilot Not Flying (PNF). The crew contacted the Radar controller at 2037 hrs as they were approaching FL80. They confirmed that they had received the ATIS and repeated the QNH of 982 hPa. They were instructed to maintain FL80 and their present heading.

The controller intended to provide radar vectors for the aircraft to intercept the localiser for Runway 15 at a distance of 9 nm. At 2038 hrs he cleared the aircraft to descend to an altitude of 4,000 ft on the QNH of 982 hPa, which the PNF acknowledged correctly. During this descent, the aircraft was cleared to descend further to an altitude of 2,500 ft and this was again acknowledged correctly by the PNF.

At 2043 hrs the crew were instructed to turn right onto a heading of 060° and to reduce speed to 180 kt; the aircraft turned onto the base leg and continued its descent. The controller, who was also controlling several other aircraft, saw F-OJHH descend through 2,500 ft. He transmitted "5020 CLEARED ALTITUDE TWO THOUSAND FIVE HUNDRED FEET SAY AGAIN TWO THOUSAND FIVE HUNDRED FEET". The PNF responded, "TWO FIVE HUNDRED 5020 TWO THOUSAND FIVE HUNDRED". Seeing the aircraft still descending the controller transmitted "YES IF YOU COULD CLIMB BACK UP TO TWO THOUSAND FIVE HUNDRED PLEASE AND TURN RIGHT NOW ONTO ONE TWO ZERO DEGREES". The PNF responded to the instruction after a short pause. Seeing the aircraft still descending, the controller repeated, "5020 YOU ARE STILL DESCENDING CLIMB TWO THOUSAND FIVE HUNDRED FEET ACKNOWLEDGE". This was acknowledged again by the PNF but the aircraft still continued to descend. The controller instructed the crew that there was a mast 4 nm due east of their position which was 1,358 ft amsl, and that they should climb immediately. The PNF acknowledged this instruction.

Suspecting that the crew had not set the QNH, the controller transmitted "5020 QNH 982 CONFIRM YOU ARE INDICATING ONE THOUSAND FIVE HUNDRED FEET". At this point the crew realised that the altimeters were still set to the standard pressure setting of 1013 hPa and not the Birmingham QNH of 982 hPa. The PF initiated a climb and he and the PNF set the Birmingham QNH and crosschecked the altimeters. The PNF informed the controller "JUST GOT IT NOW AND CLIMBING READING 2,000 FEET". The controller responded "YOU CAN LEVEL OFF AT TWO THOUSAND FEET PLEASE TO INTERCEPT THE GLIDEPATH AT NINE MILES YOU ARE NOW CLEAR OF THE TV MAST". The PNF acknowledged the instruction and they were then cleared to descend on the ILS. The crew continued with the approach and landed without further incident.

Weather

The synoptic situation at 2100 hrs on the day of the incident showed a low pressure system (969 hPa) centred near Eire. A broad warm sector was covering the southern half of the British Isles with a light to moderate south-south-westerly flow over the Midlands and Southern England. Weather conditions over the Midlands were cloudy with outbreaks of rain, mainly in the West Midlands. The surface visibility was generally 25 km but locally 10 to 15 km in rain. The mean sea level pressure in the Birmingham area was 982 hPa with the Barnsley Regional Pressure Setting, valid from 2000 hrs to 2100 hrs, of 974 hPa.

The 2020 hrs weather report at Birmingham Airport recorded a surface wind from 160º at 10 kt, with the visibility greater than 10 km in light rain, few cloud at 1,600 ft with scattered cloud at 2,200 ft, the temperature was 12ºC, the dew point was 11ºC and the QNH was 982 hPa.

Altimeter setting

The Standard Operating Procedure (SOP) for altimeter setting in the descent was set out by the operator in the descent checklist of the normal procedures. This requires both the PF and PNF to set the QNH when cleared by ATC to descend from a flight level to an altitude.

Analysis

The crew had not changed the altimeter setting from the standard setting of 1013 hPa to the Birmingham QNH of 982 hPa when first cleared to descend from a flight level to an altitude. Based on an average height of 30 ft per hPa, a height difference of 930 ft existed between the aircraft actual altitude and that indicated on the altimeters. Consequently, thus when the altimeters were indicating 2,500 ft the aircraft had actually descended to 1,570 ft. As the aircraft continued its descent below its cleared level of 2,500 ft the radar controller notified the crew and warned them of the mast ahead. Having realised that the altimeter sub scale setting was incorrect the crew initiated an immediate climb, re-set the altimeters to the correct QNH and followed the controller's instructions.

The crew could not recall any distractions or unusual flight deck activity at the point at which they would normally have adjusted the altimeter sub-scales.

INCIDENT

Aircraft Type and Registration:	Airbus A320-232, HA-LPB
No & Type of Engines:	2 IAE V2527E-A5 Turbofan engines
Year of Manufacture:	2001
Date & Time (UTC):	1 October 2006 at 1947 hrs
Location:	London (Luton) Airport
Type of Flight:	Public Transport (Passenger)
Persons on Board:	Crew - 6 Passengers - 159
Injuries:	Crew - None Passengers - None
Nature of Damage:	Abrasion marks on lower fuselage skin and on two adjacent frames
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	40 years
Commander's Flying Experience:	5,458 hours (of which 3,012 were on type) Last 90 days - 251 hours Last 28 days - 57 hours
Information Source:	AAIB Field Investigation

Synopsis

The crew were carrying out a manually flown ILS approach without the use of flight directors or autothrust. At 530 ft agl the aircraft was well above the normal 3º glideslope. The glideslope was not regained until shortly before landing, and by then the speed was below approach speed (V_{APP}) and the descent rate was high. During the flare, full back sidestick was applied and the aircraft bounced after touching down in a high pitch attitude; the second touchdown was also in a high pitch attitude. Post flight inspection confirmed that the aircraft tail had struck the ground on landing.

The commander reported the tailstrike to her company but did not advise ATC of the incident and other aircraft movements took place before the next regular runway inspection. There was no debris deposited on the runway as a result of the tailstrike.

History of the flight

The crew were operating a flight from Warsaw Airport to London (Luton) Airport with the commander as the handling pilot. Both crew members had previously operated into Luton Airport.

In accordance with normal company procedures, the first officer completed an external check of the aircraft while the commander completed the cockpit checks; the off-going crew met the commander and reported that the aircraft was fully serviceable. Engines start and after-start checks were uneventful and the commander taxied HA-LPB to Runway 29. Because of the weather conditions, which included local rain and thunderstorms in the area, the commander used TOGA power for the takeoff at 1741 hrs; the rotation appeared normal to both crew members.

The cruise towards the destination was uneventful, and prior to descent the commander briefed the first officer for the approach and landing at Luton. ATIS information 'G' was in effect from 1920 hrs and included the following information: Runway 26 was in use with a surface wind of 210º/ 16 kt, visibility was greater than 10 km, cloud was FEW at 800 ft and SCT at 2,100 ft, air temperature was 14ºC with a dew point of 11ºC, and the QNH was 1000 mb. ATIS information 'H' issued at 1950 hrs was identical. As the commander was due for a simulator check in the near future and the weather was reasonable, she decided to fly the approach manually and briefed the first officer that she would not use flight directors, autopilot or autothrust.

On arrival in the London area, HA-LPB was held in the hold at 'Abbot' for approximately 15 minutes before ATC began radar vectoring the aircraft for the approach to Runway 26. The commander disconnected the autothrust at around 3,000 ft amsl. Then, as the aircraft turned onto final approach and with the airport and runway clearly in sight, the commander disconnected the autopilot and flight directors. She used 'Managed' speed and selected TRK/FPA (Track/ Flight Path Angle) on the PFDs (Primary Flight Displays). Her primary reference for the approach was the runway PAPIs but she also had ILS displayed.

As the aircraft descended through 1,000 ft agl, both crew members noted that the wind was approximately 40 kt from the south-west and that there was some turbulence. By 750 ft agl, the aircraft was fully configured for landing with full flap and medium autobrake selected. Around 500 ft, the commander became aware that the aircraft was above the required glide path; the PAPIs were showing four 'whites'[1] and the first officer called that they were high. The commander retarded the thrust levers and applied forward sidestick and considered that she re-established on the glide path. She considered that the approach was then stable at about V_{APP} (140 kt for this approach).

As the automatic height calls activated at 50 ft agl, the commander began to retard the thrust levers and to flare the aircraft. However, she was then aware that the height calls were becoming more frequent than normal and applied more aft sidestick. Touchdown was firm and the aircraft bounced slightly. Her recollection was that she held the sidestick position steady and the aircraft touched down again within about two seconds. The autobrake system applied the wheelbrakes almost immediately and reverse thrust was used on the landing roll. During the subsequent taxi to the allocated stand, the aircraft monitoring system activated with an exceedance report. Fuel on landing was 3,120 kg.

On turnaround, the commander discovered a scrape on the underside of the fuselage and brought it to the attention of a company engineer who was on board the aircraft. He confirmed that the aircraft needed to be checked and, in accordance with the company Operations Manual, the commander contacted the company operations centre to report the event. However, she omitted to contact ATC to advise them of the tailstrike. The incident was reported by the company to the AAIB the following morning and ATC did not become aware of it until the AAIB requested the radio recordings of the event.

Footnote

[1] Four 'whites' indicated that the aircraft was above a 3º35' glideslope.

Recorded information

The aircraft was fitted with a solid-state 25-hour Flight Data Recorder (FDR) and a solid-state two-hour Cockpit Voice Recorder (CVR). Both recorders were downloaded at the AAIB; data and audio recordings were recovered for the incident landing and were time-aligned for analysis.

Additionally, the aircraft was fitted with a Data Management Unit (DMU). It was the DMU which generated the exceedance report which indicated that the vertical load factor on landing was 2.29g and the rate of descent on touchdown was 672 ft/min.

A time history of the relevant parameters during the incident is shown at Figure 1. The data presented starts with the aircraft at 1,300 ft amsl, with both autothrust and autopilot disconnected (at 6,000 ft and 4,300 ft amsl respectively), on the ILS approach to Runway 26 with the commander flying. At this point the aircraft's descent rate was approximately 750 ft/min, the airspeed was reducing through 160 kt, the pitch attitude was just above 2º, and the flaps were at 20º. Throughout the approach the aircraft remained within 1 dot of the localiser; pitch attitude predominantly varied between -1º (nose down) and +5º (nose up).

As the aircraft descended through 1,200 ft amsl, the descent rate slowed and the aircraft started to deviate above the glideslope. At 1,100 ft a small amount of thrust[2] was applied just as the flaps extended to 40º. At this point the descent rate had slowed to 270 ft/min and the airspeed was 150 kt.

As the aircraft passed through 1 dot above the glideslope, the first officer called "GLIDE". The commander then momentarily reduced the pitch attitude before returning to a pitch of 2.3º nose up. The aircraft's descent rate began to increase but glideslope deviation continued to increase; at 2 dots above the glideslope the first officer called "GLIDE GLIDE". The thrust levers were then pulled back to the flight-idle position (-2.5º TLA) and the commander again momentarily reduced the pitch attitude. However, the aircraft continued to deviate further above the glideslope reaching 3.1 dots[3] at 530 ft agl (calculated to be between 130 ft and 144 ft above the 3º glideslope) before stabilising back at 2 dots above as pitch attitude was again reduced and the descent rate increased to 900 ft/min.

At 400 ft agl, the commander started to pitch the aircraft's nose up while applying small amounts of thrust (10º TLA giving 1.05 EPR), allowing the airspeed to slow to 140 kt (the calculated approach speed V_{APP}) while still maintaining the 900 ft/min descent rate. The thrust levers were pulled back to +2.5º TLA as the aircraft passed through 300 ft agl and just as the first officer advised against using any further thrust. At 150 ft agl the airspeed started to reduce, gradually decaying to 130 kt at 50 ft agl.

The commander commenced the flare at 50 ft just as the first officer shouted "PULL". The commander then rapidly applied and held full aft sidestick (-16º) with the aircraft at 30 ft agl and coincident with the first officer shouting "PULL PULL PULL PULL". The descent rate from 75 ft agl to touchdown averaged 975 ft/min. One second before touchdown, at 11 ft agl, the aircraft passed through the glideslope from above.

Footnote

2 For clarity, only the EPR for the left-hand engine is shown but is representative of the right-hand engine. Similarly, only the thrust lever angle (TLA) for the right-hand engine is shown.

Footnote

3 The aircraft instruments display a maximum of 2 dots deviation from the glideslope: each dot reflects an angular deviation of 0.36º from the glideslope.

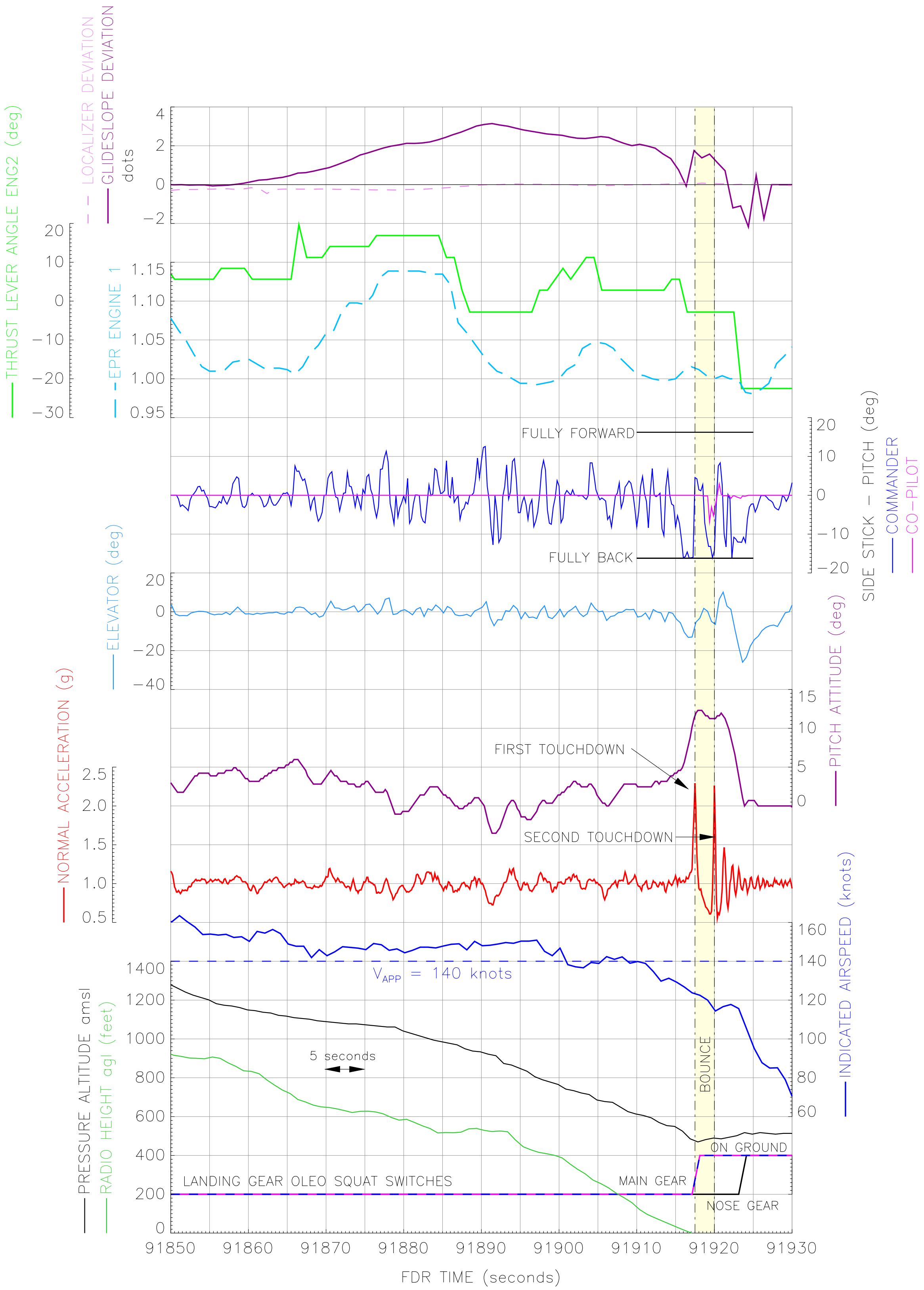


Figure 1

Salient FDR Parameters
(Accident to HA-LPB on 1 October 2006)

The aircraft touched down with +2º of roll attitude (right main landing gear first) with a vertical load factor of +2.3g and at an indicated airspeed of 125 kt. The aircraft reached a maximum pitch attitude of 12.3º nose-up. The spoilers deployed just as the aircraft bounced[4], and the pitch attitude started to reduce. The commander then made a nose-down sidestick input (+4.6º then +2.7º) before again applying full aft sidestick, and just as the first officer applied -7º aft sidestick. As neither of the priority takeover pushbuttons were pressed, the sidestick inputs from both crew would have been additive in effect.

The aircraft then touched down for a second time with a vertical load factor of +2.3g and a pitch attitude of 12º nose up. The nose was then gently lowered and the aircraft was slowed to a taxi speed. No windshear warnings were recorded during the approach and landing.

Engineering information

The damage to the aircraft (manufacturer's serial number 1635) consisted of abrasion marks approximately 70 inches long on the lower fuselage skin in the area of frames 65 to 68. At frames 65 and 66, the skin had worn away and there were light abrasion marks on both frames. There was no other damage to the aircraft structure. The damage indicated that there had been a brief, relatively light contact between the rear of the aircraft and the surface of the runway. Marks on the runway indicated a single ground contact within the normal touchdown zone.

Subsequent engineering checks revealed no further damage to the aircraft.

Footnote

4 The bounce was insufficient to cause a change in state of either of the two main landing gear squat switches.

Operational information

Runway inspections

ATC were not informed of the incident and the runway was not inspected until the next routine inspection. This was 44 minutes after the event during which 25 aircraft movements had taken place. Investigation subsequently confirmed that no debris from HA-LPB had been deposited on the runway.

