CONTENTS

SPECIAL BULLETINS

COMMERCIAL AIR TRANSPORT

FIXED WING

ROTORCRAFT

GENERAL AVIATION

FIXED WING

ROTORCRAFT

CONTENTS Continued

SPORT AVIATION / BALLOONS

ADDENDA and CORRECTIONS

(ALL TIMES IN THIS BULLETIN ARE UTC)

INCIDENT

Aircraft Type and Registration:	Airbus A320-232, G-MIDW
No & Type of Engines:	2 International Aero Engines V2527-A5 turbofan engines
Year of Manufacture:	2000
Date & Time (UTC):	8 October 2006 at 0340 hrs
Location:	En-route Kos to Glasgow International Airport
Type of Flight:	Commercial Air Transport
Persons on Board:	Crew - 6 Passengers - 156
Injuries:	Crew - None Passengers - None
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	47 years
Commander's Flying Experience:	10, 600 hours (hours on type - unknown) Last 90 days - 260 hours Last 28 days - 70 hours
Information Source:	Aircraft Accident Report Form submitted by the airline's flight safety department and additional inquiries by the AAIB

Synopsis

The aircraft was established in the cruise at FL380. A warning of excessive cabin altitude was displayed on the ECAM (Electronic Centralised Aircraft Monitoring) screen. However, the display showed the pressurisation parameters, including the cabin altitude, as normal so the crew believed that the warning was spurious, although they donned oxygen masks as a precaution. Eighteen minutes later they were advised by the cabin crew that the passenger oxygen masks had deployed and they initiated an emergency descent to FL100, at which level the flight continued to its destination without further incident.

A fault was later found within the System 1 Cabin Pressure Controller and the manufacturer is reviewing the system architecture to establish how misleading information was displayed to the crew.

History of the flight

The aircraft was on a flight from Kos to Glasgow and was established in the cruise at FL380. Two hours and six minutes after takeoff, the CAB PR EXCESS CAB ALT (cabin pressure excess cabin altitude) caption illuminated on the ECAM, followed by the Master Warning. The crew had not experienced any of the physiological symptoms they would expect with a pressurisation fault. Nevertheless, they donned their oxygen masks and established communications with each other, in accordance with the first item in the Flight Crew Operating Manual (FCOM) procedures for this warning.

The System Display (SD) Pressurisation page indicated that System 1 (SYS 1) was in operation with a cabin altitude of 7,800 feet. The commander also recalled other pressurisation parameters showing a cabin differential pressure of 8.0 psi and zero cabin vertical speed. Given that these values appeared normal for an aircraft in cruise, and the lack of physiological symptoms, the crew decided to remain on oxygen but not to initiate an emergency descent.

The cabin crew were contacted and told to prepare for a possible decompression and emergency descent although the commander found it necessary to remove his oxygen mask temporarily while he spoke to a cabin crew member. The co-pilot remained on oxygen throughout and the two flight crew discussed their available options.

Approximately 2 minutes after the first ECAM message had appeared, the commander elected to switch pressurisation from SYS 1 to SYS 2. This was in accordance with the FCOM which advised:

> *'If the pilot suspects that the operating pressurisation system is not performing properly, he can attempt to select the other system by switching the MODE SEL pushbutton to MAN for at least 10 seconds, then returning it to AUTO.'*

The selection remained on SYS 2 for about 5 to 15 seconds during which time the commander recalled that the ECAM displayed a cabin altitude of 10,400 feet, a cabin pressure differential of 8.0 psi and zero cabin vertical speed, although he had some difficulty in viewing the screen through the oxygen mask visor. He returned control to SYS 1, believing SYS 2 to be at fault. The cabin crew then reported that the cabin lights had illuminated full bright and that the seat belt signs had come on.

After a few minutes, the commander reselected SYS 2 and recalled seeing a cabin altitude of 14,000 feet and he reselected SYS 1, now believing that there was definitely a fault in SYS 2. The cabin crew then called to say that the passenger oxygen masks had deployed and the co-pilot reported the sensation of pressure change in his ears. The crew declared a MAYDAY and carried out an emergency descent to FL100. During the descent the CAB PR SYS 1 fault caption illuminated and the crew reselected SYS 2.

The flight continued to Glasgow at FL100 without further incident, landing some 50 minutes later.

Recorded information

The aircraft's Digital AIDS (Airborne Integrated Data System) Recorder (DAR) was downloaded. The data showed that an excessive cabin altitude warning occurred at 0308 UTC, followed one second later by a master warning. The 'cabin altitude sys 1 ZCB 1' parameter recorded 7,800 feet. Shortly after the warning, the Systems Display page on the ECAM changed from CRUISE to PRESS. At 0326, a step change in cabin altitude from 7,800 feet to 14,400 feet was recorded, followed six seconds later by initiation of the emergency descent.

Description of the cabin pressurisation system

The A320 uses two identical, independent automatic systems to control cabin pressurisation. Only one system controls at any one time – the other being in 'hot standby'. The systems alternate between flights or, if one system fails, control should automatically switch to the other system. Alternatively, the pilots can select the other system manually as described in the FCOM (as quoted above). The main component of each pressurisation system is the Cabin Pressure Controller (CPC), which contains a pressure sensor both for indication and control.

Each system generates its own values of cabin pressure, cabin vertical speed, differential pressure and excess cabin altitude for the warning system. Other parameters, such as outflow valve position and fault logging, are also generated. The EXCESS CABIN ALT warning is generated when cabin altitude reaches 9,550 feet in the cruise.

The passenger oxygen automatic supply uses a pressure switch which is independent of the CPC indications. The switch is set to deploy the masks at a cabin altitude of between 13,500 and 14,000 feet. As this altitude is approached, the cabin lights are switched to full bright and the seatbelt signs are automatically illuminated. A pre-recorded announcement can also be selected to play automatically as the masks deploy.

The FCOM for this aircraft gives the following instructions in the event of a CAB PR EXCESS CABIN ALT warning:

'CREW OXY MASK (if above FL100)………..ON'

and also:

'If above FL 160:

EMER DESCENT FL 100/MEA (or minimum obstacle clearance altitude)'

Maintenance actions post-incident

Both SYS 1 and SYS 2 CPCs, and the single discharge valve, were replaced. All items were despatched to the manufacturer for investigation.

Analysis

The DAR data generally bears out the crew's account of events, particularly with regard to the figures of cabin altitude, but the time elapsed (18 minutes) between receipt of the excess cabin altitude warning and commencement of the emergency descent was longer than the crew later recalled. It would appear that the cabin altitude was slowly climbing whilst SYS 1 was controlling pressurisation but it was only displaying about 7,800 feet on the ECAM. The Aircraft Maintenance Manual (AMM) suggests that each CPC generates separate signals for cabin altitude numerical values and to trigger the EXCESS CABIN ALT warning. In this case, it appears that the numerical values were incorrect but the 'excess cabin altitude' output signal was functioning correctly. It is unclear from the AMM whether the warning is generated solely from the system controlling pressurisation or whether the standby system can also trigger the warning). Although the DAR does not record SYS 2 data, the pilot's recollection that it was showing 10,400 feet (and later 14,000 feet), whilst SYS 1 was still indicating 7,800 feet, suggests that SYS 2 was reflecting the true condition.

Unfortunately, the lack of physiological symptoms seems to have convinced the crew that the situation was reversed - that SYS 1 was indicating correctly and SYS 2 was faulty (and probably responsible for the EXCESS CABIN ALT caption). Thus the crew did not initially follow the FCOM instructions to commence an emergency descent. This was compounded by the expectation that, if the controlling system was defective, control would automatically pass to the standby system.

From the crew's recollection, a caption for SYS 1 FAULT did not appear until the emergency descent was underway (it is not a parameter recorded on the DAR). Prior to that was the sudden step change, from 7,800 feet to 14,400 feet, in the Cabin Altitude (SYS 1) reading. It can be assumed with confidence that this was now the correct value and therefore the nature of the fault had changed at least as far as this parameter was concerned, although the SYS 1 CPC now recognised that there was still a fault and generated the appropriate warning. It is probable that this earlier inability to detect a fault had prevented automatic transfer of control to SYS 2.

Manufacturer's investigation

The removed items were sent to Airbus for examination. They confirmed an unspecified fault within the SYS 1 CPC but advised the following:

> *'The failure scenario has been reviewed by the Airbus PSC (Product Safety Committee) in Feb 07.*
>
> *This scenario is rare (only one case reported up to now) but the information provided to Crew was confusing. This subject will be therefore further investigated by this Safety Committee to review possible improvement in the current architecture. (next screening end of May 07).'*

Any actions arising from the PSC review will be advised in a future edition of the AAIB Bulletin.

ACCIDENT

Aircraft Type and Registration:	Airbus A340-642, G-VSHY
No & Type of Engines:	4 Rolls-Royce Trent 556-61 turbofan engines
Year of Manufacture:	2002
Date & Time (UTC):	25 February 2006 at 1254 hrs
Location:	Runway 09R, London Heathrow Airport
Type of Flight:	Public Transport (Passenger)
Persons on Board:	Crew - 18 Passengers - 268
Injuries:	Crew - None Passengers - None
Nature of Damage:	Serious damage to two tyres and wheels; minor damage to flaps and right main landing gear
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	57 years
Commander's Flying Experience:	10,000 hours (of which 7,000 were on type) Last 90 days - 240 hours Last 28 days - 80 hours
Information Source:	AAIB Field Investigation

Synopsis

Towards the end of the final approach to Runway 09R at London Heathrow Airport, in strong gusting crosswind conditions, the aircraft began to drift to the right of the runway extended centreline. At the moment of touchdown, the aircraft was drifting to the right, its heading was some 10º to the left of its track and its roll attitude was approximately 3.5º right wing low. These factors resulted in the tyres of the two outer wheels of the right main landing gear making firm contact with the right edge line of the designated runway surface. The aircraft remained on the paved surface but both tyres deformed and burst, causing minor damage to the aircraft. Following the touchdown, the aircraft tracked to the left and regained the runway centreline. The flight crew slowed the aircraft and turned off the runway on to a taxiway, where it was brought to a stop. Here, the passengers disembarked and were taken to the terminal by bus. After an inspection, the aircraft was towed to a nearby stand.

History of the flight

The crew reported for duty at 0055 hrs for their flight from Los Angeles to London. The flight crew comprised a commander and two co-pilots, with the commander acting as the Pilot Flying (PF). The aircraft took off at 0209 hrs and, prior to the landing, had an uneventful flight. Before starting the descent, the flight crew briefed for an expected landing on Runway 09L at Heathrow.

The commander was to remain the PF for the approach and landing, with one co-pilot occupying the right seat and the other occupying the flight deck jump seat.

Heathrow was experiencing delays and, during the descent, the flight crew were instructed by ATC to hold. Whilst in the hold, they were advised that they would be landing on Runway 09R, so the crew re-briefed for an approach to this runway. Due to reports of windshear on short final approach to Runway 09L, it was decided to land with Flap 3 selected[1] and fly 5 kt faster than the calculated approach speed, giving a final approach speed of 161 kt. After about twenty minutes in the hold, ATC passed radar vectors to the crew to enable the aircraft to intercept the ILS for Runway 09R. The commander elected to keep the autopilot engaged and stated that, once established on the ILS, the aircraft remained in line with the runway centreline. The commander disengaged the autopilot on passing the Decision Altitude of 275 ft and, at 50 ft radio altitude (RA), commenced the landing flare. All three pilots reported that the aircraft then began moving rapidly to the right. The commander was aware the aircraft was quickly approaching the edge of the runway and reduced the flare in an effort to expedite the touchdown. He did not attempt to kick off the drift with rudder just prior to touching down as he considered to do so might have brought the nose of the aircraft over the edge of the runway. Consequently, the aircraft touched down on the right edge of the delineated runway, with about a 10º drift angle to the left and whilst tracking slightly to the right of the runway heading. As a result, the two outboard tyres of the right main landing gear burst.

The commander brought the aircraft back towards the centreline and, as he was doing so, he became aware that the EFIS[2] display indicated the tyre pressures of the two right outer main wheels were at zero. He therefore decided to use full reverse thrust in helping to slow the aircraft. As the speed reduced through 80 kt, a master caution also alerted the crew to the loss of these tyre pressures. ATC informed the crew that they believed some tyres had burst and that the emergency services had been alerted.

The aircraft vacated the runway at exit point N5E, where it was brought to a halt on the taxiway. As there were no other adverse indications on the flight deck, the flight crew kept the engines running whilst awaiting the arrival of the emergency services. The crew made use of the aircraft's tail-mounted camera to try and assess the level of damage but, whilst they could see the wheels, the picture definition was not adequate to see them in sufficient detail.

The emergency services were quickly in attendance and were able to advise the crew on a discreet radio frequency that the two outer tyres on the right main gear were badly damaged and completely deflated. The crew consulted the aircraft manuals to see whether it was possible to taxi the aircraft in this condition but decided to remain in their current position. Also, the airfield duty manager was on the scene and was sufficiently concerned about the state of the affected landing gear to request that the passengers be disembarked and taken to the terminal by bus. Once the passengers had left the aircraft, an engineering inspection was carried out, following which the aircraft was judged safe to be towed to a nearby stand.

When later asked if he had considered going around, the commander stated that the event had happened

Footnote

1 Normal landing is made with Full Flap.

Footnote

2 Electronic Flight Indication System.

very quickly and, at such a late stage in the approach, he thought to do so might have resulted in the aircraft departing the runway.

Weather

The Heathrow ATIS valid at 1220 hrs reported the following weather:

> Wind 060º at 21 kt, visibility 10 km or more, clouds FEW at 2,500 feet, temperature +6º, dew point -4º and QNH 1018 hPa.

It also advised that there was moderate turbulence on the approach and that windshear had been reported on short final approach to Runway 09L with a loss or gain of 10 kt. The wind direction was such that that the touchdown zone for Runway 09R was generally downwind of the airport's central area, Figure 1. The turbulence downwind of the buildings/structures may have contributed to the overall turbulent conditions experienced during the landing, although LHR does not appear to be any different from most major airports in the UK in this regard.

Crosswind landing limits

The operator's aircraft manual for the A340-600 states that the maximum demonstrated crosswind for a manual landing, including gusts, is 37 kt.

Standard operating procedures

The operator's Flight Crew Operating Manual (FCOM), revision 06/01 June 2005, for the A340-600 contains the following information relating to landing in crosswinds:

> ***'Crosswind landings***
>
> *The preferred technique is to use rudder to align the aircraft with the runway heading during the flare while using lateral control to maintain the aircraft on the runway centerline.*

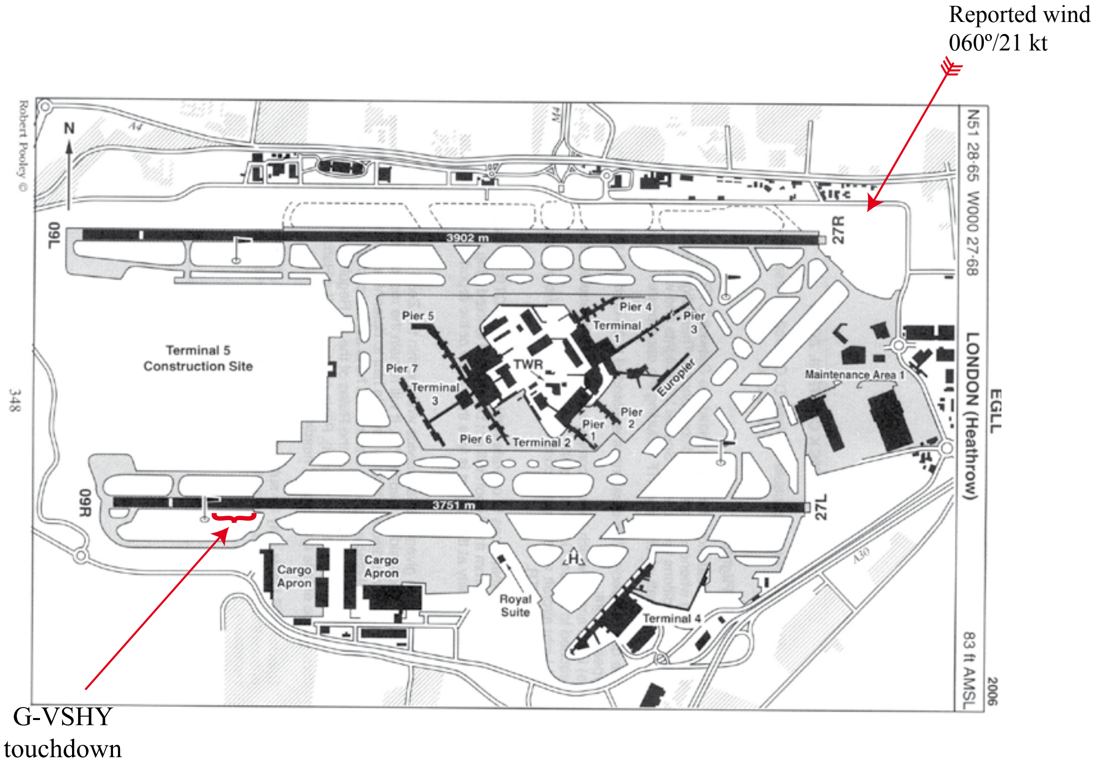


Figure 1

Routine use of into wind aileron is not recommended, because sidestick deflection commands roll rate until touchdown.

In strong crosswind conditions, small amounts of lateral control may be used to maintain wing level. The lateral stick input must be reduced to zero at the first main gear touchdown.'

An FCOM Bulletin issued by the aircraft manufacturer, No 814/1 dated Jun 04, also contains information relevant to landing the A340 in crosswinds. Extracts from this document, obtained from the operating company, are presented below:

'SUBJECT:** **AIRCRAFT HANDLING IN FINAL APPROACH'

'Approach Stabilization Criteria...........Aircraft Handling on the Lateral Axis

Generally speaking, lateral handling of fly-by-wire aircraft is conventional. But, in very gusty conditions, it is necessary to recall the principle of the flight control law in roll. With the sidestick, the pilot can order a roll rate up to a maximum of 15 degrees/second. However, the aerodynamic capacity of the roll surfaces, when fully deflected, is much higher: That is, up to about 40 degrees/second. This means that, if the aircraft is flying through turbulence that produces a roll rate of 25 degrees/second to the right, the aircraft still has the capacity to roll to the left at a rate of 15 degrees/second, with full sidestick command. This is more than what is necessary in the worst conditions.

The sidestick's ergonomical design is such that the stop at full deflection is easily reached. This may give the pilot the impression that the aircraft is limited in roll authority, because there is a time delay before the pilot feels the result of his/her action. On conventional aircraft, due to the control wheel inertia, the pilot needs considerably more time to reach the flight control stop.

The flight control system of Airbus fly-by-wire aircraft partially counteracts roll movements induced by the effects of gust, even with the sidestick in the neutral position. The PF must ensure that the overall corrective orders maintain the desired aircraft lateral axis. He/she will minimize lateral inputs and will resist applying sidestick order from one stop to the other. Every sidestick input is a roll rate demand, superimposed on the roll corrections already initiated by the fly-by-wire system. The pilot should only apply "longer term" corrections as needed.

Before flare height, heading corrections should only be made with roll. As small bank angles are possible and acceptable close to the ground, only small heading changes can be envisaged. Otherwise, a go-around should be initiated.

Use of rudder, combined with roll inputs, should be avoided, since this may significantly increase the pilot's lateral handling tasks. Rudder use should be limited to the "de-crab" manoeuvre in case of crosswind, whilst maintaining wings level with the sidestick in the roll axis.'

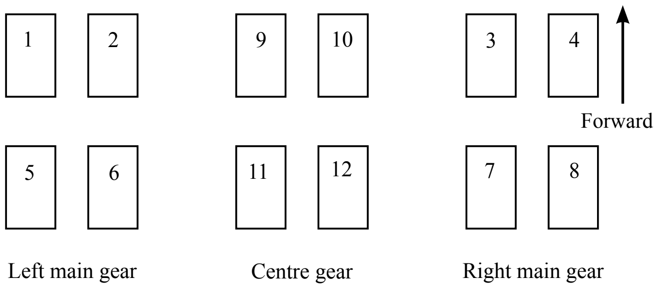
Extracts from FCOM Bulletin No 814/1, dated Jun 04

Description of landing gear and tyres

Landing gear

The aircraft is equipped with two main landing gear legs, left and right, and a centreline gear, each one being equipped with four wheels. The nose gear is fitted with two wheels. The eight wheels on the main landing gear, and the four on the centre gear, are fitted with carbon disc brakes, operated normally through anti-skid units. When airborne, with the landing gear extended, the centre gear bogey tilts forward and the main gear bogies tilt backwards. The oleo extension of the main and centre legs is such that the wheels on the centre gear always make contact with the runway after those on the main gears, irrespective of the pitch attitude of the aircraft.

The main and centre landing gear wheels are numbered as follows:



Tyres

A tyre consists of a bead, sidewall, shoulder, crown and tread, and multiple plies embedded in the rubber, Figure 2. The specific tyre type fitted to G-VSHY was the Michelin Near Zero Growth (NZG) radial tyre, Pt No M16004, size 1400 x 530R23/40/235. Tyre No 4 had undergone 133 landings and 61% of the allowable tread had worn away. Tyre No 8 had also undergone 133 landings, with 58% of the allowable tread worn away.

The stated advantages of NZG tyres over conventional tyres are that they are lighter, sustain less wear at touchdown, have an increased resistance to tears and cuts and an improved resistance to abrasion.

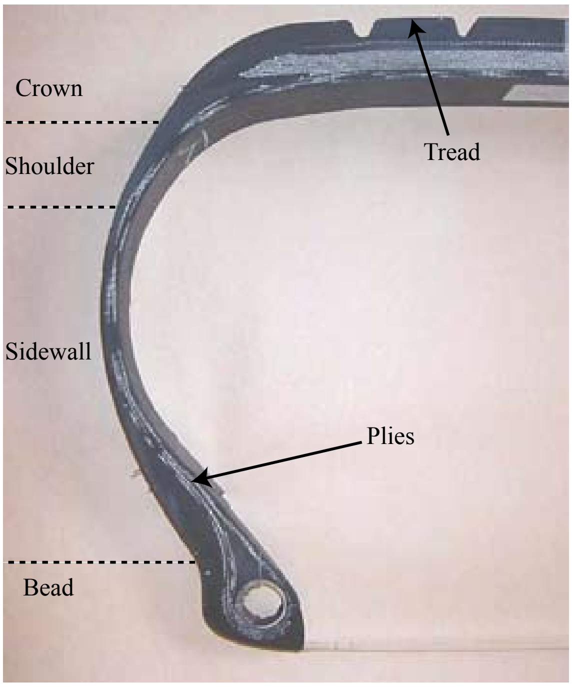


Figure 2

Runway marks

Clear tyre marks were made by all the main landing gear tyres on the runway during the landing, Figure 3. These indicated that the aircraft had touched down on a track of approximately 093º, adjacent to the aiming markers. Wheel No 7 and No 8 touched down first, followed approximately 10 m further on by wheel No 5 and No 6. Some 20 m after the inital touchdown point, wheel Nos 3, 4, 9 and 10 all made contact with the runway. Wheel No 4 and No 8 had touched down on the white line delineating the right edge of the runway. It was not possible to determine from the tyre marks where the nose wheels touched down. It was also apparent from the tyre marks that tyre Nos 4 and 8 had burst at about the same time that wheel Nos 3, 4, 9 and 10 made contact with the runway.

A gouge was present in the runway surface in the area where the two tyres had burst, most likely caused by the No 4 outer wheel rim contacting the ground. Whilst the fore and aft wheels on each bogey are in-line with the longitudinal axis of the aircraft, the marks on the runway made by the No 3 and 7 main gear tyres were consistent with the aircraft's heading being to the left of its track, ie, skidding to the right. Approximately 40 m after the start of the right main gear wheel tracks, wheel Nos 4 and 8 crossed over the runway right edge on to the hard shoulder for a short distance, after which the tyre tracks from all the main gear wheels indicated that the aircraft had tracked towards the runway centreline.

Aircraft damage

Tyres No 4 and 8 burst on landing, Figure 4. The resultant flaying rubber dislodged and broke a number of brackets on the bogey and caused several small dents on the inboard flap and flap track canoe fairing.

Damage had also occurred to the No 4 wheel, normal brake hydraulic line coupling (Part Number 201589204), sufficient to cause a slight seep of hydraulic fluid. Whilst wheel Nos 4 and 8 had remained intact, the outboard rim of the No 4 wheel had been ground flat over an arc of approximately 40º around its circumference.

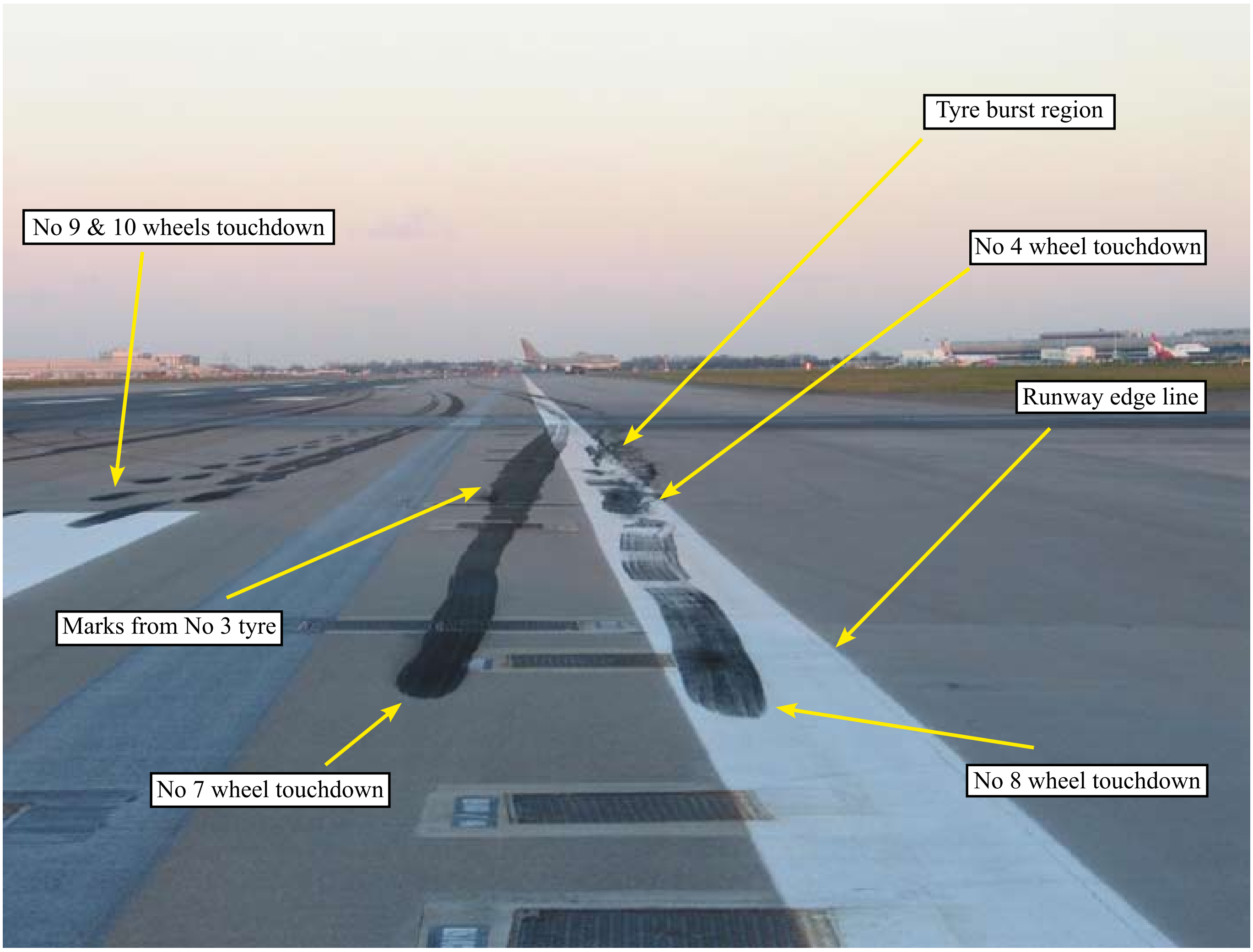


Figure 3

Marks made by the tyres from the right and centre main landing gear

Figure 4

Damage to the No 4 and No 8 tyres

Engineering investigation

On-aircraft

The No 3, 4, 7 and 8 wheel assemblies were removed from the aircraft for further investigation by the AAIB. In addition, the operator's engineers carried out the following two inspections, as detailed in the Aircraft Maintenance Manual:

> *'AMM 05-51-15 - Inspection after a tire burst or tread throw or wheel failure,*
>
> *AMM 05-51-11 - Inspection after hard or over weight landing.'*

During these inspections, the operator discovered evidence of delamination of a stator plate in the No 8 wheel brake unit (Part Number 2-1663-3) and noted that the 'temperature indication' paint on its axle had changed colour to an 'off-white'. This indicated that the axle had possibly been subjected to overheating. A hardness check was subsequently undertaken by the landing gear manufacturer, which established that the axle had not in fact overheated. Given the lack of damage to the wheel hub and the fact that there had been no overheat warnings or messages on the aircraft's Post Flight Report system, the operator's engineers assessed that the damage to the brake unit had not occurred during this flight or as a result of the landing.

Wheel examination

The fuse plugs in the No 4 and 8 wheels were intact and there was no evidence that the heat shields or wheel material had been subjected to excessive heat. In addition to the outboard rim of the No 4 wheel being ground flat over an arc of approximately 40º, the outer rim of the No 8 wheel exhibited light scratch marks that were assessed as being caused by contact with the runway. The chin ring and a section of the heat shield in both the No 4 and 8 wheels had been dented by flaying rubber. Rubber marks were also found on the inner and outer rims of both wheels, which was consistent with them running on deflated tyres. Wheel hub Nos 3 and 7 were assessed as serviceable. Examination of the remaining wheels and tyres by maintenance personnel failed to reveal any abnormalities.

No 8 wheel brake unit examination

The brake manufacturer examined the No 8 brake unit and identified that there was light oxidation on the No 3 stator to a depth of approximately 3 mm from the rim. This was consistent with the stator having been overheated at some point. However, this brake unit had been fitted to the aircraft from new and it was not possible to determine when this may have occurred. The remainder of the brake unit was assessed as being in good condition with approximately 40% of its life remaining.

Tyres examination

Tyre Nos 3, 4, 7 and 8 were returned to the manufacturer's Research & Development establishment for inspection by their quality department.

The shoulders of tyre Nos 3 and 7 both displayed signs of moderate scrubbing and the manufacturer believed that the majority of this damage probably occurred prior to the incident. Such damage often results from the shoulders making contact with the ground whenever an aircraft is manoeuvred in a confined area. However, it is possible that some of this damage was caused following the failure of the No 4 and 8 tyres.

The No 4 tyre was extensively damaged, with approximately 70% of the tyre detached from its two beads. Damage to the outboard sidewall indicated that the tyre had distorted sufficiently for the sidewall to rub along the runway, causing the plies to be ground away. This resulted in a hole in the sidewall and the sudden deflation of the tyre, which then appeared to have allowed the outboard rim of the wheel to make a brief contact with the ground. As the wheel continued to rotate, the rims cut through the tyre sidewalls, allowing most of the tyre to detach from its beads. The damage to the No 8 tyre was similar, with approximately 50% of the tyre detached from the beads. There was, however, only light scoring to the wheel flange, which probably occurred when the aircraft was taxiing off the runway.

Tyre Nos 4 and 8 both displayed evidence of overheating on their treads and sidewalls. The treads were also extensively scratched. However, given the distortion of the tyres following the loss of pressure, it was not possible to determine if this damage occurred before or after the tyres burst and such damage did not necessarily indicate the drift of the aircraft at touchdown. The manufacturer assessed that all the tyres were serviceable prior to the incident with no evidence that any had been incorrectly inflated.

Tyre performance

The performance of a tyre is not only dependent on the load applied, but also the manner in which it is applied, ie, the vertical and lateral accelerations experienced by the tyre at touchdown. Whilst the acceleration and the order and timing of the wheels touching down is known, it was not possible to determine accurately the load on the No 4 and 8 tyres, as the aircraft manufacturer was unable to provide information on the amount of lift the wing was producing when the tyres burst. However, a review of the aircraft manufacturer's test data indicated that the vertical and lateral acceleration recorded on the Flight Data Recorder for this landing placed the tyres on the edge of their performance envelope at maximum rated load.

Flight Recorders

The two solid-state flight recorders (DFDR and QAR) were removed from the aircraft and replayed, and both had retained data covering the events leading up to and during the landing. Pertinent parameters recorded during the approach and landing are shown in Figures 5 and 6.

Wind data

Strong winds were evident throughout the approach, and the wind parameters recorded on the FDR were calculated by the aircraft's inertial reference system. The aircraft manufacturer has indicated that the calculation process introduces a small delay before data is available on the aircraft databases, but were unable to quantify the time period involved. In addition, the manufacturer stated that the accuracy of recorded wind information for wind speeds in excess of 50 kt was within 10º54 and 10 kt, whilst the values for winds less than 50 kt should be used as an indication only. Wind data recorded during the approach and landing is tabled below (Table 1).

Approach Phase

By 2,500 ft agl, the aircraft had been configured for the landing; Flap 3 had been selected and the landing gear lowered. The aircraft was established on the localiser, both autopilots and the auto-thrust system were engaged and autobrake Mode 3 had been armed.

Manual speed selection was used down to 2,000 ft agl, from which point 'selected speed' was used. The approach target speed was recorded as being predominantly 161 kt, although temporary increases up to 169 kt were observed between 2,000 ft and touchdown. Recorded airspeeds during this same period ranged from 156 kt to 173 kt and the associated auto-thrust system responses resulted in variations in the N_1 speed from all four engines ranging from 25% (flight idle) to 54%. Aircraft pitch attitude varied by ±3º about an average of 1º nose up, with roll attitude values varying by ±2º about a mean of 0º. The aircraft was tracking the localiser and, with the wind from the left, adopted a drift angle of 5.6º ±1.6º.

From 430 ft agl to 225 ft agl, recorded wind speed values remained essentially constant at an average of 27 kt, but the wind direction backed by approximately 10º, resulting in a slightly higher crosswind component.