Approach lighting

The PAPIs had last been flight-checked on 10 July 2006, when they were shown to be aligned with the ILS glideslope. Additionally, the routine ground checks of the PAPI light angles showed that they were accurate on 29 September and on 10 October 2006.

Manufacturing company information

Information from the manufacturing company shows that the tailstrike rate for the A320 fleet is 2.7 occurrences per million flight cycles; the fleet has accumulated more than 19 million flight cycles.

The latest Airbus Flight Crew Operating Manual (FCOM) Bulletin giving advice on avoiding tailstrikes was 806/1 issued in June 2004. This states that for an A320 a tailstrike will occur at a pitch attitude of 13.5º with the main landing gear oleos fully extended and at a pitch attitude of 11.7º with the oleos fully compressed. For a normal 3º approach, the speed reduces by 8 kt during the flare and the normal pitch attitude at touchdown is 7.6º, giving a ground clearance angle of 5.9º. When the approach speed is decreased by 5 kt, the ground clearance angle is reduced by approximately 1.3º.

Approximately 70% of tailstrikes occur on landing. Some are associated with external factors such as turbulence and wind gradient but most are due to deviations from normal landing techniques. The sections of the Bulletin relevant to the incident involving HA-LPB are reproduced below:

'a) Allowing speed to decrease well below Vapp before flare.

Flying at too low speed means a high AOA and high pitch attitude, thus reducing ground clearance. When reaching the flare height, the pilot will have to significantly increase the pitch to reduce the sink rate. This may lead the pitch to go beyond the critical angle.

d) Too high a sink rate, just prior to reaching the flare height.

In case of a too high sink rate close to the ground, the pilot may attempt to avoid a firm touchdown by commanding a high pitch rate. This action will significantly increase the pitch attitude and, as the resulting lift increase may be insufficient to significantly reduce the sink rate, a firm touchdown may occur. In addition, the high pitch rate may be difficult to control after touchdown, particularly in case of bounce.

e) Bouncing at touchdown

In case of bouncing at touchdown, the pilot may be tempted to increase the pitch attitude so as to ensure a smooth second touchdown. If the bounce results from a firm touchdown associated with a high pitch rate, it is important to control the pitch so that it does not further increase beyond the critical pitch angle.

<u>APPROACH AND LANDING TECHNIQUES</u>

A stabilized approach is essential for achieving successful landings. It is imperative that the flare height be reached at the appropriate airspeed and flight path angle. A/THR and FPV are effective aids to the pilot.

The Vapp should be determined with the wind corrections, given in FCOM/QRH, using FMGS functions.

As a reminder, when close to the ground, the wind intensity tends to decrease and the wind direction to turn (directions in degrees decreasing in northern latitudes).

Both effects may reduce the headwind component close to the ground, and the wind correction to Vapp is there to compensate this effect.

When close to the ground, high sink rates should be avoided, even in an attempt to maintain a close tracking of the glideslope. Priority should be given to attitude and sink rate. If a normal touchdown distance is not possible, a go-around should be performed.

If the aircraft has reached the flare height at Vapp with a stabilized flight path angle, the normal SOP landing technique will lead to repetitive touchdown attitude and airspeed.

Assuming an 8-knots speed decrease during flare, and a -1º flight path angle at touchdown, the pitch attitude will increase by approximately 4.5º.

During flare, the pilot should not concentrate on the airspeed, but only on the attitude with external clues. Note: Airspeed indication during flare is influenced by the static error due to the ground effect.

The PNF should monitor the pitch attitude on the PFD and call "PITCH" whenever the following pitch value is reached: For A320: 10º.

> *After touchdown, the pilot must fly the nosewheel smoothly, but without delay, on to the runway, remaining prepared to counteract any residual pitch up effect of the ground spoilers. Note: The main part of the spoilers' pitch up effect is compensated by the flight control laws.*
>
> *BOUNCING AT TOUCHDOWN*
>
> *In case of a light bounce, maintain the pitch attitude and complete the landing, while keeping thrust at idle.*
>
> *Do not allow the pitch attitude to increase, particularly following a firm touchdown with a high pitch rate.*
>
> *In case of a high bounce, maintain the pitch attitude and initiate a go-around.'*

During an investigation into a tailstrike to another Airbus A320, C-GTDK on 16 June 2003, the AAIB recommended that:

> *'Airbus should introduce an aural warning to its fly-by-wire aircraft types to alert pilots of excessive pitch angle or excessive pitch rate during landing.'* (Safety Recommendation 2004-58)

On 2 July 2004, Airbus responded:

> *'We developed, on the A340-500 and A340-600, a system giving a visual indication on the PFD and an aural warning in case of excessive pitch angle. We are now studying the feasibility of extending this on all other fly-by-wire aircraft types.'*

Following the incident involving HA-LPB, Airbus confirmed that:

> *'Pitch limit indicator on PFD and "PITCH PITCH" auto-callout devices, that exist on A340-500 and A340-600, have been developed for all fly-by-wire aircraft. The maximum pitch attitude not to be exceeded will be indicated during take-off or landing. The auto-callout will trigger in case of excessive pitch attitude at landing below a given altitude. These improvements require a package EIS* (Electronic Instrument System) *and FAC* (Flight Augmentation Computer) *not yet available for in-service aircraft.'*

Operating company information

The company Operations Manual Part B dated 1 October 2005 contained the following relevant information:

> 1. Para 2.3.4: *'No control inputs are to be made by the non-handling pilot.'*
> 2. Para 2.3.10: *'Use of A/THR is recommended, even when flying manually.' 'FDs are to be used for all instrument approaches until visual. (Raw data approaches are of limited value, but may be flown occasionally in VMC at the captain's discretion.)'*
> 3. Para 2.5.1: *'Stabilised Approach: Go around is mandatory if an approach is not stabilised by 1000 ft AAL (IMC) or fully stabilised 500 ft AAL (VMC). Stabilised is defined as: On profile (within ½ dot (ILS) or 100 ft (NPA); Gear down and at least Flap 2; Speed no more than Vapp+20 kts decreasing or GS mini, whichever is higher. Fully stabilised is defined as: On profile (within ½ dot (ILS) or 100 ft (NPA)); Landing config; Approach power; Vapp or GS mini.'*

Discussion

There were no indications of any technical defects with the aircraft. Additionally, the PAPIs were confirmed as serviceable and accurate.

The tailstrike occurred when the aircraft touched down at a high pitch attitude with the airspeed some 15 kt below the computed V_{APP}; the aircraft then bounced before a second touchdown, again at a high pitch attitude. Indications are that either touchdown could have resulted in a tailstrike but that only one strike occurred. The initial touchdown followed an approach which had been well above the required glideslope at 530 ft agl. From that point, it is considered that the commander would have been working hard to re-acquire the glideslope and also maintain V_{APP}, particularly when not using autothrust or flight director. The aircraft remained above the glideslope until 11 ft agl, and by then it was at a high rate of descent and was slow. These conditions are acknowledged in the Airbus Bulletin as being typical conditions for a tailstrike to occur. The position of the aircraft in relation to the glideslope at 530 ft agl was such that a go-around would have been the most appropriate action. The company operations manual required such an action at 500 ft aal if the approach was not fully stabilised. While the Airbus modification to alert the crew to a high pitch attitude on landing is beneficial, the situation should generally be avoided by an early decision to go-around from an unstable approach.

One other aspect that may have been pertinent was that the commander was flying the aircraft without the use of autopilot, autothrust or flight directors. The aircraft can be safely flown manually and this is authorised by the company Operations Manual under certain conditions. However, it would then require close monitoring by both crew members and would normally only be done during benign weather conditions, to an airfield without any operating difficulties and to one that was familiar to the crew. While the weather report appeared reasonable, it became apparent to the crew that the wind at 1,000 ft was strong and that there was turbulence on approach. At night, and on an approach with undulating terrain, the conditions were such that a manual approach would require maximum concentration and monitoring. It would have been prudent to use all the available aircraft systems for the approach.

During the bounce, after the initial touchdown, the non-handling pilot made an aft sidestick input. While this had no effect on the pitch attitude, since the handling pilot had already applied full aft sidestick, the possible additive effects make dual sidestick inputs highly undesirable; the Operations Manual specifically precludes non-handling pilots from making any inputs.

Following the tailstrike, the commander reported the incident as required to the company operations centre, who then assumed responsibility for onwards reporting. However, during this time ATC were not informed of the tailstrike. During the subsequent investigation, the crew readily acknowledged their responsibility to inform ATC. Additionally, following the incident, the company issued guidance to personnel clarifying the reporting requirements after any accident or incident.

INCIDENT

Aircraft Type and Registration:	Boeing 737-377, G-CELA
No & Type of Engines:	2 CFM56-3B2 turbofan engines
Year of Manufacture:	1986
Date & Time (UTC):	7 July 2006 at 2350 hrs
Location:	En-route from Newcastle Airport to Stansted Airport
Type of Flight:	Public Transport (Cargo)
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	33 years
Commander's Flying Experience:	3,395 hours (of which 2,575 were on type) Last 90 days -122 hours Last 28 days - 50 hours
Information Source:	AAIB Field Investigation

Synopsis

During a climb to FL270 with autopilot 'B' engaged, the aircraft did not capture the selected altitude. The commander disconnected the autopilot and then experienced difficulty in accurately controlling the aircraft in pitch. He declared an emergency and was given radar vectors and an unrestricted descent to Stansted Airport, where he made a safe landing. The investigation revealed that a tripped circuit breaker for the autopilot stabiliser trim actuator had caused the failure of the aircraft to capture the selected altitude. No malfunction was found to explain the commander's difficulty in accurately controlling the aircraft in pitch.

History of the flight

The crew were on the third of a series of four flights. The previous two flights had been uneventful with no significant unserviceabilities, apart from a reported anomaly with the thrust reversers on landing at Newcastle Airport. The crew had reported that No 1 reverser had unlocked slightly before No 2 and that there had been no discernible 'spooling up' of the engines during the landing roll. Subsequent ground runs by engineers confirmed that the reverser system was operating correctly.

For the incident flight from Newcastle to Stansted, it had been agreed that the first officer would be the Pilot Flying (PF) and would fly the aircraft manually using the flight director. For takeoff, the aircraft weight was calculated as 48,423 kg with the CG at

17.6% Mean Aerodynamic Chord. The takeoff and climb, using autothrottle, was uneventful and the first officer levelled the aircraft at FL210 and then engaged autopilot 'B'. Shortly after, the aircraft was cleared direct to Manchester and to climb to FL270. As the aircraft approached FL270 with 'Lateral Navigation' (LNAV) and 'Vertical Navigation' (VNAV) selected, the first officer saw 'FMC SPD' and 'VNAV PATH' annunciate but was not aware of any change in aircraft attitude as it approached the selected level. She alerted the commander, who had been on the radio checking weather. He checked the level and saw that the aircraft was approximately 300 ft above the selected level and still climbing with the 'ALTITUDE ALERT' light illuminated. He disconnected the autopilot using his control wheel switch, disconnected the autothrottle and manually flew the aircraft back to FL270. Around this time, both crew members recalled seeing the 'STAB OUT OF TRIM' light illuminate for a few seconds but could not be certain whether it came on with the autopilot engaged or disengaged.

The commander was now flying the aircraft manually using the flight director but found that it was difficult to control in pitch and he could not seem to get the correct pitch trim position using either the electric or manual trim. During the rest of the flight, the commander did not attempt to re-engage either autopilot. He informed the first officer of his difficulties and, after a few minutes with no apparent improvement, informed Manchester ATC that he was having difficulty maintaining level flight. Shortly after, the commander declared a 'PAN' and asked for radar vectors towards Stansted Airport; he was very familiar with Stansted and had already set up the aircraft systems for an approach to Runway 23. During the subsequent descent, the commander was aware of feeling a vibration feeding back through the control wheel, mainly when he applied an aft force. Becoming increasingly concerned, he upgraded his emergency to 'MAYDAY' and asked for radar vectors to Runway 23.

Throughout the subsequent unrestricted descent, the commander used 'Level Change' (LVL CHG) and manual thrust to control his descent and noted that the aircraft appeared steady with a descent rate of about 1,000 ft/min. However, he was still aware of the vibration whenever he applied an aft force to the control wheel or increased thrust. He levelled the aircraft at 2,000 feet amsl and was still experiencing difficulties holding the aircraft level. The final ILS approach was flown at an approach speed of 140 kt with 'Flap 30'. During this final approach, the commander considered that the pitch controls appeared lighter than normal and was aware of an apparent uncommanded control wheel input to the left at about 400 feet agl, which he corrected. The landing flare appeared normal as did the final landing; the surface wind on landing was reported as from 260º at 6 kt.

Subsequent to the incident, the pilots confirmed that they had not checked the state of the Circuit Breakers (CBs) following the failure of the aircraft to capture the selected altitude.

The first officer was the holder of a Commercial Pilot's Licence with a total flying experience of 756 hours, of which 180 hours were on type. She subsequently confirmed that she had kept her hands and feet well clear of all aircraft controls following the commander's declaration that he was having difficulty controlling the aircraft.

Meteorological information

The Met Office Headquarters at Exeter provided an aftercast for the area between Newcastle and Stansted.

There was an unstable westerly flow covering the British Isles with little evidence of any cloud above 8,000 feet amsl along the aircraft route. The 0ºC isotherm level was at 9,500 feet amsl. There was no indication of any turbulence.

The Stansted weather for landing was reported as follows: Surface wind was from 260º at 6 kt, cloud was scattered at 4,000 feet amsl, air temperature was 15ºC with a dew point of 11ºC and the QNH was 1017 Mb.

Communications

An ATC recording was available of all the frequencies used by the crew of G-CELA from the declaration of the handling difficulties until the final landing at Stansted. Full and effective assistance was provided by Manchester, London and Stansted ATC services.

The initial 'PAN' was declared at 2217 hrs and was upgraded to 'MAYDAY' at 2220 hrs. The landing at Stansted was at 2249 hrs.

Flight recorders

The aircraft was fitted with a magnetic-tape 25-hour Flight Data Recorder (FDR) which recorded a range of flight parameters from the time of engine start. The aircraft was also fitted with a magnetic-tape 30-minute Cockpit Voice Recorder (CVR) which recorded crew speech and area microphone inputs when electrical power was applied to the aircraft. Both recorders were downloaded at the AAIB where data was recovered for the incident flight. CVR recordings were not available having been overwritten when G-CELA was on the ground after the flight. Additional altitude data was recovered from Radar Mode C and Mode S recordings, provided to the AAIB by National Air Traffic Services (NATS).

Horizontal Stabiliser Trim Data

Although a parameter recording horizontal stabiliser trim position was available, it was found that the recorded data for this parameter was invalid due to sensor or wiring problems. This lack of data together with the lack of a discrete replicating the 'STAB OUT OF TRIM' light severely reduced the usefulness of the recorded data to the investigation.

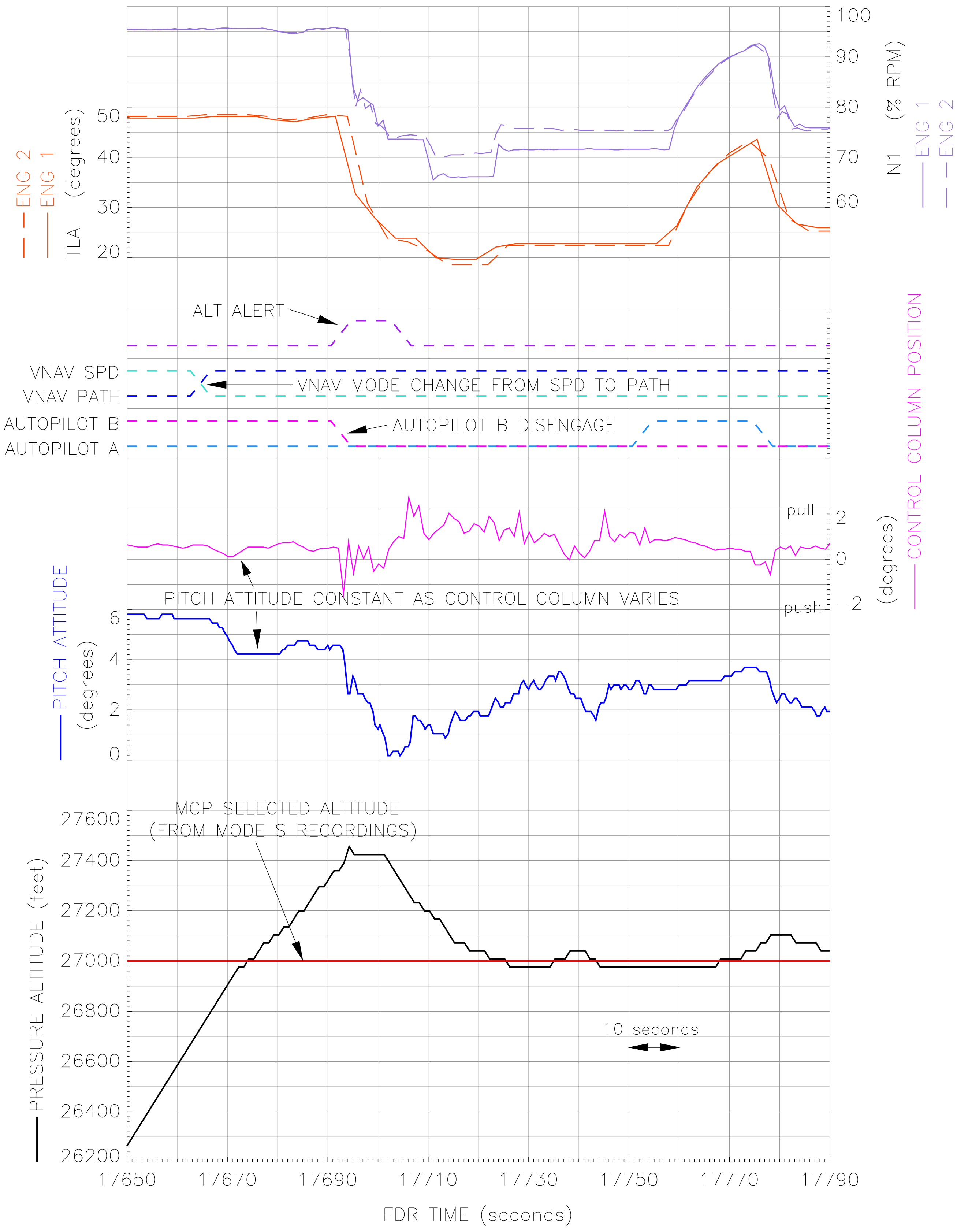
Altitude Exceedance

A time history of the relevant parameters recorded during the cleared altitude exceedance is given at Figure 1. The data starts with the aircraft climbing through 26,000 ft at 1,650 ft/min, an airspeed of 272 kt and autopilot 'B' engaged in 'VNAV PATH'. The Mode Control Panel (MCP) selected altitude, obtained from the Mode S recording, was 27,000 ft.