Height above ground (feet)	*Wind Direction (º) and Speed (kt)*	*Wind speed fluctuation (kt)*
5,000 – 4,500	070 / 40	±5
4,500 – 4,000	070 / 40	±8
4,000– 3,500	060 / 36	±8
3,500 – 3,000	057 / 35	±11
3,000 – 2,500	055 / 26	±6
2,500 – 2,000	055 / 25	±11
2,000 – 1,500	050 / 30	±11
1,500 – 1,000	043 / 21	±11
1,000 – 500	048 / 25	±9
500 - Touchdown	039 / 26	±12

Table 1

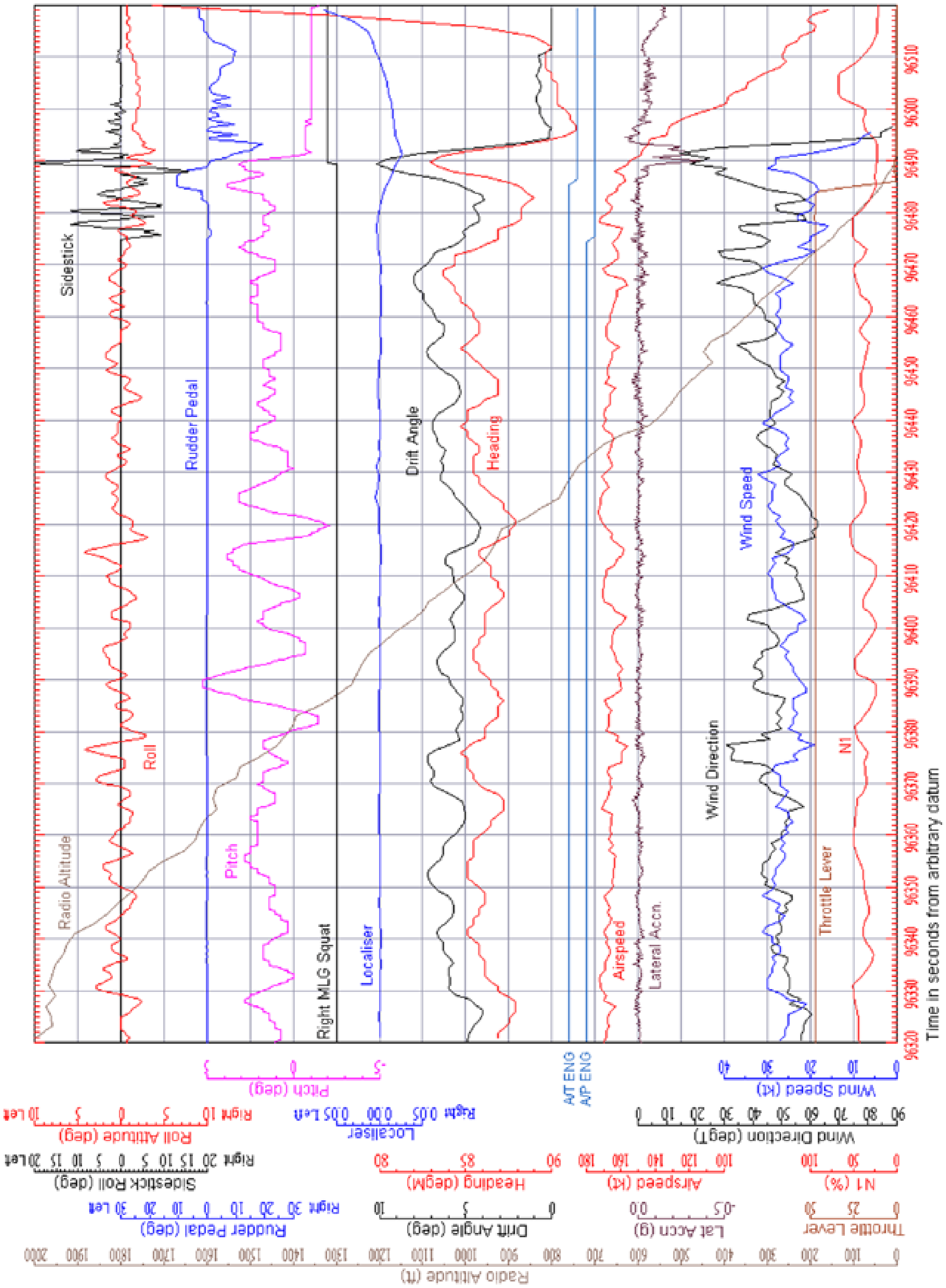

Sidestick
Rudder Pedal
Drift Angle
Heading
Wind Speed
Roll
Radio Altitude
Pitch
Right MLG Squat
Localiser
Airspeed
Lateral Accn.
Wind Direction
N1
Throttle Lever
A/T ENG
A/P ENG
Time in seconds from arbitrary datum
Pitch (deg)
Roll Attitude (deg)
Localiser
Wind Speed (kt)
Wind Direction (degT)
Sidestick Roll (deg)
Heading (degM)
Airspeed (kt)
N1 (%)
Rudder Pedal (deg)
Drift Angle (deg)
Lat Accn (g)
Throttle Lever
Radio Altitude (ft)

Figure 5

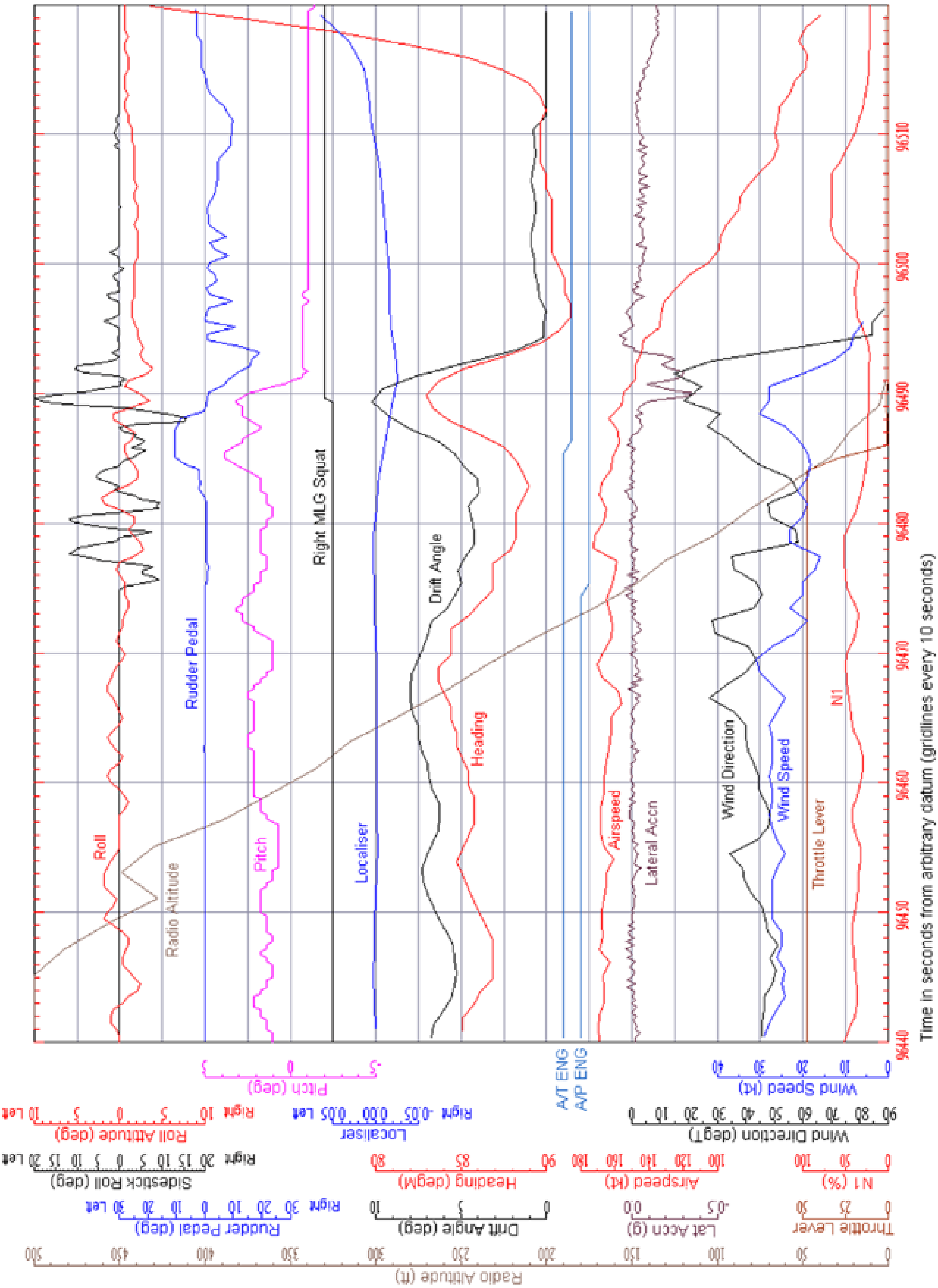

Roll
Radio Altitude
Rudder Pedal
Pitch
Right MLG Squat
Localiser
Drift Angle
Heading
A/T ENG
A/P ENG
Airspeed
Lateral Accn
Wind Direction
Wind Speed
Throttle Lever
N1
Time in seconds from arbitrary datum (gridlines every 10 seconds)
Pitch (deg)
Roll Attitude (deg)
Localiser
Wind Speed (kt)
Wind Direction (degT)
Sidestick Roll (deg)
Heading (degM)
Airspeed (kt)
N1 (%)
Rudder Pedal (deg)
Drift Angle (deg)
Lat Accn (g)
Throttle Lever
Radio Altitude (ft)

Figure 6

The aircraft began to track very slightly to the right of the extended centreline[3], its heading reduced and the drift angle increased to 8º. By 150 ft agl, the drift angle was reducing through 5º as the extended centreline was regained. The autopilots were disengaged at this point and movements of only the left sidestick indicated that the aircraft was being flown manually by the commander.

Landing Phase

Over the first two seconds after autopilot disconnection, a slight manual control input of right rudder pedal and a sidestick displacement of between 5º and 9º to the right were made. A maximum rudder surface deflection of 6.9º (trailing edge to the right) was also recorded and the aircraft began to roll to the right. Over the next four seconds, two consecutive sidestick deflections to the left of, approximately, half full scale deflection were applied to correct the roll attitude, which reached a maximum of 2.8º right wing down. At the same time, with wind speed remaining essentially constant at 21 kt, the wind direction veered 13º, which resulted in a reduction of the crosswind component and an increase in the headwind component. Airspeed then increased to 172 kt and thrust reduced, with all four engine N_1 values falling to flight idle (25%).

By 69 ft agl, the drift angle had reduced to a minimum of 4º and recorded localiser values showed that the aircraft was drifting to the right of the extended centreline. A small amount (2º) of left rudder pedal was applied followed, two seconds later, at 46 ft agl and the start of the flare, by a much larger (10º) left pedal input. At the start of the larger rudder pedal input, with the aircraft between 46 ft and 34 ft agl, the thrust levers were retarded and the auto-thrust system disengaged. N_1 values for all four engines indicated that they were at flight idle at that point. During this initial flare, pitch attitude had increased to 3.9º (nose up) by the time the aircraft had descended to 34 ft agl.

Between 34 ft agl and touchdown, the recorded wind direction backed by 30º and its speed increased by 10 kt[4]. Drift angle began to increase as the aircraft yawed left and, by 22 ft agl, aircraft pitch attitude had reduced to 1.8º nose up. The aircraft continued to deviate further right of the extended centreline whilst yawing to the left. During the two seconds before touchdown, two further deflections of the left sidestick of 15º right and full scale left (20º) were recorded. Pitch attitude was increased to 3.2º during this period and, one second before touchdown, the rudder pedals were centralised by the right pedal being depressed.

The aircraft landed at a speed of 156 kt, to the right of the centreline on a heading of 083ºM and with a drift angle of 10.2º, Figure 7.

Roll attitude at touchdown was 3.5º right wing down. The right main landing gear contacted the ground first, followed almost immediately by the centre and left main landing gears. The aircraft's rate of descent at touchdown was calculated to have been approximately 500 ft/min; a normal acceleration of 1.75g and a lateral acceleration of -0.37g were recorded. Wheel speeds were recorded by the FDR and, with the exception of wheel Nos 4 and 8, all showed normal indications during and after spin-up. Speeds recorded from wheel No 4 remained at zero, whilst that from wheel No 8 peaked at only 38 kt.

Footnote

[3] Localiser deviations indicated a displacement to the right of a maximum of 0.002 Difference in Depth of Modulation (DDM).

Footnote

[4] For reference, over the seven seconds prior to touchdown, the computed wind speed had increased from 21 kt to 30 kt and its direction had backed from 062º to 019º.

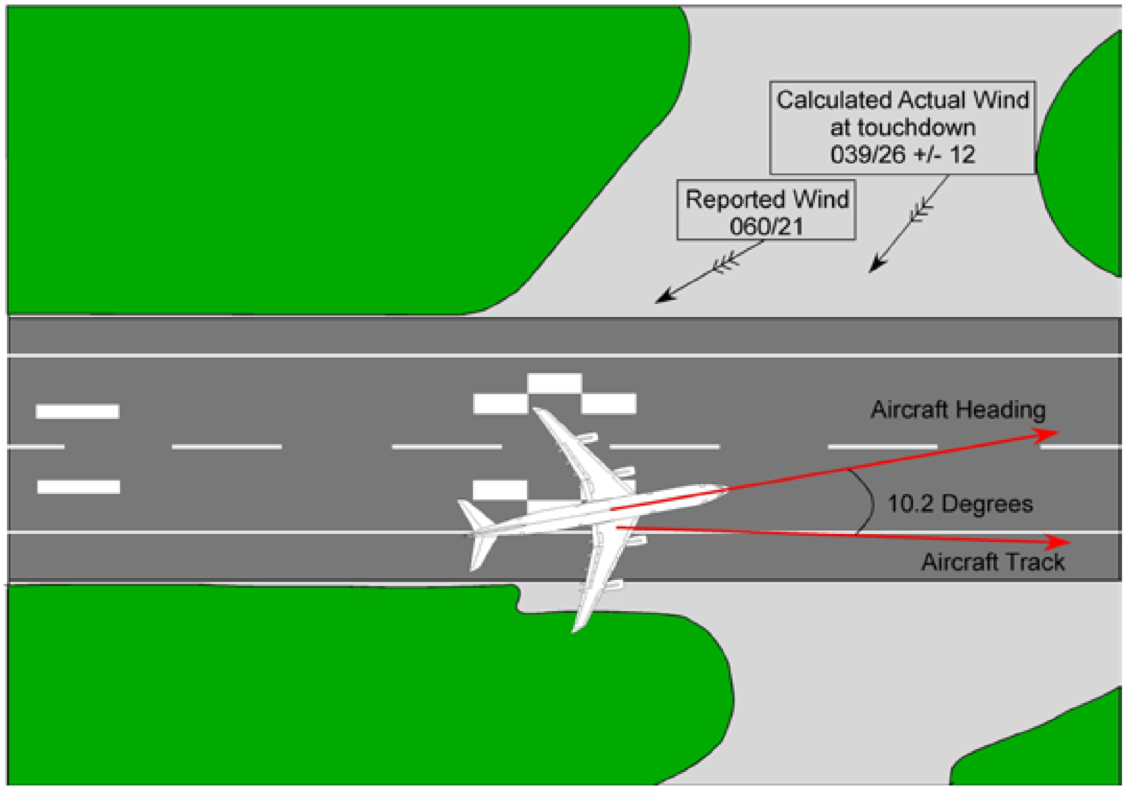


Figure 7

After Landing

Following touchdown on the main landing gear, the aircraft was de-rotated to lower the nose gear onto the runway and ground spoilers deployed. Longitudinal acceleration values between -0.28g and -0.3g were recorded which were consistent with autobrake operation. Consistent brake pressures were recorded from all main gear brake units, with the exception of Nos 4 and 8, which remained near zero. A progressively increasing application of right rudder pedal was made, culminating in 20º deflection after four seconds. The aircraft began to yaw to the right as it regained the centreline of the runway. Significant values of lateral acceleration ranging between -0.29g and -0.17g were recorded during this turn[5]. Towards the end of the turn, airspeed had reduced to 133 kt and reverse thrust was selected. Whilst slowing through 98 kt, symmetrical manual braking was applied which disengaged the autobrake system. Right rudder pedal inputs were made at various stages during the rollout and a master caution indication was recorded as the aircraft slowed through 80 kt. Idle reverse was selected at approximately 60 kt. Nosewheel steering and differential braking were used to vacate the runway to the left, following which the aircraft was brought to a halt.

At no stage during the approach and landing were any control inputs recorded on the FDR from the right sidestick. Also, no windshear or other warnings were recorded.

Footnote

[5] It should be noted that the sense of this lateral acceleration was opposite to that which may be expected during a normal turn to the right and hence may be indicative of the tyres skidding on the runway surface.

Analysis

Operational issues

The aircraft had been correctly configured to land under the prevailing weather conditions, and an appropriate approach speed had been selected. Whilst the initial approach was somewhat turbulent, the aircraft performed as expected with the autopilot accurately tracking the ILS. A drift to the right of the runway extended centreline commenced when the aircraft was at about 100 ft agl, shortly after the autopilot had been disengaged; the aircraft remaining to the right of the runway centreline until about a second after touchdown.

Despite a lag of unknown duration in recording the wind speed and direction, and an element of inaccuracy in the figures themselves, it is known that the aircraft was subjected throughout the approach to a crosswind from the left. The FDR data showed a small (no more than 2º), but predominant, roll attitude to the right when the aircraft was below about 200 ft agl and it was the combination of this crosswind and roll attitude that maintained the aircraft's drift to the right.

Whilst the exact time and extent are not known, the wind speed increased and backed significantly during the very final stage of the approach. From the crew's recollection this seems to have occurred whilst the aircraft was in the flare. The FDR data indicates that no major rudder input was made until the aircraft was at about 60 ft agl, when about 10º of left pedal was applied. Over the next five seconds, the aircraft's drift angle increased from about 5º to 10º. This coincided with the commander making various roll inputs, to compensate for the roll effect of the rudder inputs attempting to keep the wings level. These were, again, predominantly to the right, whilst the aircraft continued to deviate to the right, away from the centreline.

Just before G-VSHY touched down, the right rudder pedal was pressed sufficiently to centralise the rudder pedals, but not to have any significant de-crabbing effect on the aircraft. This supports the commander's statement that he was concerned that to de-crab the aircraft at touchdown might result in a further move to the right, possibly taking the aircraft off the runway. The effect was that the aircraft touched down with a drift angle of 10.2º and a resultant (large) lateral acceleration of -0.37g. A roll attitude at touchdown of 3.5º to the right ensured that the right main landing gear contacted the ground first and, despite the centre and left landing gear touching down immediately after, meant that the forces associated with large lateral acceleration were experienced, initially, by the two outer tyres on the right main gear.

When manually landing an aircraft in a strong crosswind, a significant drift angle may be necessary for the aircraft to track the runway centreline using the 'crabbing' technique, as well as when used in conjunction with the 'wing down' technique. In such circumstances, it is generally the practice that the aircraft should be flown so that the main landing gear tracks the runway centreline, or even slightly to its upwind side. With a long bodied aircraft such as the A340-600, before touchdown, this may require the nose of the aircraft to be aligned approximately with the upwind edge of the runway. By doing so, even with the instantaneous wind changing rapidly, it is likely that the drift may be 'kicked off' and the aircraft landed, before the aircraft drifts too far towards the downwind edge of the runway.

Safety action

Although landing in a crosswind should be within the capabilities of a qualified line crew, it is probable that an approach and a manual landing in a strong and turbulent crosswind is not experienced that often, either in reality or in the simulator. To emphasise the appropriate techniques to be used when landing in crosswinds, the operator has included the following information in a recently issued general notice to flight crews:

- *'In crosswind conditions, a crabbed approach should be flown. Aim to put the centre gear on the centerline. During the flare, rudder should be applied as required to align the aircraft with the runway heading. Any tendency to drift downwind should be counteracted by an appropriate input on the sidestick. In the case of a very strong crosswind, the aircraft may be landed with a residual drift [maximum 5º] to prevent an excessive bank [maximum 5º]. Consequently, a combination of partial de-crab and wing down technique may be required. The pilot should disconnect the autopilot early enough to resume manual control of the a/c and to evaluate the drift before flare.*
- *When disconnecting the AP for a manual landing, the pilot should avoid the temptation to make large inputs on the sidestick. The pilot should avoid any tendency to drift downwind.'*

Engineering issues

The tyre marks on the runway were consistent with data on the Flight Data Recorder, in that when the aircraft touched down, it started to skid to the right. At this point, the load placed upon tyre Nos 4 and 8, generating the aircraft vertical and lateral accelerations, distorted both tyres sufficiently to allow their sidewalls to scrape along the runway. As they were worn through, both tyres would have suddenly deflated, allowing the wheel rims to cut through the sidewalls and largely separate the tyres from the beads. Flaying rubber then caused minor damage to components in the immediate area. As the aircraft decelerated, the amount of sideways skidding reduced and the aircraft track aligned with its heading, which directed the aircraft towards the runway centreline.

Information was sought from the manufacturer throughout the investigation concerning the landing parameter limits for this aircraft/tyre combination, in respect of drift angle, landing gear and applied tyre loading. Having analysed the available data their response is summarised as follows:

- There were no anomalies seen with the performance of the aircraft systems
- The landing loads applied to the landing gears were within the design envelope
- The general aircraft parameters for the landing were within any defined limits; the event is not classified as a hard landing
- The roll and pitch angles at touchdown were acceptable
- There is no absolute crosswind limit for landing, but a 'maximum demonstrated crosswind' is demonstrated during certification tests
- Analysis of the data indicates that the aircraft landed within the demonstrated crosswind limit
- This was an extreme landing case and, as a consequence, resulted in the failure of two tyres. However, in such an event, tyre failure is an acceptable situation, as the aircraft demonstrated that it remained satisfactorily controllable.

Although there was evidence that one of the stator plates in the No 8 wheel brake unit had overheated, all other indicators suggested that this had not occurred on the subject flight and, therefore, was unlikely to have been associated with the failure of the No 8 tyre.

Conclusions

The aircraft commander had committed to making the approach in reported wind conditions that were within the maximum demonstrated crosswind limits, including gusts, for the aircraft. For most of the approach, the autopilot had maintained the aircraft on the glideslope and localiser but, when disconnected at a height of 275 ft, the pilot found it increasingly difficult to maintain the aircraft on the runway extended centreline in the demanding wind conditions.

Although the computed wind parameters immediately before touchdown were within the aircraft's limits, the crosswind component and wind speed both increased significantly during the flare. As the aircraft commenced the flare, with the aircraft already downwind of the runway centreline, the pilots' recollections and the recorded data both indicated that sudden severe turbulence was encountered at this critical stage of flight. At this point, in order to remain over the runway, the aircraft's drift angle increased to over 10º. Advice to pilots from the operator, issued after this incident, states that in very strong crosswinds, the aircraft may be landed with a maximum residual drift of only 5º, to prevent the bank angle exceeding 5º. This advice also notes that when disconnecting the autopilot for a manual landing, the pilot should do so early enough to resume manual control of the aircraft and to evaluate the drift before flare.

Whilst, according to the manufacturer, a firm landing with drift of this magnitude will not damage the aircraft, it was demonstrably outside the limits for the tyres. In the absence of any apparent pre-existing defects being identified during their detailed examination, it was concluded that the tyres had been serviceable prior to touchdown.

Although the commander momentarily considered going around, his decision to expedite the landing probably prevented the aircraft from departing the runway. Given the relatively long time required, in such circumstances, for the engines to spool-up to go-around power, the aircraft would probably have touched down in any case, with the distinct possibility that it may have departed the paved surface and become airborne having sustained more serious damage than two burst tyres.

INCIDENT

Aircraft Type and Registration:	BAe 146-300, D-AEWB
No & Type of Engines:	4 Lycoming ALF502 R5-103A turbofan engines
Year of Manufacture:	1990
Date & Time (UTC):	19 February 2007 at 1335 hrs
Location:	After departure from Birmingham
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 5 Passengers - 61
Injuries:	Crew - None Passengers - None
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	42 years
Commander's Flying Experience:	7,666 hours (of which 1,519 were on type) Last 90 days - 438 hours Last 30 days - 148 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and enquiries by the AAIB

Synopsis

Approximately 15 minutes after takeoff, the flight crew noticed an unusual smell in the cockpit and shortly thereafter began to feel unwell. They immediately donned oxygen masks, after which their condition improved significantly. An emergency was declared and the aircraft returned to Birmingham, where an uneventful landing was completed. The cause of the incident was found to be an oil leak from the No 1 engine, which had allowed oil fumes to enter the cockpit and cabin air supply.

History of the flight

In the climb, approximately 15 minutes after departing Birmingham, with the No 1 and No 4 engines selected to supply bleed air to the air-conditioning packs, the flight crew became aware of an unusual smell in the cockpit. They described it as a 'burnt' or 'exhaust' smell, but it was not accompanied by any visible smoke. Soon after, both crew members began to experience symptoms of tunnel vision, loss of balance and loss of feeling in the hands and lower arms. They immediately donned their oxygen masks, breathing 100% oxygen, which improved their condition noticeably. Two of the three cabin crew members also reported similar symptoms. An emergency was declared and the aircraft returned to Birmingham.

During the descent, the crew actioned the 'SMOKE/FUMES ON FLIGHT DECK/CABIN' abnormal checklist.

The landing at Birmingham was completed without incident and the aircraft was brought to a stop on Taxiway 'C' to allow the Airport Fire Service to investigate. The passengers were disembarked normally and taken to the terminal by bus.

The weather at Birmingham at the time was dry, with a wind direction/speed of 170º/8 kt and a visibility of 9 km.

Personnel information

Both flight crew members were suitably qualified and adequately trained to carry out the flight. They held current Class 1 medical certificates, with no restrictions. They both had a rest period of over 13 hours prior to flight on the day of the incident.

After the flight, all five crew members attended a local hospital for health checks. There was no evidence that they had suffered any long-term ill effects from the inhalation of the fumes.

Aircraft information

The aircraft was a British Aerospace BAe 146-300, serial number 3183, manufactured in 1990. It had completed 23,311 flying hours and 25,015 cycles since new.

After the incident, the aircraft was inspected in accordance with the aircraft manufacturer's Inspection Service Bulletins 21-150 and 21-156, which describe the inspections to be performed following a report of contamination of the cabin/cockpit air supply.

Evidence of oil leakage was found on the bleed band of the No 1 engine, suggesting that engine oil had been ingested into the bleed air system. The engine, serial number LF05407AC, was replaced at Birmingham. It had completed 6,973 hours/8155 cycles since new and 964 hours/1,131 cycles since its previous service. Subsequent checks confirmed the cabin/cockpit air supply to be free from contamination and the aircraft was returned to service.

Additional information

The problem of fumes in the cockpit and/or cabin on the BAe 146 and other aircraft is not a new one and has been the subject of much industry discussion. AAIB Formal Report 1/2004 presented the findings of an extensive investigation into the problem of contamination of cockpit/cabin air supply by engine oil fumes and included the results of studies into the physiological effects of such fumes. In December 2000, The UK CAA issued Flight Operations Department Communication (FODCOM), number 17/2000, providing valuable safety advice on the use of flight crew oxygen masks in the event of smoke or fumes entering the cockpit. Further updated safety advice was provided in FODCOM's 14/2001 and 21/2002.

The German Federal Bureau for Air Accident Investigation (BFU) has reported on two other incidents of oil fumes in the cockpit air supply on BAe 146 aircraft, both of which occurred in January 2007. These are described in BFU reports 5X001-0/07 and 5X003-0/07.

This incident and others, show that prompt action by the crew in donning the oxygen masks at the first signs of adverse symptoms can have significant safety benefits.

ACCIDENT

Aircraft Type and Registration:	Boeing 737-600, 7T-VJT
No & Type of Engines:	2 CFM 56-7B20 turbofan engines
Year of Manufacture:	2002
Date & Time (UTC):	31 May 2006 at 1200 hrs
Location:	London Gatwick Airport
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 6 Passengers - 18
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to engine and engine outer casing
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	54 years
Commander's Flying Experience:	10,868 hours (of which 700 were on type) Last 90 days - 195 hours Last 28 days - 45 hours
Information Source:	AAIB Field Investigation

Synopsis

The aircraft taxied onto the stand centreline but failed to stop before its left engine cowling came into contact with the airbridge. The commander misunderstood the information provided by the parking aids and overran the correct stopping point whilst looking for a positive indication to stop. The emergency stop signal was not activated by either of the two ground staff present because confusion existed about when and how to operate it. Four safety recommendations are made.

History of the flight

The aircraft landed on Runway 08R at London Gatwick Airport after an uneventful flight from Algiers. It was the only flight conducted by the crew that day. After vacating the runway the aircraft was instructed to taxi to Stand 43, at the western end of the North Terminal. As the aircraft taxied towards this stand it was given revised instructions to taxi to Stand 19, located on the north side of South Terminal Pier 2. The aircraft taxied towards the newly allocated stand without difficulty.

As the aircraft approached the stand the commander could see that the AGNIS[1] docking guidance system was illuminated and entered the stand area. As he did so, he remarked to the co-pilot that he could not see any stopping guidance, but noted the presence of a ground crew member on the right side of the stand centreline.

Footnote

[1] Azimuth Guidance for Nose-In Stands, see later text for a full explanation.

He believed that this was a marshaller. He also noted a sign to the right of the AGNIS which he thought might be a stopping guidance signal, but this was in fact an extinguished emergency STOP sign. He elected to proceed. When he realised that no stopping guidance would be provided, either automatically or by the ground crew member, he stopped the aircraft and, together with the co-pilot, completed the shutdown checks.

When cabin crew opened the main entrance door, activity around the entrance alerted the commander to the fact that the left engine cowling had come into contact with part of the airbridge. The gentle impact had not resulted in injuries, either to ground staff or aircraft occupants, and the passengers disembarked without further incident.

Examination showed that part of the stand mechanism had contacted the cowling, resulting in a three inch diameter hole in the intake lip. The stand mechanism had been slightly deformed. The aircraft had overrun its correct stopping point by 10.3 m.

Arrival of the aircraft on stand from the ground staff's perspective

An employee of the handling agent known as a GPU crewmember (GPUC)[2], (whose duties included placing chocks around the nosewheel and connecting a ground power unit (GPU) to of the arriving aircraft), was informed of the change of stand shortly before the aircraft arrived. He was able to reach the stand before the aircraft and positioned himself ahead and to the right of where he believed the aircraft would stop.

Another employee of the handling agent known as a Traffic Officer was also advised of the change of stand and reached the manoeuvrable airbridge before the aircraft arrived. In accordance with her normal duties, she lowered the airbridge from its parked height to a level corresponding approximately to the forward entrance door of the approaching aircraft, using controls located on a panel to the left of the airbridge head. As she did so she saw the aircraft continue beyond its normal stopping position. Although the airbridge remained in its parked position she realised that a collision might occur. She attempted to illuminate the emergency STOP signal but was unable to do so because she could not find the activation button.

The GPUC had seen the aircraft approaching and stated that he was aware that it had "gone a bit far" but thought that "he [the commander] knew what he was doing". The GPUC stated that he made no attempt to signal to the pilots that the aircraft was proceeding too far into the stand because he did not consider this to be one of his responsibilities. When the aircraft stopped he placed chocks in front of and behind the nosewheels but, noticing that the engine cowling had come into contact with part of the airbridge, did not connect the GPU to the aircraft.

Personnel information

GPU crewmember

The GPUC had been employed by the same handling agent since March 1999 and, according to his employer, had received training appropriate to his duties. He had been trained to marshal aircraft by a previous employer and occasionally was required to do so by his present employer.

Traffic officer

The Traffic Officer had been employed by the same handling agent since November 1997 and, according to her employer, had received training appropriate to her duties.

Footnote

2 This acronym is used for brevity in this report but is not used officially by any of the organisations involved.

Meteorological information

The runway and taxiway surfaces were dry and visibility was reported to be in excess of 10 km.

Stand layout and guidance

Throughout the incident the airbridge remained in its assigned 'guard' position[3], where it would not interfere with an aircraft manoeuvring onto and parking correctly on Stand 19 centreline.

The central parking position of Stand 19 was equipped with an AGNIS system to provide centreline guidance and a Parallax Aircraft Parking Aid (PAPA) to provide stopping guidance. Stopping guidance was provided in the Left and Right parking positions by a STOP arrow painted on the apron surface to the left of the relevant centreline and visible from the cockpit. Aircraft stop in the correct position on the centreline of Stand 19 Left or Right by taxiing towards the terminal building until the head of the STOP arrow is in line with the commander's shoulders.

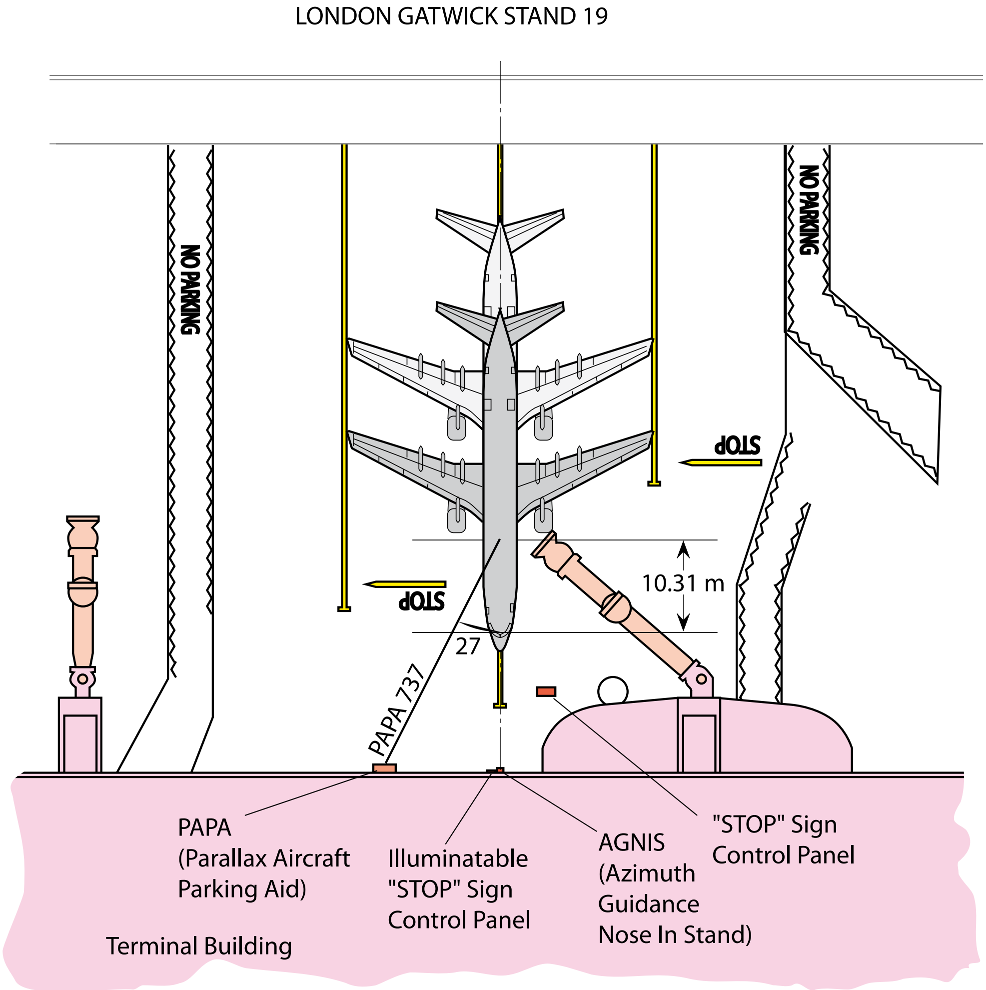


Figure 1

Layout of Stand 19, illustrating normal stopping position and stopped position of 7T-VJT

Footnote

3 When the airbridge is correctly parked in the guard position its wheels rest within a circle painted on the apron surface for this purpose.

CAP 637 – *Visual Aids Handbook*, published by the CAA, describes the various Visual Docking Guidance Systems (VDGS) currently in use in the UK. Relevant extracts are reproduced below.

'AGNIS provides Stand centreline alignment guidance and is normally used in conjunction with either PAPA, SMB or SML which provide stopping guidance separately. The system is designed for use from the left pilot position and the unit displays two closely spaced vertical light bars mounted in a box at about flight deck height ahead of the pilot. The light bars display one of the following signals:

- *(a) one red bar and one green bar, indicating that the pilot should steer away from the red towards the green bar, or*
- *(b) two green bars, indicating correct alignment*

PAPA

This aid is positioned to the left side of the Stand centreline and provides stopping guidance by employing a black board marked with white vertical lines bearing aeroplane type identification labels and in which a horizontal slot has been cut, as illustrated at Fig (2) (i). A short distance behind the slot is a vertically-mounted white fluorescent light tube which, when aligned with the required aeroplane type line, indicates the stop-point, as shown at Fig (2) (ii). An alternative layout is illustrated at Fig (2) (iii) where the board is provided without a slot and the tube is mounted in front of it; the method of use is identical.

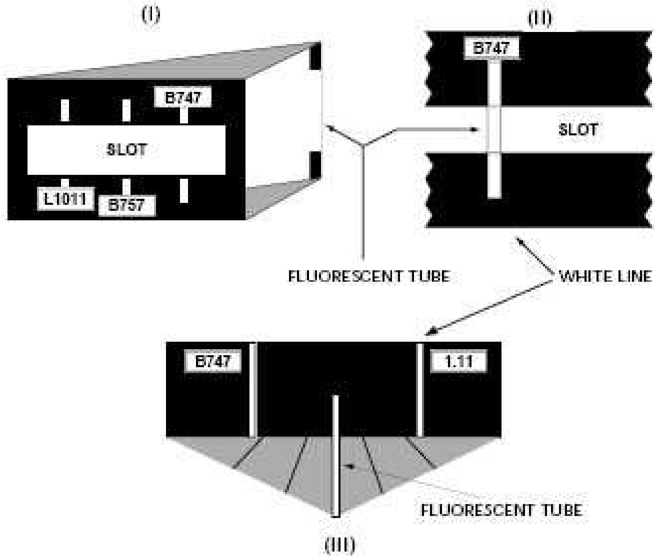


Figure 2

PAPA (typical)

On Stand 19, the PAPA, Figure 2, was installed approximately 13 m to the right of the stand centreline but designed for use from the left pilot position. Consequently, it was necessary for the commander to look across the cockpit in order to view it as shown in Figure 3.

Figure 3

Stand 19 PAPA viewed from commander's seat[4]

Footnote

[4] The photograph was taken immediately after the incident. In order to include the whole PAPA board it was necessary to lower the camera viewpoint slightly below the commander's eye line.

The system is calibrated to provide correct stopping guidance to the pilot occupying the left seat of an aircraft tracking the stand centreline. Being a parallax system, it cannot provide meaningful stopping guidance to anyone in another location, such as the pilot occupying the right seat or staff on the ground.

The PAPA for Stand 19 was serviceable and would have provided correct stopping guidance to the commander of the aircraft whilst tracking the stand centreline. The commander reported after the incident that, because of its location, it was not apparent that this PAPA referred to Stand 19.

Figure 4

Stand guidance control box (ground)

Emergency stopping guidance

Emergency stopping guidance was provided by a single red STOP sign located beside the AGNIS indicator.

Ground operation

The emergency STOP sign could be activated by pressing a button on the stand guidance control box, located at the head of the stand (nearest the terminal building) to the left of the stand centreline, Figure 4. It could also be operated by a button on an identical control box mounted above the steering controls in the cab of the airbridge, on the left side of the airbridge head (nearest the aircraft), Figure 5. The Traffic Officer was not aware of this, believing that it was located beside the door to the airbridge steps, on the other side of the airbridge head and, consequently, out of reach.

Figure 5

Stand guidance control box (airbridge)

Standards for Visual Display Guidance Systems (VDGS)

International standards for VDGS are contained in Volume 1 of Annex 14 to the Convention on International Civil Aviation. Chapter 5, section 5.3.24.14 of this document states:

> *'The stopping position indicator shall be located in conjunction with, or sufficiently close to, the azimuth guidance unit so that a pilot can observe both azimuth and stop signals without turning the head.'*

Section 5.3.24.16 contains the following recommendation:

> *'The stopping position indicator should be usable by the pilots occupying both the left and right seats.'*

The Aerodrome Standards department of the CAA Safety Regulation Group publishes an information leaflet entitled *Reference Point*. The August 2005 issue contained the following comment:

> *'Visual Docking Guidance Systems (VDGS) deployed in the UK have normally comprised AGNIS (Azimuth Guidance Nose in Stand) and PAPA (Parallax Aircraft Parking Aid) boards or mirrors. However, these systems only cater for left-hand seat operation and require the pilot to turn his/her head to ascertain the stopping position; therefore, they do not comply with ICAO requirements published in Annex 14, Chapter 5, section 5.3.24.*
>
> *The ICAO Aerodromes Panel is developing criteria for the use of advanced docking visual guidance systems (ADVGS) that provide more accurate guidance information to both pilots.*
>
> *These systems are becoming more customary at larger aerodromes and pilots that regularly operate to and from international hubs are becoming more familiar with them.*
>
> *Accordingly, the CAA encourages aerodromes to consider the replacement of existing VDGS with ICAO compliant VDGS or ADVGS as soon as practicable'.*

The airport operator reported that it was under the impression that recommended compliance with Annex 14 Chapter 5, section 5.3.24 was not required before 2018. No documentary evidence of this recommendation was forthcoming. Nevertheless, the airport operator stated that it plans to replace all PAPA/AGNIS equipment with ICAO compliant VDGS by the end of 2009 and that funding has been secured for this purpose[5]. It planned to have installed a total of 43 such systems by the end of 2006. The order of replacement is based on a risk assessment of each stand carried out by the airport operator.