At 26,700 ft, the VNAV mode changed from 'PATH' to 'SPD' and the control column moved forward (from a nominal value of +0.6º pull used for the climb to +0.1º), reducing the pitch attitude from 5.6º to 4.2º nose up and slowing the climb rate to 1,100 ft/min. The pitch attitude remained at 4.2º for just under ten seconds while the control column moved back to the +0.6º position.

As the aircraft continued to climb between 27,300 and 27,400 ft, autopilot 'B' disengaged and an 'ALTITUDE ALERT' activated. The control column was then pushed forward momentarily to -1.4º and the thrust levers were pulled back from 48º to 30º thrust lever angle and then to about 20º, with corresponding reductions in engine N1s.

The aircraft achieved a peak altitude of 27,450 ft before descending to 27,000 ft.



100
90
80
70
60
N1 (% RPM)
ENG 1
ENG 2
50
40
30
20
TLA (degrees)
ENG 1
ENG 2
ALT ALERT
VNAV SPD
VNAV PATH
VNAV MODE CHANGE FROM SPD TO PATH
AUTOPILOT B
AUTOPILOT A
AUTOPILOT B DISENGAGE
pull
push
2
0
−2
(degrees)
CONTROL COLUMN POSITION
PITCH ATTITUDE CONSTANT AS CONTROL COLUMN VARIES
6
4
2
0
PITCH ATTITUDE (degrees)
MCP SELECTED ALTITUDE
(FROM MODE S RECORDINGS)
27600
27400
27200
27000
26800
26600
26400
26200
PRESSURE ALTITUDE (feet)
10 seconds
17650
17670
17690
17710
17730
17750
17770
17790
FDR TIME (seconds)

Figure 1

Descent to Stansted

A time history of the relevant parameters during the manually controlled descent to Stansted is given at Figure 2.

During the manually controlled flight, considerably more activity was recorded on control column position compared to when autopilot 'B' was engaged and flying the aircraft. A similar increase in activity was also recorded in pitch attitude and normal load factor. This indicated that basic control column/elevator inputs were driving the activity.

Several large and rapid control wheel inputs were recorded around 400 ft agl but with no corresponding large roll attitudes.

System description

Hydraulics

The Boeing 737-300 has two primary hydraulic systems, A and B, and one standby system.

Elevator

Control cables, connected to the two control wheels, command the elevator movement. The cables are connected via quadrants and pulleys to the torque tubes which provide inputs to the two hydraulic elevator Power Control Units (PCU). The elevator feel and centering unit provides artificial feel and centres the elevator when the control wheel is released.

An elevator feel computer provides artificial feel to the pilot by applying resistance to the control quadrants. This is achieved by varying the hydraulic pressure input to the elevator feel and centering unit based on the pitot pressure from pitot heads mounted on the side of the vertical fin.

In the event of a failure of both hydraulic systems, the elevator can be manually controlled directly from the control columns. Elevator tabs, mounted to the rear of each elevator surface, augment the control forces during manual control.

Autopilot

The aircraft has two autopilot channels, 'A' and 'B', both controlled by separate Flight Control Computers (FCC). When an autopilot is selected to 'Command' (CMD), certain systems are checked for serviceability before the autopilot will engage. One system that is not checked is the autopilot stabiliser trim. Following engagement of an autopilot channel, several control modes can then be selected.

'VNAV' is one of the autopilot modes. In this mode the aircraft's vertical profile is controlled by the autopilot using commands from the Flight Management Control System (FMCS). The vertical profile is calculated based on the constraint of the altitude selected on the MCP. During a climb with 'VNAV' selected, the mode displayed to the flight crew is 'VNAV SPD'. As the aircraft approaches the MCP selected altitude, the mode changes from 'VNAV SPD' to 'VNAV PATH'. This indicates that the autopilot is now in an altitude acquire mode and will attempt to level the aircraft at the selected altitude. This is accomplished through the use of the elevator autopilot PCU in combination with the autopilot stabiliser trim actuator. The autothrottle is not used to control the pitch of the aircraft, but does maintain the aircraft's speed by altering engine power during pitch changes. Once the aircraft has attained the selected altitude, the mode continues in 'VNAV PATH' with the mode similar to that of an altitude hold.

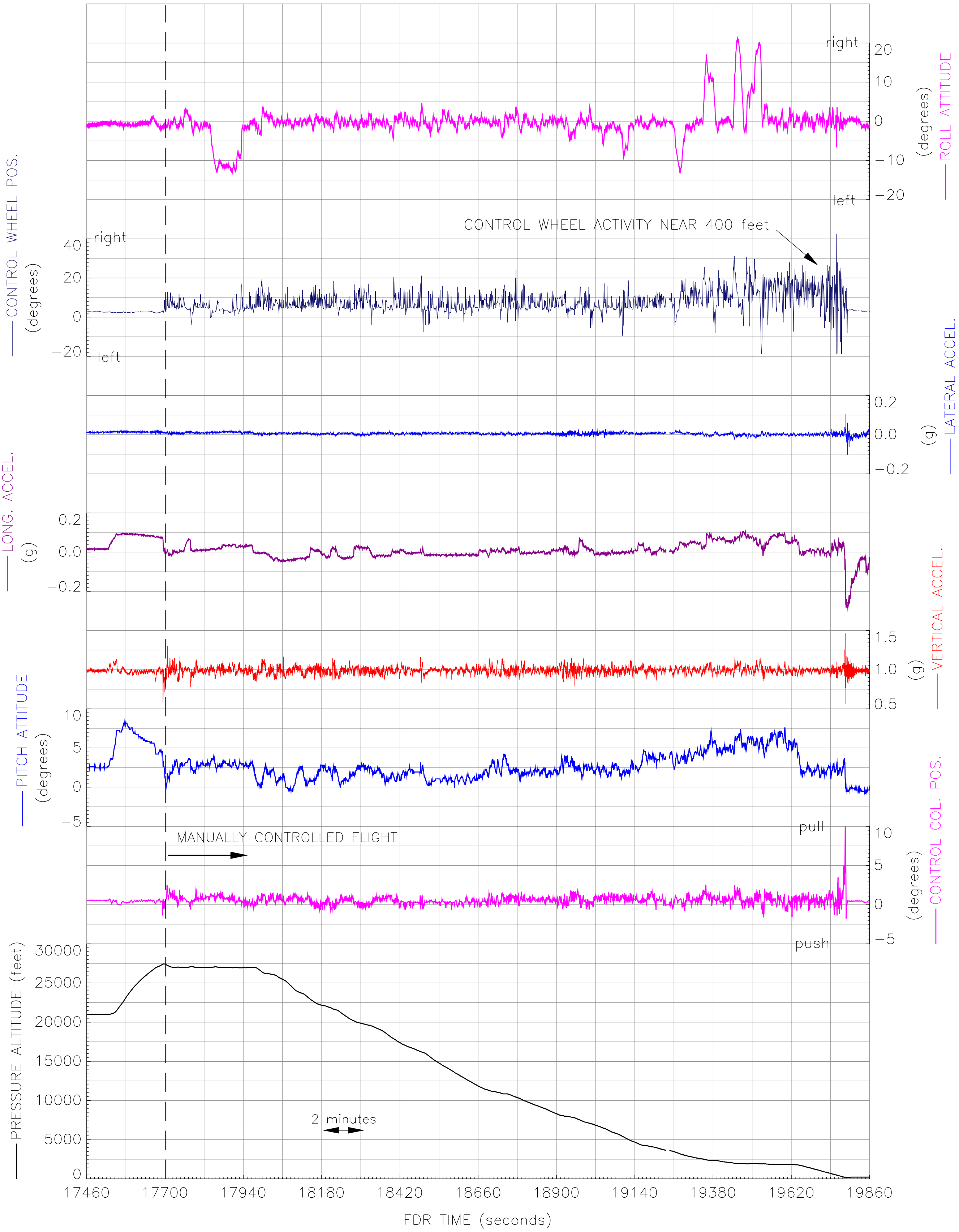

ROLL ATTITUDE
(degrees)
right
left
20
10
0
−10
−20
CONTROL WHEEL ACTIVITY NEAR 400 feet
CONTROL WHEEL POS.
(degrees)
40
20
0
−20
LATERAL ACCEL.
(g)
0.2
0.0
−0.2
LONG. ACCEL.
VERTICAL ACCEL.
1.5
1.0
0.5
PITCH ATTITUDE
10
5
−5
MANUALLY CONTROLLED FLIGHT
CONTROL COL. POS.
pull
push
PRESSURE ALTITUDE (feet)
30000
25000
20000
15000
10000
5000
2 minutes
17460
17700
17940
18180
18420
18660
18900
19140
19380
19620
19860
FDR TIME (seconds)

Figure 2

Altitude Alert

Two 'ALTITUDE ALERT' amber lights indicate that the aircraft is approaching the MCP selected altitude. When the aircraft is 900 feet below the selected altitude, the lights illuminate and an aural warning sounds. The lights remain illuminated until the aircraft is within 300 ft of the selected altitude, at which point the lights extinguish. They will also illuminate if the aircraft climbs or descends 300 ft from the selected altitude.

Stabiliser Trim

The horizontal stabiliser trim consists of an electrically commanded manual system, a cable commanded mechanical manual system and an autopilot commanded system. All three are connected to a stabiliser trim screwjack which provides movement of the all-moving horizontal tail plane.

Switches on each of the control wheels command the electrical manual system. The signal from these switches operates the primary stabiliser trim actuator which subsequently drives the stabiliser trim gearbox and the stabiliser screwjack.

Mechanical manual operation of the stabiliser trim is by a trim wheel mounted on the centre pedestal which is connected by control cables to the gearbox cable drum at the bottom of the stabiliser gearbox. Operation of the trim wheel commands mechanical movement of the stabiliser gearbox and the stabiliser screwjack.

Automatic control of the stabiliser trim is by commands from the FCC to an independent autopilot stabiliser trim actuator mounted on the stabiliser trim gearbox. The FCC commands the autopilot trim actuator to move the stabiliser via the stabiliser trim gearbox and the stabiliser screwjack. The commands are related to the elevator movement. If the elevator displacement is continuous for more than three seconds, the FCC commands the stabiliser trim to compensate for the input. The actuator is protected by a 7.5 amp CB located on the P18 panel behind the left cockpit seat.

An amber 'STAB OUT OF TRIM' light illuminates on the centre instrument panel whenever the autopilot is not trimming the stabiliser correctly. There is no associated aural warning or master caution and the autopilot will remain engaged. There are three detectors which can trigger the warning light:

1. A 3° difference between the elevator position and the elevator autopilot PCU position.
2. A stabiliser movement of less than 0.5° in 10 seconds when stabiliser movement is commanded by the autopilot.
3. The elevator PCU position is more than 5° from the elevator neutral position.

The autopilot stabiliser trim actuator also provides a speed trim function when the flaps are extended and the autopilot is disengaged. This function is to ensure positive speed stability during low speed and high thrust situations. A failure of the system results in an amber 'SPEED TRIM FAIL' light on the forward overhead panel, an associated master caution and an aural warning.

Engineering examination

Engineers from the airline operator's contracted maintenance organisation at Stansted carried out an initial examination of the aircraft on arrival. A test of the autopilot revealed a failure of the automatic stabiliser trim and upon investigation the engineer found the autopilot stab trim actuator CB tripped off. After resetting the CB, the test was successful. Additional functional tests of the elevator, manual electric stabiliser trim and autopilot were also completed without any fault indication.

Under AAIB supervision, engineers then conducted a thorough examination of the aircraft and relevant systems. An initial BITE check of the Digital Flight Control System (DFCS) revealed a recorded failure, on the last (incident) flight, of the speed trim system on both FCC ‘A’ and FCC ‘B’ channels.

A full examination of the elevator control run, including cable tension, cable friction and rigging checks, was satisfactory. The only anomaly was in the elevator feel system. During a check with the ‘A’ system hydraulics off and the ‘B’ system hydraulics on, the force required to move the elevator was 50 lb with 173 kt applied to the feel computer pitot ports; the limits were between 35 and 43 lb. The feel force of the elevator at all other settings, and in particular with both ‘A’ and ‘B’ system hydraulics on, were all well within the prescribed limits.

Two hydraulic leaks were found which related to system ‘A’, one on the hydraulic pressure module in the left wheel well and one on the No 3 flying control shut-off valve in the tail. Both of these were rectified.

The tests of the autopilot only revealed one failure. This was related to the pitch Control Wheel Steering (CWS) force transducers; the failure was due to a discrepancy between forces being measured at the commander’s and first officer’s transducers. Each transducer’s individual force output was within limits.

Due to the autopilot stabiliser trim CB being found tripped, a full test of the wiring and the actuator was conducted. This did not reveal any defects with the wiring or any of the electrical connectors. The CB was rated at 7.5 amps.

As a precaution, the autopilot stabiliser trim actuator, autopilot stabiliser trim actuator CB and the two FCCs were removed for bench testing. In addition, the elevator feel computer and the stabiliser trim position transducer were also replaced, with the removed units sent for testing.

Component examinations

The component manufacturer, under AAIB supervision, conducted bench tests on the two FCCs. The BITE information for FCC A and FCC B both revealed an in-flight fault for the incident flight related to a speed trim system failure. The only bench test failure was with the roll function in FCC ‘A’. This was due to a resistor being slightly out of tolerance. FCC ‘B’ had no other reported faults during its bench test.

A component overhaul organisation conducted a bench test and strip examination of the autopilot stabilizer trim actuator. During the test, the friction clutch slipped at a load of 160 lb in; this was lower than the required limits of between 240 and 320 lb in. However, the current draw from the actuator during the tests and with the clutch slipping, never exceeded 3 amps and was mostly at about or below 1 amp. With the CB rating of 7.5 amps, this should not have resulted in the CB tripping. The strip examination of the actuator showed normal wear on the friction clutch plates but did not reveal any faults.

The bench test and strip examination of the elevator feel computer was satisfactory and no fault could be found to explain the reported high feel force experienced on the aircraft.

The test of the autopilot stabiliser trim CB was conducted in a workshop. The tests showed the CB to perform within its specification. A force of 6 lbf was required to manually trip the CB.

The stabiliser trim position transducer tests showed that it performed within its specification. However, one connector failed the insulation resistance test due to contamination. There was also signs of grease and dirt contamination of the connector pins.

CB visibility

The autopilot stab trim actuator CB is located on the P18 panel behind the commander. It is the uppermost CB on the panel, which makes it difficult to see from the seating position of the commander and first officer. Furthermore, a map light is mounted to the right of the CB panel with its lead dropping down in a loop beside the panel. This coil of lead to the light is in such a position that it obscures the CB. Refer to Figure 3 below.

Aircraft maintenance

A full review of the operating history of the aircraft did not reveal any previous reported problems with the autopilot, stabiliser trim, elevator or hydraulics.

The last maintenance carried out on the aircraft was a service check on 5 June 2006, about 202 flying hours prior to the incident flight.

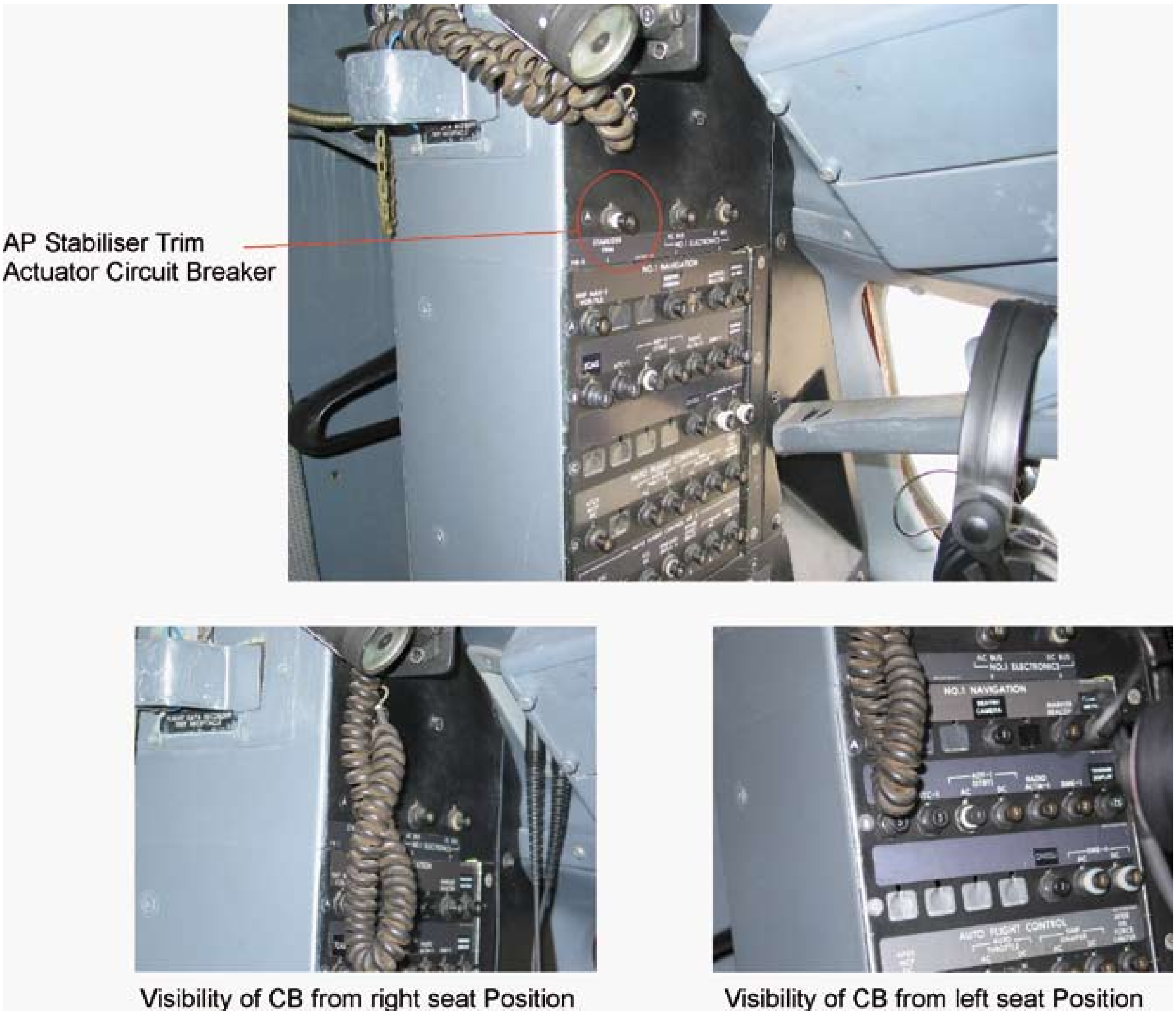


Figure 3

Analysis

The investigation indicated two apparent anomalies during the flight. Firstly, the failure of the aircraft to capture the MCP selected altitude and secondly, the difficulties experienced by the commander in controlling the aircraft in pitch.