The current edition of the UK Aeronautical Information Publication (AIP) shows that the following airports are equipped with AGNIS/PAPA type VDGS:

Birmingham, Edinburgh, Gatwick, Glasgow, London Heathrow, Manchester, Prestwick and Stansted.

Previous investigation

In October 2006 the AAIB published a report[6] of the investigation of an incident in which a B777, N864DA, collided with the airbridge on Stand 50 at Gatwick Airport. The report concluded that the design of the stand guidance system did not comply with ICAO Annex 14 and that contributory factors to the incident were the

Footnote

5 The replacement system has a STOP sign on the stand centreline in front of the aircraft. This sign illuminates automatically when the aircraft reaches the correct stopping position.

6 Report reference EW/C2005/05/04 published in AAIB bulletin 10/2006.

commander's lack of familiarity with the parking system and possible fatigue.

Ten safety recommendations were made relating to stand guidance, ground procedures, information exchange and crew fatigue, nine of which were accepted and one of which was partially accepted.

The report noted that:

> *'The CAA is encouraging UK airport operators to replace such systems with ICAO Annex 14 compliant advanced docking visual guidance systems as soon as is practicable.'*

Training

Both the GPUC and the Traffic Officer received training in the use of equipment at their respective stations, including stand guidance controls. Training materials produced by the handling agent showed clearly the location and appearance of the emergency stop button. The syllabus of operator training, produced by a third party, included the following:

> *'Emergency Procedures'*
>
> 3. *Emergency stops, location, resetting, establishing cause and hazard before resetting*
> 4. *Airport specific emergency accessories and procedures, stop short, stand emergency stop, PAPA AGNIS signs, crossing of arms above head'*

It did not contain guidance on when, if ever, a particular crewmember was expected to operate this equipment.

The accompanying *'Boarding Bridge Operator Test'* multiple choice test did not include any questions relating to use of emergency stop signs.

Before being signed off to operate airbridges, each Traffic Officer was required to undergo a final check in accordance with an *'Airbridge Operation Safety Audit – Control Form'* supplied by the airport operator. There was no item on this form referring to operation of emergency stop signs. The *'Airbridge Training Record'* maintained by the handling agent made no reference to operation of emergency stop signs.

The investigation into the incident to N864DA examined the issue of ground crew operating emergency stop buttons and highlighted the difficulty ground crew have in determining whether a particular aircraft type has overrun its stopping position. The use of unofficial, potentially ambiguous, ground markings to assist with this determination was shown to create additional problems. Consequently Safety Recommendation 2006-084 was made:

> *'It is recommended that Gatwick Airport Limited should examine the practicability of requiring a member of the ground crew to assume the responsibility of being adjacent to the ground level emergency STOP light button, and of monitoring the arrival of the aircraft onto the stand, whenever ground crews are present on a stand whilst an aircraft is manoeuvring to park. An effective means of monitoring whether the aircraft has overrun its correct parking position should also be devised.'*

The following response was received:

> *'Gatwick Airport Limited has accepted this recommendation. Gatwick Airport Limited will consult ground operation organisations working at the airport to determine whether it is feasible to have the ground level emergency stop button manned during parking manoeuvres.'*

This response did not address the second part of the recommendation, namely:

> *'An effective means of monitoring whether the aircraft has overrun its correct parking position should also be devised.'*

The airport operator produces *'Managing Director's Instructions'* (MDIs) and *'Airfield Advice Notices'* in order to advise organisations and their staff of changes to operational procedures and equipment. At the time of the incident to 7T-VJT, these instructions and notices could neither be accessed centrally nor was an index provided. This issue was addressed in Safety Recommendation 2006-082 arising from the investigation into the incident to N864DA:

> *'It is recommended that Gatwick Airport Limited should review the system by which Managing Directors Instructions are published to ensure the information they provide is readily identifiable.'*

Response to Safety Recommendation 2006-082:

> *'Gatwick Airport Limited has accepted this recommendation. A suitable index will be added to the Managing Directors Instructions to ensure that the information that they provide is readily identifiable.'*

However, neither the training or guidance material, nor copies of the MDIs were held by the handling agent in a form, such as in a bound and indexed folder, which would promote easy access and self study by its staff.

Flight Recorders

The aircraft was fitted with a Solid State Memory Flight Data Recorder (FDR) and a Cockpit Voice Recorder (CVR). Both recorders were downloaded at the AAIB and data and audio recordings were recovered for the accident.[7]

The ground track of 7T-VJT as it taxied towards the stand was calculated using ground speed and heading data taken from the FDR. Figure 6 shows the track of the aircraft as it manoeuvred onto the stand, with ground speed in knots and distances in metres. The points are one second apart.

When lined up with the stand, ground speed was between 2.5 and 3.0 kt. The aircraft then decelerated to a stop within two seconds.

Additional information

The operator of N864DA issued the following guidance to its crews:

> *'Aircraft Parking Threats*
>
> *Reading summaries from the crews who have experienced a parking incident, their comments are similar. One or more of the following extenuating circumstances appear in most all the reports:*
>
> *Insufficient review of special pages (preparation)*
>
> *Fatigue (late arrival, poor crew rest)*
>
> *Distractions (vehicles, personnel, airport and ramp construction)*
>
> *Misinterpretation of a unique parking system (inconsistent location of PAPA board)*
>
> *Fixation on one part of the guidance system – focusing on left/right alignment at the expense of fore/aft position.'*

Footnote

7 During the taxi to stand, the crew were communicating with each other without using their microphone/headset equipment; therefore, crew speech was recorded via the Cockpit Area Microphone (CAM). However, as they were also listening to the 'ground radio' via the cockpit's speaker at a high volume level and that ground-radio channel was particularly busy, the majority of the recorded crew speech was drowned out and unintelligible.

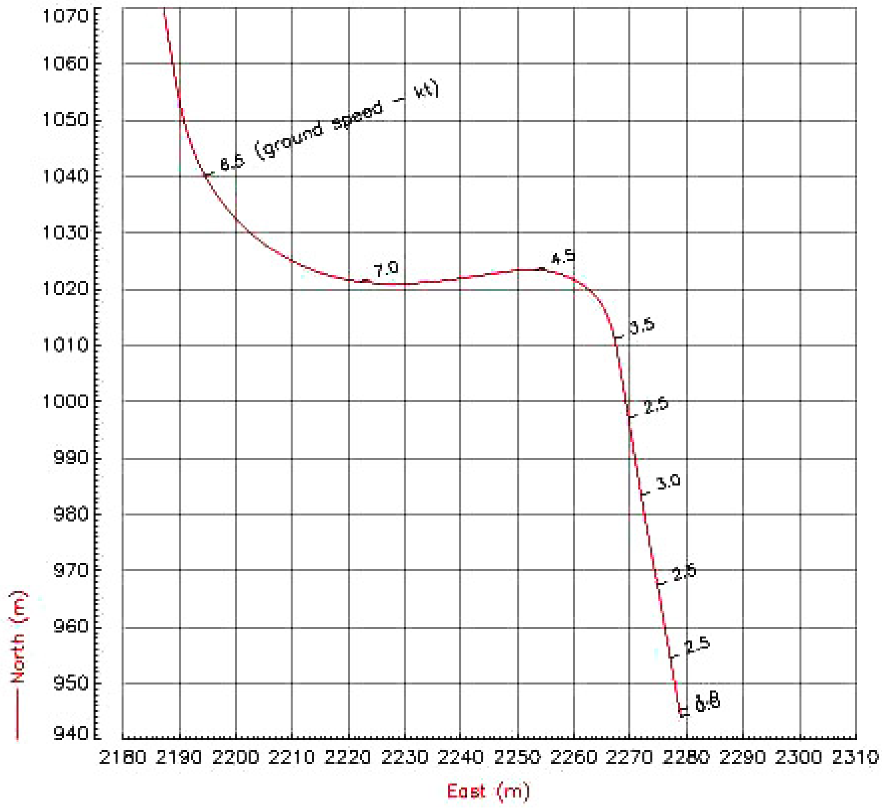


Figure 6

Ground track of 7T-VJT onto stand

The operator suggested the following strategy for mitigating these factors:

> *'Thoroughly review the* (operator's own guidance material) *and Jeppesen "Special Pages." Consider using both engines to taxi into unfamiliar gates. Before entering the ramp area, ensure that it is clear. Most parking systems are only valid from the Captain's seat but the entire crew must stay vigilant. With the PAPA/AGNIS and other unique systems, one crew member should be assigned to watch the emergency stop indication that is located near the AGNIS board in front of the cockpit because with most systems no emergency stop light is installed on the left or right side PAPA boards. Realize that some parking systems have an open area on the PAPA board and this may lead to confusion. Many parking systems have inconsistent labeling and inconsistent locations. Do not proceed into the gate area until all the parking boards are located. Depending on the location of the PAPA board, a cockpit window frame can block the view. Centerline accuracy is critical to proper guidance. Bring the aircraft to a stop if you're unsure of the guidance you're getting from the parking system.'*

Analysis

Evidence from the FDR indicated that the aircraft was correctly aligned with the centreline of the stand and had taxied along it at an appropriate speed prior to impact. The PAPA element of the stand guidance system was serviceable, calibrated and compliant with local and national standards for that system. The airbridge was parked in the appropriate 'guard' position while the aircraft manoeuvred onto the stand. Consequently, if the aircraft had been stopped in accordance with the normal guidance available to the commander, it would not have hit the airbridge.

The Traffic Officer stated that she had been willing to operate the emergency stop signal but could not find the button to do so, whereas the GPUC stated that in the circumstances of this incident he did not consider operation of the emergency stop signal to be one of his responsibilities. It was not clear, from the training materials and records provided by the handling agent, what was expected of each crewmember in this regard. Nor was it clear what sources of information were available to ground crew following their initial training. Furthermore, although updated operational information was produced from time to time by the airport operator and handling agent, it was not clear how such information was promulgated to ground crew. Finally, ground crew had no effective means of determining whether an aircraft had overrun its correct parking position.

Safety Recommendations

In view of the above, the following safety recommendations are made:

Safety Recommendation 2007-008

It is recommended that the CAA should use all measures that it can to encourage airport operators to expedite their compliance with international standards for visual docking guidance systems as specified in ICAO Annex 14, Chapter 5, section 5.3.24

In response to this recommendation, the CAA has stated that it will take action as described below:

'Background

To permit the use of AGNIS and PAPA type VDGS, the UK currently has filed a difference with ICAO for the three relevant Standards and Recommended Practices (SARPs) contained in Annex 14, Chapter 5, Section 5.3.24. However, CAP168, Licensing of Aerodromes, at Chapter 6, paragraph 7.2.4, specifies that:

> *VDGS should meet the requirements specified in ICAO Annex 14. Aerodromes should replace existing VDGS with ICAO compliant systems as soon as practicable, and when refurbishment or development of stands is undertaken.*

Action

1. The CAA will give notice to airports that the filed difference will be withdrawn at a future specified date.

2. To strengthen the statement in CAP 168, all applicable licensed aerodromes will be requested to provide an appropriate compliance action plan as an aerodrome audit theme item for 2007-08.'

Safety Recommendation 2007-009

It is recommended that Aviance UK should include in its syllabus of training for airport ground staff information on when it is appropriate to activate stand emergency stop signals during aircraft parking manoeuvres, and ensure that a specific assessment of their ability to do so correctly is tested during their initial approved and recurrent training.

Safety Recommendation 2007-010

It is recommended that Aviance UK should review the system by which operational information is provided to airport ground crews to ensure that it is readily identifiable and accessible to all members of staff who require it in the performance of their duties.

In response to these recommendations, Aviance UK has stated the following:

'….all of the staff receive Ramp safety training, which covers the operation and emergency use of the Stand Entry Guidance Systems. The operator in question, received his training on 3 March 2005; at the same time he was also trained in aircraft marshalling. Refresher training is provided every 24 months.'

'In addition to the training, we have a Safety Bulletin concerning the arrival of aircraft on-Stand - Aviance generic bulletin number 024 - which staff are required to read and sign for, every 12 months. This advises them of the emergency procedure to be used……'. '……we will be updating the bulletin to place more specific requirements on the operative allocated to chock the aircraft, so that the aircraft progress is monitored and the emergency stop activated if required.'

The contents of the original and updated (draft) Bulletin 024 are shown below.

SAFETY BULLETIN NO: GEN-024

ARRIVAL OF AIRCRAFT ON STAND

Before the arrival of aircraft on Stand, certain checks must be carried out to allow safe entry and working of aircraft:

- Stand must be cleared of FOD prior to arrival of aircraft and placed in FOD bin at head of Stand. If item is too large, call Airfield Ops
- All equipment must be withdrawn off the stand and parked beyond the Stand boundary
- Once it is deemed safe, the stand guidance entry system can be activated (only trained personnel to operate system)
- In an emergency the RED STOP BUTTON must be activated
- Personnel must not approach the aircraft until the anti collision lights have been turned off and engines have spooled down
- Chocks are to be put in place as per procedures BEFORE ANY EQUIPMENT approaches aircraft
- Ground power should be connected to aircraft as per procedures

The draft updated Bulletin replaces the fourth bullet point above with the following:

- The ground personnel allocated to chock the aircraft should monitor the aircraft's progress. If at any time they feel that the aircraft safety has been compromised, the emergency stop button located on each stand should be immediately activated. In the event they are unable to access the Stop button, then the emergency stop hand signal of both arms above the head, wrists crossed and fists clenched, should be given. It is also encumbent upon any member of staff during the course of the arrival to activate these procedures, should there be any danger (in their opinion) to the aircraft or the ground personnel.

Safety Recommendation 2007-011

It is recommended that Gatwick Airport Limited should provide ground crew with an effective means of determining whether an aircraft has overrun its correct parking position.

Conclusions

At the time of the accident the aircraft was serviceable and taxied onto the stand aligned with the centreline. The airbridge was parked in the correct location and the stand guidance system was serviceable. The commander misunderstood the information provided by the parking aids and overran the correct stopping point whilst looking for a positive indication to stop. The aircraft subsequently collided with the airbridge. The design of the parking system and uncertainty concerning operation of the emergency stop signal contributed to the incident.

INCIDENT

Aircraft Type and Registration:	Boeing 747-443, G-VROM
No & Type of Engines:	4 General Electric CF6-80C2B1F turbofan engines
Year of Manufacture:	2001
Date & Time (UTC):	8 October 2006 at 0800 hrs
Location:	Near London (Gatwick) Airport
Type of Flight:	Commercial Air Transport
Persons on Board:	Crew - 19 Passengers - 365
Injuries:	Crew - None Passengers - None
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	53 years
Commander's Flying Experience:	14,754 hours (of which 6,340 were on type) Last 90 days - 112 hours Last 28 days - 52 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and enquiries by the AAIB

Synopsis

Following an instruction to take up the hold before commencing an approach at London (Gatwick) Airport, the commander declared an emergency to avoid landing with Final Reserve Fuel. The aircraft was given priority for the approach, and the final landing was achieved with 7 tonnes of fuel remaining. Company Reserve Fuel was 7.4 tonnes and the Final Reserve Fuel was 3.9 tonnes.

History of the flight

Towards the end of a transatlantic flight the crew had checked the ATIS for the destination of London (Gatwick) Airport. For the expected landing, the weather was good with visibility greater than 10 km and the lowest cloud at 1,200 ft aal.

During the subsequent descent, the crew was instructed to take up the hold at 'Goodwood' and to expect a 10 minute delay prior to commencing approach. Due to earlier route diversions because of adverse weather and a lower than forecast tailwind during the cruise, the crew had insufficient fuel to accept any delay. The commander advised ATC that he could not accept a delay and was then asked if he wished to declare an emergency or to divert. The nominated diversion was London (Heathrow) Airport and the commander was aware that it would be very busy at that time of day. He estimated that if he accepted the hold, his landing fuel would be close to Final Reserve Fuel. With the knowledge that Gatwick Airport was on single runway operations, the commander decided that declaring an emergency was the most sensible option and declared a 'MAYDAY'. The aircraft was then given priority for an approach and landed uneventfully at Gatwick. The aircraft landed with 7 tonnes of fuel.

Relevant information

For the incident flight, the Company Minimum Reserve (CMR) Fuel was 7.4 tonnes, which was the normal minimum fuel on landing. This comprised Final Reserve Fuel of 3.9 tonnes, which was the fuel required to hold for 30 min at 1,500 ft aal, and 3.5 tonnes of fuel for the planned diversion. If, during flight, the planned fuel at destination fell below the CMR, the commander had to decide whether to initiate a diversion or continue to destination. His decision would be based on the cause of the delays, the actual and forecast weather at his alternate airfield, the serviceability of the approach aids at the alternate and the accuracy of en-route winds forecast between destination and alternate.

The company Operations Manual included the information that the term 'Fuel Emergency' was not recognised by UK ATC. Crews are instructed to declare a 'Pan' when the estimated fuel on landing was expected to be less than Final Reserve Fuel. If the fuel on board reduced to an amount only sufficient for 20 min endurance, then a 'Mayday' must be declared.

ATC procedures require that priority is given to aircraft in emergency. However, the declaration of 'MAYDAY' will not always result in a total prohibition on other aircraft taking off or landing at the nominated destination. Any prohibition would depend on the emergency and the distance and time involved before the aircraft in emergency was on final approach.

Conclusion

With the information that the aircraft had a 10 minute delay before starting the approach for landing, the commander had to decide whether to accept the hold, divert to his destination or declare an emergency. His main concern was that accepting a hold would result in the aircraft landing with close to Final Reserve Fuel. With his knowledge that he would probably encounter another delay at the alternate airfield of Heathrow, he decided to declare an emergency for an approach to his primary destination. This was in accordance with his company procedures but a 'Pan' call, rather than a 'Mayday' would have been more appropriate.

INCIDENT

Aircraft Type and Registration:	Boeing 757-236, G-CPET
No & Type of Engines:	2 Rolls-Royce RB211-535E4 turbofan engines
Year of Manufacture:	1998
Date & Time (UTC):	4 October 2006 at 1300 hrs
Location:	En route from Madrid to London (Heathrow) Airport
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 8 Passengers - 136
Injuries:	Crew - None Passengers - None
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	35 years
Commander's Flying Experience:	6,500 hours (of which 2,150 were on type) Last 90 days - 200 hours Last 28 days - 75 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

After takeoff, the flight crew detected a transient oily smell in the cockpit and, later in the flight, began to feel unwell. They donned oxygen masks and declared a 'PAN' in accordance with the published emergency procedure, after which their condition improved. The cause of the incident was determined to be an oil leak from the left engine, which allowed oil fumes to enter the bleed air/air-conditioning system and thence the cockpit air supply.

History of the flight

After takeoff on a scheduled passenger flight from Madrid to London Heathrow Airport (LHR), the flight crew noticed an oily smell in the cockpit, which seemed to be transient. Later, during the cruise, both crew members suffered from dry mouths. The commander also developed a headache and had an oily taste in his mouth, and the co-pilot's throat felt 'raw'. During the descent, both crew members began to feel disorientated and found that they had to concentrate hard to carry out their normal duties. At this point the commander began to feel 'confused'.

The decision was taken to carry out the '*SMOKE - FUMES AIR CONDITIONING*' checklist from the Quick Reference Handbook. Both crew members donned oxygen masks and a 'PAN' was declared. A normal approach was flown and an automatic landing performed on Runway 27R at LHR. After vacating the runway, the aircraft was stopped in order to assess the situation and the crew decided that it was safe to continue taxiing to the terminal. This was completed uneventfully.

The flight crew expressed concern that neither had detected the slow degradation in their performance as this only became fully apparent after they had donned oxygen masks and began to recover.

Aircraft information

Following this incident, the aircraft was inspected in accordance with specific procedures introduced by the airline for troubleshooting oil fume events. This did not identify any related defects and the aircraft was released for further service. Further inspections were performed on 16 October 2006, but these also proved inconclusive.

On 18 October, there were further reports of transient oil fumes in the cockpit on the initial climb on two sectors but, again, the source of the fumes again could not be identified.

On takeoff on 3 November 2006, there was another report of transient oil fumes in the cockpit with the flight crew reporting feeling nauseous by the end of the flight. On this occasion, engineering inspections identified oil staining on the left engine Low Pressure (LP) compressor outlet guide vanes, between the 5 o'clock and 6 o'clock positions. The left engine was removed from the aircraft on 6 November and sent to an overhaul agency for strip and repair.

Engine examination

At the time of removal, the left engine, serial number 31482, had completed 17,759 hours/13,551 cycles since new and 2,150 hours/1,532 cycles since its previous service. Strip examination identified evidence of oil leakage from the LP compressor speed sensor wiring conduit.

The speed sensor is mounted at the LP compressor front roller bearing housing and its wiring is routed radially outwards through a conduit, which is filled with silicone. With time, the sealant in the conduit can deteriorate, allowing engine oil to pass through the conduit and ultimately leak into the compressor air path. A proportion of this oil can be ingested into the bleed air system, which supplies air to the air-conditioning packs, and this can lead to reports of oil fumes in the cockpit and/or cabin.

Once the repairs were completed, the engine was run satisfactorily in a test cell. Internal visual inspection after testing did not reveal any evidence of oil leakage.

Additional information

The problem of fumes in the cockpit and/or cabin on the Boeing 757, and other aircraft, is not new and has been the subject of much industry discussion. AAIB Formal Report 1/2004 presents the findings of an extensive investigation into the problem of contamination of cockpit/cabin air supply by engine oil fumes and includes the results of studies into the physiological effects of such fumes.

In December 2000, The UK CAA issued Flight Operations Department Communication (FODCOM), number 17/2000, providing valuable safety advice on the use of flight crew oxygen masks in the event of smoke or fumes entering the cockpit. Further updated safety advice was provided in FODCOMs 14/2001 and 21/2002.

INCIDENT

Aircraft Type and Registration:	Boeing 767-2Q8, N330LF
No & Type of Engines:	2 General Electric CF6-80C2 turbofan engines
Year of Manufacture:	1989
Date & Time (UTC):	8 November 2006 at 1329 hrs
Location:	Bristol (Filton) Aerodrome
Type of Flight:	Commercial Air Transport (Non-Revenue)
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Left main landing gear door missing, hydraulic sytem failure
Commander's Licence:	Air Transport Pilot's Licence
Commander's Age:	56 years
Commander's Flying Experience:	7,536 hours (of which were on type) Last 90 days - 115 hours Last 28 days - 45 hours
Information Source:	AAIB Field Investigation

Synopsis

The aircraft was making a ferry flight from Nimes into Filton Aerodrome, Bristol, to be repainted. During taxi after landing at Filton the right hydraulic system was lost and centre system fluid quantity and pressure indications began to reduce. After reaching the stand it was observed that the left landing gear door was missing and that the hydraulic brake pipes on the landing gear leg had been severely damaged. A large portion of the landing gear door was recovered from the garden of a house in Chippenham, over which the aircraft had flown. Investigation revealed that the door had been released due to the failure of a castellated nut on the bolt associated with the door 'mid mount'. The door had been installed and rigged immediately prior to the ferry flight.

History of the flight

The aircraft had undergone maintenance in Nimes prior to entering service with a new operator, during which both of the main landing gear units were removed, overhauled and reinstalled. After completion of the maintenance input, the aircraft was to be ferried to Filton to be painted in the livery of the new operator. The flight crew reported that, on takeoff, the landing gear failed to retract on its first selection but, on reselecting the landing gear to UP and pressing the 'gear override' button, it retracted. After an uneventful flight, the flight crew decided to lower the landing gear early on the approach to Filton to allow time to assess any problems which may have arisen. The landing gear was selected to DOWN at approximately 8,000 ft and no problems were observed with its deployment. However, after a normal landing and when leaving the runway, the flight crew observed that the right hydraulic system fluid quantity and pressure were reducing. After three minutes, the right system pressure had fallen to 20 psi; the centre hydraulic system quantity and pressure then also began to fall. The flight crew reported that braking and steering remained normal until the aircraft reached its assigned stand and came to a halt. As the aircraft pulled onto the stand, the ground crew waiting to receive the aircraft observed that the left landing gear door was missing and that hydraulic fluid was leaking from the rear of the landing gear leg.

Landing gear door installation

The landing gear door is fitted with four attachment brackets which secure it to the landing gear leg; 'upper rod' and 'mid door' attachments, forward of the leg, and 'lower rod' and 'lower door' fittings, aft of the leg, Figure 1. As the names imply, both the upper and lower rod fittings make use of adjustable eye-ended rods to secure the door to lugs on the landing gear leg. The mid door attachment makes use of a nut and bolt to secure the door to a lug on the leg, and the lower attachment uses a short threaded eye-end rod and nut to secure the door to the lower rear mounting lug. When installed, the lower rod passes between the rear face of the landing gear leg and the wheel brake hydraulic pipes. The brake system is fitted with four hydraulic fuses, one in each pressure supply pipe, which are designed to shut off the hydraulic supply to individual brake units should a significant leak occur.

The procedure for installing and rigging a landing gear door is described in the Boeing 767 Maintenance Manual, task 31-12-06-404-011. This details the adjustment of the rod eye ends and the addition of spacers between the lugs on the leg and the mid and lower door fittings. This process requires the aircraft to be jacked up and landing gear to be retracted, to determine what adjustments, if any, are required. This is intended to ensure that the landing gear door maintains the correct clearance with the lower surface of the wing and is not subject to abnormal loads, either in flight or during retraction of the landing gear.

Boeing Service Bulletins

Since its entry to service, there have been several instances of landing gear doors becoming separated from Boeing 767 aircraft. In response to these events Boeing have issued four Service Bulletins:

Alert Service Bulletin (ASB) 767-32A0051

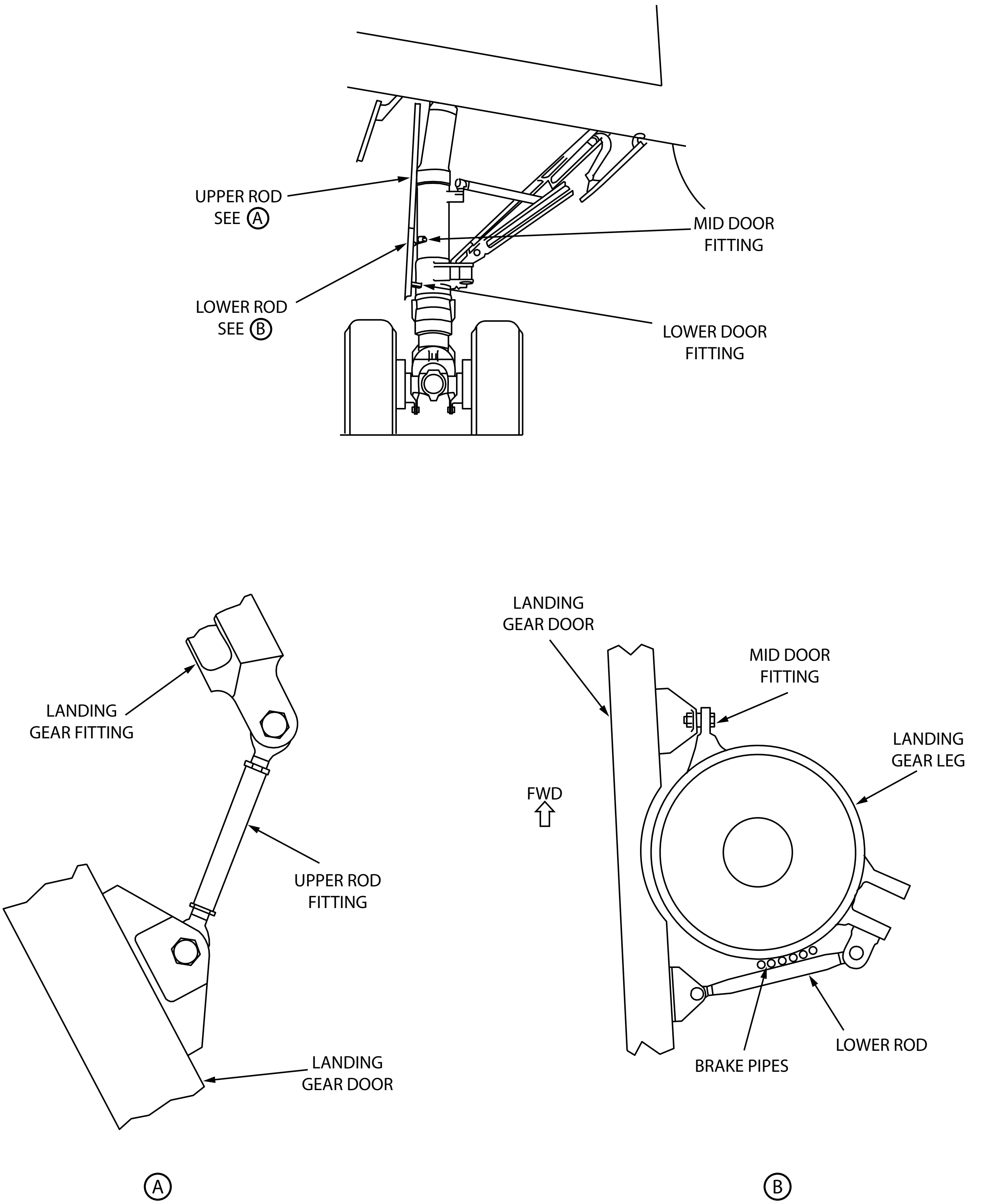
Issued in September 1985 and revised on October 1985, January 1986 and March 1997, this ASB introduced an inspection of the door mounting hardware and, as terminating action for the inspection, required the replacement of the originally installed nuts and bolts with items of improved strength.

Service Bulletin (SB)767-32-0101

Issued in January 1992 and revised in September 2003, this SB introduced a replacement lower aft attachment fitting.

Service Bulletin (SB)767-32-0146

Issued in March 1997 and revised in September 2003, this SB introduced a new mid forward door fitting together with the replacement nuts and bolts introduced by Alert Service Bulletin 767-32A0051.



Reproduced with approval of Boeing

Figure 1

Taken and adapted from:
Shock Strut Door and Linkage Installation for the Main Landing Gear (Figure 401 32-12-06)

Service Bulletin (SB)767-32-0194

Introduced in July 2002 and revised in September 2003, this SB replaced the mid forward and lower aft mounting hardware.

The aircraft maintenance records identified that only ASB 767-32A0051 had been incorporated on N330LF.

Flight Recorders

The aircraft was fitted with a Solid State Flight Data Recorder (FDR) and a Cockpit Voice Recorder (CVR). The FDR recorded over 100 hours of operation, including the incident, but the 30 minute CVR had continued to run and audio data covering the approach and landing had been overwritten.

At 14:20:17, the aircraft was descending through 8,000 ft when the landing gear was selected to DOWN. At the time of extension, the aircraft was decelerating through a Computed Airspeed (CAS) of 249.5 kt, with the speed brakes deployed. All landing gear legs were locked down 16 seconds later. The missing door was discovered at a location around 2 nm from the recorded aircraft position at landing gear extension, some 22 nm from the runway at Filton.

The aircraft touched down just over nine minutes later, at an airspeed of 127 kt. The left, centre and right hydraulic system pressures all indicated around 3,000 psi at that time and, just prior to touchdown, the fluid quantity in the right hydraulic system indicated 110%. (This parameter along with all other hydraulic quantities and pressures are only recorded every 64 seconds so only a trend can be determined.)

At 14:30:30, 52 seconds after touchdown, at a ground speed of 22 kt, the right hydraulic system quantity had decreased to 94% and continued to decrease as the aircraft taxied. Three minutes later, with the right hydraulic system quantity reading 30%, system pressure began to decay, finally reaching 0 psi three and a half minutes later. The system low pressure 'discrete' indication was triggered two minutes 45 seconds after the decay had started, at a pressure of around 1,000 psi. Subsequently, a reduction in the fluid quantity of the centre hydraulic system was observed, reducing from 82% to 65% just before the recording ceased. The final recorded hydraulic pressure of this system was 2,892 psi.

Technical examination

Examination of the aircraft revealed minor damage to the lower wings skins, the landing gear bay and the landing gear trunnion door; no other damage caused by the release of the door was observed on the aircraft structure. Visible damage to the landing gear leg was confined to the steel inserts pressed into the door attachment lugs. Approximately 10% of the landing gear door remained attached to the leg by the lower rod, the remainder having departed the aircraft prior to landing. Six hydraulic pipes, secured to the rear of the landing gear leg, had been bent and crushed by the rod, Figure 2, and two of the hydraulic fuses, those for the two rear brake units, were found to have operated.

The rod from the upper attachment, complete with the bolt and inserts from the door attachment bracket, were still attached to the landing gear leg. The remains of the lower door attachment, consisting of the threaded portion of the shank, complete with its castellated nut and cotter pin, were found on the landing gear bogie.

A bolt from the mid door attachment was recovered from the stand, which exhibited a degree of damage to the threads and which contained the remains of a cotter pin, Figure 3. With the exception of some minor bending and scoring of the shank, the bolt had not

Figure 2

suffered from any deformation and remained within manufactured dimensional tolerances. The threads of the bolt were free from contamination, evenly spaced and of uniform depth.

The remains of the landing gear door, comprising a section 1 x 1.7 m, and weighing approximately 15 kg, was discovered in the rear garden of a house in Chippenham by the house owner. Fortunately, the door had not caused any damage or injury to anyone on the ground. Three of the door attachment brackets, the upper rod, mid door and lower door attachments, remained securely fastened to the door. The upper rod mounting bracket had failed across the bolt holes, allowing the rod, complete with mounting bolt, to be released. The damage to the fitting and the nature of the fracture surfaces indicated that it had failed due to an overload condition in bending. The lower door attachment bracket still held the eye-end of the rod used to secure the door bracket to the landing gear. When the two sections of the rod were placed together, it indicated that the shank had been bent rearwards by 38º before it failed. Analysis of the geometry of the lower rod attachment hardware showed that, in order to come into contact with the hydraulic pipes, the rod must be rotated aft by 32°.

A comparison of the part numbers of the attachment hardware confirmed that the modification standard of the aircraft complied with the requirements of Boeing ASB 767-32A0051, but not subsequent Bulletins.

After the brake pipes had been repaired, the aircraft was flown to Nimes for replacement of the landing gear door. No further defects were reported during the retraction of the landing gear on this or subsequent flights.

Maintenance records

A review of the work-pack held by the organisation that carried out the landing gear removal and re-installation, confirmed that all of the landing gear units had been removed and refitted in accordance with the procedures detailed in the appropriate Boeing Aircraft Maintenance Manual. An investigation into the event conducted by the maintenance organisation commented that there had been some difficulties in rigging the landing gear, which required approximately ten retraction and extension cycles to be carried out prior to achieving a satisfactory result.

Figure 3

Analysis

Hydraulic systems

The hydraulic lines on the landing gear leg remain depressurised until the application of braking, therefore despite being damaged when the aircraft was airborne, the loss of hydraulic fluid would have been relatively slow until the aircraft had landed and the brakes were applied.

Although no braking parameters were recorded on the FDR, following the loss of the right hydraulic system, the braking system should automatically have switched to ALTERNATE, which is supplied by the centre hydraulic system. As the alternate and normal braking systems use the same hydraulic supply pipes to the brakes, fluid would have continue to leak from the damaged pipes, leading to the subsequent reduction in centre system fluid quantity as the brake system operated.

Door failure

Information from the flight data recorder revealed that the landing gear had been lowered at an airspeed close to, but below, the maximum allowable for its deployment. In flight, with the landing gear extended, aerodynamic forces apply both drag and side loads to the door. A crosswind component or aircraft manoeuvring would have a significant effect on the loads acting on the doors. Given their location, the door mounts forward of the landing gear leg would tend to experience tensile loads in addition to the drag load, and those to the rear, compressive loads, but such loading should not have caused the door to fail.

The remains of the cotter pin and the lack of distortion to the mid-fitting bolt indicated that the nut fitted to this bolt had failed due to a tensile overload. The loss of the nut would have precluded the mount from carrying tensile load, and all such loads would then have to be carried by the remaining forward mount. The damage observed on the upper rod fitting confirmed that it had been subject to tensile loading and, to a lesser degree, bending, prior to failure. Given the lack of distress to the mid-mount bolt and the damage observed to the remaining mounting hardware, it is considered probable that the loss of the landing gear door was initiated by the failure of the mid-mount nut.

The degree of distortion to the lower door mounting hardware, and the degree of rotation needed to bring the lower rod fitting into contact with the hydraulic pipes, left little doubt that both of the forward mounts, the upper rod and mid door attachments, must have failed in order to allow the landing gear door to rotate in such a manner.

The door mounting hardware fitted to the aircraft was compliant with the requirements of Boeing ASB 767-32A0051. A review of the other SB's relating to improvements in the landing gear door attachments showed that, although improved door mounting brackets had been introduced, the nut and bolt securing the mid mount to the landing gear leg remained unchanged until the release of SB 767-32-0194 in 2002. This was when the bolt was superseded. However, the part number of the nut securing this bolt remained the same as that introduced by ASB 767-32A0051. Given that the door attachment fittings remained securely attached, and that the initiation of the door loss resulted from the failure of the nut on the mid-mount bolt, the fact that the three later SB's had not been embodied is not considered to have been a factor in this event.

The report from the maintenance organisation stating that numerous landing gear retractions were required to rig the door gave rise to the possibility that the door mounting hardware, and the mid-mounting bolt in particular, may have been subject to unusual loads during the process.