Failure to capture selected altitude

The failure of the autopilot to level off at the MCP selected altitude can be directly attributed to the autopilot stabiliser trim actuator being inoperative due to its CB being tripped off. With a fully functional system, as the aircraft approaches a selected altitude, the autopilot would use the autopilot elevator PCU to level the aircraft. As the elevator moves away from its neutral position, the autopilot would command the autopilot stabiliser trim actuator to follow up on the elevator. This would give the elevator greater authority in pitch. However, with the autopilot stabiliser trim actuator inoperative the stabiliser could not follow up on the elevator command. The autopilot would run out of elevator authority and the aircraft pitch attitude could not move any further nose down. This was evident on the FDR trace which showed the pitch attitude flat line as the aircraft climbed through FL270. Concurrently, the autopilot would have detected that the stabiliser movement was less than 0.5° for 10 seconds and would have triggered the 'STAB OUT OF TRIM' warning. The crew acknowledged that this warning occurred around the time that the aircraft was near FL 270. Later in the flight, with the CB still tripped and as the flaps were lowered, the 'SPEED TRIM' warning was activated as recorded on both FCCs.

While the tripping of the CB would explain the failure of the aircraft to capture the selected altitude, there was the question of why the CB tripped. Despite thorough testing of the autopilot stabiliser trim actuator, the CB and the aircraft wiring, no defect could be identified to explain the tripping. Furthermore, after the CB was reset the system operated normally. While accepting that a check of the CB panel by the crew after the initial problem may have highlighted and rectified the reason for the altitude overshoot, the investigation continued to consider when and why the CB had tripped.

There was no reason for the CB to be intentionally tripped for any rectification. Therefore, it could only have been manually tripped by accident or by an unidentified transient electrical event. It was not possible to identify by performance evaluation when the CB tripped. The only certain factor was that it had tripped before the aircraft attempted to level at FL270.

One possibility was that the CB had been tripped inadvertently prior to flight. However, the force required to do so was measured as 6 lbf. This force would require more than a passing knock and therefore is considered unlikely. Furthermore, part of the crew pre-flight checks involved a check of the CB panels and, while such an omission cannot be ruled out, particularly when the location of the CB is considered, it is also unlikely that it would have been missed. An electrical transient fault may also have tripped the CB but despite extensive checks, no evidence of any relevant fault could be identified. Regardless of the reason for the tripping, subsequent tests confirmed that the CB could have been reset and normal autopilot operation would have been possible. The location and associated difficulties with seeing the CB from either pilot seat may have been factors in the crew not identifying the source of the problem. However, a check of CBs is a prudent action for any apparently unexplained aircraft defect.

Pitch control difficulties

Despite a thorough examination of the pitch control system, no technical reason could be found to account for the symptoms of the pitch control problems experienced by the commander following the disconnect of the autopilot. Although hydraulic leaks were found that were associated with the 'A' system, discussions with the aircraft manufacturer indicated that it was unlikely that these were significant enough to cause control problems. No hydraulic low pressure warnings were activated during the incident flight and, even if the 'A' system had failed, the' B' system would still have provided full pitch control authority. The elevator feel system also failed during one of the post-incident checks on the aircraft. The feel was higher than expected, but this was only with 'B' system pressurised and at a simulated airspeed of 173 kt. With both 'A' and 'B' system pressurised, the forces were normal. Similarly at other airspeeds, with just 'B' system pressurised, the feel forces were within limits. The removal and bench testing of the elevator feel computer revealed no faults. Installation of a replacement feel computer did resolve the problem with subsequent checks of the feel forces all being within limits. The mechanical elements of the elevator system were fully serviceable. The aircraft was returned to service and subsequently operated satisfactorily, and the investigations of the components removed did not identify any relevant defects. Nonetheless, the possibility remains that the work carried out on the aircraft had eliminated some undetected deficiency.

FDR information indicated that the control wheel movement was greatest when the aircraft was being flown manually after the level off at FL270. This was associated with an increase in pitch attitude and normal load factor and indicated that the control movements were the result of manual control inputs. While a slight difference in control forces could not be ruled out, it is possible that the failure of the aircraft to level off induced some concern within the commander and may have resulted in him overcontrolling. In that situation, it may have been appropriate for him to hand over control to the first officer for another opinion. Nevertheless, with an apparent control difficulty the crew ensured priority and full assistance from ATC by declaring an emergency.

INCIDENT

Aircraft Type and Registration:	Bombardier DHC-8-400, G-JECE
No & Type of Engines:	2 Pratt & Whitney PW150A turboprop engines
Year of Manufacture:	2004
Date & Time (UTC):	4 August 2005 at 0748 hrs
Location:	Near Leeds, West Yorkshire
Type of Flight:	Public Transport (Passenger)
Persons on Board:	Crew - 4 Passengers - 56
Injuries:	Crew - None Passengers - None
Nature of Damage:	Internal damage to No 2 engine
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	35 years
Commander's Flying Experience:	4,150 hours (of which 400 were on type) Last 90 days - 150 hours Last 28 days - 70 hours
Information Source:	AAIB Field Investigation

Synopsis

Shortly after initiating a descent, an oily smell was noticed on the flight deck, almost immediately followed by a smoke build-up in the flight deck and cabin. The flight crew carried out the initial part of the smoke checklist procedure, declared an emergency and carried out a diversion. The cabin crew members donned smoke hoods, which caused appreciable communication difficulties, and prepared the cabin for an emergency landing. After landing, an emergency evacuation was carried out, without injury.

The smoke was found to be the result of fatigue cracking of a compressor support member of the No 2 engine. This had led to damage to an oil seal, allowing oil to leak into the bleed air supplying one of the air conditioning units. Fleet modification action aimed at preventing fatigue cracking of the component and at improving the affected oil seal was completed on all of the operator's fleet by July 2006.

No means of rapidly ascertaining the source of the smoke was available to the crew. Carrying out the subsequent actions prescribed in the checklist would have stopped the supply of smoke but the procedure was relatively protracted and could not be completed because of a high flight crew workload associated with the diversion.

Four safety recommendations have been made.

History of the flight

The following information was obtained from reports by the aircraft crew, ATC controllers and from RTF recordings.

The aircraft was on the second sector of the day, from Birmingham to Edinburgh. On the first sector the commander noticed a slight musky smell on engine start but, as engine maintenance activities had just been completed, he did not consider it to be out of the ordinary. During the previous sector a slight oily smell had been noticed on the flight deck for approximately 30 seconds during the descent.

On the second sector, while in the cruise at FL200, a 'de-ice pressure' caution activated when the de-icing system was switched on. The caution light remained illuminated after the relevant checklist from the Flight Crew Operating Manual (FCOM) had been actioned and consequently, at 0731 hrs, some 15 minutes after takeoff, the crew requested a descent to FL120. At around 0736 hrs Manchester ATC, which was controlling the aircraft at the time, gave an initial clearance to descend to FL160. Shortly after retarding the throttles and while descending through FL180, both pilots noticed the same oily smell as before. They asked the cabin crew, via the interphone, whether the smell was evident in the passenger cabin and, almost immediately, noticed a white/blue haze appearing on the flight deck, accompanied simultaneously by the toilet smoke alarm.

The commander initiated the procedure specified in the FCOM smoke checklist and both pilots donned their smoke masks and actioned the checklist memory items. One item, switching off the recirculation fans, was initially omitted but was carried out subsequently. Smoke goggles were not used as there was no difficulty in reading the instruments. While the pilots were actioning the checklist the two cabin crew members heard the smoke alarm in the forward toilet sound and then found that the toilet was full of whitish coloured smoke. The senior cabin crew member informed the flight crew using the interphone. The pilots' response was delayed because they were occupied with the checklist actions. The cabin crew then donned smoke hoods.

The commander declared a 'MAYDAY' and was given clearance for a further descent. He then requested vectors to the nearest suitable airport. ATC suggested Leeds Bradford International Airport (LBA), around 45 nm away, and this was accepted by the commander. After some delay due to communication difficulties, ATC informed G-JECE's crew of the required heading, requested selection of the emergency transponder code and transferred the aircraft to a quiet frequency. At the crew's request, ATC passed the crew an airfield weather report, after a further delay while the information was obtained from LBA. The report indicated a wind of 14 kt from 260ºM, visibility of 20 km, scattered cloud at 1,100 ft and 1,500 ft above aerodrome level (aal) and an ambient temperature of 14ºC.

The commander considered that the smoke level in the flight deck was unchanged, so the cabin crew were briefed to prepare the cabin for an emergency landing in 10 minutes and a passenger evacuation on the runway. The cabin crew found the smoke in the cabin getting thicker, until they could no longer see the length of the cabin. The senior cabin crew member played an emergency announcement tape and made a public address to the passengers, briefing them that there would be an emergency landing, for which they should adopt the brace position. The cabin crew then checked the passengers and secured cabin baggage. Some passengers enquired about breathing protection for themselves, but smoke protection for passengers is not a requirement on public transport aircraft.

The ILS frequency and runway heading at LBA were passed by ATC on request from the crew and the aircraft was radar vectored for an ILS approach to Runway 14. About 15 nm from the airport ATC suggested a frequency change to Leeds Approach, which was accepted. The flight crew judged that their priority was to get the aircraft safely on the ground. With the limited time available and the high workload situation the flight crew were able to complete only the first item of the subsequent actions of the Smoke checklist, which was '*No 1 Bleed Off and wait up to 1 minute*' (Section 4). As power was increased during the approach a significant increase in the smoke level was experienced. Because of hearing difficulties caused by the smoke hoods, the cabin crew members did not hear the landing calls from the flight deck.

The aircraft landed on Runway 14 at 0748 hrs, around 12 minutes after the crew had become aware of the smoke. To expedite their arrival the crew accepted a tailwind reported, at that time, to be 15 kt. A firm landing was made and the aircraft stopped around two-thirds of the way along the runway.

After coming to rest the park brake was applied, the engines were shut down and an evacuation was ordered. This was carried out through the left forward exit, using the airstairs, and the left and right aft exits. The first officer left the aircraft to assist and supervise the passengers while the commander completed the shutdown actions. The passenger evacuation proceeded in an orderly fashion, with the Aerodrome Fire and Rescue Service (AFRS) present, and was completed without injury. The commander confirmed that the cabin was empty and left the aircraft. A check by AFRS personnel found no signs of fire and the aircraft was towed to a stand.

Crew communications

In their reports on the incident the flight crew noted that, after the emergency had been declared, a high workload had prevented them from communicating with the cabin crew for some time. The cabin crew commented that delays in obtaining a response from the flight deck to cabin emergency calls at times had caused concern as to the state of the flight crew. It was suggested that consideration should be given to introducing a standard method by which the flight crew could confirm to the cabin crew that they were not incapacitated but were temporarily too busy to reply, such as a triple activation of the seat belt audio alert in the cabin.

The cabin crew also reported that the smoke hoods had severely hindered communications with the passengers, impeding both hearing and being heard. Because of this, one of the cabin crew had removed her hood shortly before landing.

FCOM checklist

The '*FUSELAGE FIRE OR SMOKE – SMOKE*' checklist in the operator's FCOM had the following memory items:

- *Oxygen Masks............................On + 100%*
- *Smoke Goggles ....On*
- *Mic switch... MASK*
- *Hot Mic ....OFF*
- *Headset ....On*
- *Recirc Fans ....OFF*
- *Emergency Lights .... ON*
- *Passenger Signs...................................... ON*
- *Descend .... ASAP - Check MSA*
- *Land immediately at nearest suitable aport*

The initial part of the subsequent actions in the checklist were:

"IF Unknown Source of Fire or Smoke:

- *Bleed 1 .... OFF*

  Wait up to one minute, if no improvement:
- *Bleed 1 .... ON*
- *Bleed 2 .... OFF*

  Wait up to one minute, if no improvement:
- *Bleed 2 .... ON*
- *Flt Compt Pack.................................... OFF*

  Wait up to one minute, if no improvement:
- *Flt Compt Pack....................AUTO or MAN*
- *Cabin Pack .... OFF*

  Wait up to one minute, if no improvement:
- *Cabin Pack ....AUTO or MAN*

IF Source of Fire or Smoke still cannot be identified:

Caution: Following completion of this drill fly A/C from the LHS (torches req'd at night) in order to read active instruments. 45 mins battery duration.

- *Battery master........................... Confirm ON*
- *DC and AC Gens 1 and 2 .... OFF*
- *Main, Aux and Stby Batteries .... OFF*
- *Emergency Lights .... OFF (until finals)*
- *Descend and Land .... <10000 ft ASAP – Check MSA*
- *Refer to 'battery essential services' – Page 17B.*
- *When cabin diff is 0.5psi or less, complete Ram Ventilation page 10A"*

Engine description

The Pratt & Whitney Canada PW150A is a gas turboshaft engine with a nominal sea level static power output of approximately 5,100 shaft horsepower. It has an axial Low Pressure (LP) compressor, a centrifugal High Pressure (HP) compressor, a two-stage gas generator turbine and a two-stage power turbine. Bleed air for the fuselage air conditioning units is taken from either the LP or HP compressors, depending on the power settings.

A ring of stator blades at the outlet of the LP compressor is located on an approximately conically shaped component known as the Inner Compressor Support (ICS). With the modification standard of G-JECE's No 2 engine, the ICS is radially located by a fit with the No 3 bearing housing. A flange on the ICS, provided with an O-ring static oil seal, mates with the Inter Compressor Case (ICC) and the ICS and ICC together form part of an engine bearing chamber. At the forward end of the chamber a double spring-loaded carbon oil seal (the 'No 2.5 bearing seal') mounted in the ICS seals against the LP shaft.

Previous cases had occurred of loss of material from the outer part of the ICS where it contacts the stator ring, due to frettage wear that had resulted in a change in the ICS vibration characteristics and consequent fatigue cracking. The material detached from the ICS could cause impact damage to compressor blades and could lodge inside the compressor rotor and unbalance it. Abnormal vibration associated with the ICS damage and/or the effects on the compressor could lead to degradation of both the static oil seal and the bearing chamber carbon oil seal and possibly to fatigue cracking of the ICC struts. Degradation of the oil seals could allow oil to escape into the gas flow through the compressor and thence into the air conditioning units, leading to oil mist or smoke in the cabin and flight deck. The aircraft was not fitted with an engine vibration monitoring system.

A Service Bulletin (P&WC SB No 35158), issued by the engine manufacturer on 22 July 2005, noted that:

> *'Summary: There can be a possible material loss from the Inner Compressor Support (ICS). The piece of material can either enter the Low Pressure (LP) Compressor or the high pressure compressor. This can result in a possible deterioration in engine oil sealing.'*

The SB also noted:

> *'Cause Relative movement between the support and the LP compressor stator causes fretting wear on the support. This reduces the fit between both parts, which allows the support to freely vibrate and crack.'*

The SB recommended:

> *'Do boroscope inspection to verify for cracks and loss of material of the LP inner compressor stator support.'*

The recommended time for initial and repeat inspections of an individual engine varied according to the engine's background, thus determining which of three groups it fitted into. See Table 1 below.

G-JECE's No 2 engine was in Group 2. The SB recommended that, if ICS cracks were found, the boroscope inspection should be repeated at an interval of not more than 65 flight hours. If a loss of material were evident the engine should be removed for ICS replacement.

Information from the engine manufacturer indicated that at July 2005 there had been 12 incidents of oil smell or smoke in the fuselage, of which five had been attributed to ICS cracking.

Emergency air and oxygen supplies

The DHC-8-400 was not required to be fitted with individual passenger oxygen masks because of the limited maximum altitude capability of the aircraft type. However, on aircraft types where individual masks are provided they are typically not intended to be used in the case of smoke in the cabin, as this may be associated with a fire which could be fuelled by oxygen from the masks. G-JECE was provided with portable therapeutic oxygen equipment, which was available for use in the event

Group	Engine Background	Initial Inspection Time flight hr	Repeat Inspection Time flight hr
1	LP ICS replaced at previous shop visit due to cracks or material loss	≤200	≤200
2	LP ICS not inspected at last shop visit or never had a shop visit	≤500	≤500
3	LP ICS replaced at previous shop visit due to fretting or reinstalled	Latest of 500 hr or 2,000 hr ICS TSN (time since new)	≤500

Table 1

of passenger breathing difficulties being experienced. Smoke protection for passengers is not a requirement on public transport aircraft and was not provided.