Conclusions

The loss of the landing gear door was initiated by the failure of the castellated nut on the door mid-mount fitting. Whilst the speed at which the landing gear was deployed was higher than that expected in routine operation, it was within the aircraft's landing gear limit speed, and was considered unlikely to have initiated the nut failure.

Given that the part number of the castellated nut fitted to the door mid-mount remained the unchanged in the Service Bulletins released after SB 767-32A0051, the modification standard of the door mounting hardware is also unlikely to have been relevant to the loss of the landing gear door.

However, the possibility that the failure of the nut resulted from overload during the repeated landing gear retractions carried out during the door rigging procedure prior to the incident flight, could not be dismissed.

INCIDENT

Aircraft Type and Registration:	Boeing 767-383, G-VKNI
No & Type of Engines:	2 Pratt & Whitney PW4060 turbofan engines
Year of Manufacture:	1989
Date & Time (UTC):	28 September 2006 at 1854 hrs
Location:	Royal Air Force Brize Norton, Oxfordshire
Type of Flight:	Public Transport
Persons on Board:	Crew - 12 Passengers - 136
Injuries:	Crew - None Passengers - None
Nature of Damage:	Abrasion damage to tailskid
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	42 years
Commander's Flying Experience:	8,700 hours (of which 2,300 were on type) Last 90 days - 210 hours Last 28 days - 70 hours
Information Source:	Aircraft Accident Report Form submitted by the commander, operator's reports, and flight data analysis by Boeing

Synopsis

Immediately after touchdown, the aircraft pitched nose-up and the tailskid came into contact with the runway, causing light abrasion damage. Recorded flight data showed that the pitch-up was probably caused by an 'up-elevator' control input by the handling pilot when the aircraft 'skipped' on landing. It may also have been aggravated by the simultaneous manual deployment of speed brakes by the non-handling pilot. The aircraft had touched down at less than the recommended speed, which resulted in an increased pitch attitude and therefore a reduced tail clearance margin. Additionally, a significant mass of baggage had been loaded in the rearmost hold, which the crew had not accounted for in their weight and balance calculations. Although centre of gravity limits were not exceeded, this served to make the aircraft more sensitive in pitch.

History of the flight

The aircraft was being flown under charter to the UK Ministry of Defence (MoD) and was landing at RAF Brize Norton when the incident occurred. The aircraft's crew had travelled by road from Gatwick Airport to RAF Brize Norton the previous day, reporting on the day of the incident at 1030 hrs. They were scheduled to operate a return flight to Zagreb, in the Republic of Croatia, and then to fly the aircraft empty to Gatwick.

Among the Acceptable Deferred Defects (ADDs) entered in the aircraft technical log was one concerning the automatic speed brake system (used to deploy the wing spoiler panels after landing). According to the log entry, the system was inoperative pending rectification. Although manual operation of the speed brakes was unaffected. The control lever on the flight deck was labelled "INOP". This was the only item of significance regarding the outbound flight to Zagreb.

The aircraft was subject to a longer than usual turn-round at Zagreb due to baggage handling problems. A Loading Instruction Report (LIR) was compiled and passed to the flight crew. The co-pilot used the LIR to complete a load sheet, which was then countersigned by the aircraft commander. The aircraft departed Zagreb at 1640 hrs with 136 passengers on board (maximum capacity 325), and with the co-pilot as the handling pilot.

The co-pilot later reported that, as the aircraft reached V_R during the takeoff run, it began to pitch up without any control column movement. The aircraft rotated to about eight degrees of pitch, after which control inputs were required to continue pitching to the target attitude. No excessive control inputs were required, and the commander was unaware that the co-pilot had experienced anything unusual with the rotation manoeuvre. The co-pilot reported that he raised the issue with the commander later in the climb but the commander did not pursue the matter. The commander reported that he did not recall the matter being raised.

During the co-pilot's approach and landing briefing the crew discussed the requirement for manual deployment of the speed brakes after landing. The weather for the approach was fine, with a reported visibility greater than 10 km and a surface wind from 200º(M) at 5 kt. The aircraft was vectored for an ILS approach to Runway 26, and the autopilot and autothrottle were disconnected at about 1,000 ft aal during the approach. At a late stage of the approach, the commander alerted the co-pilot to the fact that the airspeed was slightly low and the co-pilot applied engine power to correct the situation. The aircraft then deviated slightly above the glide slope, and the co-pilot made a control input to correct this. The resultant increased descent rate had been arrested by a height estimated to be 20 ft above the runway and, following the flare, an apparently normal main-gear touchdown was achieved.

The co-pilot selected reverse thrust at touchdown and the commander manually deployed the speed brakes. The co-pilot recalled that, as he relaxed the rearwards pressure on the control column in order to lower the nose gear to the runway, the aircraft unexpectedly pitched up. Both pilots pushed forwards on their control columns, and the co-pilot delayed further application of reverse thrust. A significant amount of forward control column movement was required to stop the pitch up and to return the aircraft to a normal attitude. Subsequent nose gear touchdown and the remainder of the landing roll were normal.

Once the aircraft was parked, a normal unloading sequence was begun before the crew intervened. This prevented an accurate assessment of the mass distribution in the aircraft's holds, for comparison against the LIR. An aircraft inspection revealed that a tail strike had occurred, but that damage was light and confined to the tailskid friction pad; there had been no compression of the tailskid. It was also later established that the automatic speed brake system had actually been rectified two days before the flight, and was thus serviceable. Although an entry to this effect had been made in the technical log on a previous sector record page, the ADD page itself had not been amended, nor had the "INOP" placard been removed from the control lever. The aircraft was subsequently flown empty by the same crew to London Gatwick without further incident.

Loading and performance information

The loading operation at Zagreb was undertaken by the operator's local handling agents, and military personnel assisted with manual tasks. There were certain ground handling aspects of such MoD charter flights that were unusual, so a company representative from the operator's Airport Services department travelled on the aircraft and oversaw the turn-round process.

As the operator kept no stock of baggage containers at Zagreb, baggage had first to be unloaded from the containers off the inbound flight before they could be loaded with baggage for the return flight. It was agreed with the flight crew that the same container positions would be used for the return as were used on the outbound flight. However, on this occasion a greater volume of baggage necessitated that 2,339 kg of loose bags be loaded into the bulk hold (hold five) at the rear of the aircraft. The load figures were passed to the company representative, who then completed the LIR and gave it to the flight crew. The LIR accurately reflected the load distribution, including the bags in the bulk hold.

When the co-pilot compiled the load sheet, he did not notice the bags recorded on the LIR as being in the bulk hold, so they were not reflected on the load sheet. Nor was the error noticed by the commander, who countersigned the load sheet. The aircraft takeoff mass as stated on the load sheet was 129,868 kg, and the Centre of Gravity (CG) was calculated at 26% Mean Aerodynamic Chord (MAC). This represents a lightly loaded aircraft at a slightly aft CG. Using this information the crew determined a stabiliser trim position of 2.0 units and takeoff speeds of: V_R 139 kt, V_2 145 kt. With the additional 2,339 kg in the bulk hold, the takeoff mass was actually 132,207 kg and the CG was further aft, at 30.5% MAC. The aft CG limit at the actual takeoff mass was at 33.3% MAC. The stabiliser trim setting for the actual takeoff mass and CG would have been approximately 1.3 units, and the takeoff speeds would have been increased by between 1 and 2 kt. G-VKNI was re-weighed on 23 May 2007, and no change of any significance was found to the mass or indices used by the crew at the time of the incident.

The landing data card, completed by the crew in-flight, showed a landing mass of 119,500 kg. The flaps 30 V_{ref} speed for this mass was 131 kt, which the crew obtained from the Flight Management Computer (FMC). The actual landing mass was approximately 121,839 kg. The V_{ref} speed for 121,800 kg (the FMC displayed masses to the nearest 100 kg) would have been 132 kt.

Recorded information

Boeing's Air Safety Investigation Department conducted an analysis of the Flight Data Recorder (FDR) data for both the takeoff and landing events. However, several parameters were not valid during the period of the takeoff and initial climb. These parameters included the EPR and speeds for both engines, both elevator positions, and the stabilizer position. The stabilizer position remained invalid throughout the flight, while the elevator and engine data returned to normal after the initial climb period. The nature of the data anomalies suggested a maintenance issue existed, which the aircraft operator has been made aware of. The airspeed, groundspeed and vane angle data confirmed that the atmospheric conditions were relatively calm during the landing event. A simplified presentation of the relevant fight data is at Figure 1.

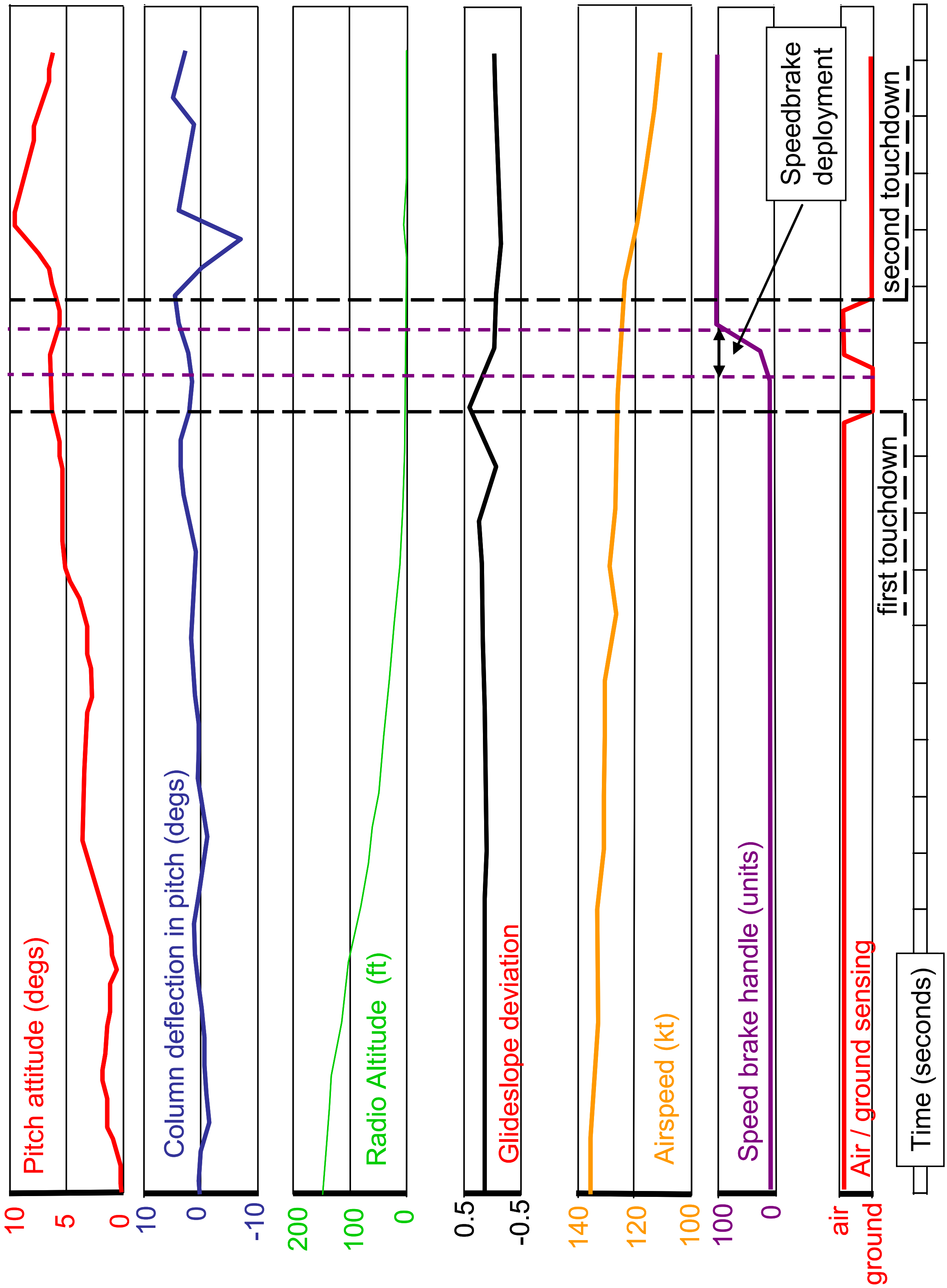


Figure 1

Relevant flight data (simplified)

Takeoff event

The recorded data showed an incremental nose-up control column input of 2.5º to 3º at 135 kt, which initiated aircraft rotation. This was compared with Boeing flight test data. It showed that 5º-6º of column movement was required at maximum takeoff thrust with the recommended stabilizer position set, at a similar mass and with the further-aft centre of gravity location of the incident aircraft. In order to validate the control column data, the column-elevator relationship implied by the recorded data for the subsequent landing was checked against values obtained in the simulator. This comparison showed that the column-elevator gearing was as expected.

Landing event

The data showed that the approach was stabilized as the aircraft descended through 700 ft radio altitude, and confirmed the crew's report that the aircraft began to deviate above the glideslope shortly before landing. At 40 ft radio altitude, a nose-up control input was made, to check the descent rate and subsequently flare the aircraft. A nose-down elevator input followed, which increased the descent rate. Initial touchdown occurred at 6.4º pitch attitude and at 126 kt (V_{ref}30-5). The descent rate was approximately 80 feet per minute, or 1.3 feet per second, with a load factor of 1.3g.

At touchdown, the main gear untilted (producing an 'on ground' signal) then tilted again, suggesting that the aircraft unloaded or 'skipped' before touching down again with a maximum recorded vertical acceleration of 1.55 g. An incremental 9º nose-up elevator command commenced with speed brake deployment, shortly before the main gear tilted again. There was a significant pitch-up after the second touchdown, which led to the pitch attitude increasing from the touchdown attitude of 6.4º to 9.5º in 1.5 seconds. The flight crew responded to this pitch-up with an incremental nose-down elevator input of 26º (from 16º nose up to 10º nose down).

Handling information

The Boeing Flight Crew Training Manual (FCTM) for the B767-300 gives guidance and advice to flight crews regarding landing techniques. It recommends that the aircraft touchdown at no less than V_{ref} speed, producing in this case a pitch attitude of about 5.5º. Touchdown at a speed of V_{ref}-5 increases the touchdown pitch attitude, effectively reducing the tailskid clearance margin. Tailskid contact will occur at a pitch attitude of 7.9º with the main gear oleos compressed, and at 9.6º with the oleos extended. Tailskid contact during landing is therefore possible between these two values. According to the FCTM, touchdown in this instance would theoretically have occurred at a pitch attitude of 6.9º.

Some nose-up pitching moment is normal with speed brake deployment on landing and is caused by the resulting movement of the centre of lift. However, Boeing considers that this moment is negligible (with both manual and automatic deployment), provided that correct airspeeds and pitch attitudes are used, and that additional factors do not contribute to pitch-up. However, the pitching moment increases if touchdown is made at speeds less than V_{ref} with associated higher pitch attitudes.

When automatic speed brake deployment is used, some spoiler panels are delayed by 1.25 seconds, which reduces the initial pitch-up moment. If speed brakes are deployed manually, and if the rate of deployment is rapid, there may be reduced or zero delay in spoiler panel deployment. However, reviews of landing tail strike events by Boeing have indicated that manual speed brake deployment was not a factor in any of the cases studied.

Discussion

Although the loading operation in Zagreb was protracted, it was completed in accordance with the operator's instructions and the LIR was accurate, as far as could be ascertained. The co-pilot's error in compiling the load sheet (and the likely reason why the commander did not detect it) probably occurred because of an expectation of how the aircraft would be loaded. The flight crew was asked about the loading configuration, and had indicated that the same container positions should be used for the return as were used on the outbound flight. Thus, with a relatively small passenger load, the crew would not have anticipated a need for the bulk hold to be loaded. As the bulk hold was not commonly used during routine operations, it may have been prudent for the company's Airport Services representative to bring its use to the flight crew's attention.

Takeoff speed errors (which resulted from the load sheet error) were small, and fell within the natural tolerances experienced during line operations. The effect of the error on aircraft trim was more significant, as it resulted in the stabilizer trim being mis-set for takeoff, although the CG limitations were not exceeded. The co-pilot's recollection was that the aircraft started rotation without control input, but data analysis confirmed that a control input had been made which was sufficient, given the loading configuration and mis-set stabilizer trim, to initiate rotation, albeit at some 5 kt below V_R. Additionally, the more aft CG would have resulted in lighter than normal control forces to initiate rotation. The lack of valid recorded engine and stabilizer position data during the takeoff made it difficult to draw further conclusions.

There is a discrepancy in the crew's reports concerning whether the aircraft's behaviour during takeoff was discussed later in the flight. The principles of good Crew Resource Management require that other crew members be made aware of any unusual handling characteristic as soon as possible. If the matter had been raised, it would be expected that the loading paperwork would have been reviewed during the flight, which should have revealed the load sheet error. If, as the co-pilot reports, the commander chose not to investigate his comments, there should have been nothing to prevent the co-pilot from reviewing the paperwork independently.

As with the takeoff speeds, the landing V_{ref} speed error was small and should not have been significant during a normal landing. However, in this case it did serve to increase the pitch attitude, albeit by a small amount. If the aircraft had touched down at V_{ref} speed, the pitch attitude would have been about 5.5º. When the extra mass in the bulk hold is considered, the touchdown speed was actually V_{ref}-6. The reduced touchdown speed lead to an increased pitch attitude and thus a reduced tail skid clearance margin. The nose-up elevator command may have been a reaction to the lack of lift resulting from speed brake deployment, which would have been evident during the landing 'skip'. Alternatively, it may have been in anticipation of an expected input to prevent the nose-gear making too firm a contact with the runway; some aft control column pressure is normally required during landing as the aircraft 'de-rotates'.

As the pitch attitude increased after landing, the aircraft quickly entered the pitch band at which a tail strike was possible, almost reaching the upper limit at which a tail strike would occur even with the main gear oleos fully extended. It is probable that the nose-up elevator command, combined with the speed brake deployment and aft CG, produced the significant pitch-up after the second gear tilt, which resulted in tailskid contact.

ACCIDENT

Aircraft Type and Registration:	Cessna T303, Crusader, D-IAFC
No & Type of Engines:	2 Continental Motors Corporation IO-520-AE piston engines
Year of Manufacture:	1983
Date & Time (UTC):	19 September 2006 at 1228 hrs
Location:	North Sea, approximately 9.5 nm south-east of Aldeburgh, Suffolk
Type of Flight:	Commercial Air Transport (Cargo)
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Serious) Passengers - N/A
Nature of Damage:	Destroyed
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	67 years
Commander's Flying Experience:	24,000 hours (of which 6,000 were on type) Last 90 days - 65 hours Last 28 days - 35 hours
Information Source:	AAIB Field Investigation

Synopsis

Whilst on a cargo flight from Braunschweig, Germany, to Oxford, England, when approximately 30 nm from the English coast, the right engine started to run roughly. On checking the fuel gauges, the pilot observed that they were indicating in the 'red sector'. The right engine subsequently stopped, shortly followed by the left engine. The aircraft then glided from FL100 towards the Suffolk coast and ditched in the sea approximately 9.5 nm southeast of Aldeburgh. The pilot was able to abandon the aircraft, which sank quickly. He was rescued from the sea some 18 minutes later by a Royal Air Force Search and Rescue helicopter and taken to hospital, where he was found to have suffered a fractured a vertebra. The investigation determined that the aircraft had run out of fuel, due to insufficient fuel for the intended journey being on-board the aircraft at the start of the flight.

Background information

Four days prior to the accident the pilot flew D-IAFC from Braunschweig (EDVE), Germany, to Bratislava (LZIB) in the Slovak Republic. The pilot believed he filled the fuel tanks to full before returning to EDVE; this flight took 1 hr 59 mins. The aircraft was then not flown again until the accident flight.

On the morning of the accident, the pilot received a telephone call asking him if he could fly an ad hoc cargo charter flight from EDVE to Oxford (Kidlington) Airport (EGTK), to which he agreed. Because the flight was to be conducted as soon as possible, the pilot called a friend in Hanover, Germany, and asked him to prepare the routing, fuel plan and submit the ATC flight plan[1]. Having done this, his friend faxed the paperwork to the pilot at EDVE.

The pilot calculated that the fuel remaining in the aircraft from the previous flight would be sufficient to complete the flight to EGTK. This was based on his experience from numerous long flights using a 'Digi-Flow' fuel flow meter fitted to the aircraft. He believed that, with full fuel and careful leaning of the fuel/air mixture to the engines during the cruise, the aircraft would have an endurance of 5 hrs 30 mins to fuel exhaustion. Reasoning that he had refuelled the fuel tanks to full at LZIB prior to returning to EDVE, and with a planned flight time of 2 hrs 30 min to EGTK, he estimated that the aircraft had an endurance remaining of 3 hrs 30 mins. Additionally, he could not refuel to full tanks prior to flying to EGTK as he thought that this would have put the aircraft above its Maximum Take Off Weight (MTOW).

The pilot reported that upon checking the fuel gauges prior to departure from EDVE, they were both indicting three-quarters full.

History of the flight

D-IAFC took off from EDVE at 1003 hrs with 262 lb of cargo on-board[2]. The aircraft climbed to FL100 for the cruise, and flew at a TAS of 170 kt; this gave a groundspeed of approximately 160 kt as computed by the aircraft's Global Positioning System (GPS) receiver.

The aircraft's routing took it west through Germany and southern Holland before entering UK airspace. During the flight the pilot did not notice anything untoward and the times overhead en-route waypoints correlated reasonably well with the calculated times. As the weather was good he planned to continue under VFR after the Clacton VOR (CLN), so as to fly around the London Terminal Manoeuvring Area to minimise any potential delays. The flight progressed without incident until shortly after the aircraft crossed the UK FIR boundary at reporting point REFSO, 56 nm to the east of CLN, at 1158 hrs. He was then transferred to London ATC and, upon initial contact, was given clearance to fly direct to CLN.

At 1212 hrs, when 30 nm from the Suffolk coast and still at FL100, the aircraft's right engine began to run roughly. Initially, the pilot thought this might have been caused by water in the fuel so he switched on the fuel booster pump. The engine recovered momentarily and then stopped. On looking at the fuel gauges, he noticed both were indicating in the 'red sector'. As a result, the pilot transmitted a PAN call to ATC, advising them that he was short of fuel and asked them what was the "next airport?" They advised him it was Stansted Airport, 72 nm away. The pilot said he thought he had only five minutes of fuel remaining and declared an emergency. ATC asked the pilot to squawk 7700[3] and advised him that Clacton Airport was 38.6 nm away; he replied that this was too far. ATC informed him that the closest point on the coast was 30 nm distant and gave him a heading to fly. He then said that he was looking for a ship below,

Footnote

[1] Although the pilot had intended the flight-plan to state that the flight would be conducted as a General Aviation IFR flight, it was in fact submitted as a Commercial IFR flight.

[2] See paragraph titled **Aircraft's Weight**.

Footnote

[3] Squawk code 7700 is the MAYDAY transponder code.

that he was descending at approximately 500 ft/min and could only fly for about another 10 nm. ATC advised him that the emergency services had been alerted.

At 1217 hrs, the pilot was informed by ATC that the coast was now 23 nm away and they asked him if the aircraft's engines had stopped. He replied saying that the right engine had stopped and only the left was working. Three minutes later the pilot was transferred to the Distress and Diversion (D&D) radio frequency of 121.5 MHz[4].

On initial contact with D&D, the pilot informed the controller that "both engines are dead now" and that he was planning to ditch in the sea near to one of three ships that he could see. They advised him that a Search and Rescue (SAR) helicopter had been scrambled and, upon enquiring how far away it was, the pilot was informed 15 mins. He replied that he thought he had only three minutes before he would have to ditch.

At 1225:30 hrs, the pilot reported he was at 1,500 ft amsl, to which D&D informed him he was 9 nm from the coast. Shortly thereafter, they informed him radar contact had been lost. He replied that he expected to ditch in about 30 seconds and removed his headset in preparation. No further communications were received from the aircraft. Although the aircraft's Operating Manual contains a section on '*Ditching*', and the pilot later stated that he carried out the ditching check list from memory.

As the aircraft approached the sea, the pilot positioned it to fly parallel to the heading of a ship he had seen during the descent, planning to ditch near it in order to minimise the time taken to be rescued. At 100 ft amsl, he opened the emergency hatch located in the right door. Just before the aircraft touched down, the pilot flew the aircraft level, until the stall warning sounded. At a speed of about 80 kt, the tail of the aircraft hit the sea, followed by the fuselage. The aircraft survived the impact without breaking up and, when it came to rest, the pilot unstrapped, abandoned the aircraft through the emergency hatch, climbed onto the right wing, took off his shoes and got into the water. Due to the swell of the sea, water entered the aircraft cabin through the open hatch and it sank after approximately three minutes. The accident occurred at 1228 hrs.

The ditching was witnessed by personnel on the ship, who immediately launched a lifeboat. Just before this reached the pilot, the SAR helicopter arrived on the scene and winched him on board. Once in the helicopter, the pilot was found to be suffering from the effects of immersion in cold water. He was flown to a hospital in Ipswich, Suffolk, where he was found to have suffered a fractured vertebra.

Search and Rescue

At 1216 hrs, D&D were informed by London ATC that an aircraft had run out of fuel and was going to ditch in the sea. Control of the SAR operation was subsequently transferred to the Aeronautical Rescue Control Centre (ARCC) at RAF Kinloss, Scotland. As a result, at 1240 hrs, two lifeboats, one from Harwich and one from Aldeburgh, Suffolk, were launched. The SAR helicopter from RAF Wattisham, near Ipswich, was scrambled at 1226 hrs and, by 1245 hrs, had winched the pilot on board. The Harwich lifeboat was then stood down but the Aldeburgh lifeboat continued to the scene to search for wreckage and to check for possible pollution. On arrival on the scene, at 1312 hrs, no evidence of either was found.

Footnote

[4] This was to enable radio contact to be maintained for as long as possible in the descent, as this frequency had a better low level capability than the en-route frequency.

During D-IAFC's gliding descent, the crew of a commercial passenger aircraft inbound to London Heathrow Airport (LHR) from Brussels, was asked by ATC if they could offer assistance in locating the aircraft during the final stages of descent before radar contact was lost; at this point D-IAFC was 15 nm ahead. Having assessed that their aircraft had an excess endurance of approximately 15 mins, the crew were able to help. ATC cleared the aircraft to descend to FL100 and vectored it in the direction of D-IAFC. Once above D-IAFC's position, the crew became visual with the aircraft and watched it ditch approximately one nautical mile ahead of a ship. They then informed ATC that the aircraft was floating and had not broken up, and passed on its position before continuing to LHR.

Another commercial passenger aircraft, also inbound to LHR, had fuel available to remain in the area for two hours and offered further assistance. This aircraft proceeded to the position passed by the previous aircraft and, with ATC clearance, descended to 3,000 ft asml. Once overhead, the crew observed a stationary ship, but no aircraft, and passed the description of the ship to ATC. At this time, the SAR helicopter was approximately 5 nm west of the position. Upon arriving at the scene the helicopter crew became visual with the ship and its lifeboat before locating the pilot in the water. On hearing this over the radio, the passenger aircraft continued to LHR.

Survival aspects

The pilot was fortunate to locate a ship prior to ditching and to have commercial air traffic in the vicinity to expedite his rescue. He was dressed in a long sleeved shirt and trousers. At the time of the accident the sea temperature was 17ºC and, at this temperature, without appropriate survival equipment, he had an expected survival time of just over one hour[5]. He was in the water for 18 minutes.

Footnote

[5] Data from the Royal Air Force.

Weather

An aftercast covering the duration of the flight was obtained from the Met Office. This stated that the wind at FL100, was from 230º at 25 to 30 kt. At the ditching location there was scattered cumulus cloud at 3,000 ft amsl, the surface wind was from 270º at 15 to 20 kt and the visibility was in excess of 10 km. Additionally, the sea swell was 0.5 to 1 m with a period of five seconds. The average track for the flight was 260º. The wind at FL100 would have given a headwind component of approximately 22 kt.

Pilot's comments

The pilot was interviewed by the AAIB in hospital the day after the accident. He was also interviewed by the German Federal Bureau of Aircraft Accidents Investigation - Bundesstelle für Flugunfalluntersuchung (BFU) - after his return to Germany.

He stated that he had planned the flight on the basis of an average fuel consumption rate of 104 litres/hr. He added that there was a 'Digi-Flow' meter fitted to the aircraft but that it had not been serviceable for "some time". Because the manufacturing company had ceased trading it had not been possible to obtain any spare parts. Additionally, he stated that the aircraft's fuel gauges were "pretty inaccurate" and so he usually trusted his own calculations. The aircraft was not fitted with low fuel quantity warning lights.

The pilot also stated that there was no way of directly establishing the contents of the fuel tanks on the ground, due to the dihedral of the wings and the fact that the refuelling caps are located close to the wing tips. Also, there were no dip sticks fitted. The only indication of fuel quantity on board the aircraft were the readings from the fuel gauges located close to the cockpit floor. He added that he had not checked these during the cruise until the right engine started to run roughly, as they were difficult to see as well as being inaccurate[6].

The aircraft did not carry a liferaft, but two lifejackets were located in the rear of the cabin. The pilot stated he had not worn one as he had not remembered that they were there.

Aircraft fuel system

The Cessna T303 has one fuel tank in each wing, with a total useable fuel capacity of 579 litres (918 lb). There are two fuel gauges, one for each tank, marked left and right, located at the rear of the centre console just above floor level, Figure 1.

The lower sector of the fuel level scale is marked in red, to indicate when only unusable fuel is remaining in each tank; unusable fuel is quoted in the manual as 12 lb.

A separate low fuel level warning system, incorporating two warning lights on the instrument panel, was available as a customer option on the T303, but this was not fitted to D-IAFC. Each light illuminates when the fuel remaining in its respective tank reduces to 38 litres (60 lb) or less.

The aircraft had been modified to incorporate a 'Digi-Flow' digital fuel flow meter, but this had been inoperative for some time.

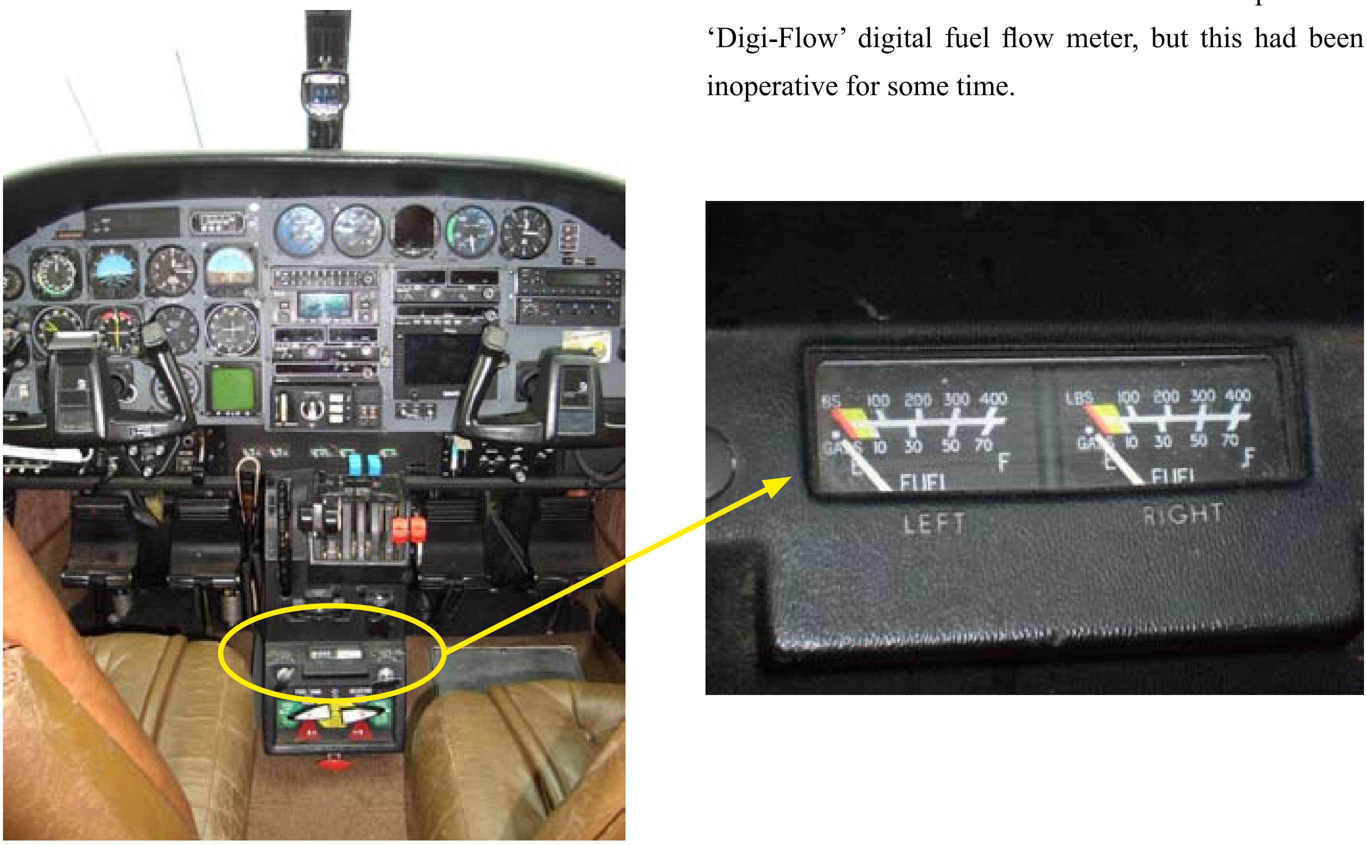


Figure 1

Footnote

6 Another operator of this aircraft type has also reported that the fuel gauges are inaccurate.

Company information

The aircraft's operating company had an Air Operator's Certificate (AOC) issued by the German authorities. This gave approval for the company to transport cargo and passengers. The AOC was valid at the time of the accident.

The company's flight planning documentation states that 25 lb of fuel should be allowed for during start-up and taxi, and a fuel flow rate of 174 lb/hr should be used for calculating the trip fuel. This includes the fuel used during climb and descent. Additionally, there are columns to add to the trip fuel for contingences such as diversion to an alternate airfield and 45 mins holding.

Aircraft performance

The flight planned track from EDVE to EGTK was 468 nm and the head wind component was approximately 22 kt. When this data is plotted on the Fuel and Time Required (60% power) graph in the aircraft's Operating Manual, a flight time of approximately 3 hrs 21 minutes and fuel required of approximately 585 lb is predicted. This includes fuel for engine start, taxi, takeoff, normal climb, descent and 45 minute reserve. The time required includes that for normal climb and descent, all of which equates to a fuel consumption rate of 174 lb/hr. The Holding Time table states that 80 lb of fuel is required for 45 minutes holding at 45% power.

Fuel plan

All pre-flight and in-flight paperwork was on-board the aircraft and was not recovered. However, the refuel certificate for D-IAFC was obtained from LZIB, and this showed that 200 litres (317 lb) of fuel was uplifted prior to the aircraft returning to EDVE. Table 1 compares the pilot's assumed fuel load and endurance with the (AAIB) estimated fuel load and endurance, for the accident flight and the two previous flights. The estimated departure fuel figures were derived with reference to the aircraft's

	Depart EDVE	Arrive LZIB	Depart LZIB	Arrive EDVE	Depart EDVE	Arrive EGTK
Pilot's assumed fuel on board (lb)	918 (a)	406	918 (b)	548	548 (d)	113
AAIB estimated fuel on board (lb)	918 (a)	406	723 (c)	353	353 (d)	-107
Pilot's assumed endurance	5 hr 30 min	---	5 hr 30 min	---	3 hr 30 min	1 hr
AAIB estimated endurance	5 hr 8 min	---	4 hr 0 min	---	1 hr 53 min	-37 min
Flight time	2 hr 48 min	---	1 hr 59 min	---	2 h 30 min (e)	---

Table 1

Pilot's assumed and AAIB estimated fuel figures and endurances

Notes:
(a) Aircraft departed EDVE with full tanks
(b) Pilot assumed the tanks were full prior to departing LZIB
(c) Fuel records show only 200 litres (317 lb) uplifted at LZIB, giving 723 lb on departure
(d) Aircraft was not refuelled again prior to departing for EGTK
(e) Flight plan estimated elapsed time

refuelling records. The arrival fuel figures and the endurances were calculated using the fuel consumption figures quoted in the operator's flight planning logs.

The estimated endurance figures are to fuel exhaustion and make no allowance for reserve and alternate fuel.

Aircraft's weight

The MTOW of D-IAFC was 5,150 lb.

When interviewed after the accident, the pilot stated to the AAIB that there was 200 lb (90.9 kg) of cargo on board the aircraft. When interviewed by the BFU, on his return to Germany, he amended this to 540 lb (242.5 kg). He later explained that he had expected a cargo of this weight and, as this would have placed the aircraft close to its MTOW, he decided not to refuel prior to departing for EGTK. Documents recovered from the supplier of the cargo indicate that its total weight was actually 262 lb (119 kg). As this flight was an ad hoc charter flight, the cargo supplier is convinced there was no additional cargo on board. Furthermore, the operating company's insurer has not been notified of any other loss other than the 262 lb of documented cargo.

The following tables compare the aircraft's takeoff weight for its flight from EDVE to EGTK (using the two different cargo weights) with the maximum permitted takeoff weight, with the pilot's assumed fuel on board (Table 2) and the AAIB estimated fuel on board (Table 3). These tables use a basic aircraft weight of 3,654 lb, a pilot weight of 187 lb and the fuel figures from Table 1; all weights are in pounds.