Other cases of fuselage air contamination

A search of the CAA database revealed that in the three-year period to 1 August 2006 there had been 153 cases of fumes, abnormal odour or smoke or haze in the flight deck and/or cabin of UK registered public transport aircraft of various types. Details on a number of the cases were limited but the available information suggested that around 119 of the cases had probably resulted from conditioned air contamination. This had commonly been caused by oil release from an engine, APU or air conditioning unit or ingestion of de-icing or compressor wash fluid by an engine or APU, with consequent smoke and/or oil mist in the conditioned air supply to the fuselage. It appeared that in many of the cases the crew members had found it difficult or impossible to establish the source of the contamination.

Adverse physiological effects on one or both pilots, in some cases severe, were reported in 40 of the cases. A diversion was made in 31 cases.

In the event of smoke or fumes, there is the possibility that an uncontrolled fire is burning. Although infrequent, some catastrophic events have occurred to large public transport aircraft as a result of fires which were not, or could not be, extinguished. A well-known example was a catastrophic fire which occurred on an MD-11 aircraft, registration HB-IWF, near Halifax, Nova Scotia, in 1998, with the loss of the 229 occupants (Transportation Safety Board of Canada Report No A98H0003). The report notes that in this case the crew had initially assessed that an unusual odour and smoke on the flight deck had originated from the air conditioning system. In fact, there was a fire spreading above the ceiling in the fuselage. Damage from the fire resulted in a loss of control and the aircraft impacted the sea around 20 minutes after the odour was first noticed.

In December 2006 the Flight Operations Group of the United Kingdom's Royal Aeronautical Society and the Guild of Air Pilots and Navigators (GAPAN) published a specialist paper entitled '*Smoke, Fire and Fumes in Transport Aircraft*'. This paper draws extensively on work by the International Air Transport Association (IATA), the US Federal Aviation Administration (FAA), National Transportation Safety Board (NTSB) and Flight Safety Foundation (FSF) and the UK's Civil Aviation Authority (UK CAA). It uses material culled from numerous major accident investigations worldwide, from research organisations and from industry. It makes a large number of recommendations to reduce the risk arising from fires, smoke and fumes.

The report states that:

> *'during the 36 months examined (by IATA), there occurred an average of two and a half smoke events each day.'*

It takes into account the unique nature of an emergency due to fire or smoke, and this special concern is clearly stated in one of the report's appendices:

> *'The stress and workload of responding to these events is exceptionally high and unlike many other types of emergency or abnormal situations, the flight and cabin crews absolutely must communicate and co-ordinate their assessment and response. However, even the most rigorous joint training cannot realistically present crews with the full extent of the demands they will face when dealing with smoke, fire and fumes in flight.'*

The report makes a recommendation as follows:

> *'Increase the number and location of sensors to alert the flight crew of smoke/fumes. These sensors should take advantage of new technology to minimise the false alarm rate.'*

Engine examination

Inspection of G-JECE's No 2 engine by the engine manufacturer found that a one inch long piece of the ICS ring in contact with the stator ring had broken off, due to fatigue cracking. Pieces of the detached portion were found within the LP compressor rotor and a small fragment of material that had probably broken off the ICS was found within the No 2.5 bearing carbon oil seal assembly. The seal had been severely damaged. One of the sealing elements had been chipped and the manufacturer concluded that this had been caused by interference with part of the detached ICS portion. Additionally, the tension spring and metal plates between the carbon elements of the seal were found worn and broken; this was considered to be the result of abnormal vibration due to imbalance caused by the presence of the detached part of the ICS inside the LP compressor rotor. Other damage consisted of extensive fatigue cracking of two of the ICC struts. Substantial quantities of oil were found inside the LP compressor 2nd stage rotor and in the HP compressor bleed path, fully consistent with the effects of the damage to the No 2.5 bearing oil seal.

The No 2 engine (Serial number FA0214) had been constructed in May 2004 and had accumulated 2,103 flight hours and 2,614 flight cycles since new at the time of the incident. It had not undergone overhaul or repair.

A programme to fit an ICS of updated design, intended to prevent fatigue damage similar to that experienced by G-JECE, has been instituted by the engine manufacturer. The change had been incorporated on 91% of the worldwide engine fleet by the end of December 2006, and all of the operator's fleet by July 2006. Incorporation of an improved No 2.5 bearing oil seal commenced in June 2006.

Other remedial actions

For aircraft with unmodified engines, the operator amended the after-start checklist by introducing a check for fumes in order to identify any similar failure of the ICS and consequential damage to the No 2.5 bearing oil seal. Bombardier subsequently adopted this as a Standard Operating Procedure for unmodified engines.

Cabin crew smoke hoods

Checks made during the investigation confirmed that verbal communications while wearing a cabin crew smoke hood were difficult, even when in close proximity to another person. This was due to the combination of a reduction in speech and hearing volume due to the hood and to interference from relatively loud sounds perceived by the hood wearer, caused by rustling of the hood, the sound of the wearer's breathing and the sound of the wearer's voice.

The operator's training regime required cabin crew members to practise donning a smoke hood once a year, and once every three years to practise operating in a smoke-filled environment while wearing a smoke hood.

Discussion

Fuselage smoke

A substantial portion of the No 2 engine ICS had broken off as the result of fatigue cracking. The detached material had caused severe damage to a bearing oil seal, both directly and by virtue of unbalancing the LP compressor rotor, and this allowed engine oil to leak into the gas path through the compressors. The air bled from the HP compressor to supply the No 2 air conditioning pack would then have been contaminated with oil, resulting in the smoke (or oil mist) that had been experienced in the flight deck and cabin (referred to as 'smoke' in this report).

The source of the smoke should have been identifiable had it been possible for the crew to continue the FCOM smoke checklist actions to the point where the No 2 air conditioning pack had been selected off. This would have stopped the bleed air from the No 2 engine and should have resulted in a decrease in the level of smoke in the flight deck and cabin. However, the flight crew judged that landing was the priority, given the rapid rate of increase in the smoke, the lack of information as to its source and the appreciable time that would be required to complete the checklist. It was unclear to the flight crew whether the smoke was emanating from a fire or from the bleed air supplies, and it was uncertain that completing the checklist actions would stop the smoke build-up. Once the decision to land had been made, the workload in arranging a safe descent and diversion to LBA, coupled with communication difficulties, left insufficient time for the checklist actions to be completed.

It appears that in other cases where smoke has been detected in the fuselage there may well have been a similar dichotomy between either completing the specified checklist actions or making a landing as a matter of urgency. Information on previous cases indicated that most had resulted from contamination of the conditioned air supply. The information also suggested that the inability of the crew to establish rapidly the source of the smoke could result in a decision to divert and land urgently, in case of adverse physiological effects and in case there was actually a fire. Catastrophic in-flight fires have historically given crews very little time, perhaps just a few minutes, to land. This aspect was a factor in the case of the loss of HB-IWF near Halifax, Nova Scotia, where the odour and smoke from the fire was initially assessed as having originated with the air conditioning system.

In cases where smoke did in fact result from contamination of the conditioned air supply, due to a problem with an engine, APU or air conditioning system, this could typically only be established in flight by carrying out relatively protracted checklist procedures. Modern aircraft are commonly fitted with smoke detectors in areas such as baggage bays, toilets and/or electronic component cooling air ducts but are generally not provided with means for detecting and warning of smoke in the conditioned air supplied to the fuselage. Such a warning system would provide immediate indications of smoke entering the fuselage as the result of an engine or air conditioning unit problem and also provide rapid verification of the smoke's source. This could reduce the number of cases where an urgent landing was made unnecessarily and minimise possible physiological effects on the crew and passengers. Should a false warning occur, the absence of odour or visible smoke would make it obvious that the warning was false.

In order to enable the flight crew to rapidly identify the source of smoke in conditioned air supplies, to rapidly stop its entry, to avoid unnecessary emergency actions including diversions and to minimise possible adverse physiological effects, the AAIB makes the following two Safety Recommendations:

Safety Recommendation 2007-002

It is recommended that the EASA consider requiring, for all large aeroplanes operating for the purposes of commercial air transport, a system to enable the flight crew to identify rapidly the source of smoke by providing a flight deck warning of smoke or oil mist in the air delivered from each air conditioning unit.

Safety Recommendation 2007-003

It is recommended that the FAA consider requiring, for all large aeroplanes operating for the purposes of commercial air transport, a system to enable the flight crew to identify rapidly the source of smoke by providing a flight deck warning of smoke or oil mist in the air delivered from each air conditioning unit.

Crew communication

The cabin crew experienced a delay in obtaining a response from the flight deck during the descent, due to the high workload the flight crew was experiencing. This delay caused appreciable concern to the cabin crew. Although it was suggested to the investigation that this could have been allayed by a standard procedure for giving a 'standby' signal, such as repeated operation of the seatbelt audio tone, this would be no substitute for direct communication between the flight crew and cabin crew, and might constitute a greater distraction to the flight crew than responding normally. The problem was exacerbated by the locked flight deck door, which also impeded the cabin crew in offering any assistance which might, in other circumstances, have been necessary.

In the UK, the National Aviation Security Programme and the Aviation Security Act (1982) impose legal requirements on operators of large aeroplanes operating for the purposes of commercial air transport. These requirements are, however, consistent with the legal obligations of operators under the Air Navigation Order, which states:

> *'In the case of: ...(b) a door between the flight crew compartment and any adjacent compartment to which passengers have access, the door may be locked or bolted if the commander of the aeroplane or helicopter so determines, for the purpose of preventing access by passengers to the flight crew compartment…' (Rule 72 (3)(b)).*

Flight deck and cabin crews work together to ensure the safety of the operation. Interphone systems, historically, have been provided and used as backups to face-to-face communications. With the advent of the locked flight deck door policy, full reliance for operationally necessary communications is placed on the electronic communications systems, and failure of the interphone system is itself considered to be an in-flight emergency. However, these systems were designed before the advent of present-day security policies and do not provide the necessary reliability for use in this role, particularly in emergencies as the busbars which supply them are not the aircraft's essential busbars. As a result, such essential communications will be lost if there is a loss of the associated electrical busbar supplies as, for example, if the aircraft were to be configured into a typical emergency electrical configuration such as might be expected if the flight crew were dealing with an electrical fire. In a recent AAIB investigation, due to such a power shutdown, a large public transport aircraft was evacuated on the stand without the knowledge or authority of the Commander (AAIB Bulletin 1/2007, Avro RJ 146-100 G-CFAE on 11 Jan 2006). In those situations where the training and resources of the flight and cabin crews are required to minimise injuries or loss of life, the necessary communications may be impeded, and may not be available at all. Therefore the AAIB makes the following Safety Recommendation:

Safety Recommendation 2007-004

It is recommended that for all large aeroplanes operating for the purposes of commercial air transport, the UK CAA and the EASA should take such steps, procedural or technical, as are necessary to improve the reliability and availability of communications between flight and cabin crews, including the reliability of communications equipment and associated power supplies in both normal and emergency configurations.

Smoke hoods

The passengers, seeing the smoke build-up in the cabin and the cabin crew don smoke hoods, enquired about breathing protection for themselves. None was provided, nor did current regulations require any for the passengers. The operator subsequently noted that portable oxygen equipment was available for use should any passengers have experienced breathing difficulties; however the use of oxygen is not permitted unless it can be confirmed that there is no fire in the vicinity.

The cabin crew, although concerned about the delay in flight deck response, prepared the cabin for the emergency landing and evacuation. However, the smoke hoods caused them appreciable difficulties in communicating with passengers and a trial during the investigation confirmed that communication difficulties would be inevitable. While the cabin crew members had undergone training with smoke hoods, it appeared that this had not fully prepared them for the extent of the associated communication difficulties, raising questions about the effectiveness of the training. Therefore the AAIB makes the following Safety Recommendation:

Safety Recommendation 2007-006

It is recommended that the UK CAA and the EASA review the current training requirements for cabin crew members in the use of smoke hoods to mitigate the communication difficulties which may be encountered and to improve the ability of all the crew members to communicate while wearing smoke hoods.

INCIDENT

Aircraft Type and Registration:	Bombardier DHC-8-402, G-JECI
No & Type of Engines:	2 PW150A turboprop engines
Year of Manufacture:	2005
Date & Time (UTC):	9 January 2007 at 0728 hrs
Location:	Manchester Airport
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 4 Passengers - 48
Injuries:	Crew - None Passengers - None
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	44 years
Commander's Flying Experience:	4,678 hours (of which 820 were on type) Last 90 days - 170 hours Last 28 days - 55 hours
Information Source:	Aircraft Accident Report Form and further telephone enquiries

Description of the event

The aircraft landed on Runway 24R at Manchester Airport and vacated the runway onto the rapid exit Taxiway KC, which is 46 m wide. The weather conditions were clear; it was 50 minutes before sunrise, and thus it was dark.

The commander brought the aircraft to a stop at the first junction along the rapid exit taxiway, the intersection with Taxiway K, and awaited taxi instructions. ATC cleared the aircraft to taxi via Taxiway C, to hold at C1. The commander taxied ahead and at the next junction, where he was expecting to turn right onto C, he saw a sign board to his right indicating Taxiway A ahead. There are five paved surfaces which intersect at this junction; they are, in anticlockwise direction from the runway exit: KC, B (23m wide), C (23m wide), KC and B (See Figure 1).

The commander had some knowledge of the airport and knew that Taxiway A was beyond Taxiway C. Confused by the sign board, and believing he had somehow passed Taxiway C, the commander advised the co-pilot that he had missed the taxiway and turned hard right to get back to where he thought it to be. While he was turning ATC issued further taxi instructions, which the co-pilot needed to write down, thus taking his attention away from monitoring the aircraft's position. The commander estimated that in the turn the nose gear had cleared the edge of the paved

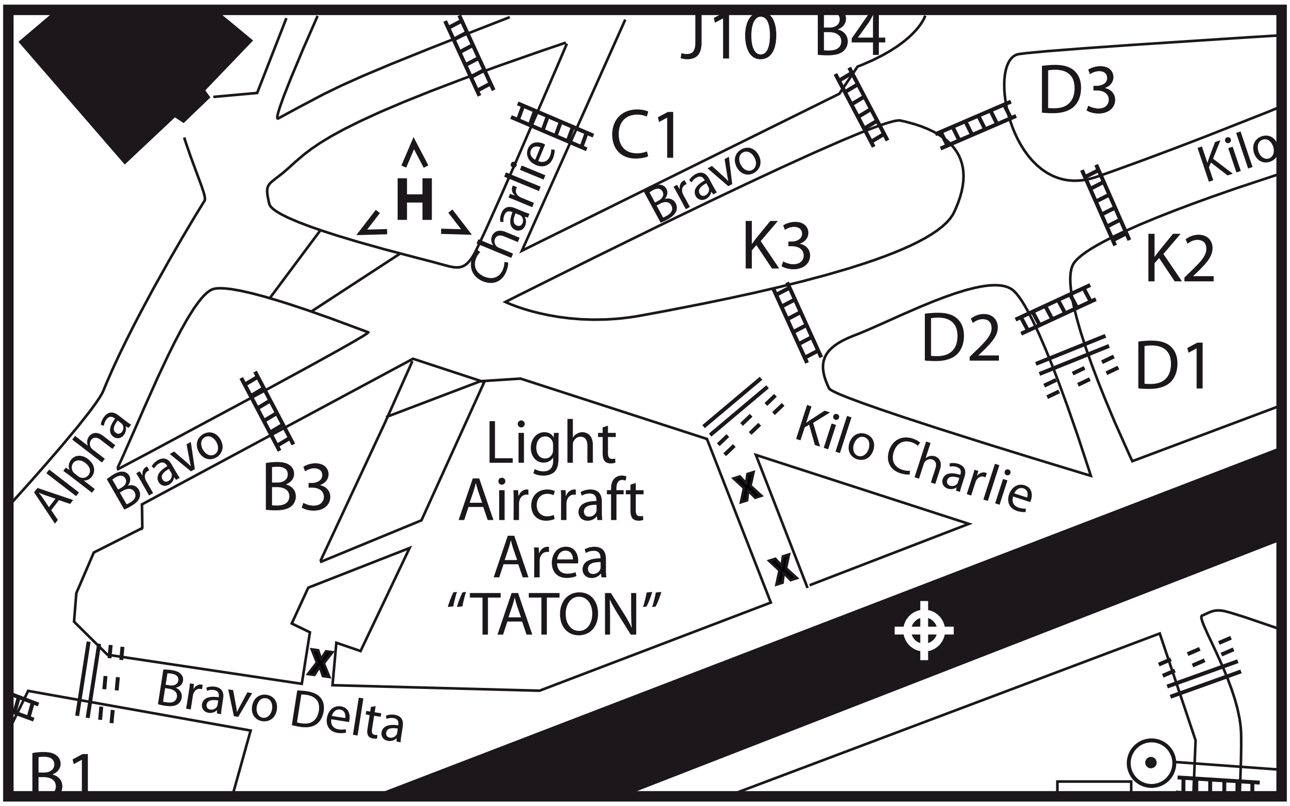


Figure 1

Taxiway intersection KC,C,B

area by about 2 m and, believing that the aircraft was now safely round, he reduced the turning angle.

ATC now advised the crew that the aircraft had taken a wrong turn onto Taxiway B, so the commander brought the aircraft to a stop. ATC then instructed the aircraft to proceed but as the commander applied power he realised that the aircraft was stuck, the left main gear having sunk into the edge of the grass between Taxiway B and Taxiway C.

The intersection of Taxiways KC, C and B is complex and this creates a difficulty for the airport operator in providing clear sign boards. Furthermore the runway exit taxiway, KC, is wider than a normal taxiway. Although the sign boards alongside are located at the recommended distance from the edge of the taxiway, they are further from the taxiway centreline than would be the case for a normal width taxiway. The airport is undertaking a trial of surface markings as a supplement to the existing signs and is also reviewing the positioning of the sign boards.