	540 lb cargo	262 lb cargo
Aircraft's weight with pilot	3,841	3,841
Pilot's assumed fuel	573	573
Fuel used during start up/taxi	-25	-25
Pilot's assumed takeoff weight	4,929	4,651
Fuel weight available, but not used, limited by the MTOW	221	499
Additional flight time if fuel weight available had been used, assuming fuel consumption at 174 lb/hr	1 hrs 16 mins	2 hrs 52 mins

Table 2

	540 lb cargo	262 lb cargo
Aircraft's weight with pilot	3,841	3,841
Pilot's assumed fuel	378	378
Fuel used during start up/taxi	-25	-25
Pilot's assumed takeoff weight	4,734	4,456
Fuel weight available, but not used, limited by the MTOW	415	694
Additional flight time if fuel weight available had been used, assuming fuel consumption at 174 lb/hr	2 hrs 23 mins	3 hrs 59 mins

Table 3

Joint Aviation Requirements - Operations (JAR-OPS) 1

'*JAR-OPS 1 Subpart B - General, Appendix 1 to JAR-OPS 1.005(a) paragraph (12) 1.255 Fuel Policy*' states:

> *'(ii) For A to B Flights – An operator shall ensure that the pre-flight calculation of usable fuel required for a flight includes;*
>
> *(A) Taxi fuel - Fuel consumed before take-off, if significant; and*
>
> *(B) Trip fuel (Fuel to reach the destination); and*
>
> *(C) Reserve fuel -*
>
> *(1) Contingency fuel - Fuel that is not less than 5% of the planned trip fuel or, in the event of in-flight re-planning, 5% of the trip fuel for the remainder of the flight; and*
>
> *(2) Final reserve fuel - Fuel to fly for an additional period of 45 minutes (piston engines) or 30 minutes (turbine engines); and*
>
> *(D) Alternate fuel - Fuel to reach the destination alternate via the destination, if a destination alternate is required*
>
> *(E) Extra fuel – Fuel that the commander may require in addition to that required under subparagraphs (A) – (D) above.'*

Joint Aviation Requirement - Flight Crew Licensing (JAR – FCL) 1

'JAR – FCL 1, subpart A – General Requirements', states:

> *'JAR–FCL 1.060 Curtailment of privileges of licence holders aged 60 years or more*
>
> *(See Appendix 1 to JARFCL 1.060)*
>
> *(a) Age 60–64. The holder of a pilot licence who has attained the age of 60 years shall not act as a pilot of an aircraft engaged in commercial air transport [CAT] operations except:*
>
> *(1) as a member of a multi-pilot crew and provided that,*
>
> *(2) such holder is the only pilot in the flight crew who has attained age 60.*
>
> *(b) Age 65. The holder of a pilot licence who has attained the age of 65 years shall not act as a pilot of an aircraft engaged in commercial air transport operations.*
>
> *(c) Any national variant to the requirements in (a) and (b) above are given in Appendix 1 to JAR-FCL 1.060.'*

There are no German national variants to the requirements in (a) and (b) in Appendix 1.

Analysis

Licensing

The pilot was 67 years old at the time of the accident. He held a Commercial Pilot's Licence. This was valid until 18 June 2007, but this only permitted him to fly in Germany, which he also did as a flying instructor. His licence, however, was not valid for him to fly as a pilot of an aircraft engaged in CAT operations, as he was over 65 years old.

Fuel planning

The fuel flow rate (of 104 litres/hr) that the pilot stated he used in his calculations, equates to 164 lb/hr. With the aircraft's fuel tanks full, this equates to a flying time (to fuel exhaustion) of 5 hrs 26 mins, allowing 25 lb for start up and taxi. This figure is effectively the same as the pilot's assumed full tanks endurance of 5 hr and 30 mins, if slightly optimistic.

Although the pilot believed that he had filled the aircraft's fuel tanks to full at LZIB, it was estimated that they may have been less than full by some 195 lb (123 litres). If this were so, and the tanks had been refuelled to full, the aircraft should have been able to fly for, approximately, an additional one hour seven minutes before running out of fuel. The fuel on board prior to taking off from EDVE, estimated by the AAIB, was 353 lb. This equates to an endurance of two hours. The fuel on-board became exhausted after 1 hr 53 mins and 314 nm, approximately 160 track miles from EGTK. At a ground speed of 160 kt in the cruise, the aircraft was, therefore, approximately one hour short of its destination. Thus, although the aircraft should have been able to reach EGTK, had the fuel tanks been full on departure from LZIB, it would not have had any reserve or fuel to fly to an alternate airfield.

If the aircraft's fuel gauges were accurately indicating three-quarters full prior to takeoff for EGTK, there should have been approximately 688 lb (434 litres) in the fuel tanks. This equates to an endurance of around 3 hr 50 minutes to fuel exhaustion, using the operating company's fuel burn figure of 174 lb/hr, allowing 25 lb for start up and taxi. The flight planned route was 468 nm and, at a ground speed of 160 kt, this should have taken 2 hr 55 minutes. In order to fly to EGTK in the flight planned time of 2 hrs 30 minutes, the aircraft would have had to fly at a groundspeed of 187 kt; this is an unrealistic speed for the aircraft with the headwind at the time, given that average groundspeed of D-IAFC from takeoff to fuel exhaustion was 149 kt. At this average speed, it would have taken 3 hr and 8 mins to fly from EDVE to EGTK, and would have required 545 lb of fuel. The AAIB estimate of fuel on-board at the start of the flight, from Table 1, was 353 lb.

It appears the pilot may have thought the weight of his cargo was 540 lb, not its actual weight of 262 lb. Using the pilot's assumed weight of the cargo and his assumed fuel on-board (573 lb, see Table 2) prior to departure, this would have allowed him to load an additional 221 lb of fuel to take the aircraft up to its MTOW. This would have given the aircraft an additional 1 hr 16 min of flying time to fuel exhaustion. Thus, flying at an average groundspeed for the trip of 149 kt, the aircraft would probably have reached EGTK, but would not have had any alternate or reserve fuel. Using the AAIB estimated fuel quantities from Table 3, and the pilot's assumed weight of the cargo, he should have been able to load an additional 415 lb of fuel without exceeding the aircraft's MTOW. This would have given an additional 2 hrs 23 min flying time to fuel exhaustion. Thus, the aircraft should have been able to reach EGTK with sufficient fuel remaining to reach an alternate airfield, plus reserve fuel.

Survivability

Although the pilot's survival time, at a water temperature of 170ºC, was theoretically predicted to have been about one hour, his useful conscious time would have been significantly less. It was fortunate that the SAR helicopter and the rescue boat from the nearby ship were on scene so quickly as, after only 18 minutes in the water, he was diagnosed as already suffering from the effects of cold. It was also fortunate that the sea state was slight, given that the pilot was not wearing a life jacket. Had it been greater, his chances of surviving in the open sea long enough to be rescued would have been much reduced. Although the aircraft was not carrying a dingy, had the pilot been able to deploy and board one, his survival time would have been greatly increased. It would, therefore, seem prudent for single and multi-engine aircraft not required to carry a dingy, to do so when transiting large areas of water, and for pilots to be trained in their deployment and operation.

The CAA have published Safety Sense Leaflet 21, titled '*Ditching',* which contains comprehensive information on this subject.

Conclusion

The accident occurred as a result of the aircraft running out of fuel approximately 160 nm short of its destination. Although the wreckage of the aircraft was not recovered, all the evidence suggests that this occurred due to insufficient fuel being on-board the aircraft prior to departure, rather than because of a technical problem. The pilot's lack of awareness of the fuel quantity and the actual weight of the cargo on board D-IAFC prior to takeoff, are considered to have been significant causal factors in the accident. A contributory factor was that the pilot did not monitor the reportedly 'unreliable' fuel gauges, thus missing a chance to notice the aircraft's low fuel state and divert to a suitable airfield before the situation became critical.

ACCIDENT

Aircraft Type and Registration:	DHC-8-311, G-WOWD
No & Type of Engines:	2 Pratt & Whitney Canada PW123 turboprop engines
Year of Manufacture:	1991
Date & Time (UTC):	13 December 2006 at 1450 hrs
Location:	St Mawgan, Cornwall
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 4 Passengers - 33
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to one main wheel and associated axle
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	58 years
Commander's Flying Experience:	7,886 hours (of which 5,162 were on type) Last 90 days - 156 hours Last 28 days - 34 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and AAIB examination of components

Synopsis

After takeoff from St Mawgan the flight crew were informed by ATC that a main wheel had fallen from the aircraft. The aircraft returned to St Mawgan and landed uneventfully. The wheel was released due to a failure of the wheel bearing, but only a limited amount of the failed bearing was recovered. The failure mode of the bearing was not determined. The aircraft manufacturer has investigated several other such events and, as a result, introduced several measures to improve the durability of the bearing.

History of the flight

Immediately after takeoff from St Mawgan the flight crew were informed by ATC that a wheel had fallen from the aircraft. The flight crew reported that the takeoff had appeared normal and neither they nor the cabin crew had experienced any unusual noises or vibration. A fly-by of the ATC tower confirmed that the right inboard main wheel was missing. After contacting their company for advice the flight crew briefed the cabin crew for an emergency landing back at St Mawgan. The landing was uneventful and the aircraft was brought to a halt on the taxiway where a precautionary disembarkation of the passengers was carried out before towing the aircraft onto a stand. An examination of the aircraft by the company's engineers found that, with the exception of damage to the main landing gear stub axle, the aircraft was undamaged.

Technical examination

The main wheel together with some fragments of the retaining nut and wheel bearing were recovered from the runway. These, together with the stub axle, were dispatched to the AAIB for a detailed examination. The wheel and axle exhibited rotational damage to their bearing surfaces which was consistent with a failure of either the retaining nut or the wheel bearing. Metallurgical examination of the fragments of the retaining nut confirmed that it had been subjected to very high loads on its inner face which had resulted in its failure. The small number of bearing fragments recovered consisted of the remains of one roller and fragments of cage material. The surface of the roller exhibited heavy 'smearing'. The bearing cage fragments had been heavily distorted and their fracture surfaces were indistinct due to secondary damage which had occurred during the failure sequence. There was insufficient evidence to identify the primary failure mode of the bearing.

A review of the aircraft technical log showed that the wheel had been fitted to the aircraft on 19 November 2006 and had operated for 199 landings prior to this incident. Before being installed, the wheel assembly had passed through a maintenance facility to replace a worn out tyre. Records supplied by the maintenance organisation which replaced the tyre confirmed that the wheel and bearing had been cleaned, inspected and reassembled in accordance with the wheel manufacturers Component Maintenance Manual. No defects had been observed with the wheel or the bearing during this process.

The aircraft manufacturer reported that it has been notified of several other main wheel losses which have been attributable to bearing failures. To date, no single cause for these events has been identified. However, several factors which may have contributed to a wheel bearing failure have been identified including a build-up of brake dust within the bearing, failure to follow the correct installation procedure and inadequate filling of the bearing with grease. The manufacturer has now approved two new greases for use in the wheel bearings to improve their durability. In cases of adverse operational conditions they recommend that operators replace the wheel bearings at every wheel change. The manufacturer has stated that they are continuing to monitor the wheel bearings in service and will introduce additional steps to improve their performance should this be necessary.

Conclusion

The loss of the main wheel was the result of a failure of the wheel bearing. The small amount of bearing material recovered and severity of the damage to the fragments prevented the failure mode being confirmed. Prior to installation, the bearing and wheel assembly had been inspected and re-greased in accordance with the manufacturer's requirements. The aircraft manufacturer has introduced several measures to improve the performance of the main wheel bearing and will take additional steps should they be required. In view of this, no further safety action is considered necessary at this time.

ACCIDENT

Aircraft Type and Registration:	Gulfstream Commander 840 Model 690C, N51WF
No & Type of Engines:	2 Garrett 331 turboprop engines
Year of Manufacture:	1981
Date & Time (UTC):	23 January 2007 at 1057 hrs
Location:	Fairoaks Airport, Surrey
Type of Flight:	Private
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Right engine shock-loaded and propeller blades damaged
Commander's Licence:	FAA Private Pilot's Certificate
Commander's Age:	74 years
Commander's Flying Experience:	1,671 hours (of which 381 were on type) Last 90 days - 25 hours Last 28 days - 6 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

While taxiing through the apron, which had work in progress, the aircraft's right propeller struck a hazard warning cone and a concrete block.

History of the flight

The pilot landed on Runway 06 at Fairoaks Airport where the weather was good. He vacated the runway and taxied to the north along Taxiway C towards the apron. As he approached the apron the pilot noticed a large crane to his left and some ground obstruction cones to his right. He reported that he stopped the aircraft before reaching the crane and was then aware of someone in a yellow jacket, whom he presumed was a marshaller, appearing ahead of him. The pilot taxied N51WF forward watching that he had clearance from the crane and assuming that the 'marshaller' would ensure that the aircraft was clear of the warning cones on the right side. As N51WF moved forward, the pilot heard a noise, which he thought may have been the right engine contacting an obstruction. He shut down both engines and found that the right propeller had contacted a cone and a concrete block.

Discussion with the 'marshaller' revealed that he was working with the crane and had come out purely because he was worried that the aircraft was going to contact the crane.

The pilot, who confirmed that he had previously operated N51WF into Fairoaks but always using Runway 24, subsequently commented that he should have been warned by the 'Tower' and that signs should have been put up on the taxiway to indicate that the condition of the taxiway and ramp were a danger to aircraft.

ATC information

Fairoaks Airport operates a Flight Information Service (FIS), which is provided at aerodromes without an air traffic control unit but where the provision of an air traffic service is desirable. Civil Air Publication (CAP) 427 includes the following in the list of responsibilities of a Flight Information Service Officer (FISO):

> *'Issuing instructions and information to aircraft moving on the manoeuvring area to assist pilots in preventing collisions between aircraft and vehicles and obstructions on the manoeuvring area, or between aircraft moving on the apron.'*

The FISO, who had previously seen the aircraft operating at Fairoaks, confirmed that it landed on Runway 06 but he did not recall the pilot calling "Finals" prior to landing or "Vacated" after clearing the runway. He watched the aircraft taxi quickly along Taxiway C towards the apron.

The crane and rubble, associated with the Work in Progress (WIP) on the apron area were marked by frangible cones. The FISO was aware of the position of the crane but not of the WIP across the taxiway from the crane which significantly narrowed the taxiing channel. He stated that had he been aware of this WIP, he would have transmitted a warning to the aircraft.

The UK Aeronautical Information Package (AIP) includes the following warnings in the entry for Fairoaks Airport:

> *'Pilots are to exercise extreme caution when taxiing through the apron/ parking areas due to reduced wingtip clearances. Pilots should satisfy themselves that they have adequate wingtip clearances whilst taxiing.'*

This warning is also included within other aviation publications such as 'Pooleys Flight Guide'. The CAA's Safety Sense Leaflet No 6d entitled '*Aerodrome Sense*' includes the following information for pilots after landing:

> *'Look for any marshaller's signals, but remember you are still responsible for your aircraft's safety.'*

Discussion

The pilot was familiar with the airport and had responsibility for the safety of his aircraft. While he thought that the crane operator was a 'marshaller', who was guiding him through the area of the marked obstacles, the pilot was ultimately responsible for ensuring that he had sufficient clearance.

The WIP was clearly marked and appropriate warnings were contained within aviation publications. Nevertheless, the FISO considered that the aircraft was taxiing quickly and he had not heard any R/T calls from it on the ground. It would have been prudent for him to transmit an additional warning about the WIP as the aircraft taxied towards the affected area.

INCIDENT

Aircraft Type and Registration:	SD3-60 Variant 100, G-BPFN
No & Type of Engines:	2 Pratt & Whitney PT6A-67R turboprop engines
Year of Manufacture:	1988
Date & Time (UTC):	27 December 2006 at 1610 hrs
Location:	Jersey Airport
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 3 Passengers - 14
Injuries:	Crew - None Passengers - 1 (Serious)
Nature of Damage:	None
Commander's Licence:	Air Transport Pilot's Licence
Commander's Age:	64 years
Commander's Flying Experience:	16,850 hours (of which 1,070 were on type) Last 90 days - 31 hours Last 28 days - 23 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

An elderly passenger slipped and injured his shin whilst boarding the aircraft using an integral ladder at the rear of the fuselage. The ladder was serviceable and operated correctly.

History of the flight

The passenger was taken by wheelchair to the aircraft which he intended to board with two relatives for a scheduled flight to Guernsey. As he climbed the integral ladder at the rear left side of the fuselage, with the assistance of his relatives and a member of ground staff, his right foot slipped forward and his shin hit the front edge of the top tread. A relative and the cabin attendant helped the passenger into the cabin where he took his seat. At that point the cabin attendant noticed that the passenger's leg was bleeding and called for the assistance of airport paramedic staff. Paramedics attended to the passenger's injury until the arrival of the Jersey Ambulance Service which took him to hospital. His relatives also disembarked. The aircraft load sheet was amended before the aircraft departed.

Aircraft ladder

The Shorts SD3-60 has a single main entrance door at the rear left side of the fuselage. The doorway is provided with an integral ladder comprising four open treads covered with a 'non-slip' tape or paint. The Commander reported that the ladder was serviceable and operated correctly at the time of the incident. There was no indication that the design of the ladder or the manner in which it was being operated caused the incident. No other such occurrences involving Shorts SD3-60 aircraft have been reported to the AAIB.

Assistance available to passengers

The operator stated that passengers with reduced mobility may request assistance at any time before boarding its aircraft. In the case of the Shorts SD3-60, a passenger unable to use the ladder could be carried aboard by ground staff in a wheelchair designed for the purpose. One of the relatives travelling with the elderly passenger commented that the family had not requested assistance because they thought he would have no difficulty using the ladder.

Accident reporting

Regulation 8(3) of the Civil Aviation (Investigation of Air Accidents and Incidents) (Jersey) Order 2000 ("the Regulations") requires that an investigation be carried out into accidents and serious incidents which occur in or over the States of Jersey. In this context the Regulations define an accident as:

> *'an occurrence associated with the operation of an aircraft which takes place between the time any person boards the aircraft with the intention of flight until such time as all such persons have disembarked, in which a person suffers a fatal or serious injury as a result of:*
>
> - *being in or upon the aircraft*
> - *direct contact with any part of the aircraft, including parts which have become detached from the aircraft, or*
> - *direct exposure to jet blast.'*

The definition of the term *'serious injury'* includes injuries such as that sustained by the passenger whilst boarding this aircraft.

ACCIDENT

Aircraft Type and Registration:	Aerotechnik EV-97 Eurostar, G-LYNI
No & Type of Engines:	1 Rotax 912-UL piston engine
Year of Manufacture:	2006
Date & Time (UTC):	21 April 2007 at 0900 hrs
Location:	Swinford Airstrip, Leicestershire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Substantial to left landing gear and left wing
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	54 years
Commander's Flying Experience:	327 hours (of which 77 were on type) Last 90 days - 17 hours Last 28 days - 8 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

Shortly after landing on Runway 02 the pilot realised he was travelling too fast. He applied the brakes but the left wheel dug into soft ground, causing the left main landing gear to fail.

History of the flight

Following an uneventful flight from Stoke Golding, the pilot arrived overhead at Swinford airstrip. As there was no response to his radio calls, the pilot checked the signal square and windsock to determine the wind direction and runway in use. He then joined the circuit for an approach to Runway 02. The approach and landing were carried out with full flaps, but on landing the pilot found that the aircraft was travelling too fast. He applied the brakes in an attempt to slow the aircraft but in so doing it slewed to the right. The left wheel then dug into soft ground, causing the landing gear leg to fold and break. Shortly after that, the left wing was damaged as it contacted the ground. The pilot and passenger were uninjured and exited normally.

The pilot later realised that the wind was from 230º at 10 mph. This meant that the landing on Runway 02 had been with a tailwind. The pilot, in a full and frank assessment, could not fully explain why he misinterpreted the windsock. The pilot did, however, mention that the reason may have been complacency and a lack of concentration, as he had used the airfield on numerous occasions.

ACCIDENT

Aircraft Type and Registration:	Cessna 150, G-APXY
No & Type of Engines:	1 Continental O-200-A piston engine
Year of Manufacture:	1960
Date & Time (UTC):	7 April 2007 at 1220 hrs
Location:	Runway 08, Compton Abbas, Wiltshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to nose landing gear and propeller
Commander's Licence:	Private Pilot's Licence
Commander's Age:	52 years
Commander's Flying Experience:	46 hours (of which 23 were on type) Last 90 days - 9 hours Last 28 days - 2 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

After landing, the aircraft hit a bump in the runway and became airborne again. It touched down again on the nose landing gear which collapsed, causing damage to the propeller and engine cowling.

History of the flight

The aircraft had been flown from Exeter to Compton Abbas and, after a normal approach, landed on Runway 08. Early in the landing roll it hit a bump in the runway surface and became airborne for a brief period. The aircraft touched down again on its nose landing gear, causing it to collapse. The propeller struck the ground and the lower engine cowling was damaged. The two occupants, who were uninjured, vacated the aircraft without difficulty via the cabin doors.

ACCIDENT

Aircraft Type and Registration:	Cessna F150L, G-BABB
No & Type of Engines:	1 Teledyne Continental O-200-A piston engine
Year of Manufacture:	1972
Date & Time (UTC):	19 July 2006 at 1530 hrs
Location:	Eastwood Park, Southend on Sea, Essex
Type of Flight:	Training
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Fatal) Passengers - N/A
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Student pilot
Commander's Age:	16 years
Commander's Flying Experience:	15 hours (all of which were on type) Last 90 days - 7 hours Last 28 days - 4 hours
Information Source:	AAIB Field Investigation

Synopsis

The student, who was training at Southend Airport towards the issue of a Private Pilot's Licence, was on his second solo flight. Having established the aircraft on final approach, the student was instructed to go around so that a faster aircraft approaching to land behind his aircraft would not catch up with it. Both the controller's instruction and the student pilot's acknowledgement involved non-standard RTF phrases. In order to avoid any possibility of conflict between the two aircraft the student was then instructed to turn away from the final approach track. During this manoeuvre, the student flew level at low altitude and it is likely that the aircraft remained in the approach configuration with insufficient power applied to maintain flying speed. In level flight, the aircraft stalled at a height from which recovery was impossible and it struck the ground in a public park approximately 1 nm from the airport. The student pilot was fatally injured. Four safety recommendations were made.

History of the flight

The student pilot was training towards the issue of a Private Pilots Licence (PPL). On the morning of the accident he attended the flying school in order to sit an Aviation Law written examination[1]. Two days previously he had successfully completed his first solo flight and the instructor intended to consolidate that exercise with

Footnote

[1] One of several written examinations that a student must pass prior to the grant of a PPL.

a dual flight in preparation for a second solo flight. After the examination, at approximately 1430 hrs, the student met his instructor to be briefed for his next flight. Following the briefing the student proceeded to the aircraft to inspect it before flight.

Meanwhile, the instructor contacted Air Traffic Control (ATC) by telephone to book out[2], spoke to the Senior Air Traffic Control Officer (SATCO)[3] and informed him that following a short dual flight, the student pilot would probably continue solo. The SATCO asked if this would be the student's first solo. The instructor replied that it would not be, but he could not recall if he advised the SATCO that it would be his second solo flight. The SATCO passed details of the intended flight to the Aerodrome Controller (ADC)[4] in the form of a Flight Progress Slip (FPS). The SATCO omitted from the FPS the number of persons on board for each portion of the flight because he considered that this could not be done without ambiguity. He did, however, explain verbally to the ADC on duty at the time that at some stage the student pilot would be sent solo.

The instructor went to the aircraft after booking out and found that the student had "completed his usual meticulous walk-round and was keen to go flying in his usual cheerful manner". Before takeoff the aircraft was prepared for flight in accordance with the normal checklist, which included an engine 'power check'. During this procedure, which involved checking the ignition system, carburettor heat and engine performance parameters, the engine performed normally. At 1449 hrs the aircraft lined up and took off from Runway 06.

The instructor considered that the student's first circuit was "text book" (ie accomplished entirely competently) but he decided to conduct a further dual circuit in order to assure himself that the student was landing the aircraft consistently. After the aircraft landed at 1505 hrs the instructor called the tower: "GOLF BRAVO BRAVO CLEAR AT ALPHA PLEASE FOR SOLO CIRCUITS", indicating that G-BABB had vacated the runway onto Taxiway Alpha (which passes the flying school at the eastern end of the airport) and that the subsequent circuits would be flown solo. The ADC replied "APPROVED". The instructor then told the student to carry out three further solo circuits and disembarked beside the flying school.

At 1508 hrs the student called the tower: "BRAVO BRAVO TAXI FOR CIRCUIT SOLO CIRCUIT PLEASE"[5]. He was instructed to taxi to Holding Point C1, at the south-west end of the aerodrome. He was not required or expected to carry out a further power check and there is no evidence to suggest that he did so.

At 1510 hrs the ADC who had been on duty during the dual flight handed over to another controller. There is no record of the information exchanged during this verbal handover, but, in the opinion of the SATCO, the relieving ADC may not have been aware at this stage that the pilot of G-BABB was an inexperienced student. Moreover, the ADC himself stated that he had not been made aware of this fact.

At 1512 hrs the ADC received from London Terminal

Footnote

[2] A formal requirement, in which the commander of an aircraft gives ATC details of the intended flight, including the nature of the intended flight, and number of persons on board.

[3] The SATCO was manning the Air Traffic Control Assistant support position in the visual control room.

[4] The arrangement of air traffic services at Southend is explained later in this report under the heading **Communications**.

Footnote

[5] The text of all communications on the tower frequency is taken from the Certified Recorded Speech Transcript covering the period 1508 to 1528 hrs on 19 July 2006.

Control Centre (LTCC) a release for a BAe 146 airliner which had been waiting to depart from Southend on a flight into controlled airspace. This enabled the ADC to give the BAe 146 a departure clearance and, subsequently, clearance to take off. At 1516 hrs, in his first exchange with the new controller, the student reported that he was holding at C1 and was instructed to hold position. The BAe 146 commenced its takeoff roll from the beginning of Runway 06 at 1517 hrs and departed.

Light aircraft such as G-BABB would usually commence their takeoff roll from the intersection of Holding Point C1 with Runway 06. Although this is 376 m from the start of the runway, it still permits a takeoff run of 1,083 m, which is considerably more than G-BABB required in the prevailing conditions. However, the departure of a light aircraft such as G-BABB following a larger aircraft such as the BAe 146 must be delayed in order for the disturbance of the air in the wake of the preceding aircraft ('wake turbulence') to diminish. In this case the minimum spacing is two minutes if both aircraft depart from the same point, or three minutes if the following aircraft departs from an intermediate point. Accordingly, as G-BABB approached the holding point, the ADC instructed the student "TO MINIMISE VORTEX DELAY RUNWAY 06 ENTER BACKTRACK LINE UP", intending that the student should enter the runway and taxi to the beginning of Runway 06. When, after a short delay, the student had not replied, the ADC repeated the instruction. The student then read back "BRAVO BRAVO ZERO SIX BACKTRACK".

Later, when the ADC saw that, rather than entering the runway as instructed, the student had manoeuvred the aircraft at the holding point until it was facing back along the taxiway in a north-easterly direction, he transmitted "GOLF BRAVO BRAVO ER REPORT YOUR INTENTIONS". The student responded "BACKTRACK RUNWAY ZERO SIX", to which the controller replied "ER YEAH YOU'RE NOW FACING TOWARDS THE TOWER", and shortly afterwards "GOLF BRAVO BRAVO JUST ENTER THE RUNWAY AND LINE UP AS NORMAL". Fifty seconds later the student replied "BRAVO BRAVO LINING UP", to which the ADC responded "GOLF BRAVO BRAVO ROGER LINE UP AND WAIT JUST A SHORT DELAY NOW FOR VORTEX ONE FURTHER MINUTE". The student replied "BRAVO BRAVO LINING UP".

At 1520 hrs the ADC transmitted "GOLF BRAVO BRAVO LEFT HAND CIRCUIT ZERO SIX CLEARED FOR TAKEOFF SURFACE WIND ZERO EIGHT ZERO DEGREES EIGHT KNOTS". The student replied "BRAVO BRAVO CLEAR TAKEOFF LEFT HAND CIRCUIT". At the time there were no other aircraft in the circuit at Southend Airport.

The instructor watched the student's flight from the flying school and listened to transmissions on the tower frequency. He considered that the flight was progressing normally and that the aircraft was maintaining the correct height.

Meanwhile, the Approach Controller (APC) had received from the London Terminal Control Centre details of N347DW, a Piper PA-46T Malibu Meridian[6], which was arriving from controlled airspace to the south. The APC identified this aircraft on radar when it was southeast of the Detling VOR beacon, 16 nm south of Southend, but it was not released to the APC's control until it was approximately 8 nm from Southend which represented about two minutes flying time.

Footnote

6 The Meridian is a high performance light aircraft with a single turboprop engine. N347DW commenced its approach at a speed of over 120 kt. The normal approach speed of G-BABB was approximately 60 kt.

At 1523 hrs the student pilot reported "BRAVO BRAVO DOWNWIND" to which the ADC responded " GOLF BRAVO BRAVO NUMBER ONE REPORT FINAL ZERO SIX" and the student read back "BRAVO BRAVO REPORT FINAL NUMBER ONE".

At 1526:00 hrs the aerodrome and approach controllers started discussing the co-ordination of circuit traffic and the arriving aircraft. At 1526:10 hrs the ADC stated "THE CESSNA" (G-BABB) "IS TO ROLL BUT OBVIOUSLY HE'S GOING TO BE SLOW DOWN FINAL". The APC replied "I THINK YOU MIGHT HAVE TO SEND THE OTHER ONE" (G-BABB) "AROUND". The ADC responded "JUST TURN HIM" (N347DW) "THE LONG WAY ROUND ON FINAL" this manoeuvre would have increased the separation between the Piper and the Cessna. The APC replied "YEAH I'M JUST A BIT WORRIED ABOUT ALL THESE UNKOWNS" referring to aircraft in the vicinity of Southend which were visible on primary radar but with which she had no communication and no altitude information. The ADC acknowledged this message but made no further comment.

At 1526:30 hrs the student reported on final; the positions of the two aircraft when the student pilot reported on final approach is shown in Figure 1. The ADC replied "GOLF BRAVO BRAVO ROGER AND ER MAINTAIN RUNWAY CENTRELINE BUT GO AROUND ER CIRCUIT HEIGHT ONE THOUSAND FEET THERE'S FAST TRAFFIC BEHIND TO LAND". The student replied "BRAVO BRAVO MAINTAIN CENTRELINE". At this stage the ADC was concerned that N347DW's high speed might result in it having to go-around beneath G-BABB, a situation he considered dangerous and which he intended to resolve before it could occur. Consequently the ADC replied "ER GOLF BRAVO BRAVO DISREGARD THAT JUST TAKE A LEFT TURN AND FLY NORTH I'LL CALL YOU BACK IN VERY SHORTLY". At that moment the APC asked the ADC "DO YOU WANT ME TO TURN HIM AWAY" ("him" in this context being N347DW). The ADC replied "NO". The APC asked "ARE YOU SURE" and the ADC replied "YEAH".

Also at 1526:30 hrs the APC asked the commander of the Malibu "NOVEMBER SEVEN DELTA WHISKEY DO YOU HAVE THE AIRFIELD IN SIGHT". He replied "HAVE THE AIRFIELD IN SIGHT ER TURNING FINAL SEVEN DELTA WHISKEY". At 1526:40 hrs the APC transmitted "SEVEN DELTA WHISKEY ROGER THERE IS CESSNA TRAFFIC AHEAD OF YOU RANGE OF ONE MILE CLEARED VISUAL APPROACH AND ER CONTINUE" to which the commander replied "SEVEN DELTA WHISKEY ROGER". Ten seconds later the APC transmitted "NOVEMBER SEVEN DELTA WHISKEY THAT CESSNA TRAFFIC COMMENCING A GO-AROUND AND ER CONTINUE APPROACH" to which the commander replied "SEVEN DELTA WHISKEY LOOKING FOR THE TRAFFIC AND CONTINUE THE APPROACH". At 1527:00 hrs the APC instructed the Malibu commander "NOVEMBER SEVEN DELTA WHISKEY CONTACT SOUTHEND TOWER ONE TWO SEVEN SEVEN TWO FIVE" and the commander acknowledged this instruction.

Meanwhile, having received no reply to his previous instruction to G-BABB, at 1527:00 hrs the ADC transmitted "GOLF BRAVO BRAVO JUST TO CONFIRM TURN NORTHBOUND NOW". Shortly afterwards, having still received no reply, the controller called "GOLF BRAVO BRAVO TURN NORTH CONFIRM". The student replied "BRAVO BRAVO TURN NORTH". The controller responded "THANKS I'LL BRING YOU BACK IN BEHIND THE OTHER TRAFFIC THANKS FOR YOUR HELP". Moments later, N347DW called the tower frequency and announced "SOUTHEND TOWER JETPROP THREE FOUR SEVEN DELTA WHISKEY WITH YOU FOR ZERO SIX WE HAVE THE ER TRAFFIC

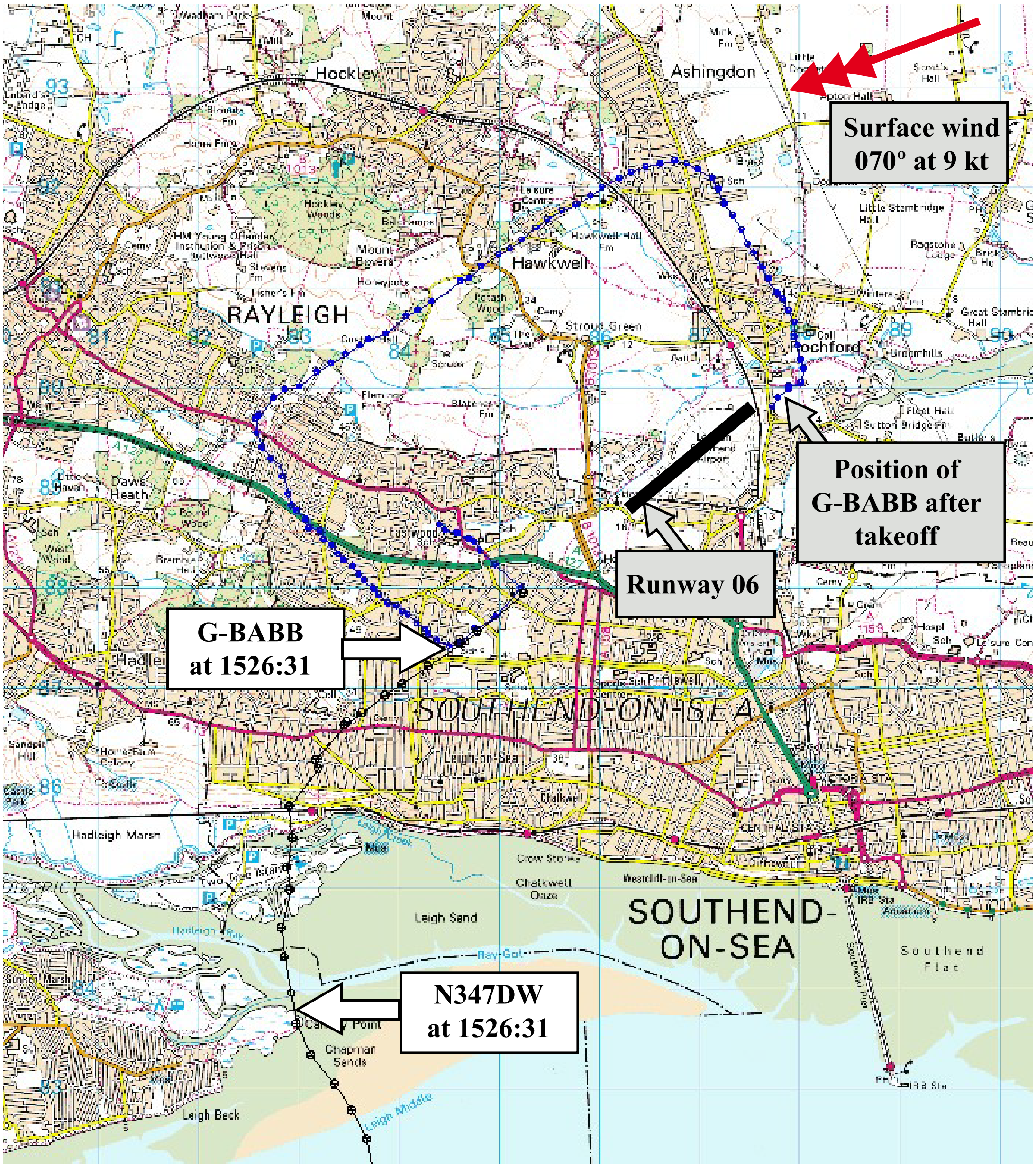


Figure 1

Locations and tracks of G-BABB and N347DW at 1526:31 hrs

IN SIGHT ON ER GO AROUND". The ADC replied "NOVEMBER THREE FOUR SEVEN DELTA WHISKEY SOUTHEND TOWER GOOD DAY RUNWAY ZERO SIX YOU'RE CLEARED TO LAND THE SURFACE WIND ZERO SEVEN ZERO DEGREES NINER KNOTS". The Malibu pilot read back the landing clearance correctly.

At 1527:40 the ADC transmitted "GOLF BRAVO BRAVO YOU CAN TU- (*part word*) MAKE ER A LEFT TURN AND ORBIT BACK ONTO FINAL APPROACH". The student replied "GOLF BRAVO BRAVO MAKE LEFT HAND TURN ONTO FINAL APPROACH".

The instructor recalled becoming anxious that visibility was reducing in bright sunshine and haze. He was also concerned that the student would have been unfamiliar with the instruction to turn north away from the final approach track and might find it bewildering. He decided that when the student had turned back onto final he would telephone the tower and request that G-BABB be instructed to make a "full stop" landing (intending that he should not conduct further circuits). Using binoculars he watched the aircraft fly away from the final approach track in what appeared to be the opposite direction to base leg, at lower than normal circuit height with what he considered to be a nose-up attitude and low airspeed. He then saw the aircraft reverse direction with a high rate of turn before entering a spiral dive, from which he considered there was no possibility of recovery.