ACCIDENT

Aircraft Type and Registration:	Denney Kitfox Mk 3, G-BTMX
No & Type of Engines:	1 Rotax 582 piston engine
Year of Manufacture:	1993
Date & Time (UTC):	6 August 2006 at 1445 hrs
Location:	Near Wheaton Ashton, Staffordshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - 1 Passengers - 1
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Private Pilot's Licence
Commander's Age:	54 years
Commander's Flying Experience:	255 hours (of which 70 were on type) Last 90 days - 6 hours Last 28 days - 4 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

A few minutes into a short local flight the engine stopped without prior warning. The pilot selected a field in which to land, however as he flew closer to this field on the downwind leg he became aware of cables crossing the field. He then selected another field, but the aircraft had insufficient height to reach this and landed short in cereal crops some three to four feet high.

Both occupants, who had been wearing full harnesses, were air-lifted to hospital suffering from spinal fractures and other injuries. The engine failure was later attributed to a big-end bearing failure.

History of the flight

The aircraft was a few minutes into a short local flight and was returning to Otherton. Due to the short distance of the intended flight, the pilot decided to cruise at 1,000 ft amgl. During the flight the engine suddenly stopped and the pilot was unaware of any warning of engine failure.

The pilot selected a field and commenced a downwind leg for an approach. His passenger noticed some cables in the selected field and notified the pilot. The pilot was unable to see the cables but was conscious of the aircraft's lack of height, and quickly selected another field slightly further downwind. This field appeared, from pictures taken by the Police Air Support Unit after the accident, to be suitable in both size and surface condition for a forced landing. However, on final approach the aircraft was too low to reach the intended field and landed approximately 80 m short in another large field containing a three to four foot high cereal crop. During the landing the aircraft slewed round 180º and decelerated rapidly.

The pilot crawled out of the aircraft through a door and called the emergency services using a mobile phone. Both occupants, who had been wearing full harnesses, were airlifted to hospital suffering from spinal fractures and other injuries.

Although the aircraft was upright and largely intact, there was damage to the propeller, left wing leading edge, both landing gear legs, the underside of the fuselage, and significant damage to the rear fuselage. As a result the aircraft was written off.

Weather

The pilot reported the wind to be light and variable. The Police Air Support Unit reported the wind near the surface to be from 265º at 6 kt, and from the Police photographs, the aircraft was tracking approximately into wind for the landing. This latter wind direction and speed agrees well with the Met Office's aftercast for the area at that time. The wind does not appear to have been a significant factor in this accident.

Pilot's comments

The pilot had 250 hours experience on all types and had made two successful forced landings on previous occasions. He also routinely practised forced landings during local flights and estimated that he would practise forced landings at least 12 times a year. On this occasion the low cruising height, due to the short distance between departure and arrival airfields, and the presence of cables in the field that was initially selected, both presented a more demanding situation than he encountered during training, and contributed to him being unable to reach the intended field.

The pilot also noted that he never used the flaps on the aircraft since the small reduction in stall speed was offset by reduced aileron effectiveness. Whilst a reduction in flying speed when the aircraft struck the crop might potentially have been obtained had the flaps been deployed prior to touchdown, not using the flaps maximised the aircraft's range in the glide.

Forced landings without power

Typical advice for pilots for choosing a suitable field for a forced landing includes selecting a field that is well within gliding range, free from obstructions (particularly in the undershoot and overshoot areas) and with a suitable surface. Once the engine has stopped the drag will increase and the glide angle is steeper than during a practice forced landing when the propeller is still rotating.

Engine information

The Rotax 582 is a two-cylinder, two-stroke engine. There are two versions, the -90 and the -99 (also known as the blue top). The engine fitted to G-BTMX was the 582-90, and for this engine the crankshaft assembly includes the big-end bearings and connecting rods. The manufacturer recommends that after 300 hours the engine should be overhauled, and this includes the replacement of the complete crankshaft assembly.

The engine was removed from the aircraft and stripped. The big-end bearing on the front cylinder was found to have failed. The engine had completed 325 hours, all with this crankshaft assembly. An inspection had been carried out at 294 hours and this included an inspection of the crankshaft and bearings; however the crankshaft assembly was not replaced.

A discussion with the UK distributor for the engine concluded that a big-end bearing with a similar utilisation and operating hours as this engine could be passed as satisfactory at an inspection and could still fail within about 10 to 15 hours of use.

Discussion

The aircraft suffered an engine failure, something which pilots of single engined aircraft are trained to anticipate, and land successfully from the subsequent forced landing. The pilot selected a field which, at a late stage, turned out to be unsuitable and he was then poorly placed to rectify the situation. As a result he was then unable to reach a suitable field and the field in which the aircraft subsequently landed contained a three to four foot high cereal crop.

Whilst the engine was not maintained in accordance with the manufacturer's recommended schedule, the replacement of the crankshaft assembly after 300 hours is not mandatory. The engine in this, and many similar small aircraft, is not certificated, and in the event of an engine failure a pilot should be able to make an adequate forced landing.

Pilots of single-engined aircraft should be aware of the importance of selecting a suitable field within gliding range given the aircraft's glide performance. They should also be aware that the glide angle will normally be steeper when the engine has stopped. Identification of cables and other obstructions at an early stage is a high priority, as late identification of such hazards can make it impossible to complete a successful forced landing.

ACCIDENT

Aircraft Type and Registration:	Gulfstream American GA-7, G-TANI
No & Type of Engines:	2 Lycoming O-320-D1D piston engines
Year of Manufacture:	1979
Date & Time (UTC):	14 January 2007 at 1600 hrs
Location:	Stapleford Airfield, Essex
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to fin and rudder
Commander's Licence:	Private Pilot's Licence
Commander's Age:	70 years
Commander's Flying Experience:	1,667 hours (of which 1,095 were on type) Last 90 days - 20 hours Last 28 days - 5 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft was on the final approach to Runway 22L at Stapleford aerodrome. Although the pilot's forward vision was impaired when flying towards the setting sun he could see the runway and two aircraft that were ahead of him. When the aircraft was approximately 2 km from the threshold of Runway 22, its fin struck the earth wire suspended between two electricity pylons. Despite damage to the fin and rudder the aircraft landed without further incident.

History of the flight

The pilot had planned to fly to France and back with a friend. He left Elstree that morning and flew to Stapleford aerodrome, where he collected his friend, and then flew to Le Touquet. After lunch, they departed Le Touquet at about 1520 hrs to return to Stapleford where the pilot intended to leave his friend before returning to Elstree. He was familiar with Stapleford, having operated into the aerodrome on many occasions. The weather was good throughout the flight with a light south-westerly wind and CAVOK conditions. Approximately 5 nm from Stapleford the pilot contacted 'Stapleford Radio' and was passed the landing information. He joined overhead the aerodrome for a left-hand circuit, descending from 2,200 ft to a circuit altitude of 1,200 ft on the airfield QNH.

The runway in use at Stapleford was Runway 22L, which is 1,077 metres long, 46 metres wide and has an asphalt surface: the airfield elevation is 185 ft amsl. A line of pylons supporting electricity power cables is located 2 km north-east of the threshold for Runway 22. The pylons are 140 ft high, with the top of the pylons up to 395 ft amsl. A single earth cable is suspended from the tops of the pylons, below which are the main electricity power cables. The distance between the earth cable and the upper power cables is 21 ft. The presence of the power line is promulgated in the UK AIP and the aerodrome flight guide. The map at Figure 1 shows the proximity of the pylon line to Stapleford aerodrome. The distance of the pylons from the runway threshold means that their height falls below that required for any form of illumination.

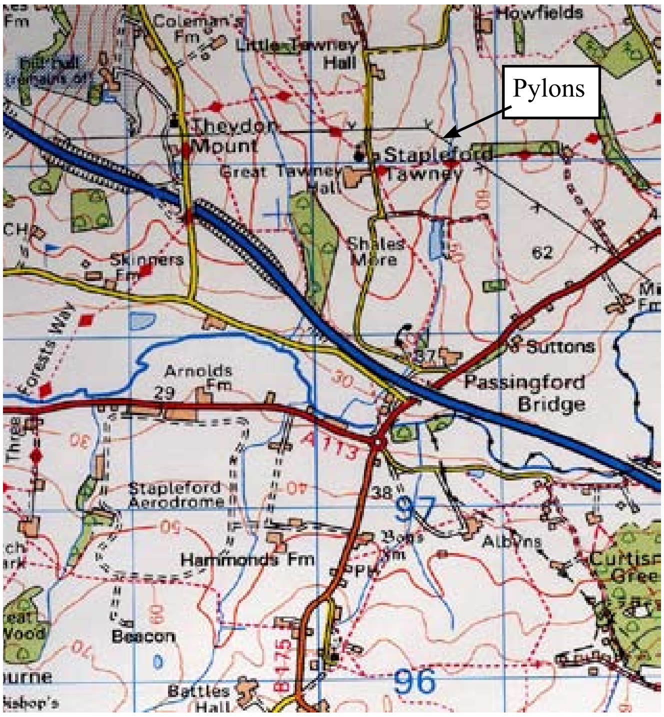


Figure 1

Having turned onto the downind leg, the pilot lowered the landing gear and the first stage of flap adjusting engine power to fly at 100 kt. The pilot was aware of two other aircraft, one on the final approach and another which was approaching Stapleford from the north. In order to ensure adequate separation from these aircraft he extended his downwind leg. At approximately 2 nm he turned onto the base leg keeping the other two aircraft in sight. During the base leg the pilot lowered the second stage of flap and reduced power to descend to 1,000 ft for the turn onto the final approach.

When the aircraft was established on the final approach the pilot selected the third stage of landing flap. He reduced the airspeed to 85 kt and adjusted the power to achieve a normal rate of descent. The runway was visible but the setting sun impaired his forward vision. However, he could see that the first aircraft was about to touch down and he heard the aircraft ahead transmit that he was going around. Almost immediately there was a loud bang, the cause of which was not apparent to the pilot. The aircraft responded normally to the flight controls and the pilot continued his approach, notifying Stapleford Radio of the situation. After landing, the pilot taxied the aircraft clear of the runway but was instructed to stop and shut down by the radio operator who could see the damage at the rear of the aircraft. The Rescue and Fire Fighting Service deployed but both persons on board vacated the aircraft unassisted through the normal exit.

An external inspection of the rear of the aircraft showed extensive damage to the fin and rudder. The aircraft had passed between the earth wire and the electrical power cables suspended between the pylons. The top of the fin had contacted the earth wire.

Previous accident

On 26 December 1994 a Robin 100 was returning to Stapleford from a short navigation exercise. The surface wind was from 220° at 15 kt and Runway 22 was the active runway. The circuit was busy and the pilot of the Robin extended the downwind leg to accommodate other landing traffic. Witnesses on the ground thought that the aircraft was low on the approach but in a constant descent attitude. The aircraft struck the power cables to the north-east of the aerodrome and broke up; all four persons onboard were fatally injured. Other pilots flying at the same time commented on the difficulty in seeing Runway 22 in the bright winter sun.

Analysis

The pilot had used Runway 22 at Stapleford on many occasions previously and was aware of the power line to the north-east. On this flight he had extended the downwind leg to ensure separation from the two aircraft ahead of him. This placed his aircraft further beyond the power line than was normal. However, he then applied his usual speeds, aircraft configuration and power settings, as if he was flying a normal circuit. By adopting this profile and a normal descent rate the aircraft became low on the approach path and struck the earth wire. The combination of the low sun affecting the pilot's forward vision and the need to monitor the other traffic were distractions that consumed much of the pilot's attention. There were clearly similarities between this event and the previous tragic accident.

ACCIDENT

Aircraft Type and Registration:	Murphy Rebel, G-BZFT
No & Type of Engines:	1 O-320-C2A piston engine
Year of Manufacture:	2001
Date & Time (UTC):	5 September 2006 at 1530 hrs
Location:	Branscombe, 10 nm east of Exeter
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to right landing gear attachment point, right wingtip and propeller
Commander's Licence:	Private Pilot's Licence
Commander's Age:	72 years
Commander's Flying Experience:	2,261 hours (of which 180 were on type) Last 90 days - 32 hours Last 28 days - 18 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and AAIB enquiries

Synopsis

After a satisfactory three-point landing, the aircraft completed about half its expected ground roll but then started to turn left. The pilot was unable to correct the turn with full right rudder and full right brake. During the subsequent ground loop the right landing gear leg collapsed and the aircraft came to rest after turning through approximately 120º. No-one was injured in the accident.

It was not possible to determine with confidence the cause of the ground loop. The most likely reason appeared to be a stiff main wheel bearing.

History of the flight

After a satisfactory three-point landing on Runway 27, the aircraft completed about half its expected ground roll but then started a left turn. The pilot was unable to correct the turn with full right rudder and full right brake. During the subsequent ground loop the right landing gear leg collapsed and the aircraft came to rest on the right wing tip after turning through approximately 120º. After turning off the fuel, ignition and electric master switch, the occupants evacuated the aircraft through the left door.

The pilot reported that the wind at the time was calm and that the forecast wind at 2,000 ft was 10 kt at 230º. The pilot also reported that the Centre of Gravity (CG) was

14.5 inches aft of datum, well within the limits of 10.85 to 18.10 inches aft of datum.

Aircraft information

The Murphy Rebel is a two-seat, high-wing, home-build aircraft which has a tail-wheeled landing gear, a steerable tail-wheel, and differential hydraulic brakes. The aircraft has good short field performance with a typical final approach speed of 55 mph.

Ground looping

Ground looping is a phenomenon that tail-wheeled aircraft can be subject to since the aircraft's centre of gravity is behind the main wheels. They are more likely to be affected when the aircraft decelerates after landing and the stabilising effect of the vertical tail reduces as the air flow slows. Any tendency to yaw (from aerodynamic or wheel forces) needs to be corrected by some combination of rudder, tail-wheel steering, and asymmetric braking. Ground looping can also be initiated by any failure in the operation of the brakes or wheels which causes an abnormal yaw force.

Pilot's comments

The pilot had 2,261 hours flying experience of which over 2,000 hours were on tail-wheeled aircraft, and over 180 were on type. He initially thought that a large bump in the ground might have caused the onset of the ground loop.

The aircraft had suffered ground loops on three occasions before this accident. The cause of the first event was attributed to a mishandled attempt at a main-wheels only landing; a different pilot was flying the aircraft on that occasion. The second event occurred after the aircraft was firmly into the landing roll after a three-point landing, and was possibly cross-wind related since significant local thermal activity was reported. The third event occurred at low speed near the end of a normal landing roll, and resulted in no damage to the aircraft. After this event the pilot consulted the manufacturer and tried to set the main wheels as close to zero toe-in/toe-out as possible, but this did not prevent the subsequent occurrence.

During the repair of the aircraft two possible causes of this accident were found. Firstly, one of the wheel bearings was found to be stiff when the retaining nut was tightened in accordance with the manufacturer's recommended torque. It was not possible to determine whether this bearing was on the left or right wheel at the time of the accident.

Secondly, there was some damage around the fuselage skin where the steerable tail-wheel unit is mounted to the rear fuselage. The pilot considers that this damage could have been present before the accident and might have contributed to one or more of the ground loops.

As a result of his investigation, the owner has decided to replace the stiff wheel bearing, as well as both the left and right brakes. He is also replacing the tail-wheel unit with one of an alternative design as well as repairing and reinforcing the rear fuselage where the tail-wheel is attached.

Analysis

The pilot has considerable experience with tail-wheeled aircraft and it seems unlikely that the ground loop was pilot induced. Also, neither a rearwards CG nor a high cross-wind component appears to be a factor in this accident. Therefore the most likely cause of the ground loop would appear to be a stiff main wheel bearing.

ACCIDENT

Aircraft Type and Registration:	Piper PA-15, G-ALGA
No & Type of Engines:	1 Lycoming O-145-B2 piston engine
Year of Manufacture:	1949
Date & Time (UTC):	22 July 2006 at 1345 hrs
Location:	Marshland, Suffolk, (Farm Strip, East of Fenland)
Type of Flight:	Training
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to left landing gear and propeller
Commander's Licence:	Private Pilot's Licence
Commander's Age:	69 years
Commander's Flying Experience:	760 hours (of which 30 were on type) Last 90 days - 12 hours Last 28 days - 10 hours
Information Source	Aircraft Accident Report Form submitted by the pilot

Synopsis

Following a normal landing, with a slight crosswind from the left, the left main landing gear failed at the shock strut end fitting. The aircraft came to a stop resting on the right main landing gear, the tail wheel and the left wing tip. Engineering investigation revealed that the incident was the result of progressive deformation of the end fitting bolt hole, which resulted in it failing in tensile overload.

History of the flight

The pilot reported that he made a normal approach onto Runway 03, which has a grass surface and is 850 m long. The weather was benign, with good visibility and a slightly gusty north-westerly wind at about 5 kt. Having considered the wind, the pilot flew the approach with the left wing slightly low, and touched down slightly left of the runway centreline. The pilot heard a *"crack"* as the left main landing gear and tail wheel touched down, and the left main landing gear immediately folded outwards. The propeller tips then contacted the ground and detached and the left wing tip then struck the ground. The aircraft slid along the ground for a short distance, coming to rest on the left wing tip, right main landing gear, and tail wheel. The pilot switched off the ignition and fuel and exited the aircraft without difficulty. There was no fire.

Engineering examination

Examination of the aircraft revealed that the collapse of the left landing gear was caused by the shock strut lower end fitting 'pulling' from the strut. The lower end fitting, see Figure 1, fits into the strut and is secured by a bolt. While the aircraft is on the ground the fitting is under a tensile load. The hole for the securing bolt had become elongated in the direction of the load before failing in overload. A review of the aircraft log book failed to identify when this component was fitted, but its general condition indicated that it had been installed for a considerable time. The damage to the bolt hole could not have been seen with the fitting attached to the strut and there is no requirement to remove the fitting from the shock strut for inspection.

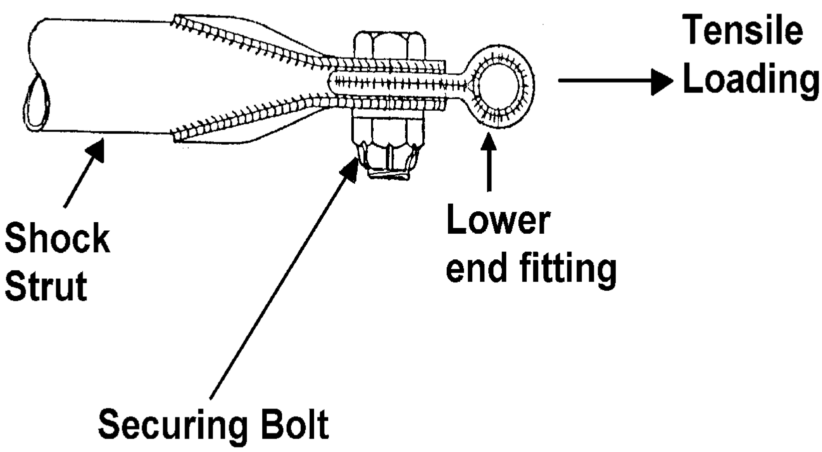


Figure 1

INCIDENT

Aircraft Type and Registration:	Piper PA-28-180 Cherokee, G-AYEE
No & Type of Engines:	1 Lycoming O-360-A4A piston engine
Year of Manufacture:	1970
Date & Time (UTC):	28 November 2006 at 1915 hrs
Location:	Oxford Airport
Type of Flight:	Training
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - None
Nature of Damage:	Impact damage to nosewheel oleo, engine mount and right wing leading edge and additional damage to the fuselage due to electrical arcing, plus impact damage to three electrical power cables
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	31 years
Commander's Flying Experience:	2,100 hours (of which 1,640 were on type) Last 90 days - 195 hours Last 28 days - 53 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

A private pilot and an instructor were conducting a night circuit training exercise. During a practice flapless approach, with the trainee acting as handling pilot, the aircraft descended below the correct approach path. It struck a set of power lines about 50 ft agl situated about 0.5 nm from the runway. The instructor took control, went around and subsequently carried out a successful landing at the airfield.

History of the flight

The qualified private pilot was undertaking training to obtain a night rating and was familiar with the airfield. Early in the evening the instructor briefed the private pilot (the trainee) for the intended night circuit exercise before flying with a different student for an hour. After a short break the instructor then took off again at 1820 hrs with the trainee for the exercise. Runway 19 was in use and the trainee was acting as handling pilot.

The trainee flew five normal circuits during which various emergency scenarios were discussed. The trainee then flew two flapless circuits. This training was accomplished without incident and the instructor stated that he was confident in the trainee's abilities.

The trainee then commenced a further circuit with the intention of carrying out another flapless approach. An aircraft ahead in the circuit caused the trainee to extend the downwind leg before turning onto base leg and commencing the approach. The instructor stated that when the aircraft was approximately 400 metres from the threshold, he became aware of some power cables ahead which the aircraft then struck in the area of the nosewheel. The instructor immediately took control of the aircraft and commenced a go-around whilst declaring a "MAYDAY" to ATC. After conducting a handling check overhead the airfield to check for normal control response and handling qualities, the instructor flew a circuit and low go-around to allow the AFRS an attempt at visually inspecting the aircraft using spotlights. They could not see any damage and the instructor rejoined the circuit. He then briefed the trainee for an emergency landing before commencing a final approach to the runway. The aircraft touched down normally and the instructor was able to taxi it clear of the runway without assistance before shutting down the aircraft.

A subsequent inspection revealed the aircraft's nose landing gear had struck power wires causing minor impact damage to the oleo, the engine mount and the leading edge of the starboard wing. There was also visible damage on various points of the fuselage caused by electrical arcing.

Runway description

Runway 19 has threshold and runway lighting but no approach lighting. It is equipped with Precision Approach Path Indicators (PAPI) set for an approach angle of 3.1º and the threshold crossing height is 50 ft. A set of electrical power lines, approximately 50 ft high, run perpendicular to the approach path about 0.5 nm from the runway threshold.

Analysis

In order to hit the power lines the aircraft must have been considerably below the correct approach path. The trainee had extended the downwind leg and had, as a result, turned onto finals further from the runway than during his previous flapless circuits. He could, therefore, have either adjusted the point at which he started his descent or altered his initial descent rate to ensure that he did not become low on the approach. It appears likely that the trainee did not compensate adequately for the extended circuit when making his final approach and neither he nor his instructor realised just how low the aircraft had become during the approach.

The increased pitch attitude of the flapless approach may have masked the pilots' view of the threshold and runway lights; it may also have changed the apparent runway aspect. The previous flapless approach was carried out with the PAPI lights off but they had been switched on for the incident approach. The PAPI lights would have enabled both pilots to judge accurately their glidepath all the way down finals until the landing flare.

Because this was the trainee's first night circuit training exercise, the instructor would normally have been particularly alert to the aircraft's three-dimensional position. However, at the time of the accident, he and the trainee had completed nearly an hour of continuous circuits and the instructor had also flown circuits continuously for about an hour during his previous flight. He stated that he had confidence in the trainee's abilities and so it is possible that he was not monitoring the aircraft's position as diligently as he otherwise would.

The situation might have been averted had the instructor introduced more variety into the training flight by having the trainee leave and re-join the circuit occasionally.

ACCIDENT

Aircraft Type and Registration:	Piper PA-28R-200, G-TORC
No & Type of Engines:	1 Lycoming IO-360-C1C piston engine
Year of Manufacture:	1974
Date & Time (UTC):	17 February 2007 at 1315 hrs
Location:	Sandown Airfield, Isle of Wight
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 3
Injuries:	Crew - None Passengers - None
Nature of Damage:	Nose wheel collapsed, propeller damaged, and engine shock loaded
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	60 years
Commander's Flying Experience:	238 hours (of which 64 were on type) Last 90 days - 11 hours Last 28 days - 6 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot, and MOR report submitted by the airfield operator

Synopsis

After touching down on a soft area of the runway, the aircraft veered to the left and ground looped through 90º. In doing so, the nose landing gear collapsed.

History of the flight

Upon arrival at Sandown after a cross-country flight from Old Sarum, the pilot of G-TORC was asked to land on the left side of Runway 05 due to part of the surface being soft.

During the aircraft's approach, the Air/Ground radio operator at the airfield reported that it appeared a little high and thought that it might be overshooting since a a microlight aircraft which had landed ahead was just clearing the runway. However, G-TORC touched down about 250 m beyond the 05 threshold and then started to veer to the left. Despite the pilot's application of right rudder, the aircraft entered some rough ground on the left side of the runway. Here it ground looped through 90º to the left, before coming to rest just off the side of the runway, with its nose landing gear collapsed. After making the aircraft safe, all four occupants, none of whom was hurt, vacated the aircraft.

The pilot attributed the loss of directional control to the aircraft encountering a combination of soft ground and a deep rut during the landing roll.

ACCIDENT

Aircraft Type and Registration:	Pitts S-1S, G-BOXH
No & Type of Engines:	1 Lycoming O-360-A4A piston engine
Year of Manufacture:	1974
Date & Time (UTC):	10 December 2006 at 1120 hrs
Location:	Near to Drayton level crossing, southeast of Goodwood
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Severe damage to lower right wing and landing gear, engine, propeller, fin and rudder
Commander's Licence:	Private Pilot's Licence
Commander's Age:	31 years
Commander's Flying Experience:	215.25 hours (of which 8.83 were on type) Last 90 days - 7.92 hours Last 28 days - 0.75 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot, and follow-up telephone inquiries to pilot

Synopsis

The pilot carried out a forced landing in the correct attitude and at the correct speed into a ploughed field, following a loss of power thought to have been caused by carburettor icing. Nevertheless, the aircraft flipped over and came to rest inverted. There was no fire. The pilot was uninjured but could not escape from the cockpit. The crew of a Robinson R22 helicopter was in the area and became aware of the accident. They promptly landed close to the aircraft and were able to lift the tail of G-BOXH high enough for the pilot to crawl clear.

History of the flight

Having departed Goodwood for a familiarisation flight in the local area, and having successfully flown a series of basic aerobatic manoeuvres that included loops and rolls, the pilot carried out two spins. On completion of the second of these, the engine started coughing so she selected carburettor heat. Subsequently, with cold air restored, the engine ran normally.

As a precaution, the flight was abandoned with the intention of returning to Goodwood. En-route, at an altitude of about 2,500ft, the engine started misfiring again and carburettor heat was re-applied. This time, the misfire continued and the pilot advised Goodwood that she was returning with engine trouble. The engine then recovered and returned to full power, but subsequently started to misfire again and stopped as the aircraft was passing approximately 1,000 ft. Having decided against further attempts to restore power, a forced landing was executed into a ploughed field and, although the aircraft touched down in the proper attitude and at the correct airspeed, it nosed over and came to rest inverted.

The cockpit space was not significantly compromised during the accident and the pilot was uninjured. However, the side of the cockpit was so close to the ground that she was unable to extricate herself. Very shortly afterwards, the pilots of an R44 helicopter routing through the area, landed to render assistance and, by lifting the aircraft's tail, they were able to increase the ground clearance sufficiently for her to crawl clear.

The pilot of G-BOXH expressed the opinion that the engine failure was most probably caused by carburettor icing. Data from the Met Office indicated that the air temperature and dew point in the Goodwood area at the relevant time were +9.5ºC and +5ºC respectively, conditions which are conducive to serious carburettor icing at any power setting. After the event, the pilot was unable to recall how long she had left the carburettor heat in the HOT position, or whether it had been in the HOT or COLD position at the time when the engine stopped.

The extent of carburettor icing can be difficult to assess in flight. Under conditions of severe icing, it is possible for the application of carburettor heat to restore smooth running before all of the accumulated ice in the carburettor has fully dissipated. If the carburettor heat control is prematurely returned to the COLD position, it is possible for a new amalgam of ice to build up rapidly, which could result, ultimately, in engine stoppage. CAA Safety Sense Leaflet 14b, accessible via the UK CAA website (http://www.caa.co.uk/docs/33/SRG_GAD_WEBSSL14/PDF) provides general information on the subject of carburettor and induction icing, and practical advice on dealing with this problem.

ACCIDENT

Aircraft Type and Registration:	Raytheon Beech Bonanza A36, N4VQ
No & Type of Engines:	1 Continental IO 550 piston engine
Year of Manufacture:	1996
Date & Time (UTC):	30 October 2006 at 0850 hrs
Location:	Fenland Airfield, Lincolnshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 3
Injuries:	Crew - 1 (Minor) Passengers - None
Nature of Damage:	Impact damage to the engine, firewall, propeller, wings, undercarriage and underside of fuselage
Commander's Licence:	Private Pilot's Licence
Commander's Age:	45 years
Commander's Flying Experience:	1,527 hours (of which 20 were on type) Last 90 days - 79 hours Last 28 days - 21 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft became airborne too early in the takeoff roll and, at a height of about 15 to 20 ft, it began to roll to the left, reaching an angle of about 45º. The pilot shut down the power, levelled the wings and deployed full flap. He subsequently landed the aircraft, with the wings almost level, in a field beyond the runway before the aircraft came to an abrupt halt against a dyke. All four occupants disembarked safely although the pilot sustained a minor injury.

History of the flight

The aircraft, which was a recent purchase, was taking off from the grass Runway 18 with the pilot and three passengers on board. The pilot held the nosewheel off to prevent it digging in and slowing the aircraft down. About halfway down the runway the aircraft became airborne, and this was earlier than the pilot expected. It touched down briefly before become airborne again. It then reached a height of about 15 to 20 ft and began to roll to the left, reaching an angle of about 45º. The pilot was concerned about the proximity of the ground and he elected to shut down the power, level the wings and deploy full flap. He subsequently landed the aircraft, with the wings almost level, in a field beyond the runway before coming to an abrupt halt against a dyke. All four occupants disembarked safely, although the pilot sustained a minor injury.

The pilot attributed the accident to the aircraft becoming airborne too early as result of holding off the nosewheel for too long, and as a consequence the left wing stalled.

Airfield information

Fenland Airfield is a grass airfield at an elevation of 18 ft amsl and Runway 18 is 512 m long. The Take Off Distance Available (TODA) for Runway 18 is 594 m. South of Runway 18 is a field and this is bounded on its south by a dyke running perpendicular to the runway.

Fenland Airfield has another grass runway, Runway 08/26, and this is 670 m long.

Weather conditions

The pilot reported that the condition of Runway 18 was soft and that the wind was from 220° at 15 kt. A Met Office aftercast estimated the wind to be '*220° at 15 kts, with perhaps gusts to 22- 25 kts*'.

Aircraft performance

The aircraft takeoff roll and distance to 50 ft were calculated using the Pilot's Operating Handbook. These calculations are based on a takeoff mass of 3,600lbs at sea level on a paved runway, with no flaps, and with the local weather conditions being 12ºC and with a 12 kt headwind component (as reported by the pilot).

The CAA's Aeronautical Information Circular (AIC) 67/2002 specifies that *25% or more* be added to these distances for soft ground or snow. For information, 20% is specified for dry grass on firm soil and 30% is specified for wet grass on firm soil. These factors are the same as those specified in LASORS guide for pilots. AIC 67/2002 also strongly recommends that an additional 33% factor is added to the takeoff distance, in keeping with Public Transport operations.

The unfactored distances were achieved by the manufacturer as a result of flight tests using a new aircraft in ideal conditions. The factored distances provide an additional 33% margin of safety to take account of different meteorological conditions or flying techniques from those used during flight testing. The takeoff roll and distance to 50 ft are contained in the table in Figure 1.

Aircraft handling characteristics

The aircraft manufacturer was consulted regarding handling characteristics. They confirmed that the aircraft will yaw to the left and then roll to the left after the aircraft leaves the ground if insufficient right rudder is used to compensate for the propeller slipstream effect. They also noted that the situation can initially be compounded if right aileron, and not right rudder, is used to counteract the turn to the left; this is due to adverse aileron yaw.

	Unfactored distance specified in Pilot's Operating Handbook	1.25 factor for soft ground	With recommended Public Transport factor of 1.33
Takeoff roll m	335	419	557
Distance to 69 ft m	579	724	963

Figure 1

Analysis

This aircraft, when operated in the reported conditions, is expected to lift off after 419 m and to be at 50 ft after 724 m. Therefore on Runway 18 at Fenland, the aircraft would be expected to be at around 30 ft at the end of the available takeoff distance. Note that these figures assume a factor of 1.25 for soft ground, and that the CAA recommends 1.25 or more.

Whilst the aircraft was capable of taking off from Runway 18 at Fenland, the margins were small and the aircraft would be well down the runway at lift off, and low as it passed the end of the runway. The aircraft lifted off too early and, as a result, was at too low an airspeed and possibly at too high an angle of attack. In such a situation it would not accelerate normally and, close to the stall, a wing drop, as described by the pilot, could readily occur. The pilot had only 20 hours on type, and this may also have been a factor.

The wind was from 220°. Therefore a better option would probably have been to use Runway 26 which was 670 m long.

ACCIDENT

Aircraft Type and Registration:	Thruster T600N 450, G-ORUG
No & Type of Engines:	1 Jabiru 2200A piston engine
Year of Manufacture:	2003
Date & Time (UTC):	26 November 2006 at 1600 hrs
Location:	Near Haile Fort, Humberside
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Left wing structural damage, left wing lift-strut bent, propeller and cockpit nacelle broken
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	61 years
Commander's Flying Experience:	110 hours (of which 100 were on type) Last 90 days - 20 hours Last 28 days - 6 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The pilot was practising cross-wind approaches on a beach, however he misjudged his height and landed unintentionally. During the attempted takeoff, the aircraft started to turn and the takeoff was abandoned, causing the nosewheel to dig into the sand and the aircraft flipped over and came to rest inverted.

History of the flight

The pilot returned to North Coates airfield after a 45 minute local flight. On reaching the overhead at 1,500 ft agl, he changed his mind and decided to practise cross-wind approaches along the coast instead. On reaching the sands just south of Haile Fort, he lined up on a southerly heading, parallel to the sea, and made a glide approach towards the beach. The pilot states that his intention was to descend to about 50 feet before applying power and climbing away.

However, as he reached the point where he was about to round out, he was taken aback when the aircraft landed quite smoothly on the sand. After overcoming his initial surprise (he thought he had been at 50 feet), the aircraft rolled about 50 feet before he applied full power to attempt to take off. He then became aware that the aircraft was yawing to the left and, as it reached a point where it was heading for the sea, he throttled back to abort the takeoff. As he did so, the nosewheel dug into the soft sand and the aircraft flipped onto its back; The pilot was unhurt and evacuated the aircraft without assistance.

Later, the aircraft was righted and pulled to safety with help from the Coastguard. The pilot freely admits that he failed to judge his height correctly, possibly exacerbated by fading light, and that he used poor technique for what then effectively became a 'soft field' takeoff.

ACCIDENT

Aircraft Type and Registration:	Yak-52, G-YAKI
No & Type of Engines:	1 Ivchenko Vedeneyev M-14P piston engine
Year of Manufacture:	1986
Date & Time (UTC):	7 September 2006 at 1800 hrs
Location:	Popham Airfield, Hampshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passenger - 1
Injuries:	Crew - None Passenger - None
Nature of Damage:	Broken propeller; minor damage to flaps; two small dents to right wing leading edge
Commander's Licence:	Private Pilot's Licence
Commander's Age:	44 years
Commander's Flying Experience:	113 hours (of which 12 were on type) Last 90 days - 1 hour Last 28 days - 1 hour
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

Following an uneventful local flight, the aircraft landed with its landing gear retracted.

History of the flight

On returning to Popham airfield after an uneventful 20 minute local flight, the aircraft joined the cross-wind leg for a right-hand circuit on Runway 03. The pilot reports that, at this point, he attempted to lower the landing gear but the lever would not move beyond the MID or OFF selection and the landing gear would not lower. After several orbits, during which he made several further unsuccessful attempts, he made a pass over the airfield followed by a steep pull-up. As this had no effect, the pilot reports that late on the downwind leg he operated the emergency lowering system and that he heard the hissing of air but the landing gear stayed retracted.