The aircraft was seen by several witnesses to descend vertically into Eastwood Park, a public park approximately 0.5 nm north of the final approach track, where it struck the ground still rotating. The student pilot was fatally injured.

The instructor telephoned the SATCO to advise him that the aircraft had crashed. The SATCO immediately pressed the "crash button" to alert the Aerodrome Fire and Rescue Service (AFRS), who responded immediately by requesting the whereabouts of the accident site. The SATCO also telephoned 999 to alert local authority emergency services but he experienced a delay of approximately 60 seconds before being connected. Nevertheless, local emergency services were in attendance by 1535 hrs. The AFRS arrived five minutes later.

Damage to the aircraft

The accident site was surrounded by a residential area. The ground was hard and dry and the aircraft came to rest on the front of the engine and its main wheels with the tail in a near vertical position. The nose wheel with its fork assembly was found approximately 40 m behind the aircraft. Transparent plastic from the cockpit windows and other items from the cockpit were lying randomly around the aircraft out to a distance of 18 m. Both wings had sustained extensive compression damage along the leading edges and the outer portion of the left wing tip had bent upwards and backwards. The wing flaps were extended by approximately 24° relative to the wing trailing edges. The tail assembly was undamaged but the rear fuselage was creased and buckled. Whilst both fuel tanks had fractured, approximately 2 gallons of clean fuel was recovered from each tank. The engine mounting frame had buckled and failed due to impact forces. Both propeller blades had bent backwards and the propeller flange on the crankshaft had also failed through a combination of bending and torsional loads. Ground marks indicated that the propeller stopped almost immediately after it struck the ground. The cockpit was severely disrupted and the control columns had broken in several places. The magneto switch key had snapped off and the switch was found at the RIGHT (magneto) position. The throttle control was bent and had been pulled out by approximately 61 mm. The carburettor heat control had been pulled out by approximately 22 mm and the mixture control was pushed fully in (the RICH position). The pilot was wearing an intact three-point harness providing lap and diagonal torso restraint.

The damage to the aircraft and ground marks indicated that the aircraft struck the ground at a very steep angle, left wing first. The aircraft then rotated slightly to the left before tilting back onto its mainwheels.

Meteorological information

The weather report for Southend Airport, valid at 1520 hrs, indicated a surface wind from 060° at 9 kt with visibility in excess of 10 km and no cloud with a base below 5,000 ft. The surface temperature was 28°C and the dew point was 17°C. The surface wind, reported by the ADC to N347DW 30 seconds before the last transmission from G-BABB, was from 070° at 9 kt. An aftercast produced by the Met Office indicated a wind at 500 ft from 120° at between 10 and 15 kt and a surface wind varying between 060° and 120° at 10 kt. The aftercast did not consider local wind effects such as sea breezes.

Communications

At the time of the accident ATC at Southend Airport used two frequencies: The ADC used one frequency (callsign Southend Tower) to provide aerodrome control services and the APC used the other (callsign Southend Radar) to provide approach control services.

The Manual of Air Traffic Services (MATS) Part 1 defines the responsibilities of aerodrome control as follows:

> *'Aerodrome control is responsible for issuing information and instructions to aircraft under its control to achieve a safe, orderly and expeditious flow of air traffic and to assist pilots in preventing collisions between:*
>
> *a) aircraft flying in, and in the vicinity of, the aerodrome traffic zone;*
>
> *b) aircraft taking off and landing;*
>
> *c) aircraft moving on the apron;*
>
> *d) aircraft and vehicles, obstructions and other aircraft on the manoeuvring area.'*

According to the same document, an air traffic unit shall provide approach control services to aircraft from the time and place at which they are released by area control (in this case LTCC) until control is transferred to aerodrome control. Outside controlled airspace, an air traffic control unit shall provide approach control services to arriving aircraft which place themselves under the control of approach control until control is transferred to aerodrome control.

In addition MATS Part 1 states:

> *'Approach control shall co-ordinate with aerodrome control:*
>
> *a) Aircraft approaching to land; if necessary requesting clearance to land.*
>
> *b) Arriving aircraft which are to be cleared to visual holding points.*
>
> *c) Aircraft routeing through the traffic circuit.'*

On the day of the accident the controllers manning each frequency were seated approximately 3.5 m apart in the same room of the control tower building and communicated through their headsets using an intercom which could not be heard on either frequency. This enabled the two controllers to coordinate their efforts without interrupting transmissions on the two control frequencies.

A dedicated telephone line between Southend ATC and LTCC allowed information about traffic arriving from or departing to controlled airspace to be passed between the two agencies. The approach controller commented that it was common for LTCC to advise Southend about aircraft inbound from controlled airspace when such aircraft were already very close to the airport. This was the case with N347DW.

The flying school was equipped with a radio which enabled instructors to listen to communications between aircraft and ATC on the tower frequency. The radio was capable of transmitting on that frequency, but the Chief Flying Instructor stated that in order to communicate with a student, it would be necessary to 'go through ATC at an opportune moment'. In practice this meant contacting ATC by telephone. Instructors were not permitted to contact students directly using this radio.

Eyewitness statements

Witnesses observed the accident from several viewpoints in and around Eastwood Park and from the Airport. All reported seeing the aircraft flying level in a northerly or north-westerly direction with a nose-up attitude prior to its final descent. Those who lived nearby and were accustomed to seeing light aircraft operating around Southend commented that it was lower than usual. One witness, who in the course of training some years ago had made an approach to Runway 06, saw the accident from a position beneath the flight path of G-BABB and stated that he believed the aircraft to be flying at right angles to the approach path, at or below the normal glide path[7] (which would be approximately 300 ft agl at that point). He had not previously seen an aircraft in that location, flying in that direction at a similar altitude. He stated that it had a "substantial nose-up attitude", suggesting that "the pilot was attempting to maintain lift at a low airspeed... the aircraft looked like it was going to stall".

Immediately before its final descent the aircraft was seen to climb slightly or raise its nose before the left wing dropped. The nose of the aircraft then dropped and it entered a vertical dive with some rotation. Most witnesses who saw the aircraft in its final descent observed it to be rotating anti-clockwise (in a left turn as viewed from above).

One witness reported that, from her garden approximately 1 nm south of the accident site, she saw an aircraft proceeding north at low height. She commented that it appeared to be under the control of the pilot but that the engine, which was very noisy, sounded as though it was "cutting out". Another witness who watched the aircraft from beside Beaver Tower[8] reported that the propeller slowed down very rapidly as the aircraft entered the spiral dive. A further witness, who was standing approximately 200 m south of the accident site, stated that the engine stalled after the aircraft entered the spiral dive.

Several witnesses closer to the accident site who were familiar with the sight and sound of light aircraft mentioned that aircraft sometimes "cut their engines" when landing at Southend. One witness, who watched the aircraft from his garden 0.3 nm from Eastwood Park, estimated that it had flown past his house at approximately 300 ft. He considered that the engine note seemed steady with no misfiring. He noted, however, that "the engine note sounded more like cruise power than full power". Two witnesses near to the accident site, who both commented that aircraft landing at Southend often appeared to be using low power, thought that the aircraft was quieter than usual.

The pilot of the Piper, N347DW, reported that he could see a Cessna during his approach to land. He recalled thinking that the spacing was going to be "pretty tight" if the Cessna was going to make a full stop landing because his aircraft had a faster approach speed. He estimated the separation to be between 1 and 1.5 nm. He then saw the Cessna "break off" the approach and make a left turn. He assumed it was conducting practice approaches and had executed a missed approach. He then focused on his own landing and lost sight of the Cessna.

The SATCO stated that he saw the aircraft turn northbound, in a position slightly north of the normal final approach track, adding "it seemed very low and I had the impression that the flaps were still extended". He added the aircraft "had the nose pointing as if to

Footnote

7 Aircraft approaching Runway 06 at Southend would normally follow a vertical path making an angle of approximately 3° with the horizontal.

Footnote

8 A block of flats at the western edge of Eastwood Park.

climb; it was noticeably having difficulty in attaining any significant rate of climb".

Recorded information

National Air Traffic Services provided recordings from Stansted Airport of radar returns corresponding to G-BABB, starting at 1521:11 hrs at the north-easterly end of Runway 06. Altitude data were not recorded.

A radar return recorded at 1527:09 hrs confirmed that when G-BABB was 0.82 nm from the Runway 06 threshold, N347DW was 1.20 nm from G-BABB. The aircrafts' positions are shown in Figure 2.

The next radar return from G-BABB was recorded at 1527:24 hrs. Several returns were missing around the time of the instruction to turn north which reduces the resolution of this position. After the instruction to turn north there were seven further recorded points which showed G-BABB tracking north-west. Due to the tolerances of the radar recording system, it was not possible to calculate an accurate instantaneous groundspeed towards the end of this flight. However, after applying the surface wind reported to N347DW of 070º/09 kt to the radar derived groundspeeds, the aircraft's average true airspeed on final approach was 69 mph (60 kt) whereas its average true airspeed on its north-westerly track was 54 mph (47 kt). Computations were also carried out using the aftercast 500 ft mean wind of 120º/12 kt; these produced likely average speeds of 67 mph (58 kt) on final approach and 46 mph (40 kt) on the north-westerly track.

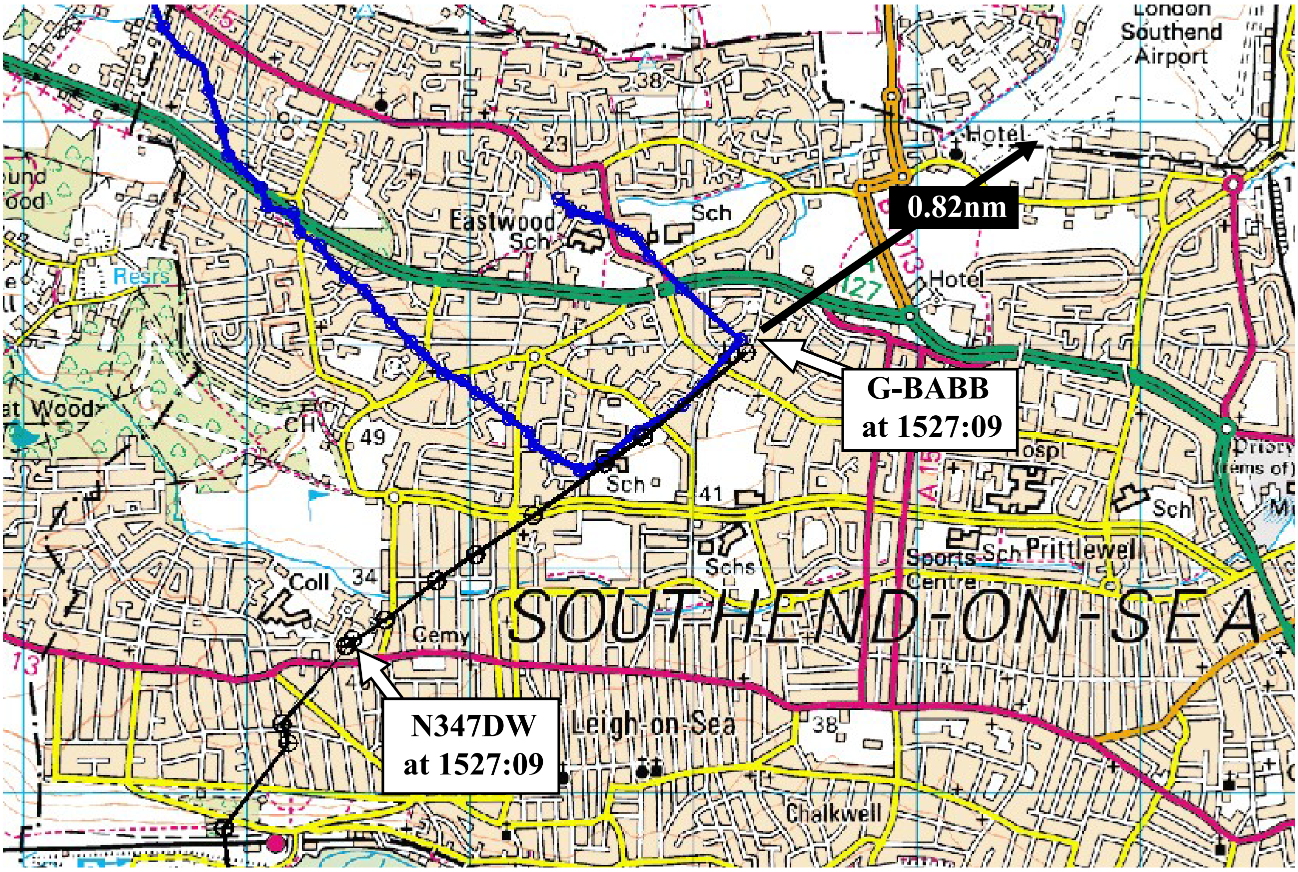


Figure 2

Locations of G-BABB and N347DW at 1527:09 hrs

The last radar return from N347DW, recorded at 1527:47 hrs, indicated that the aircraft was 0.82 nm from the runway threshold. Again, some returns were missing, including an 11.25 sec gap between the penultimate and last points. The final radar return from G-BABB, recorded at 1527:51, indicated that it had continued in a north-westerly direction. The wreckage was found 170 m to the south-west of the final radar return.

Personnel information

Aerodrome controller (ADC)

The ADC on duty at the time of the accident gained his initial Aerodrome Instrument Controller rating in 2000 and an Approach Control Procedural rating in 2001. He completed an Approach Control Surveillance rating in 2004 and started work at Southend Airport, in 2005. At the time of the accident his qualifications were current and appropriate to his duties. The ADC also possessed a United Kingdom PPL issued in 1996.

On the day of the accident the ADC arrived for work at 1215 hrs. Having been on leave for two weeks, he reviewed the ATC memorandum file and operational instructions before taking over the aerodrome control position at 1300 hrs. He remained at that position for approximately one hour before taking a meal break. He then returned to the aerodrome control position at 1510 hrs.

Approach controller (APC)

The APC had worked at Southend throughout her career as an air traffic controller. She gained her initial Aerodrome Instrument Controller rating in 1998, an Approach Control Procedural rating in 2001 and an Approach Control Surveillance rating in 2004. She was also an "On the Job Training Instructor", authorised to supervise other controllers in a live air traffic environment. The APC also possessed a United Kingdom PPL issued in 1993.

On the day of the accident the APC started work at 0800 hrs. Before lunch she operated the aerodrome control position but after lunch she operated the approach position. At the time of the accident her qualifications were current and appropriate to her duties.

Flying instructor

The flying instructor who authorised the solo flight had been the student's only instructor throughout his training. He had been flying at Southend for approximately 25 years; he joined the flying school in 1991 as an instructor and had held the post of Chief Flying Instructor before becoming a freelance flying instructor. He held a 'Flight Examiner Ground Examiner (Private Pilot Licence)' rating, authorising him to conduct: skill tests for the issue of a PPL; skill tests and proficiency checks for the issue, revalidation and renewal of class and type ratings on single-pilot aeroplanes; flight tests for the grant and renewal of IMC ratings; ground examinations for the grant of a PPL. This rating was valid until 30 September 2008. During his most recent Instructor Rating assessment, carried out on 24 May 2006, he was found to meet the appropriate requirements for this rating. He possessed a current Class One medical certificate, valid until 16 September 2006. At the time of the accident his qualifications were current and appropriate for the instructional flight.

Aircraft information

The Cessna 150L is a high wing twin-seat aircraft equipped with a four-cylinder piston engine and a two-bladed propeller. Fuel is supplied to the engine from two tanks, one mounted in each wing. The fuel flows under gravity through a fuel shut-off valve to an engine-driven fuel pump which provides fuel under pressure to the carburettor. The aircraft is equipped with conventional flight controls operated by pulleys and cables. The trailing edge flaps are operated electrically and controlled by a three-position flap selector switch located to the right of the centrally mounted engine controls. To select flaps DOWN the switch must be held down and released when the required amount of flap is obtained. There are no detents to provide exact positioning and so to position the flaps it is necessary to monitor a position indicator located in the left door forward post. To select flaps UP the switch is moved to the UP position; the switch will remain in this position unless it is moved to the OFF position. Gradual flap retraction can be accomplished by intermittent operation of the flap switch between the UP and OFF positions. The aircraft is fitted with a stall warning device which is not dependent on either a switch or electrical power; the warning horn is operated by air pressure sensed at the leading edge of the wing.

Detailed examination of wreckage

General

All the damage to the aircraft was consistent with the aircraft hitting the ground. Continuity of the flying controls was established and there was no evidence of a control restriction. Whilst the aperture of the stall warning sensor had been damaged in the crash, the hose to the horn was intact and the horn made a loud noise when suction was applied to the hose. An instructor who introduced another student to slow speed handling three days before the accident flight reported that during the lesson, the stall warning horn operated normally. The pitot probe had snapped off and parts of the pressure hose in the cockpit area had been damaged in the crash. However, as far as could be determined, the hose between the pitot probe and the ASI was intact. The ASI dial was marked in mph; its needle moved full scale and returned to zero when air pressure was applied at the inlet but damage to the instrument rendered calibration impractical. The flap screw jack had extended by 96 mm which the aircraft manufacturer stated was consistent with a flap setting of approximately 20º. The key in the magneto switch had broken off and the switch was found in the second of four positions; that position corresponded to RIGHT MAGNETO ON. The side of the engine air intake duct, which had been badly distorted in the crash, was cut away and it was established that carburettor heat had been selected ON at the time of the accident. The glass on the engine rpm gauge had broken. Both the face and the gauge's internal mechanism had been damaged causing the needle to freeze at 900 rpm. There was also an impact mark on the face of the gauge caused by the tail of the needle striking the face during impact, which again corresponded to an engine speed of 900 rpm.

Fuel

The fuel lines were intact and the fuel selector valve was in the ON position. Compressed air passed freely through the valve indicating there was no restriction in the valve. Fuel was found in the pipes on either side of the selector valve and there was no evidence of debris in any of the fuel system components.

The aircraft was last refuelled at 1805 hrs the day before the accident and had since flown 1.3 hours. Therefore it was estimated that at the start of the accident flight, there would have been approximately 18 USG of fuel in the tanks, which would have been sufficient for approximately 2.4 hours of flying. Fuel samples from each of the fuel tanks and the bowser from which the aircraft was last refuelled were analysed by the QinetiQ fuels laboratory. All the samples were found to be of an acceptable standard.

Engine

The engine was taken to a specialist overhaul facility were it was stripped. Several components were tested under the supervision of an AAIB Inspector.

The crankshaft could not be rotated because the forward left side of the engine casing had been badly damaged. Consequently, the engine timing could not be checked. Nevertheless, it was established that all the engine components worked correctly with no evidence of overheating or the engine having seized. Oil was found in all the galleries and no debris was found in the oil filter. The spark plugs and cylinder heads were all light grey in colour indicating that the fuel/air mixture was correct.

The carburettor was inspected and a float test carried out which indicated that the carburettor was probably working correctly at the time of the accident. The mixture lever had broken and bent in a position corresponding to the mixture lever set at RICH. The carburettor air inlet orifice had distorted in the impact but the butterfly valve, which sits inside the orifice, was undamaged. This could have only occurred if the throttle stop on the carburettor had been at least 10 mm off the idle stop. This stop is illustrated in Figure 3.

Whilst the ignition system high tension leads had been badly damaged, there was no evidence of chafing or arcing and the leads were assessed as being in good condition at the time of the accident.

The magneto timing was last checked 500 flying hours before the accident. After the accident both magnetos performed satisfactorily when run on a test rig for approximately 15 mins each. The magnetos should have been set such that their points started to open at $10 \pm 4^{\circ}$ before Top Dead Centre (TDC). However, during the examination of the magnetos it was established that the internal timing of the left magneto was 18° before TDC and the right magneto was 15.5° before TDC. The screws securing the points on both magnetos were still tight and there was no evidence that the points had moved during the crash. A current leakage test undertaken on the condenser from the left magneto revealed that the leakage was 26 microamps; the maximum permitted value is 8 microamps. Because the functional test of

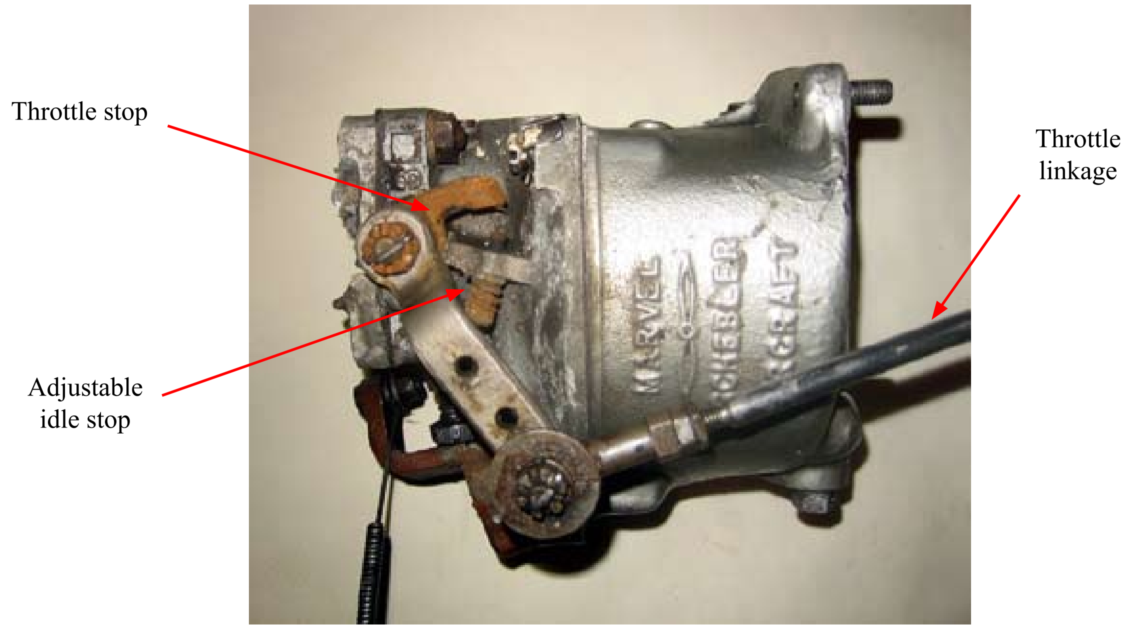


Figure 3

Carburettor removed from G-BABB
(Oxidation of the throttle stop and idle screw occurred after the accident)

the left magneto was satisfactory, the deterioration of its condenser had probably not reached a level sufficient to affect the magneto's operation.

Propeller and crankshaft flange

Damage to the propeller and the crankshaft were consistent with the blades stopping suddenly when they struck the ground.

Medical and pathological information

The student pilot held a valid Class Two medical certificate issued on 19 September 2005. Post-mortem examination confirmed that he died of multiple injuries sustained on impact. There was no evidence of natural disease which could have caused or contributed to the accident. The accident was considered to be non-survivable and it is unlikely that any additional or alternative restraint would have saved the pilot's life.

Training for a PPL

The student pilot was undertaking training towards the issue of a United Kingdom PPL (UK PPL). UK PPLs are issued in accordance with the Joint Airworthiness Requirements (JARs) as specified in the document JAR-FCL 1. Students must comply with the following:

JAR-FCL 1.085:

> *(a) A student pilot shall meet requirements specified by the Authority in the State in which the student intends to train. In prescribing such requirements the Authority shall ensure that the privileges granted would not permit student pilots to constitute a hazard to air navigation.*
>
> *(b) A student pilot shall not fly solo unless authorised by a flight instructor.*

JAR–FCL 1.090:

> *Minimum age*
>
> *A student pilot shall be at least 16 years of age before the first solo flight.*

JAR–FCL 1.095:

> *Medical fitness*
>
> *A student pilot shall not fly solo unless that student pilot holds a valid Class 1 or Class 2 medical certificate.*

Syllabus

A summary of the training course requirements is contained in JAR-FCL 1.125. Under the heading *'Flight instruction'*, Appendix 1 to JAR-FCL 1.125 states:

> *The PPL(A) flight instruction syllabus shall cover the following:*
>
> *(a) pre-flight operations, including mass and balance determination, aeroplane inspection and servicing;*
>
> *(b) aerodrome and traffic pattern operations, collision avoidance precautions and procedures;*
>
> *(c) control of the aeroplane by external visual reference;*
>
> *(d) flight at critically slow airspeeds, recognition of, and recovery from, incipient and full stalls;*
>
> *(e) flight at critically high airspeeds, recognition of, and recovery from, spiral dives;*
>
> *(f) normal and crosswind take-offs and landings;*

> *(g) maximum performance (short field and obstacle clearance) take-offs, short-field landings;*
>
> *(h) flight by reference solely to instruments, including the completion of a level 180 degrees turn;*
>
> *(i) cross-country flying using visual reference, dead reckoning and radio navigation aids;*
>
> *(j) emergency operations, including simulated aeroplane equipment malfunctions; and*
>
> *(k) operations to, from and transiting controlled aerodromes, compliance with air traffic services procedures, communication procedures and phraseology.*

Section 2 of JAR-FCL 1 describes Acceptable Means of Compliance (AMC) associated with each requirement. The '*Syllabus of flight instruction for the Private Pilot Licence (Aeroplanes)'* contained in AMC FCL 1.125 is divided into 19 exercises in which techniques are demonstrated by an instructor and then practised by the student. Each exercise is intended to build on its precursor in order to equip a student with the practical skills necessary to operate an aeroplane safely. Exercises 1 to 13 are conducted prior to a student's first solo flight, which itself is known as Exercise 14. Early exercises teach the student the effects of the various controls in the aircraft and how to manoeuvre the aircraft on the ground and in the air. Exercises 10 and 11 give the student experience of slow flight, stalling and spin avoidance. Exercise 12 concerns the takeoff and climb to the downwind position. During Exercise 13 a student is taught procedures for flying a circuit at an aerodrome including landing, missed approach and go-around. Extracts of the relevant parts of AMC FCL 1.125 are reproduced in Appendix A at the end of this report.

Whereas Appendix 1 to JAR-FCL 1.125 indicates that students are expected to be able to operate safely within the *'traffic pattern'* (circuit), the teaching of manoeuvres intended to increase the spacing between aircraft in the circuit, other than the go-around, is not specified. Specifically, the practice of orbiting is not included in the PPL syllabus, although it is often demonstrated to students. There was no documentary evidence of the student having carried out orbits. However, the CFI of the flying school which operated G-BABB stated that "students have practice in three-sixty delaying actions downwind (orbits)" and that "orbits, extended downwind legs and go-around manoeuvres all happen as a matter of course at Southend because it's a busy circuit with big aircraft". He commented that the student involved in this accident would not have practised orbits in the approach configuration.

Student's record of training

Before the accident the student had flown for a total of 15 hours 35 mins, including 1 hour 5 mins of stall and spin appreciation (Exercises 10 and 11) on 3 April 2006 and 7 hours 10 mins of circuit training (Exercises 12 and 13). His first solo flight was on 17 July 2006 and lasted 15 mins. His training record indicated that he had made good progress throughout.

Circuit and approach technique

A diagram of a typical circuit is shown in Figure 4.

Independently of each other, the instructor and CFI described the technique which the student would have been taught for flying the base leg and final approach in a Cessna 150. On base leg he would select carburettor heat HOT, 1,700 rpm and check that the airspeed was below the 100 mph maximum speed for operating with flaps extended. He would then set 20° of flap, adjust power as necessary to maintain an approach speed of 70 mph and

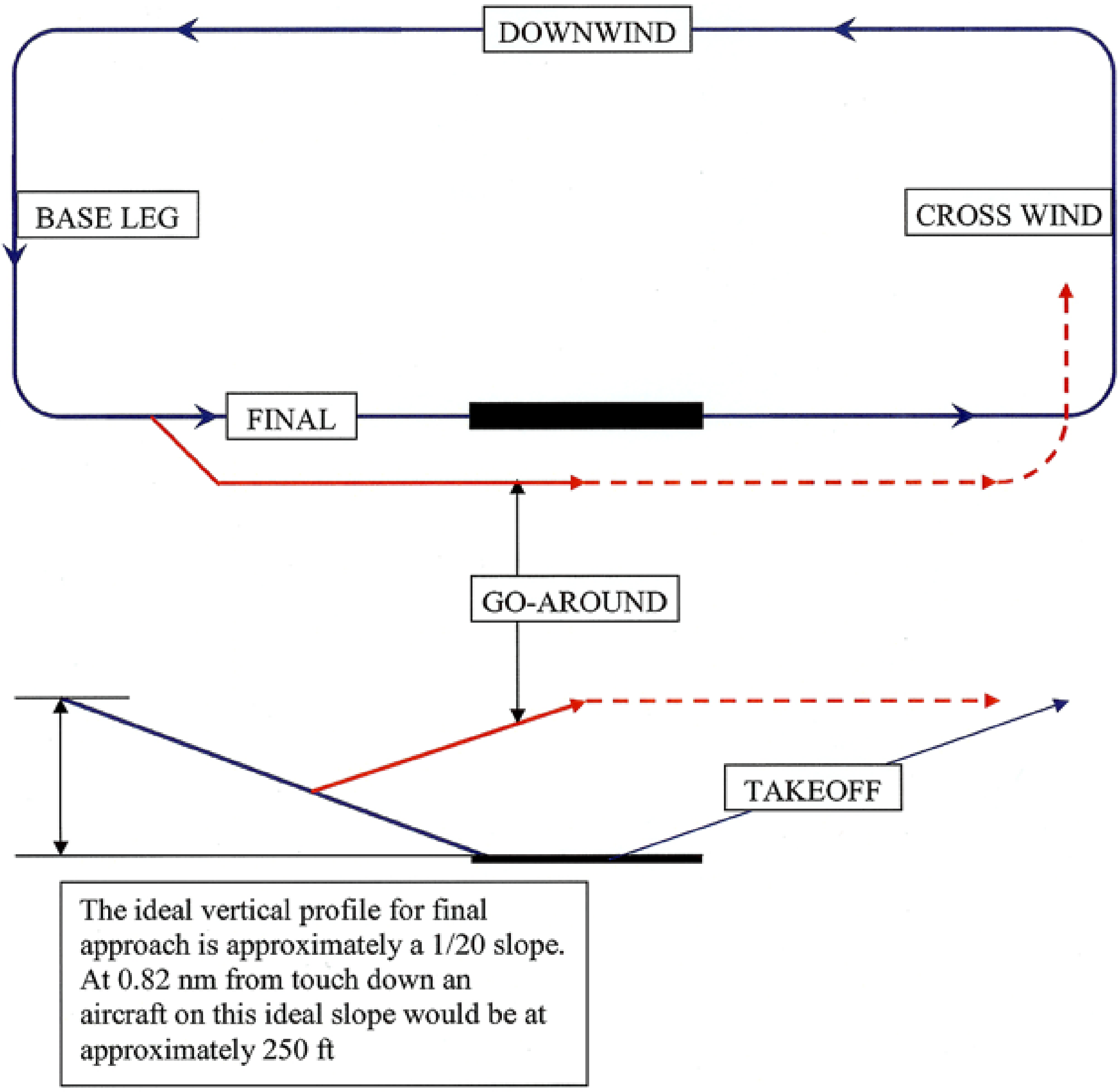


Figure 4

Typical circuit pattern

trim the aircraft. If instructed to go around, the student had been taught to apply full power, position the aircraft slightly to the right of the centreline[9], maintaining a positive climb, fly straight ahead and select the flap up in stages.

When interviewed the CFI was not aware of the configuration or manoeuvres of the aircraft immediately before impact. He commented that if the aircraft was flown level in the approach configuration with approach power set, it would eventually stall. He added that the aircraft could also drop a wing "quite viciously", particularly if it was already turning as it stalled. He also stated that without positive recovery action by the pilot, the aircraft would probably enter a spiral dive.

Footnote

[9] Students are taught that when established in the go-around from a visual approach they should fly parallel with the runway on the side of the runway opposite normal circuit traffic, so that the runway remains in view. This advice is published in commercially available flying training manuals and in *'Safety Sense Leaflet 6 – Aerodrome Sense'*.

Flight observations

As part of the investigation a Cessna F150L was flown in order to experience its handling characteristics in the approach configuration, with carburettor heat selected HOT and 20º of flap set.

A series of approaches were flown, during which it was established that engine speeds of between 1,500 and 2,000 rpm were required to maintain the ideal approach path at 70 mph IAS (61 KIAS).

Before flight, inspection of the sample aircraft revealed that opening the throttle control to the position noted in the cockpit of G-BABB corresponded to the carburettor throttle stop being 10 mm off the idle stop. This is consistent with the position of the throttle stop as found on the engine of G-BABB. In flight in the approach configuration, this throttle position resulted in an initial engine speed of 2,000 rpm, decreasing with aircraft speed. In level flight the aircraft decelerated and eventually stalled, with a high nose attitude, at approximately 42 mph IAS (37 KIAS). Approaching the stall, the IAS fluctuated by approximately ± 2 mph.

As it stalled, the example aircraft rolled quickly to the left, adopting a bank angle of approximately 60º within one second. Simultaneously, the nose dropped approximately 45º below the horizon and a high rate of descent developed. Holding the control column fully aft produced a tighter turn but no reduction in the rate of descent. Entering the manoeuvre from a turn to the left resulted in a high rate of turn as soon as the aircraft stalled. Recovery was achieved by relaxing the back pressure on the control column and applying full power, which resulted in a height loss of at least 400 ft. Without positive recovery action the aircraft entered a steep spiral dive with anti-clockwise rotation as viewed from above.

Each time the manoeuvre was repeated, the aircraft behaved in the same manner. On each occasion an audible stall warning sounded approximately 5 mph before the stall.

Owner's manual performance data

Performance information was published in the '*Cessna Model 150 Owner's manual*' for G-BABB, produced by Cessna. This manual also covered operation of the Reims manufactured Cessna F150L. The manual stated

> *'stall speeds are presented as calibrated airspeeds because indicated airspeeds are unreliable near the stall'.*

A table in the manual indicated that at a gross weight of 1,600 lbs, in standard atmospheric conditions with power off, aft CG and 20º of flap set, the aircraft would stall at 49 mph CAS (43 KCAS). In the same configuration but with 20º angle of bank, the aircraft would stall at 51 mph CAS (44 KCAS). With 40º angle of bank it would stall at 56 mph (49 KCAS). The manual did not include information enabling these speeds to be corrected for lower gross weights or higher than standard air temperatures, such as that encountered at the time of the accident. However, stall speed decreases with reducing gross weight and increases with higher air temperature.

Guidance to Air Traffic Controllers

The Manual of Air Traffic Services (MATS)

The Manual of Air Traffic Services contains procedures, instructions and information which are intended to form the basis of air traffic services within the United Kingdom. It is published for use by civil air traffic controllers and is arranged in two parts. MATS Part 1 is published by the CAA's Air Traffic Standards Department and contains instructions that apply to all United Kingdom air traffic services units. MATS Part 2 is compiled by each air traffic services unit and contains instructions that apply to that particular unit.

MATS Part 1

Section 1 page 1 of MATS Part 1 states:

> *'The Manual of Air Traffic Services contains instructions and guidance to controllers providing air traffic services. Nothing in this Manual prevents controllers from using their own discretion and initiative in any particular circumstance.'*

Appendix E of MATS Part 1 describes communication techniques and standard phraseology. Paragraph 1.3 states:

> *'Controllers may find, on occasions, that it is necessary to extend or modify phrases. However, they should take care not to confuse or prejudice the basic meaning or intention of a phrase.'*

Paragraph 5.2.2 states:

> *'Messages should not contain more than three specific phrases comprising a clearance, instruction or pertinent information. In cases of doubt, e.g. a foreign pilot having difficulty with the English language or an inexperienced pilot unsure of the procedures, the number of items should be reduced and if necessary passed, and acknowledged, singly.'*

In relation to the lists of standard phrases, paragraph 5.3.2 states:

> *'The lists are not exhaustive and controllers may have to devise additional phrases for unusual situations. However, where a phrase does exist for a particular purpose it must be used.'*

Standard phrases are given in the Attachment to Appendix E of MATS Part 1. The instruction to go around should be given as follows:

> *'go-around, I say again, go-around (instructions), acknowledge'*

Under the heading *'Flight Priorities'*, MATS Part 1 contains the following information:

> *'10.1 Normally requests for clearances shall be dealt with in the order in which they are received and issued according to the traffic situation. However, certain flights are given priority over others and the following table shows the categorisation.*
>
> *10.2 When two or more flights of different categories request clearance the flight with the highest category shall be dealt with first. Flow control procedures are implemented and actioned by the Central Flow Management Unit. A flow control priority will be allocated automatically on receipt of a flight plan.'*

The *'categorisation'* referred to accords 'normal' flights such as that conducted by N347DW a higher priority than 'training' flights such as that undertaken by G-BABB. MATS Part 1 does not contain specific advice on the priority or otherwise to be given to preceding traffic or to inexperienced pilots when conflicts such as that between G-BABB and N347DW arise.

The Air Navigation Order contains the Rules of the Air. Rule 17 – '*Rules for avoiding aerial collisions'* states:

> *'(4) Overtaking*
>
> *(a) Subject to sub-paragraph (b), an aircraft which is being overtaken in the air shall have the right-of-way and the overtaking aircraft, whether climbing, descending or in horizontal flight, shall keep out of the way of the other aircraft by altering course to the right, and shall not cease to keep out of the way of the other aircraft until that other aircraft has been passed and is clear, notwithstanding any change in the relative positions of the two aircraft.'*

Also:

> *'(6) Order of landing*
>
> *(a) An aircraft while landing or on final approach to land shall have the right-of-way over other aircraft in flight or on the ground or water.*
>
> *(b) (i) Subject to sub-paragraph (ii), in the case of two or more flying machines, gliders or airships approaching any place for the purpose of landing, the aircraft at the lower altitude shall have the right-of-way, but it shall not cut in front of another aircraft which is on final approach to land or overtake that aircraft.*
>
> *(ii) (aa) When an air traffic control unit has communicated to any aircraft an order of priority for landing, the aircraft shall approach to land in that order.'*

The Attachment to Appendix E of MATS Part 1 is a list of standard phrases. Under the heading *'Approaching visually to land'* it includes the phrases:

> *'Extend downwind number (number) to an (aircraft type and position)'*

and

> *'orbit right/left and report again (position)'*

Chapter 4, paragraph 1.8.5 of CAP 413 – '*Radiotelephony manual'*, states:

> *'It may be necessary in order to co-ordinate traffic in the circuit to issue delaying or expediting instructions'*

Chapter 4, paragraph 1.10 of the same document states:

> *'Instructions to carry out a missed approach may be given to avert an unsafe situation. When a missed approach is initiated cockpit workload is inevitably high. Any transmissions to aircraft going around shall be brief and kept to a minimum.'*

In each case, CAP 413 reiterates the standard phraseology shown in MATS Part 1. These documents do not specify or restrict the location where such delaying manoeuvres may be conducted.

MATS Part 2

MATS part 2 is produced locally and accepted[10] by the CAA. The instructions amplify and interpret, at local level, MATS Part 1 instructions. Any authorisation required by MATS Part 1 should appear in the MATS Part 2.

MATS Part 2, promulgated by Southend Airport, contains procedures specific to that aerodrome.

Footnote

[10] The word 'accepted' means that the document is reviewed by the CAA. The CAA may require alterations during the acceptance process and must approve locally sponsored alterations but it does not take responsibility for the contents.

Pertinent extracts follow:

> *'CIRCUIT FLYING*
>
> *By day, circuit flying may be undertaken at the discretion of the Aerodrome controller. Approach control is to be kept fully informed of the number of such aircraft and of any manoeuvre which departs from the normal circuit pattern.*
>
> *CO-ORDINATION WITH APPROACH CONTROL*
>
> *Aerodrome control is to keep Approach control updated of the current state of any circuit flying activity.*
>
> *CIRCUIT TRAINING FLIGHTS*
>
> *The Aerodrome controller may exercise discretion in respect of the number and variety of aircraft accepted for simultaneous circuit training flights. Factors to be taken into consideration include the forecast and actual weather, other pending movements including instrument training flights, and whether it is day or night.'*

The version of the Southend MATS Part 2 current at the time of the accident (dated 31 August 2004) contained no guidance about how to deal with inexperienced pilots such as students under training.

Southend ATC memorandums

A memorandum dated 15 April 1997 from the then Senior Air Traffic Control Officer (SATCO) stated:

> *'…club aircraft (have been) instructed to orbit or fly through final and reposition on opposite base leg. This is not an acceptable practice, particularly with club pilots, and especially those of low hours, in a situation where the aircraft is in approach configuration – ie reduced power, low airspeed and with flaps extended.*
>
> *In this situation, the pilot should be instructed to go-around. The clubs are very happy for their pilots to get this practice and that they should be encouraged to initiate a missed approach themselves.'*

The ADC stated that he had never been informed of or discovered the existence of this memorandum which was dated some eight years before he started working at Southend ATC.

On 19 July 2006, immediately after the accident to G-BABB, the advice contained in the 1997 memorandum was reiterated by the SATCO in a memorandum to Air Traffic Control Officers (ATCOs)

> *'Light aircraft on or approaching final will have limited manoeuvrability available.*
>
> *Such aircraft, particularly those with club pilots, and especially those with low hours, are not to be instructed by ATC to:*
>
> 1) *Orbit on final*
> 2) *Fly through final approach and reposition on opposite base leg;*
> 3) *Be given any other significant manoeuvres whilst at low level (ie: below 600 ft) in the vicinity of the final approach and base leg positions.*
>
> *Any of these unacceptable practices could put the pilot in a position where the aircraft is in approach configuration – ie reduced power, low airspeed and with flaps extended, and as a result with very limited safe manoeuvrability available.*

> *If necessary the pilot is to be instructed to go-around using standard MATS PT 1 phraseology. Solo student pilots should be aware of this possible requirement and should be reasonably familiar with the procedure to be followed. Wherever possible, student pilots should be allowed to follow the standard circuit pattern, once making the missed approach.*
>
> *Turns below 600 ft are always to be avoided unless there is an over-riding safety issue.*
>
> *The AFS[11] are to be informed before a student is about to commence a 'First Solo' exercise, and also at the discretion of the flying club instructors or the duty ATCO for nervous or low-hours students.*
>
> *With immediate effect, the number of POB for circuit training is to be recorded (on the flight strip). The number of POB is to be updated whenever there is a change, (ie: due to dropping off of the instructor, etc). Other pertinent information such as '1st Solo' or 'Tyro' (to denote low hours student or recently qualified) is also to be added when so informed by pilot or flying club.'*

These issues were discussed in the forum of the Guild of Air Traffic Control Officers (GATCO) before the accident. The consensus was that inexperienced pilots should not be instructed to manoeuvre on or near the final approach except to go-around. Contributors suggested that it was, however, acceptable to 'orbit' aircraft at the end of the downwind leg in order to increase separation from other landing or departing traffic. They also suggested that instructors should ensure that students were familiar with this procedure, particularly at aerodromes with significant commercial air transport operations.

Footnote

[11] Airfield Fire Service.

Human factors reports

Reports addressing the circumstances of this accident were obtained from two human factors experts. One specialised in the human factors affecting pilots and the other specialised in ATC human factors. Insights from these reports are included in the analysis below.

Analysis

Aircraft

The aircraft's technical log showed that it had been regularly maintained in accordance with LAMS.[12]. Apart from an excessive left magneto drop, which occurred 28 flying hours prior to the accident flight, and which was rectified by replacing one spark plug and cleaning the others, there was no recent fault history recorded in the aircraft's technical documentation.

At the time of the accident the mixture was set at RICH, the throttle position was consistent with an approach power setting, the carburettor heat was at HOT and the flaps were set at positions consistent with an indication of approximately 20º. The ground marks and damage to the aircraft were consistent with it having stalled and entered a steep spiral dive to the left.

The magneto switch was found at the RIGHT position. Its abnormal position indicates either that it remained in this position after the magneto check, moved to that position when the aircraft crashed or the pilot moved it in flight. During the power check the student was trained to check for a drop in engine rpm when the magneto switch is rotated from BOTH to LEFT or RIGHT, and that the rpm returns to its previous value when the switch is moved back to the BOTH position.

Footnote

[12] Civil Air Publication 411 '*Light Aircraft Maintenance Schedule-Aeroplanes*'.

He probably did not carry out a second power check before taking off solo and so, under the supervision of his instructor, the switch was most probably returned to the BOTH position before the first takeoff.

The student made no mention during any of his radio calls that he was experiencing problems with the engine, which suggests that he did not move the key intentionally whilst airborne. However, experience from other accidents suggests that impact loads on the key which are sufficient to cause it to snap, can also rotate it to another position. Therefore it is possible that the ignition switch moved during the ground impact sequence of events.

Whilst the magnetos' internal timing was outside the normal tolerances, the aircraft had been flown for 500 hours since the timing was last checked. It had been flown by a number of instructors and students, none of whom had noticed any reduction in engine power. It is therefore likely that either the timing was disturbed during the accident sequence without leaving any tell-tale marks, or any reduction in power would have been negligible and would not have been a factor in this accident.

The deterioration of the condenser in the left magneto did not affect its performance when it was run on the test bed but it is not known what effect heat from a hot engine would have had on the condenser's performance. The worse case would have been a loss of the left magneto's output which would have resulted in a reduction in engine speed of between 100 and 150 rpm.

Evidence indicating whether or not the engine was producing power when the propeller struck the ground was evaluated. The speed and steep descent of the aircraft and the relatively low power output of the engine meant that it was not possible to tell from the damage to the propeller blades if the propeller had been under power or windmilling when the blades struck the ground. The rpm gauge had frozen at 900 rpm and the engine manufacturer reported that at normal approach speed the engine would windmill at a speed between 600 to 900 rpm. Although the propeller blades stopped almost immediately after they struck the ground, it would have taken slightly longer for the body of the rpm gauge to distort and freeze the needle. In this case, the frozen gauge would have captured the speed of the engine as the needle froze rather than the speed of the engine prior to impact. Therefore, it is likely that the engine speed would have been greater than 900 rpm, which indicates that the engine was probably still producing power.

The engine manufacture stated that with carburettor heat selected to HOT, there would have been a reduction in engine power output of approximately 10% at moderate power settings. Carburettor heat also adversely affects the engine acceleration. This adverse effect would have been compounded if the pilot had advanced the throttle rapidly, such that the accelerator pump in the carburettor added more fuel to an already rich mixture. The result would be an engine that would be slow to accelerate and might be heard to misfire.

The student pilot had established the aircraft on final approach before being instructed to fly north away from the final approach track. If it had been operated in accordance with the student's training, it would have been in the approach configuration with approximately 20º of flap selected and the carburettor heat at HOT. Inspection of the damaged aircraft indicated that it was still in this configuration immediately before impact. Moreover, the target airspeed on final approach in this configuration was 70 mph and the aircraft's average airspeed on final approach, as derived from radar data and the reported surface wind, was 69 mph which is consistent with the target speed. The engine speed would have been approximately 1,700 rpm unless the throttle had been opened as if for a go-around. Witnesses reported that the aircraft flew north-west at low level. If the aircraft had followed the normal vertical profile of the approach before turning north-west, it is likely that it did so at a height between 200 and 300 ft. Radar data, though inaccurate when used to determine instantaneous airspeed, indicated that the average true airspeed of the aircraft had decreased by about 15 mph after it turned north-west. By the final radar return it may have been at or close to the stall speed. The aircraft was seen to adopt an increasingly nose-high attitude before entering a manoeuvre very similar to the stall characteristics determined during this investigation.

Although the foregoing engineering analysis does not eliminate the possibility of power loss, the investigation determined that the aircraft, in this configuration, would have performed in this manner with the engine responding normally to the throttle position as found. It is therefore likely that, having configured the aircraft for the approach, the student did not change this configuration prior to the accident. It is also likely that he did not significantly alter the throttle setting immediately before or after he turned left onto a north-westerly track.

Human factors affecting the student pilot

The student pilot had received the training required by JAR-FCL1 for him to conduct the flight. However, the process of flying a visual circuit is complex. In the early stages of flying training, reliance upon a relatively easily recalled routine reduces this complexity and simplifies the judgements required. For example, the steps involved in flying the base leg and turning onto final (including flap selection and setting the power and attitude of the aircraft) should, if correctly executed, position the aircraft close to the extended centreline of the runway and in the appropriate configuration for a 3º approach. In this way, the task is made less demanding and the need for large or complicated adjustments to the flight path is minimised. The circuit routine provides a means of achieving the basic requirements so that an inexperienced pilot can build experience and gain confidence. The sequence of the routine allows the pilot to concentrate on the task immediately at hand by defining specific sections with associated activities and priorities so that, having established the aircraft on the final approach path, the pilot should be able to concentrate on maintaining the approach path until touchdown. The instruction to report on final would provide him with an assurance that this could be his main or only priority. He would expect the next stage to be landing. The benefits of the procedural routine are most significant in the early stages of solo flying when the student is fully occupied with the basics of flying and has no spare capacity for strategic thinking or expanding his awareness beyond immediate requirements. These additional tasks are known as 'airmanship'.

Due to his inexperience the student probably relied heavily on the routine he had learned for circuit flying, which would have defined his actions and expectations.

The standard phrase *'go-around, I say again, go-around (instruction) acknowledge'* is intended to provide a clear, unambiguous instruction to a pilot, which places the important information first and is designed to trigger a sequence of actions that even an inexperienced pilot would have been taught and practised. The go-around instruction was, however, embedded in the transmission and was subsequently countermanded by the instruction "…DISREGARD THAT JUST TAKE A LEFT TURN AND FLY NORTH…" At the conclusion of this exchange the student had not acknowledged the instruction to go-around, but he had read back "BRAVO BRAVO TURN NORTH".

The instruction to turn left and fly north would certainly have been unexpected. The fact that it followed other instructions that he was told to disregard may have suggested to the student a degree of urgency. He turned as instructed, but he probably had no clear idea what would follow or how he should behave. The fact that he turned onto a track of 330º (the reciprocal of the base leg track), rather than heading north as instructed, suggests that he felt constrained to remain in the circuit. The fact that he was now flying in the reverse direction to the normal circuit would have been outside his experience and possibly alarming, particularly if he was not absolutely sure that no other aircraft were in the circuit. It is likely that his capacity for constructive thought and for monitoring the state of the aircraft was reduced and it is conceivable that some of his attention was directed to searching for other aircraft in the circuit or for the "FAST TRAFFIC BEHIND". Strategies that a more experienced pilot might have adopted include:

> Re-configuring the aircraft and climbing to circuit height, then repositioning to rejoin the circuit on the downwind leg (a go-around, in effect).
>
> Re-configuring the aircraft for level flight and awaiting instructions to reposition onto final, where he could use his judgement to configure for the approach once again and start the descent.

or:

> Reconfiguring for level flight and asking ATC for clarification.

All of these strategies would require a degree of confidence that is unlikely in a student on his second solo flight, particularly one only 16 years old. When the student pilot taxied for takeoff, the ADC instructed him to backtrack, meaning that he should taxi to the end of the runway. The ADC had to repeat the instruction which, it appears, the pilot misunderstood. This exchange highlights the difficulty an inexperienced pilot has interpreting an unusual or unexpected ATC transmission and his reluctance to request clarification. Furthermore, early in training, a student pilot experiences and is supported by two authoritative voices: his instructor's and that of ATC. When the student begins to fly solo exercises, the absence of an instructor emphasises the authority of ATC. The experience of misunderstanding the instruction to backtrack may also have been unsettling.

There were, therefore, several reasons why the pilot's capacity to cope with novel demands may have been compromised. A second solo flight is an exciting experience. In addition, the experience of misunderstanding the taxi instructions may have been unsettling. Later, on final approach, he received a complex transmission that he appears to have misunderstood and was then asked to execute an unfamiliar manoeuvre. This placed him in a situation for which his training and experience had not prepared him. It is likely that without the guidance of a familiar routine his capacity for monitoring the flight instruments was reduced. His ability to think clearly about his future flight path, to prioritise his activities, and to monitor aircraft performance were probably compromised to the extent that he did not reconfigure the aircraft for level flight and did not notice the decreasing airspeed.

Human factors affecting the aerodrome controller

The ADC on duty at the time of the accident may not have been made aware that the pilot of G-BABB was an inexperienced student when he returned to the Aerodrome Control position at 1510 hrs and received a handover from the outgoing controller. The student's misunderstanding of the instruction to backtrack the runway may have been the first indication available to the ADC that the student was inexperienced. The subsequent exchange might have provided a further indication but these indications may not have been obvious to the controller.

Before G-BABB reported final, the ADC received an intercom call from the APC informing him of the approaching Piper, N347DW. The APC was reluctant to instruct this aircraft to carry out manoeuvres intended to increase spacing between it and G-BABB because of "unknown" traffic in the vicinity and suggested instead that the ADC instruct G-BABB to go-around. The outcome of the exchange was that the ADC assumed responsibility for controlling both aircraft. Aware that the distance between the aircraft was decreasing, and believing that there was insufficient time for G-BABB to land and vacate the runway ahead of N347DW, he instructed G-BABB to go-around. This instruction was not in the standard format, however, and the student did not acknowledge that a go-around instruction had been given.

The ADC reported that before instructing the pilot to turn north, he waited until the aircraft had established a positive rate of climb and appeared to be in stable flight. This does not accord with the statement made by the SATCO that the aircraft was "noticeably having difficulty" doing so.

The ADC intended that his instructions would solve the problem of the fast moving Piper catching up with the slower Cessna. The APC's reluctance to turn N347DW away was understandable given the number of aircraft in the vicinity which were visible on radar but over which the APC had no control, no communication and no indications of altitude. However, this complicated the ADC's task and forced him, at short notice, to rethink his plan. Eventually he opted to take control of both aircraft and terminated the conversation with the APC. By turning G-BABB to the north he intended to place G-BABB safely out of the way, focus attention on N347DW until it had landed and then re-direct his attention to G-BABB. However, it is likely that of the two pilots immediately involved, the pilot of N347DW, who was bound to be more experienced, would have been better equipped to deal with demanding or unusual instructions.

Procedures for handling inexperienced pilots

At the time of the accident, although instructors would inform ATC of a first solo flight, there was no agreed method of exchanging information regarding inexperienced pilots on subsequent solo flights and no specific guidance in the Southend Manual of Air Traffic Services Part 2. The memorandum issued by the SATCO following the accident partially addressed these issues but will only continue to do so while the parties concerned remain aware of its existence. Therefore, the following recommendation was made:

Safety Recommendation 2007-036

It is recommended that London Southend Airport includes information relating to the notification and handling of flights by inexperienced solo pilots in its Part 2 of the Manual of Air Traffic Services.

With regard to this recommendation the CAA stated, in a letter to the AAIB, that it believes there is merit in bringing into use a suitable prefix for student pilots, such as 'Student', 'Trainee' or 'Tyro' and that it be applied until holders are issued with a PPL. The CAA suggests that this prefix could be used on the first call to a unit, for example:

'Student G-BXLM'

and that after acknowledgement communications would revert to the normal callsign. The FPS could then be annotated accordingly, which might eliminate the potential to lose this information when handing over to another controller. Such a system has been in use in military flying, where the word 'Tyro', when included in a transmission denotes an inexperienced pilot. This word is in casual use in civilian air traffic communications but has no formal meaning. Therefore the following safety recommendations were made:

Safety Recommendation 2007-050

The Civil Aviation Authority should instigate the use of a suitable prefix, for use in civil radiotelephony, to signify a student pilot, flying solo.

Safety Recommendation 2007-051

The Civil Aviation Authority should amend the Manual of Air Traffic Services Part 1 and the Radio Telephony Manual (CAP413) to emphasise to controllers that pilots identifying themselves as students have limited ability, which must be taken into consideration when issuing instructions.

Manoeuvres intended to increase separation

Both MATS Part 1 and the Radiotelephony Manual refer to orbiting and extending the downwind leg as examples of manoeuvres that may be used to co-ordinate traffic in the circuit. Students are not required by JAR-FCL1 to have practised these manoeuvres but they are required, at the conclusion of their training, to be familiar with standard phraseology. This requirement implies that at that stage they would be able to comply with instructions to orbit, to extend downwind and to go around from base leg or final approach. It is acknowledged, however, that students conducting their first and subsequent solo flights early in their training have accumulated only sufficient knowledge to operate within a restricted environment, and instructors are trained and assessed on their ability to consider that environment before authorising a student to fly solo. In this context, the CFI of the flying school stated that students practised orbits, extensions of the downwind leg and go-arounds at Southend.

Although there was no documentary evidence that the student pilot had practised orbits and extensions, he had completed Exercise 13 which includes missed approach and go-around manoeuvres. He had also been trained to comply with those ATC clearances that might be expected after turning onto the base leg and commencing his approach to the runway. These would be: to 'continue' and await clearance to land; to 'land' having been cleared to do so; and to 'go-around'. Consequently, it is likely that he was properly prepared for the circuit environment that his instructor might reasonably have anticipated.

The CFI added, however, that the student would not have practised orbits in the approach configuration. Any aircraft configured for a stable, descending approach will require additional power to maintain speed if it is subsequently required to fly level. Consequently, although the use of non-standard phraseology probably exacerbated the student's difficulties, even a clear instruction to orbit in the approach configuration would have been problematic. Under existing provisions, air traffic controllers are not expressly prohibited from instructing this manoeuvre. Therefore, the following recommendation was made:

Safety Recommendation 2007-037

The Civil Aviation Authority should amend MATS Part 1 so that, with the exception of issuing instructions to go-around, controllers shall not issue instructions that would require an aircraft in the final stages of approaching to land to deviate from its expected flight path unless exceptional overriding safety considerations apply.

Conclusion

During his second solo flight the student was instructed to carry out an unfamiliar and non-standard manoeuvre. Presented with a situation beyond his experience, he failed to reconfigure the aircraft for level flight. The aircraft continued to fly level at a power setting which the available evidence indicates would have been insufficient to maintain flying speed, and eventually the aircraft stalled at a height from which recovery was impossible.

Appendix A

Extract from AMC FCL 1.125

'Syllabus of flight instruction for the Private Pilot Licence (Aeroplanes)'

Exercise 10A Slow flight

NOTE: The objective is to improve the student's ability to recognise inadvertent flight at critically low speeds and provide practice in maintaining the aeroplane in balance while returning to normal airspeed.

- safety checks
- introduction to slow flight
- controlled flight down to critically slow airspeed
- application of full power with correct attitude and balance to achieve normal climb speed
- airmanship

Exercise 10B Stalling

- airmanship
- safety checks
- symptoms
- recognition
- clean stall and recovery without power and with power
- recovery when a wing drops
- approach to stall in the approach and in the landing configurations, with and without power, recovery at the incipient stage

Exercise 11 Spin avoidance

- airmanship
- safety checks
- stalling and recovery at the incipient spin stage (stall with excessive wing drop, about 45º)
- instructor induced distractions during the stall

NOTE 1: At least two hours of stall awareness and spin avoidance flight training shall be completed during the course.

NOTE 2: Consideration of manoeuvre limitations and the need to refer to the aeroplane manual and mass and balance calculations.

Appendix A (cont)

Exercise 13 Circuit, approach and landing

- circuit procedures, downwind, base leg
- powered approach and landing
- safeguarding the nosewheel
- effect of wind on approach and touchdown speeds, use of flaps
- crosswind approach and landing
- glide approach and landing
- short landing and soft field procedures/techniques
- flapless approach and landing
- wheel landing (tail wheel aeroplanes)
- missed approach/go around
- noise abatement procedures
- airmanship

Exercise 12/13E Emergencies

- abandoned take-off
- engine failure after take-off
- mislanding/go-around
- missed approach

Exercise 14 First solo

- instructor's briefing, observation of flight and de-briefing

NOTE: During flights immediately following the solo circuit consolidation, the following should be revised.

- procedures for leaving and rejoining the circuit
- the local area, restrictions, map reading
- use of radio aids for homing
- turns using magnetic compass, compass errors
- airmanship

ACCIDENT

Aircraft Type and Registration:	Cessna 152, G-BPME
No & Type of Engines:	1 Lycoming O-235-L2C piston engine
Year of Manufacture:	1982
Date & Time (UTC):	28 April 2007 at 1527 hrs
Location:	Southend Airport, Essex
Type of Flight:	Training
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to nose landing gear, engine, engine frame and propeller
Commander's Licence:	Student pilot
Commander's Age:	38 years
Commander's Flying Experience:	21 hours (of which 21 were on type) Last 90 days - 5 hours Last 28 days - 1 hour
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft was being flown by a student pilot on her second solo flight. During the landing the aircraft bounced twice and then the nose landing gear collapsed.

History of the flight

The student pilot flew a number of circuits with her instructor, which were completed satisfactorily. He then left the aircraft so that she could practise some solo circuits; this was her second solo flight. Runway 06, in use at the time, has an asphalt surface 1,605 m in length. The landing threshold is displaced by 174 m and there is a public road which crosses the undershoot, close to the touchdown end of the runway.

As the aircraft crossed over the road at around 50 ft the pilot felt the aircraft roll from side to side. She then felt that the aircraft was too fast although it had been trimmed for the approach at 65 kt. As she pulled back to flare the aircraft for landing the nose pitched up at a greater rate than she expected and she released the back pressure. The aircraft struck the runway surface and bounced. She tried to control the landing but the aircraft bounced again and then came to a stop.

The pilot said that at the time she could not remember what she should do if the aircraft bounced but remembered afterwards that she should have opened the throttle for a go-around.

After the aircraft had stopped she selected the magnetos to 'OFF' and attempted to pull the mixture to 'idle cut off' but it was jammed. The fire service arrived and she vacated the aircraft.

ACCIDENT

Aircraft Type and Registration:	Cirrus SR-22, N220RJ
No & Type of Engines:	1 IO-550-N piston engine
Year of Manufacture:	2006
Date & Time (UTC):	6 April 2007 at 1322 hrs
Location:	Saddlewood Manor Farm, Tetbury
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to propeller and wheel fairing
Commander's Licence:	Private Pilot's Licence
Commander's Age:	49 years
Commander's Flying Experience:	227 hours (of which 145 were on type) Last 90 days - 95 hours Last 28 days - 15 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

As the pilot applied the brakes after landing, the aircraft skidded and could not be stopped before the end of the runway. The aircraft over-ran at low speed, colliding with a dry stone wall.

History of the flight

The pilot reported that he made a normal full flap landing, touching down about 100 m in from the threshold of Runway 09. As he applied the brakes, the wheels locked and skidded on the grass runway, which has an LDA of 635 m. The weather at the time was good, the grass was dry and there was a headwind of about 5 kt. He stated that he varied the brake pressure but this had no effect. In an effort to steer the aircraft he then applied full right brake only, but again with no effect. The aircraft over-ran the runway at slow speed and collided with a dry stone wall, causing damage to the propeller and a wheel fairing.

Comment

CAA Safety Sense leaflet 7c, '*Aeroplane Performance*', describes the effects of a grass runway and touch down point on landing performance.

ACCIDENT

Aircraft Type and Registration:	Europa (monowheel) homebuilt, G-SHSH
No & Type of Engines:	1 Rotax 912-UL piston engine
Year of Manufacture:	2002
Date & Time (UTC):	16 April 2007 at 1541 hrs
Location:	Rochester Airport, Kent
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Minor
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	53 years
Commander's Flying Experience:	10,000 hours (of which 13 were on type) Last 90 days - 102 hours Last 28 days - 33 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft hit a rut during the landing roll, causing the landing gear to become unlocked and collapse, resulting in damage to the propeller and underside of the fuselage.

History of the flight

The pilot was completing the last of three circuits on Runway 02R at Rochester after having returned from the Isle of Wight. The approach was flown at 55 kt to 65 kt and an early touchdown was achieved prior to the intersection of Runways 02 and 34. During the rollout he felt a bump, after which the monowheel landing gear retracted, bringing the aircraft to a sudden stop. Observing smoke, the pilot quickly secured and evacuated the aircraft; the airport emergency services attended and later assisted with its recovery. There was no fire and the smoke was believed to have been caused by the mainwheel tyre rubbing against its housing.

The pilot stated that the bump was due to a rut at the intersection of the two runways and he believed that this had caused the undercarriage to become unlocked and retract.

ACCIDENT

Aircraft Type and Registration:	Hal-26 Push Pak, G-AVPO
No & Type of Engines:	1 Continental C90-8F piston engine
Year of Manufacture:	1967
Date & Time (UTC):	17 April 2007 at 1715 hrs
Location:	Combrook Farm Air Strip, Near Wellesbourne, Warks
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to left wing
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	64 years
Commander's Flying Experience:	10,514 hours (of which 12 were on type) Last 90 days - 92 hours Last 28 days - 25 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

During the landing roll, the aircraft 'ground looped' after it had curved to the left of the grass runway and struck a hedge, despite the application of full right rudder by the pilot. The pilot assessed the cause of the loss of directional control to be the tailwheel sinking into a patch of soft ground, and the springs connecting it to the rudder circuit being insufficiently strong to counteract the wheel castoring forces.

History of the flight

The Hal-26 Push Pak is configured with two main landing gear wheels and a tailwheel. Having been airborne for about and 1 hour 20 minutes, the pilot returned to Combrook with the intention of finishing off with two circuits. The wind was 350º/12 kt and Runway 04 was in use, which the pilot reported has a downslope towards the left side.

After a normal approach and touchdown, the aircraft began to curve gently to the left towards the end of a hedge which adjoined the left side of the runway. Despite the rapid application of full right rudder, the aircraft continued to veer left and its wing struck the end of the hedge. The collision swung the aircraft through approximately 270º and it came to rest just off the runway, facing back towards it. The occupants were uninjured and left the aircraft through the cabin door.

The pilot is positive that his foot was not impeded by aircraft structure and that he was able to achieve full right rudder; he also believes that he was able to apply right wheel brake. He stated that there was no indication of it binding when he taxied out prior to the flight, or during the takeoff, and that the left wheel brake was not binding when he subsequently pushed the aircraft back to its hangar.

When he inspected the runway after the event, he was able to identify his aircraft's wheel tracks and noted that after his point of touchdown, the ground initially was firm but subsequently became softer. It was evident that the tailwheel had sunk in to the soft ground to approximately 2/3 of the depth of its tyre, leaving a square-sided groove. He inferred from this that the tailwheel must, for all practical purposes, have been castoring rather than actively steering the aircraft in response to rudder inputs.

The tailwheel is designed to be disconnected for ground handling and this mechanism reportedly was working correctly after the event. The pilot concluded that the loss of directional control was possibly because the springs, which connect the tailwheel to the rudder circuit, were insufficiently strong to turn the wheel against the depth of the trough that the wheel was making in the soft ground. He noted that the normal practice of holding the control column hard back during the ground roll would have encouraged the tailwheel to bed down into the soft ground.

ACCIDENT

Aircraft Type and Registration:	Ikarus C42 FB100, G-WSSX
No & Type of Engines:	1 Rotax 912 ULS piston engine
Year of Manufacture:	2006
Date & Time (UTC):	15 March 2007 at 1445 hrs
Location:	Old Sarum Airfield, Wiltshire
Type of Flight:	Training
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Nose landing gear collapsed, propeller damaged and engine shock-loaded
Commander's Licence:	Student Pilot
Commander's Age:	68 years
Commander's Flying Experience:	50 hours (of which 50 were on type) Last 90 days - 10 hours Last 28 days - 5 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

History of the flight

Following a number of dual circuits from Runway 24 at Old Sarum Airfield, the student pilot's instructor sent him off for his first solo circuit from the same runway. Whilst landing after completion of this circuit, the student flared a little too high, the airspeed decayed, the nose dropped, and the aircraft landed heavily on its nose wheel. This caused the nose landing gear to collapse and the propeller to strike the ground.

ACCIDENT

Aircraft Type and Registration:	Piper PA-28-140 Cherokee, G-ZEBY
No & Type of Engines:	1 Lycoming O-320-E2A piston engine
Year of Manufacture:	1973
Date & Time (UTC):	20 November 2006 at 1446 hrs
Location:	Humberside Airport
Type of Flight:	Training
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Nose landing gear leg, propeller and engine damaged
Commander's Licence:	Student pilot
Commander's Age:	42 years
Commander's Flying Experience:	40 hours (of which 40 were on type) Last 90 days - 25 hours Last 28 days - 14 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

On landing, the nosewheel of the aircraft made firm contact with the runway and separated from the nose gear leg.

History of the flight

The student pilot was flying from Nottingham to Humberside on a cross-country navigation exercise which formed part of his training towards the grant of a Private Pilot's Licence. He made what he considered to be a normal and uneventful approach to Runway 21 at Humberside and he reported that on landing, the aircraft touched down main wheels first. When the nosewheel touched down, the aircraft pitched up sharply. The student pilot attempted to hold the nose level but the aircraft pitched down until the nosewheel struck the ground, causing the nose to bounce up again. As it did so, the pilot could see the nosewheel rolling alongside the aeroplane. When the aircraft pitched down once more, the nose landing gear leg scraped along the runway surface. The aircraft yawed to the right but stopped on the runway.

A member of the Aerodrome Fire and Rescue Service who witnessed the landing commented that the aircraft appeared to bounce three or four times.

Engineering inspection

The maintenance organisation responsible for repairing the aircraft found that the nosewheel oleo was bent and the fork to which the nosewheel was normally attached had sheared off. The engine and propeller were also damaged. There was no evidence of any pre-existing mechanical defect that might have contributed to the accident and the engineer who carried out the inspection commented that the damage was consistent with the nosewheel having made firm contact with the runway.

Discussion

The nose landing gear of most aircraft is intended to provide stability and control on the ground but not to support the loads encountered on first contact with the runway during landing. The pilot's decision to attempt to hold the nosewheel off the runway as the aircraft bounced was correct, but he may have misjudged the appropriate attitude. The pilot remarked that he may have lowered the nose whilst attempting to hold it level. Inexperienced pilots may find the transition from a nose-down approach attitude to the required nose-up landing attitude difficult to assess but can learn to do so with practice and the assistance of a qualified flying instructor.

ACCIDENT

Aircraft Type and Registration:	Piper PA-28-180, G-BCCF
No & Type of Engines:	1 Lycoming O-360-A4A piston engine
Year of Manufacture:	1973
Date & Time (UTC):	4 April 2007 at 1240 hrs
Location:	Sleap Airfield, Shropshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Dent in left wing leading edge, left navigation light broken, propeller bent and engine shock-loaded
Commander's Licence:	Private Pilot's Licence
Commander's Age:	59 years
Commander's Flying Experience:	202 hours (of which 47 were on type) Last 90 days - 3 hours Last 28 days - 1 hour
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft's left wing struck a barbed wire fence during taxi.

History of the flight

The pilot was planning to depart from Sleap airfield for a flight to Manchester Airport. Runway 05 was in use and local procedures involved taxiing along the intersecting Runway 18 and then making a 90 degree turn to the right towards the threshold of Runway 05. The pilot was unfamiliar with this procedure so he followed three other aircraft which were already taxiing down Runway 18. The pilot reported that, at the southern end of Runway 18, he failed to negotiate the right turn correctly. His left wing struck a wooden post, which was part of a barbed wire fence located close to the taxiway. The impact caused the aircraft to swerve to the left, resulting in the propeller hitting the barbed wire and the engine stopping abruptly.

ACCIDENT

Aircraft Type and Registration:	Reims Cessna F172N, G-BHDZ
No & Type of Engines:	1 Lycoming O-320-H2AD piston engine
Year of Manufacture:	1979
Date & Time (UTC):	28 October 2006 at 1112 hrs
Location:	900 ft above Snetterton, Norfolk
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	No damage incurred during forced landing, but fire damage behind instrument panel
Commander's Licence:	Private Pilot's Licence
Commander's Age:	45 years
Commander's Flying Experience:	411 hours (of which 334 were on type) Last 90 days - 18 hours Last 28 days - 5 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and additional AAIB inquiries

Synopsis

An electrical system failure which occurred in-flight, but close to an airfield, resulted in flames and smoke emanating from behind the left instrument panel, after the pilot attempted to re-set the alternator circuit breaker. During short final approach to the airfield for a precautionary landing, the engine stopped and the aircraft landed in a field close to the runway.

A combination of a defective battery and a failure of the voltage regulator was identified as the main causal factor of this event. Two safety recommendations are made.

History of the flight

After departing from Great Ashfield on what was intended to be a local flight, the pilot noted that the fuel contents were indicating a significantly lower quantity than on his pre-flight inspection. As a precaution, he decided to call Old Buckenham Airfield, which was nearby, but received no reply. On checking the circuit breakers, he noted that one of them, most probably the 60 amp alternator unit, had tripped. He reinstated it, but this produced a noise described by the pilot as a "phut". He retransmitted his call to Old Buckenham and stated his problem, but smoke and flames immediately issued from behind the instrument panel; he briefly observed that the fuel contents indication was restored to its original reading. The pilot then received a reply from Old Buckenham, who advised him to turn off the battery master switch. The pilot complied, after having made a 'PAN' call; however, although the flames diminished, smoke continued to emerge from behind the panel.

The pilot positioned the aircraft downwind at Old Buckenham before turning onto final approach for the asphalt Runway 25. At this point, the flames reappeared above and below the left instrument panel, with the associated smoke hindering the pilot's forward visibility. On short final approach, the engine stopped and, with insufficient height to clear obstacles, the pilot was forced to land the aircraft in a field to the right of the runway. This was successful and the occupants evacuated the aircraft immediately. The airfield fire crew had just completed their Saturday morning practice and were able to meet the aircraft as it came to rest. The pilot considered that their prompt arrival most probably saved the aircraft from more serious fire damage.

Examination of the aircraft

The maintenance organisation that subsequently examined the aircraft suspected that a fault in the voltage regulator had caused the fire. This unit, which was a 'solid state' device, together with the alternator, were removed, and tests confirmed that the regulator was not controlling the voltage. The regulator, an Electrodelta VR515GA, was marked with the letters 'FAA/PMA' (Federal Aviation Administration/Parts Manufacture Approval). Reference to the aircraft log books indicated that it had been fitted on 31 July 2002, some 400 flight hours earlier, and that it was fitted as a replacement, according to a log book entry, due to the '*alternator not charging battery*'. It should be noted that G-BHDZ is equipped with a 28v DC electrical system, and that the regulator was the correct unit for such a system.

Damage to the wiring behind the instrument panel was extensive and centred on the area around the magneto/start switch and the immediately adjacent combined battery master and alternator switch. In addition, many of the instruments had been affected by heat and/or smoke, and some of the surrounding plastic trim had melted. It was established that the correct type of battery and alternator ganged switch was fitted, in that a battery OFF selection also switched off the alternator. Photographs of some of the components, including the alternator circuit breaker, are shown at Figure 1, where it can be seen that the circuit breaker casing has suffered an explosive event, with melting of the brass and copper terminal fittings on the associated feed wire.

It was found that the aircraft battery had an '*unserviceable*' label tied to it, together with the words '*Jump Battery*', and the registration of another aircraft written on the casing. Subsequent inquiries revealed that this other aircraft had been de-registered in July 2006. According to the owner of G-BHDZ, the battery had been installed as a temporary measure following problems with the previously installed unit.

The voltage regulator consisted of a circuit board mounted inside a sealed aluminium alloy box. An internal inspection revealed that some of the components, including a transistor and at least two resistors, showed evidence of heat damage. An amplifier block, which was central to the regulating function of the unit, showed evidence of corrosion on some of its terminals. It was considered that this may have been the result of moisture ingress, as was evident elsewhere on the circuit board.