The pilot states that, as his passenger was now feeling sick, he decided to land with the gear retracted but with the engine rotating and flaps extended. Although it was part of the design intention that the Yak-52 would be able to land with the landing gear retracted with minimal damage, it is inevitable that, if the propeller is still rotating, then damage to this (and the engine) will occur and, if the flaps are extended, they too will incur damage. The aircraft rolled to a halt with the expected damage, plus some minor dents in the leading edge of the right wing consistent with the wheels-up landing. The pilot and passenger evacuated normally without injury.

After fitment of a replacement engine and propeller and some temporary airframe repairs, the aircraft was ferried to its maintenance organisation at White Waltham, who are specialists in Yak aircraft. There, extensive testing of the landing gear system did not replicate the symptoms reported by the pilot and no faults were found.

ACCIDENT

Aircraft Type and Registration:	Enstrom 280FX, G-VVWW
No & Type of Engines:	1 Lycoming HIO-360-F1AD piston engine
Year of Manufacture:	1990
Date & Time (UTC):	20 July 2006 at 1815 hrs
Location:	1.5 to 2 miles north of Epsom Racecourse, Surrey
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Tail rotor blades bent and tail rotor transmission system shock loaded
Commander's Licence:	Private Pilot's Licence
Commander's Age:	41 years
Commander's Flying Experience:	137 hours (of which 137 were on type) Last 90 days - 27 hours Last 28 days - 11 hours
Information Source:	AAIB Field Investigation

Synopsis

A few minutes after leaning the fuel mixture the pilot felt a significant engine vibration, shortly after which the low rotor rpm warning horn sounded and the warning light illuminated. The pilot lowered the collective lever and opened the throttle which briefly restored the rotor rpm. The engine rpm continued to decrease and the pilot realised that the helicopter could not maintain level flight and decided to enter an autorotation to land. During the landing flare the tail rotor contacted the ground. Following repair a number of test flights were conducted where full engine power was achieved. It was found that there was an unusual engine-generated vibration which, on examination, was found to have been caused by a partially restricted fuel injector nozzle.

History of the flight

After departure the pilot climbed the helicopter to 1,300 ft amsl where he leaned the fuel mixture until the exhaust gas temperature (EGT) gauge indicated 1,600ºF. The manifold pressure was noted as reading 29 inches, the engine rpm was in the green sector of the gauge and the fuel flow decreased to 80 lb/hr. After a few minutes the pilot felt a significant engine vibration, shortly after which the 'LOW ROTOR RPM' warning horn sounded and the warning light illuminated. The pilot lowered the collective lever and increased the engine power which restored the rotor rpm for a brief period of time. As the engine rpm continued to decrease he became aware that continued level flight would not be possible and transmitted an RTF 'MAYDAY' call. The pilot lowered the collective lever and commenced autorotation. He selected a suitable landing site and, while keeping the rotor speed 'in the green', reduced the helicopter's airspeed. The pilot cushioned the touchdown by use of the collective lever but did not level the helicopter in time to prevent the tail rotor from striking the ground. The pilot cannot recall if he moved the fuel mixture control towards the rich position following the initial indication of a possible engine power problem or when he entered the autorotation.

The weather at the time was reported as a wind of 8 kt from 240º, scattered cloud at 3,000 ft, temperature 29ºC and QNH 1026 mb.

Engineering examination

A licensed aircraft engineer, who maintains this particular helicopter and is extremely familiar with the type, went to the accident site and recovered it to his maintenance facility where he and the AAIB carried out an extensive examination. During the examination, which included testing and a partial strip of the fuel injector unit, no fault or failure of the engine or engine systems could be found that would explain the circumstances experienced by the pilot. It was observed that the spark plugs and the engine exhaust, and its surrounding area of the engine cowling, showed very good evidence that the engine had been running on a very lean fuel mixture for a period of time.

Following the repair of the damage to the tail rotor, a number of engine runs and test flights were conducted. During the first two test flights, when full engine power was achieved, it was noted that there was an unusual engine-generated vibration and that the No 4 cylinder temperatures were marginally lower than those of the other three cylinders. The No 4 cylinder fuel injector nozzle was removed and found to be partially restricted by what appeared to be a light sandy-coloured hard deposit similar to that observed on the spark plugs and engine exhaust when the helicopter was first examined following the accident. This partial restriction of the injector nozzle would have reduced the maximum fuel flow that could be delivered and would have severely disrupted the fuel spray pattern. The injector nozzle was cleaned and refitted to the engine. A further test flight was carried out during which the engine performed satisfactorily and without any unusual vibrations.

ACCIDENT

Aircraft Type and Registration:	Robinson R22 BETA, G-JWFT
No & Type of Engines:	1 Lycoming O-320-B2C piston engine
Year of Manufacture:	1989
Date & Time (UTC):	16 November 2006 at 1020 hrs
Location:	Carluke, South Lanarkshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to the tail rotor and the tail boom
Commander's Licence:	Private Pilot's Licence
Commander's Age:	54 years
Commander's Flying Experience:	198 hours (of which 90 were on type) Last 90 days - 12 hours Last 28 days - 2 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The pilot had been on a short local flight and was returning to land at a private landing site. The weather conditions were good with a light westerly wind of 1 to 2 kt. The pilot made a successful approach and hover taxied to land on a raised deck area but as he completed the landing the tail rotor struck a wooden trestle at the edge of the deck. The tail rotor was damaged and the helicopter spun around several times above an area of sloping ground to the south-west. The pilot tried to avoid touching down on the slope but, as he attempted to manoeuvre the helicopter away, it struck a wooden post. He then landed the helicopter alongside the wooden deck area. The helicopter remained upright and he was able to vacate through his side door.

The pilot considered that he should have given closer attention to the surrounding area prior to the landing.

ACCIDENT

Aircraft Type and Registration:	Pegasus Quantum 15, G-MZLH
No & Type of Engines:	1 Rotax 582-40 piston engine
Year of Manufacture:	1998
Date & Time (UTC):	3 November 2006 at 1115 hrs
Location:	Blakeney, Forest of Dean, Gloucestershire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - 1 (Serious) Passengers - 1 (Serious)
Nature of Damage:	Damage to right hand wing, fuselage and landing gear
Commander's Licence:	Private Pilot's Licence
Commander's Age:	51 years
Commander's Flying Experience:	199 hours (of which 74 were on type) Last 90 days - 4 hours Last 28 days - 1 hour
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

A forced landing was executed when the aircraft's engine stopped following the loss of a propeller blade. On touch-down, the aircraft's right landing gear dug into the field's soft furrowed surface and caused the aircraft to ground loop and stop abruptly.

History of the flight

On the morning of the accident the pilot had flown two passenger flights without incident. There was a light north-westerly wind with no cloud and excellent visibility. Before commencing the third flight, the passenger was dressed in a flying suit and gloves and fitted with a helmet worn over a headset and microphone. The pilot maintained three helmets of different sizes for passengers to choose from and both the passenger and the pilot confirmed that the chosen helmet was secure with the chinstrap secured prior to departure. Approximately 35 minutes after takeoff, whilst in the cruise at 1,100 ft amsl, the pilot made a left hand turn through 90º to avoid overflying a village. Immediately after rolling out of the turn, the aircraft vibrated violently and the engine stopped. The passenger reported to the pilot that her helmet had come off and the pilot concluded that it had struck the propeller causing the engine to stop. After attempting to restart the engine without success, the pilot executed a forced landing into a grass field, landing into wind. On touch-down the aircraft's right landing gear dug into the soft ground causing the aircraft to pivot to the right about this wheel. The aircraft came to a rapid stop as the nose wheel and right wing hit the ground. The pilot, who was wearing a lap and diagonal harness, and the passenger, who was wearing a full harness, were able to exit the aircraft over the right hand side. They received first aid before an air ambulance arrived and took them to hospital.

Accident site inspection

The passenger's helmet was recovered and it was found that one of the chinstrap securing pins was missing. It was not possible to confirm whether the missing pin caused the helmet to separate from the passenger or whether the pin became detached as a result of the subsequent impact with the propeller blade.

One of the three propeller blades was missing from the aircraft and recovered from an adjacent field. There was evidence of an impact mark close to the outboard end of its leading edge and the blade had detached from the hub at its root.

Photographs of the landing field showed that in the area of the aircraft's touchdown, there were a series of deep furrows, probably caused by heavy agricultural machinery, that were running perpendicular to the landing direction.

Conclusion

The investigation was unable to determine the reason why the helmet became detached during the flight, particularly given the care that the pilot undertook to ensure a secure fit. Whatever the reason for the detachment the position of the propeller on many microlights is such that any loose articles in the cockpit area have a significant possibility of striking it should they become free during forward flight.

Having successfully flown a forced landing profile to land into wind, it seems likely that the aircraft's right wheel touched down in one of the furrows preventing further forward motion and leading to the ground loop.

AIRCRAFT ACCIDENT REPORT No 2/2007

This report was published on 16 March 2007 and is available on the AAIB Website www.aaib.gov.uk

REPORT ON THE SERIOUS INCIDENT TO BOEING 777-236, G-YMME ON DEPARTURE FROM LONDON HEATHROW AIRPORT ON 10 JUNE 2004

Registered Owner and Operator:	British Airways PLC
Aircraft Type and Model:	Boeing 777-236
Registration:	G-YMME
Place of Incident	On departure from London Heathrow Airport Latitude: 51º 29' N Longitude: 000º 28' W
Date and Time	10 June 2004 at 1907 hrs All times in this report are UTC unless otherwise stated

Synopsis

The incident was notified to the Air Accidents Investigation Branch (AAIB) on 11 June 2004. The AAIB investigation team comprised:

Mr J J Barnett	(Investigator-in-Charge)
Mr K Conradi	(Operations)
Mr S J Hawkins	(Engineering)
Mr C Pollard	(Engineering)
Mr A Foot	(Flight Recorders)

After takeoff from London Heathrow Airport a vapour trail was seen streaming aft of the aircraft. The flight crew diagnosed that the aircraft was probably leaking fuel from the centre wing fuel tank. They declared an emergency and decided to jettison fuel to reduce to maximum landing weight before returning to Heathrow. Their intention was to minimise heating of the brake units during the landing roll in order to reduce the risk of fire if fuel was to leak onto the wheelbrakes. After landing, the aircraft was met by the Airfield Fire and Rescue Service who reported some vapour emanating from the left landing gear but no apparent fuel leaks.

The fuel leak was caused by fuel escaping through an open purge door inside the left main landing gear bay, on the rear spar of the centre wing tank. The purge door had been removed during base maintenance at the operator's maintenence organisation in Cardiff, between 2 May and 10 May 2004, and had not been refitted prior to the aircraft's return to service.

The investigation identified the following causal factors:

1. The centre wing tank was closed without ensuring that the purge door was in place.

2. When the purge door was removed, defect job cards should have been raised for removal and refitting of the door, but no such cards were raised.

3. The centre wing tank leak check did not reveal the open purge door because:

   a. The purge door was not mentioned within the Aircraft Maintenance Manual (AMM) procedures for purging and leak-checking the centre wing fuel tank.

   b. With no record of the purge door removal, the visual inspection for leaks did not include the purge door.

   c. The fuel quantity required to leak check the purge door was incorrectly stated in the AMM.

4. Awareness of the existence of a purge door on the Boeing 777 was low among the production staff working on G-YMME, due in part to an absence of cross references within the AMM.

Following the incident, significant safety action was taken by both the maintenance organisation and the aircraft manufacturer to address issues discovered during the investigation. The AAIB made five safety recommendations.

Findings

1. The fuel leak was caused by fuel escaping from the centre wing tank through the open purge door.

2. The flight crew correctly diagnosed and handled the fuel leak incident.

3. The aircraft manufacturer determined that the fuel leakage resulted in the potential for a wheel well fire.

4. In this incident there was little risk of an in-flight fire because there were no ignition sources in the vicinity of the fuel leak.

5. By jettisoning fuel to land at maximum landing weight, the flight crew were able to reduce the brake energy required and thus reduce the risk of fire immediately after landing.

6. The purge door was removed from G-YMME during base maintenance, between 2 May and 10 May 2004, and not re-installed prior to departure.

7. The open purge door was not detected between the aircraft's return to service and the incident flight on 10 June 2004 because the open door was not visible from the ground with the left inboard main gear door closed and the aircraft's fuel loads had been insufficient to create a leak.

8. Contrary to the maintenance organisation's procedures, the removal of the purge door was not recorded on a defect job card.

9. No person came forward stating that they were involved with the purge door removal.

10. A potential opportunity to detect the open purge door was lost when the rear spar inspection was carried out in the wrong location because of an error in a diagram in the Aircraft Maintenance Manual (AMM).

11. The maintenance organisation was aware of the error in the AMM diagram and had notified the

aircraft manufacturer, but no action was taken to communicate this fact to production staff.

12. The Licensed Aircraft Engineer (LAE) and Technician who closed the centre wing tank access panels did not check that the purge door was in place because they were not aware that the purge door existed and because there was no paperwork recording its removal.

13. The absence of cross references in the AMM between the fuel tank purging procedure and the purge door removal procedure, and between the fuel tank leak detection procedure and the purge door leak check procedure, contributed to the lack of awareness of the purge door's existence.

14. The fuel quantity stated in the AMM as being required to leak-check the purge door was incorrect and insufficient to detect a leak from the purge door.

15. The centre wing fuel tank leak check did not reveal the open purge door because the specified fuel quantity used was incorrect and no visual check of the purge door was made.

16. No routine job card calling for a specific purge door leak check had been generated because there was no routine card for the purge door to be removed. A defect card calling for a purge door leak check should have been raised when the purge door was removed.

17. The aircraft maintenance manual did not mention or depict the centre wing tank baffle doors in any procedure.

18. The maintenance organisation had been aware of the missing baffle door reference for two years before the G-YMME incident but no action had been taken to create routine baffle door removal cards.

19. During the period leading up to and shortly after the incident, a shortage of planning resources had led to priority being given to the development of the EWS database, at the expense of job card engineering and responding to PQF queries.

20. There was a perception among some engineers that PQFs were not being answered and so these engineers had stopped raising them.

21. The maintenance organisation's Technical Services group did not formally track long-term unresolved QEANs which resulted in the 'missing baffle door' query being unresolved more than two years after it was reported.

22. The maintenance organisation did not have a procedure in place for handling removable panels, such as the purge door, which can be left tethered to the aircraft.

23. In February 2004 another Boeing 777 undergoing a 2C check at the maintenance organisation had its purge door removed without the removal being recorded. In that case an experienced engineer noticed the open purge door before the aircraft left the facility and raised a job card to have the panel refitted but he did not raise an occurrence or discrepancy report.

24. Maintenance errors identified before an aircraft left the maintenance organisation's facility were not being routinely reported.

25. For some staff at the maintenance organisation it was not clear where the blame boundary lay and the perception among them varied from the company having a good safety culture to the company having "very much a blame culture".

26. The maintenance organisation's disciplinary policy did not address what disciplinary action might be taken if an engineer self-reported a maintenance error and this may have discouraged maintenance error reporting.

27. The maintenance organisation had a Maintenance Error Management System (MEMS) in place but it did not adequately meet all the elements of the MEMS guidance contained in CAA Airworthiness Notice 71 (Issue 2).

28. The maintenance organisation had no process in place for ensuring that Technical Team Leaders were adequately disseminating information from Technical Team Leader meetings to the Technicians and Mechanics in their team.

29. Some of the production staff working on the G-YMME centre wing tank were more experienced on the Boeing 747 aircraft and had not recently worked on a Boeing 777 aircraft.

30. The purge door was routinely removed on the Boeing 747 aircraft to assist with purging, and was left hanging on its lanyard in accordance with the 747 AMM.

31. The routine removal of the Boeing 747 purge door could have contributed to an experienced 747 engineer removing the purge door on the 777 without realising that its removal was not required on the 777.

Safety Recommendations

The following safety recommendations were made as a result of this investigation:

Safety Recommendation 2006-097

British Airways Maintenance Cardiff should actively encourage staff to raise problems with procedures in job cards and in the Aircraft Maintenance Manuals, take prompt action to remedy the problems and provide subsequent feedback.

Safety Recommendation 2006-098

British Airways Maintenance Cardiff should identify and publish clear disciplinary policies and boundaries relating to maintenance errors to encourage uninhibited internal reporting of maintenance errors.

Safety Recommendation 2006-099

British Airways Maintenance Cardiff should ensure that its Maintenance Error Management System fulfils all the elements recommended in the Civil Aviation Authority's Airworthiness Notice 71.

Safety Recommendation 2006-100

British Airways Maintenance Cardiff should ensure that its Technical Team Leaders are adequately disseminating information from Technical Team Leader meetings to the Technicians and Mechanics in their team.

Safety Recommendation 2006-125

When British Airways Maintenance Cardiff has addressed safety recommendations 2006-097 to 2006-100, British Airways should carry out a safety audit at British Airways Maintenance Cardiff.

FORMAL AIRCRAFT ACCIDENT REPORTS ISSUED BY THE AIR ACCIDENTS INVESTIGATION BRANCH

2005

1/2005 Sikorsky S-76A+, G-BJVX
near the Leman 49/26 Foxtrot Platform
in the North Sea on 16 July 2002.

Published February 2005.

2/2005 Pegasus Quik, G-STYX
at Eastchurch, Isle of Sheppey, Kent
on 21 August 2004.

Published November 2005.

3/2005 Boeing 757-236, G-CPER
on 7 September 2003.

Published December 2005.

2006

1/2006 Fairey Britten Norman BN2A Mk III-2
Trislander, G-BEVT
at Guernsey Airport, Channel Islands
on 23 July 2004.

Published January 2006.

2/2006 Pilatus Britten-Norman BN2B-26
Islander, G-BOMG, West-north-west of
Campbeltown Airport, Scotland
on 15 March 2005.

Published November 2006.

3/2006 Boeing 737-86N, G-XLAG
at Manchester Airport
on 16 July 2003

Published December 2006.

2007

1/2007 British Aerospace ATP, G-JEMC
10 nm southeast of Isle of Man
(Ronaldsway) Airport
on 23 May 2005.

Published January 2007.

2/2007 Boeing 777-236, G-YMME
on departure from
London Heathrow Airport
on 10 June 2004.

Published March 2007.

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