Similar occurrences

The Civil Aviation Authority (CAA) database lists six occurrences, since January 2002, of cockpit smoke in UK registered Cessna 172 aircraft. Most of these reports contained little detail and some did not confirm

View of wiring damage

Ignition switch

Alternator circuit breaker and feed wire

Figure 1

that an electrical problem was the cause of the smoke. However, in March 2005, an incident occurred in which the high and low voltage lights illuminated, and which the pilot attempted to rectify by recycling the battery master switch. This failed to clear the problem and a subsequent burning smell was followed by black smoke issuing from behind the left side of the instrument panel. A Mayday was declared and a successful forced landing was carried out at a nearby airfield. It was found that the voltage regulator, an Electrodelta VR600, had failed: this designation indicates that the aircraft was equipped with a 14 volt system. This incident was not investigated by the AAIB and there was no indication as to whether the alternator circuit breaker had tripped.

In July 2004, the FAA issued a Special Airworthiness Information Bulletin (SAIB), CE-04-72, addressed to owners and operators of Cessna 150, 172, 177, 180, 182, 185, 188, 206, 207 and 210 series aircraft. It related to aircraft equipped with Electrodelta VR600A regulators which had been fitted as replacements for the Cessna-supplied items in 14v systems. Installation instructions for the regulator called for the removal of the Cessna-installed over-voltage sensor and the modification of the wiring. The SAIB was prompted by over-voltage conditions following a failure of such a regulator in a Cessna 172N aircraft, which did not result in the tripping of the alternator circuit breaker. It was determined that the aircraft electrical system was no longer protected in the event of a regulator failure. Owners were therefore recommended to incorporate Cessna Owner Advisory SEB03-3A and Service Bulletin SEB03-3, which, together with an associated Service Kit, replaced the VR600A regulator with a VR600 unit. The Bulletin also required the reinstallation of the over-voltage sensor, and, if the aircraft wiring had been modified, the installation of a VR600A regulator together with returning the wiring to the manufacturer's original configuration.

The FAA had not received any reports of similar problems affecting aircraft with 28v systems, which is why the SAIB was aimed at aircraft with 14v systems. Whilst it is possible that similarities in the design of the regulators could affect 28v systems, the fact that the circuit breaker tripped at least indicated that G-BHDZ had the correct wiring.

Discussion

The evidence suggests that the alternator circuit breaker probably tripped shortly after the engine was started, with this not being noticed by the pilot at the time. It is also likely that the poor condition of the temporary replacement battery accounted for the relatively short time period before the voltage deteriorated to the point where the fuel gauges and radio did not operate correctly. The probable failure mode of the regulator resulted in a high current being applied to the alternator field coil, and in consequence, a high alternator power output. Resetting the circuit breaker thus caused this output to be applied through the circuit breaker to the aircraft wiring, which melted the insulation and led directly to the smoke and flames. It is likely that a cascade of short-circuit conditions ensued within the wiring loom, to the extent that the pilot's action of switching off the battery master was likely to have been ineffective. Almost certainly, the cause of the engine failure was due to the grounding of the magnetos as a result of wiring damage around the magneto switch.

If the alternator circuit breaker indeed tripped at around the time the engine was started, it is perhaps not surprising that the pilot failed to notice it as the aircraft checklist, in common with those of most other light aircraft, only called for a check of the circuit breakers before engine start. It is generally understood, following incidents concerning wiring failures in Commercial Air Transport aircraft, that circuit breakers found to have tripped in flight should be subject to a once-only attempt at resetting, but then only if deemed essential for continued safe flight. In this incident, this action resulted in dramatic consequences that endangered the aircraft and its occupants. It is fortunate that the aircraft was at a low altitude at the time of the occurrence; indeed, the pilot had already decided to land, prompted by the spurious low fuel indication. Had the aircraft been higher, the additional time required to reach a suitable landing area could have allowed the situation to deteriorate to the point where a potentially more serious outcome could be expected.

There have been a number of incidents in the United Kingdom involving smoke in the cockpit of Cessna 172 aircraft caused by electrical problems, although the incident to G-BHDZ was more severe in terms of the extent of the damage. In America, the FAA has identified issues with single-engine Cessna aircraft equipped with 14v systems, which may be left unprotected following the fitting of PMA voltage regulators. It was concluded that these issues were unrelated to the G-BHDZ incident; the fact that the circuit breaker functioned as intended indicates that the wiring was correct. Nevertheless, since the potential effect, ie electrical fires and fumes, is the same, it is considered pertinent to discuss the matter in this Bulletin. The fact that the FAA transmitted the information in the form of an SAIB, indicated that they did not consider the matter critical to the safety of the affected aircraft. However, it is likely that most owners and operators would prefer to be aware of any dormant faults in the wiring of their aircraft, but it is unclear how many maintenance organisations in Europe routinely trawl through SAIB's.

Safety Recommendations

The majority of popular light aircraft operated in the United Kingdom, such as the Cessna and Piper series, share similarities in the design of their electrical systems, with many of the components being sourced from the same vendors. All have a number of circuit breakers that control the electrical supply to systems such as the flaps and the avionics although, in most cases, only the one in the alternator circuit could be described as 'heavy duty'.

The action of the pilot of G-BHDZ, in resetting the circuit breaker, subjected the aircraft wiring to a high-power surge from an unregulated alternator, which in turn challenges the wisdom of attempting a once-only re-setting operation of 'heavy duty' circuit breakers whilst airborne. In single engine aircraft, the battery, assuming it is in good condition, can sustain operation of the radio, other avionic systems and lighting for more than 30 minutes from the point at which it ceases to be charged. This would normally allow sufficient time for a safe landing to be made. Accordingly, the following Safety Recommendations are made:

Safety Recommendation 2007-048

It is recommended that the European Aviation Safety Agency, in conjunction with the Civil Aviation Authority, publish specific information aimed at discouraging the resetting of high power circuit breakers on light aircraft, such as those that control alternators, whilst in flight unless considered essential for the safe continuation of the flight.

Although the potential problems identified by the FAA, affecting those Cessna single-engine aircraft equipped with 14v electrical systems, were unrelated to the G-BHDZ incident, the information contained in SAIB CE-04-72 may be relevant to European registered aircraft. However, the SAIB issued by the FAA is considered a relatively obscure method of transmitting airworthiness information, and it is possible that many owners and operators are unaware of the potential vulnerability of their aircraft. The following Safety Recommendation is therefore made:

Safety Recommendation 2007-049

It is recommended that the European Aviation Safety Agency, in conjunction with Civil Aviation Authority, promulgate the information contained in FAA Special Airworthiness Information Bulletin CE-04-72, so that European operators of single-engine Cessna aircraft, together with their maintenance organisations, can ensure that the aircraft electrical systems have the required level of over-voltage protection.

ACCIDENT

Aircraft Type and Registration:	Skyranger 582(1), G-CCDW
No & Type of Engines:	1 Rotax 582/48-2V piston engine
Year of Manufacture:	2003
Date & Time (UTC):	13 March 2007 at 1720 hrs
Location:	Cromer Airfield, Norfolk
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Collapsed undercarriage, damage to propeller, wing and cowling
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	51 years
Commander's Flying Experience:	298 hours (of which 233 were on type) Last 90 days - 8 hours Last 28 days - 4 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

After takeoff, on climbing through 300 to 400 feet, the aircraft engine suddenly stopped. The pilot made a forced landing in a field during which the landing gear collapsed.

History of the flight

The pilot reported that before takeoff he completed all the required pre-flight inspections, ran the engine up to temperature and confirmed that all engine indications were normal. He then departed for a solo local area flight from Runway 18 at Cromer Airfield, a single grass strip surrounded by farmland. There was a westerly wind of about 4 kt, good visibility and a temperature of 15ºC. The pilot stated that after takeoff, whilst climbing through 300 to 400 feet, the engine stopped and, despite his attempts, could not be re-started.

Before departure the pilot had assessed that should the engine fail on takeoff, his primary option would be to land in the field immediately to the east of the airstrip. When the failure occurred, he attempted to land in this field parallel to the crop furrows which ran in the same direction as the airstrip. However, with the height available, he was unable to turn far enough and landed at approximately 45º to the furrows. All three landing gear legs collapsed due to the rough ground on the landing roll. The pilot made the switches safe and turned off the fuel before vacating the aircraft, via his pilot's door.

Comment

The cause of the engine failure has not been determined.

ACCIDENT

Aircraft Type and Registration:	Socata TB10 Tobago, G-JURE
No & Type of Engines:	1 Lycoming O-360-A1AD piston engine
Year of Manufacture:	1986
Date & Time (UTC):	25 September 2006 at 2028 hrs
Location:	Delamere, near Chester, Cheshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passenger - None
Injuries:	Crew - 1 (Serious) Passenger - N/A
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Private Pilot's Licence
Commander's Age:	52 years
Commander's Flying Experience:	300 hours (of which 25 were on type) Last 90 days - 4 hours Last 28 days - 0 hours
Information Source:	AAIB Field Investigation

Synopsis

Whilst in the approach phase of a night currency flight, the aircraft suffered a sustained loss of engine power that required the pilot to make a forced landing. In the darkness, the pilot was unable to locate a clear area in which to land and the aircraft flew into a tree, where it came to rest. Shortly afterwards the aircraft caught fire and the pilot, unable to open the aircraft's door, vacated the aircraft through a perspex window. He fell to the ground and was taken to hospital with serious burn injuries.

History of the flight

The pilot intended to perform a night currency flight, having not flown at night for nearly three months. When he arrived at Liverpool Airport the aircraft was parked on the general aviation apron. Having removed the aircraft's soft cover the pilot carried out the usual pre-flight inspection, which included a check for water contamination of the fuel. The start, taxi, power checks and takeoff were uneventful and he departed the Liverpool Control Zone at 1933 hrs, heading towards Chester.

The pilot flew to Llangollen between 2,000 and 2,500 ft amsl, and then headed back towards Oulton Park, the visual reporting point for his return to Liverpool Airport. At 1953 hrs, the pilot transmitted to Liverpool ATC that he was 'FOUR MILES SOUTH WEST OULTON PARK FOR REJOIN AT OULTON PARK' and then descended to 1,500 ft to comply with Liverpool Airport's special visual flight rules. He completed his rejoin checks, which included selecting carburettor heating which he left selected for between 30 seconds and one minute. After levelling off at an airspeed of approximately 100 kt, the pilot recalled that the engine noise changed slightly but he was unable to identify why. As he began the turn towards Liverpool Airport from Oulton Park, the engine note changed significantly and there was a significant loss of power; he thought that the sound was mechanical rather than rough running. The pilot moved the throttle marginally backwards and then forwards and selected the mixture to fully rich, but neither action increased the engine power. At his stage he completed the engine restart checks which included setting the mixture to FULL RICH, the propeller to FULL FINE, full throttle and the carburettor heat to ON. He cannot recall any of the instrumentation at this stage but transmitted 'MAYDAY MAYDAY MAYDAY, G-JURE HAS AN ENGINE PARTIAL FAILURE AND IS DESCENDING CURRENTLY AT 800 FEET AND JUST THREE MILES TO THE NORTH WEST OF OULTON PARK'.

Liverpool ATC passed the surface wind to the pilot but nothing more was heard from the aircraft. The pilot, unable to maintain level flight, established the aircraft in a glide towards an area of darkness at 80 kt, with the wings level, and switched on the landing light in an attempt to identify a landing field. The light illuminated a canopy of trees and he then switched the light off to preserve his night vision. Shortly afterwards the aircraft impacted the tree canopy and rapidly came to rest in an upright position. The pilot's lap and diagonal restraint held him in his seat and he remained conscious throughout. Within a few seconds a fire started just forward of the cockpit and the pilot attempted to vacate the aircraft. Although he was unable to open the door as the latch positioned at the front of the door was now engulfed in the fire, he was able to undo his harness. He then positioned his back against the side plexiglass panel and, pushing with his feet, popped the panel out and then fell backwards through the opening, straight down to the forest floor. With some difficulty he moved away from directly beneath the burning wreckage towards a witness who was searching for survivors. The witness called the emergency services and, whilst they were waiting, another passer-by poured a bucket of water over the pilot as his clothing continued to emit smoke. The pilot was taken to hospital by the emergency services where he spent several weeks in intensive care with serious burn injuries.

Technical examination

After coming to rest suspended in trees the aircraft suffered an intensive post-crash fire, which destroyed the fuselage immediately aft of the engine firewall. The fuel tanks were damaged in the impact and although no fuel was recovered there was significant evidence of fuel spillage at the accident site. A detailed examination of the wreckage was carried out after recovery of the aircraft from the accident site. All the instrumentation had been destroyed together with the fuel lines and selector valve in the fuselage. The propeller, engine, control cables and the fire wall were the subject of a detailed examination by the AAIB.

Although one blade had been bent backwards, the propeller was relatively undamaged and there were no witness marks to indicate that it was rotating with significant speed as it passed through the trees. Measurement of the exposed 'inners' of the engine control cable indicated that the engine controls were in the following positions: throttle 80% fully open, mixture 75% toward the RICH position and the carburettor heat had been selected. There was no evidence to suggest that the position of these cables had been disturbed during the recovery process and given that the surrounding structure had been destroyed prior to the recovery it is considered that they represent their approximate positions immediately after the impact. Moreover, since the carburettor control knob must be pulled towards the pilot to select the carburettor heat it is considered unlikely that impact forces would have moved it into this position.

It was not possible to test the carburettor and the magnetos because of fire and impact damage and the position of the carburettor air intake valve at the time of impact could not be verified. The spark plugs showed no evidence of oil fouling and examination of the cylinder bores confirmed that there was no evidence of scoring or other abnormalities to the liners and pistons. No other mechanical abnormalities were identified.

Aircraft records

A review of the aircraft's records showed that at the time of the last annual inspection in December 2005 the engine was suffering from low compression and all of the cylinders were removed and overhauled. After a further seven hours of operation the number two cylinder was again removed for 'rework' to rectify an oil fouling problem. After reinstallation of the cylinder, the engine operated for a further 54 hours without any reported defects prior to the accident.

Carburettor icing

The Liverpool Airport weather, observed at 2001 hrs, reported a surface wind from 310º at 5 kt, scattered cloud at 2,500 ft amsl and a temperature of +16ºC with a dew point of +12ºC.

Examination of carburettor icing charts, using the prevailing atmospheric conditions for the altitude of the aircraft, suggests that the aircraft would experience moderate levels of carburettor icing at cruise power settings and serious icing during a descent (Figure 1). The presence of carburettor icing would lead to the engine losing power and running roughly. The application of carburettor heat would then result in an increase in the rough running and further power loss until all the ice had dissipated. The periodic application of carburettor heat for short periods of time during cruise checks may not have been sufficient to remove completely any accumulated ice. Whilst running roughly at low power the effectiveness of carburettor heat quickly diminishes as the engine exhaust manifold rapidly cools. In the event of a significant build-up of ice, it could take a considerable amount of time to clear all the ice and regain full engine power.

The dangers of carburettor icing are discussed in detail in the CAA General Aviation Safety Sense Leaflets 03, (*Winter Flying*) and 14b (*Piston Engine Icing*).

Analysis

The engine had operated for 54 hours following its last significant maintenance without any reported defects prior to the accident. There was no evidence of a mechanical failure within the engine and the spark plugs and cylinders confirmed that the engine had not suffered from oil fouling immediately prior to the accident. Evidence from the crash site and the intensity of the post crash fire confirm that the aircraft had fuel in its tanks at the time of the crash. It was not possible to test the fuel and ignitions systems because of damage and they cannot therefore be eliminated as a possible cause of the loss of engine power and rough running.

The possibility remains that despite the occasional use of carburettor heating, the conditions in which the aircraft was operated resulted in a build-up of carburettor ice causing a loss of engine power. This power could not be recovered by the use of carburettor heat before the aircraft crashed into the trees.

The weather was suitable for the flight, the pilot was familiar with the area and the planning of the flight appears

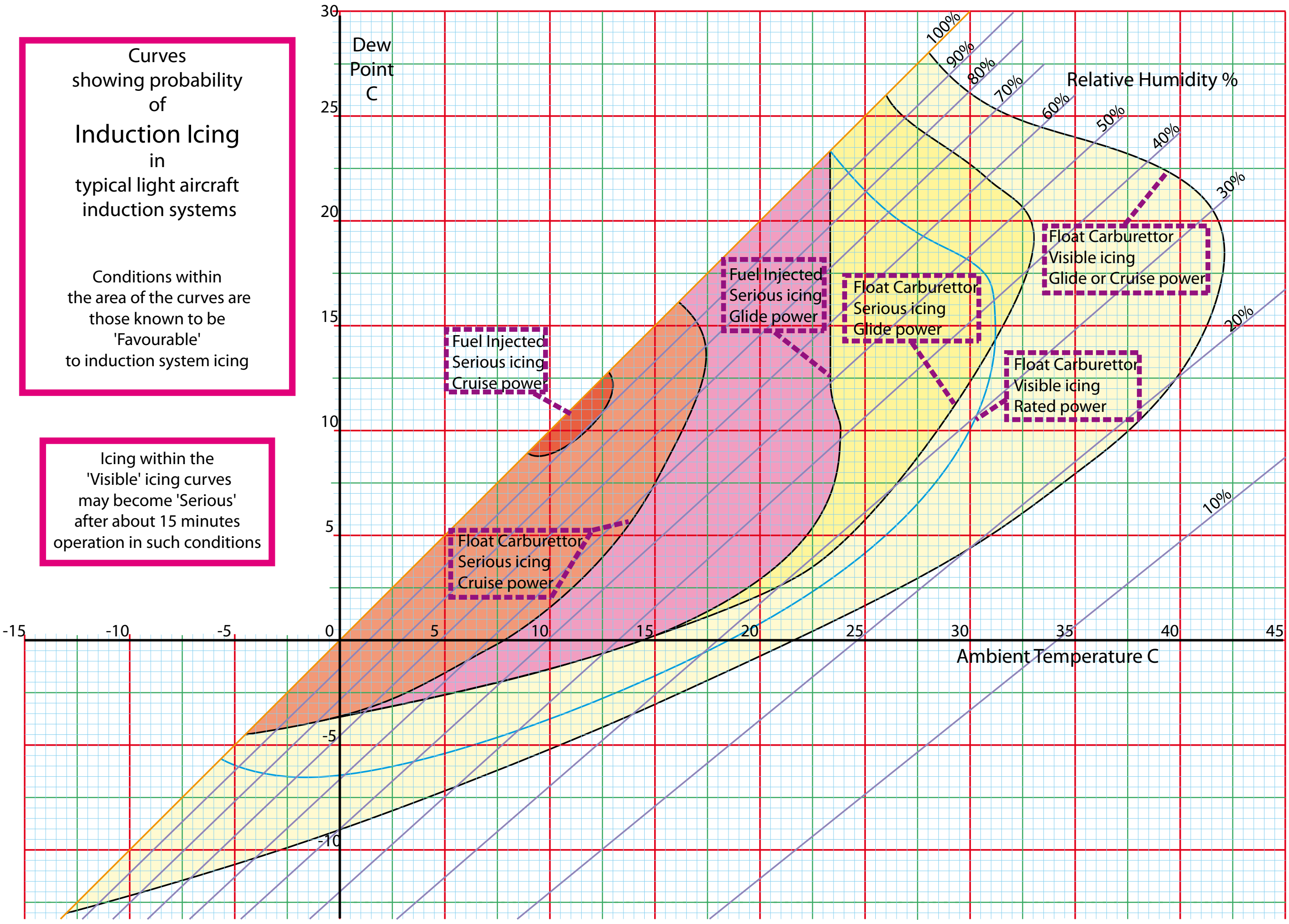


Figure 1

well considered. Regardless of the reasons behind the power failure, the pilot was required to attempt a forced landing at night, away from an illuminated airfield. This is always likely to be a hazardous manoeuvre and anything that can be done to mitigate the risk should be considered. Although the CAA does not offer any specific guidance on night forced landings, flying schools recommend looking to land into wind in 'dark' areas which are less likely to have obstructions, although as in this accident, these maybe areas of woodland. They also consider that any form of ground illumination should be maintained in order to give the pilot the optimum opportunity to avoid obstructions. The pilot's emergency call included position information, which assumes a greater significance since a night accident is less likely to be observed by ground witnesses.

A further consideration is the use of an aircraft ballistic recovery system. These whole aircraft parachute systems can be fitted to a variety of light aircraft and potentially offer a reduced risk option in the event of an engine failure at night on a single-engine aircraft.

ACCIDENT

Aircraft Type and Registration:	Bell 206B Jet Ranger III, G-CODE
No & Type of Engines:	1 Allison 250-C20J turboshaft engine
Year of Manufacture:	1985
Date & Time (UTC):	30 April 2007 at 1400 hrs
Location:	Bredbury, Stockport, Cheshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - 1 (Minor)
Nature of Damage:	Damage to the main rotor blades, main gearbox, transmission, fuselage, tail boom and engine
Commander's Licence:	Private Pilot's Licence
Commander's Age:	53 years
Commander's Flying Experience:	93 hours (of which 20 were on type) Last 90 days - 18 hours Last 28 days - 10 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The pilot reported that, while carrying out a spot turn to the right prior to taking off, the wind gusted and he experienced a sudden loss of tail rotor effectiveness. The helicopter struck the ground and came to rest on to its right side. It was severely damaged but there was no fire. The pilot and his passenger, who sustained minor injuries, exited the helicopter through the left windscreen.

The wind speed at the time of the accident was probably in excess of the demonstrated maximum sideways and rearwards airspeeds to which the helicopter had been cleared.

History of the flight

The helicopter was departing from the centre of a field, a private landing site, where it had landed some three hours earlier. Having lifted into the hover, approximately into wind, the pilot turned and hover-taxied the helicopter downwind, in order to give himself the full length of the field for the takeoff. As he was carrying out a spot turn to the right, to point back into the wind, he reported that the wind gusted and he experienced a sudden loss of tail rotor effectiveness (LTE). The helicopter began to spin to the right and after about one and a half turns, before the pilot could recover control, one of the skids struck the ground and G-CODE rolled onto its right side.

Despite extensive damage to the helicopter, the engine was still running. The pilot shut it down and made the helicopter safe, before he and his passenger exited the aircraft through the left windscreen, which the passenger had kicked out. During the impact the passenger received a cut on the top of his head but, the pilot was uninjured. Once outside the helicopter the pilot disconnected the battery. A witness immediately reported the accident to the emergency services, who arrived about 20 minutes later. There was a fuel leak, but no fire ensued. The passenger subsequently received treatment for his minor head injury.

The weather at the time was fine but the surface wind at Manchester International Airport, 10 miles away, was recorded as being from 075º at 16 kt gusting to 27 kt. The aircraft flight manual advises that the helicopter has been demonstrated in sideways and rearwards flight up to 17 kt. Therefore, the surface wind at the accident site may well have been in excess of the wind speeds in which the helicopter's sideways and rearwards controllability has been proven.

The pilot concluded that, in the conditions, he could have taken off from the position where he had initially lifted into the hover. Also, although he would normally have carried out the spot turn to the left, on this occasion he was keen to keep some nearby power cables in sight whilst he manoeuvred the helicopter. Carrying out a spot turn to the right involved reducing the thrust produced by the tail rotor. Furthermore, he appreciated that carrying out the manoeuvre in wind conditions in excess of the maximum speeds for which the Jet Ranger has been demonstrated in sideways and rearwards flight contributed to the accident.

ACCIDENT

Aircraft Type and Registration:	Robinson R44 Astro, G-TATY
No & Type of Engines:	1 Lycoming O-540-F1B5 piston engine
Year of Manufacture:	1999
Date & Time (UTC):	16 September 2005 at 0855 hrs
Location:	Near Amersham, Buckinghamshire
Type of Flight:	Training
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Serious) Passengers - N/A
Nature of Damage:	Severe disruption of fuselage, main and tail rotor blades, cockpit canopy and tail rotor drive shaft
Commander's Licence:	Student Pilot (Helicopters) Private Pilot's Licence (Aeroplanes)
Commander's Age:	59 years
Commander's Flying Experience:	224 hours (of which 31 were on helicopters) Last 90 days - 17 hours Last 28 days - 3 hours
Information Source:	AAIB Field Investigation

Synopsis

The student pilot had departed from Denham airfield on his first solo cross-country exercise. About five minutes after the helicopter had taken off it was seen flying at a low height just to the south of the town of Amersham. Seven members of the public then saw G-TATY perform some energetic manoeuvres before it struck the ground in a nose-down attitude, coming to rest upright. The pilot received serious injuries and the helicopter was seriously damaged. Subsequent investigation found no technical fault with the helicopter that would have contributed to the accident. The weather had been fine but the reported surface wind at the time of the accident exceeded the manufacturer's and operator's limitations for a pilot of this experience. The pilot could not recall any of the events on the flight and it was not possible to conclude what caused the helicopter to descend from the cruise at about 1,500 feet amsl. However, the evidence indicated that the rotational speed of the rotor blades was below the 'power on' limits at the moment G-TATY struck the ground.

History of the flight

The student pilot and an instructor had completed 10 minutes of circuits at Denham Airfield before the instructor disembarked from the helicopter, rotors running, and authorised the student as competent to carry out his first solo navigation exercise in the local area. The planned route for the flight was from Denham, north-west to overhead Westcott disused airfield, a distance of 23 nm, and back to Denham. The pilot had annotated his 1:500,000 chart with a figure of 312º (M), for the required track outbound, and a time of 14 minutes, which equated to a ground speed of 100 kt.

G-TATY took off from Runway 06 at 0849 hrs and turned left for a standard departure via the Maple Cross NDB. This was observed by the flight information service officer (FISO) on duty in the control tower at the airfield. He stated that the pilot sounded normal on the radio and that there was nothing unusual about the departure. After that, the FISO received no further calls from G-TATY and was not advised of any frequency change by the pilot. Before reaching Maple Cross the helicopter turned further left on a track towards Westcott, which took it in the direction of the town of Amersham.

Shortly before 0855 hrs, a member of the public, who was walking her dogs in a field on the southern edge of Amersham, became aware of a "noisy" helicopter approaching from an easterly direction. On looking up she saw a blue helicopter flying towards her at a height which was much lower than normal. She explained that helicopters often flew overhead in that vicinity and that she was used to hearing and seeing them. On this occasion she observed that the helicopter's main rotor blades appeared to be turning more slowly than usual. The helicopter flew past on the far side of a hedge on her right side and then turned left and pitched nose down as it "swung round" through 360º. After that manoeuvre it flew away from her, up a sloping field, and, although the blades appeared to be turning more slowly, seemed to recover some energy. The witness then lost sight of the helicopter. Almost immediately she heard a sound which was a "combination of a crash and a thud". Without delay she called the emergency services on her mobile telephone. That call was timed at 0855:29 hrs.

While remaining on her telephone, the witness moved towards the helicopter, which was about 500 metres away from her. Initially it was hidden by the hedge that was on her right, and the slope of the rising ground beyond, but eventually she was able to see the helicopter near the far side of the field, adjacent to a wood. The rotor blades were stationary but the engine was still running and the only occupant, who was strapped into the front right seat, was moving. While continuing to tell the emergency services what she could see and hear, this lady approached the occupant of the helicopter. He had a visible injury in the area of his throat and was unable to talk, despite apparently trying to. He was also attempting to release his seat belt, without success, so the witness assisted him.

Fifteen minutes after the impact the fire service arrived, switched off the engine and removed the pilot, still conscious, from the helicopter. He had suffered significant head injuries in addition to those to his neck. Shortly after that he was airlifted to hospital by a police air support unit helicopter, which had arrived at the accident site at 0918 hrs.

While the pilot of the police helicopter was on the ground at the accident site, he made G-TATY safe by switching off its master battery switch and alternator switch. The helicopter had been severely damaged in the impact but there was no fire.

The helicopter struck the ground at an elevation of 420 feet amsl.

Other witnesses

As the helicopter was flying to the south of Amersham, an unusual noise prompted six other members of the public to look up at it. The noise was described as sounding like two very loud "choking" noises, a dull "pop" or a few "phuts". Two witnesses stated that the engine sounded as if it was going to cut out and one of those recalled the noise "oscillating up and down". Two of the witnesses, in addition to the lady who was walking her dogs, saw the helicopter turn left and one of those commented that it was banked steeply "as if in a whirlpool". There was agreement between all the witness statements that the helicopter adopted a very steep nose-down pitch attitude and descended rapidly before appearing to regain a level attitude. It then pitched steeply nose down again and turned to the right. At that point most of the witnesses lost sight of the helicopter as it disappeared from view before crashing. However, one witness did see G-TATY strike the ground nose first and fall back, coming to rest in an upright attitude. The aircraft stopped a few metres from the northern edge of Rodger's Wood.

Figure 1

G-TATY, 16 September 2005

The pilot

The pilot had briefly held a Private Pilot's Licence (Flying Machine), with a rating for Group A Landplanes, in 1963. That had lapsed and he qualified for a new Private Pilot's Licence (Aeroplane) in January 2002. He had been the owner of a Scottish Aviation Bulldog from 2002 until June 2005 and held a current rating for single-engine piston ('SEP (Land)') aeroplanes.

In January 2005 he commenced a course of helicopter instruction on the Robinson R44, all but one of the flights being in G-TATY. He had accrued a total of 31 hrs on type, of which 2 hrs 30 mins had been solo. The accident occurred on his first solo cross-country flight.

Following the accident the pilot was unable to remember much of the events of 16 September and none of the accident flight. The head injuries which he had suffered during the accident were considered to have contributed to this memory loss, which bore the usual traits for this condition. He did, however, volunteer to take part in a lengthy cognitive interview with an experienced, qualified practitioner. This technique has been used, with success, to help willing participants recall events which they seem to have forgotten; on this occasion, it did not produce further information.

The pilot was regarded by his most regular instructor as a slow learner but one who handled the helicopter well with the cyclic trim ON. He was considered to be good at controlling the rotor rpm with the governor OFF and good at autorotations. However, hovering was not such a strong point. He was also described as having a tendency to treat the helicopter like a fixed-wing aircraft and was sometimes slow to react to a problem. In addition, the instructor recollected the pilot overriding the governor by gripping the twist grip throttle too tightly "at one time or another". Downwind landings were not a manoeuvre that the instructor encouraged and the pilot recalled receiving very little, if any, instruction on the subject. Therefore he was unfamiliar with the increased power that is required as the helicopter transitions through zero airspeed during such an approach. He was also unfamiliar with the handling requirements in such a manoeuvre, with the potential for the helicopter to enter 'vortex-ring state'[1]. His RTF skills were not considered good.

Aircraft description

The Robinson R44 Astro is a four-seat single-engined helicopter of conventional layout with a maximum gross takeoff weight of 1,089 kg. The primary fuselage structure is constructed of welded steel tubing covered with riveted aluminium skin and is fitted with a skid landing gear. The aircraft is powered by a 6-cylinder Lycoming O-540 piston engine fitted with a carburettor and a carburettor heat system. The engine power output shaft drives a pulley sheave which transmits power to an upper sheave via four rubber 'vee' belts. The belts are tensioned by an electric screwjack clutch actuator which, when activated, raises the upper sheave and automatically sets and maintains the required tension. A freewheel clutch within the upper sheave transmits power forward to the main rotor gearbox and aft to the tail rotor driveshaft. The flying controls are all mechanically operated via push-pull tubes and bellcranks without hydraulic assistance. To ease pilot control forces the cyclic control is fitted with an automatic electric trim system.

The helicopter was equipped with a carburettor heat assist device which, according to the Pilot's Operating Handbook (POH):

> *'correlates application of carburettor heat with changes in collective setting to reduce pilot work load. Lowering collective mechanically adds heat and raising collective reduces heat. Collective input is transmitted through a friction clutch which allows the pilot to override the system and increase or decrease heat as required. A latch is provided at the control knob to lock carburettor heat off when not required. It is recommended that the control knob be unlatched (to activate carb heat assist) whenever OAT* [Outside Air Temperature] *is between 27ºC and -4ºC and the difference between dew point and OAT is less than 11ºC.'*

Aircraft maintenance history

The aircraft was manufactured in July 1999 and the airframe and engine had accumulated 421.2 hours by the time of the accident. The aircraft's last 'STAR' annual inspection was completed on 6 September 2005 at 418.9 hours. There were no recorded defects in the aircraft's technical log.

Meteorology

A meteorological aftercast described the synoptic situation at 0600 hrs on 16 September 2005 as showing high pressure in the central Atlantic which was feeding a moderate north-easterly flow over much of England. At the location of the accident, this gave a visibility of 40 km or more, few clouds at 2,000 feet amsl and a

Footnote

[1] Vortex-ring state, or 'settling with power' is a condition where a helicopter settles into its own downwash. It is characterised by a substantial sink rate and low forward airspeed. The result is an unsteady turbulent flow over a large area of the rotor disk, causing loss of rotor efficiency.

surface wind of 010º/13 kt gusting 20-26 kt. The wind at 1,000 feet agl was calculated to be 030º/25-30 kt and at 2,000 feet agl it was 030º/30 kt.

The Terminal Area Forecast (TAF) for Northolt, which is 4 nm to the south-east of Denham airfield, for the period 0600 hrs to 2300 hrs on 16 September 2005 predicted a surface wind of 350º/10 kt, becoming 010º/15-25 kt between 0700 hrs and 1000 hrs, with visibility greater than 10 km and scattered cloud at 3,000 feet aal. The actual wind at Northolt at 0850 hrs, as recorded on the Aerodrome Meteorological Report (METAR), was 010º/13 kt. At Heathrow, which is 7 nm to the south-south-east of Denham, the surface wind recorded at the same time was 010º/13-26 kt. Respective temperatures and dew points at that time were 12ºC/7ºC (relative humidity (RH) 71.5%) and 13ºC/8ºC (RH 71.6%).

The chart of carburettor induction system icing probability in Safety Sense Leaflet 14 of LASORS[2] indicated that, in these conditions, there was a serious risk of icing at any power setting for a typical light aircraft piston engine without carburettor hot air selected.

A report, which was submitted by the flight information service officer (FISO) on duty at Denham airfield at the time of the accident, recorded the wind as varying in direction between 360º and 010º at a speed of 15-20kt with gusts to 28kt. The cloud was recorded as being broken at 2,000 feet aal.

The regional pressure setting was 1017 mb.

Footnote

[2] LASORS (Licensing Administration Standardisation Operating Requirements Safety) is an annual publication by the CAA containing '*essential licensing requirements and safety information for pilots of all aircraft*'.

Navigation

For a cross-country training flight the operator recommended using a 1:250,000 chart. The planned route to Westcott and back was a typical first solo cross-country exercise and the student pilot recalled that he was advised to remain on the Denham Radio frequency throughout the flight. He would not have been expected to use the GPS.

The pilot had prepared the route on a 1:500,000 aeronautical chart of Southern England and Wales. The outbound and return tracks had been represented by a single line, 8.5 cm in length, drawn in green and annotated 312ºM and 132ºM respectively, with a time of 14 minutes. The distance was 23 nm and this indicated a still air airspeed of 100 KIAS. Radio frequencies for Denham Radio, Northolt Approach, Benson Zone and Brize LARS (Lower Airspace Radar Service) had been handwritten on the chart in red.

Limitations and procedures

The R44 Pilot's Operating Handbook (POH) states:

'The following limitations (1-3) are to be observed unless the pilot manipulating the controls has logged 200 or more flight hours in helicopters, at least 50 of which must be in the RHC Model R44 helicopter, and has completed the awareness training specified in Special Federal Aviation Regulation (SFAR) No. 73, issued February 27, 1995.

1) *Flight when surface winds exceed 25 knots, including gusts, is prohibited.*
2) *Flight when surface wind gust spreads exceed 15 knots is prohibited.*
3) *Continued flight in moderate, severe, or extreme turbulence is prohibited.'*

This was supplemented locally by guidance in the operator's Flying Order Book which stated that solo student pilots should not fly in wind speeds exceeding 15 kt.

The POH Safety Notice SN-25 states:

> *'Carburettor ice is most likely to occur when there is high humidity or visible moisture and air temperature is below 21ºC. ....*
>
> *<u>During Climb or Cruise</u> – Apply carb heat as required to keep CAT (carburettor air temperature) gage [sic] out of yellow arc.'*

The pilot, however, stated that he had considered the carburettor heat, with its 'carburettor heat assist device', as being an essentially automatic system and not something which he would adjust.

The R44 POH normal procedure in the cruise is:

> *'1. Adjust carb heat if required.*
>
> *2. Verify RPM in green arc.*
>
> *3. Set manifold pressure with collective for desired power.*
>
> *4. For aircraft with manual controls, adjust cyclic trim to zero forces.*
>
> *5. Verify gages in green, warning lights out.*
>
> ***CAUTION***
>
> *Inflight leaning with engine mixture control is not recommended. Engine stoppage may result as there is no propeller to keep engine turning should overleaning occur.'*

The pilot stated that it was not his practice to operate the mixture control after the engine was started.

For power failure above 500 feet agl, the POH procedure is;

> *'1. Lower collective immediately to maintain RPM and enter normal autorotation.*
>
> *2. Establish a steady glide at approximately 70 KIAS.*
>
> *3. Adjust collective to keep RPM in green arc or apply full down collective if light weight prevents attaining above 97%.*
>
> *4. Select landing spot and, if altitude permits, maneuver [sic] so landing will be into wind.*
>
> *5. A restart may be attempted at pilot's discretion if sufficient time is available.*
>
> *6. If unable to restart, turn off unnecessary switches and shut off fuel.*
>
> *7. At about 40 feet AGL, begin cyclic flare to reduce rate of descent and forward speed.*
>
> *8. At about 8 feet AGL, apply forward cyclic to level ship and raise collective just before touchdown to cushion landing. Touch down in level attitude with nose straight ahead.'*

The rate of descent of an R44 Astro during a stable autorotation is between 1,600 fpm and 1,800 fpm. The POH states that the configuration for minimum rate of descent during autorotation is:

> *'1. Airspeed approximately 55 KIAS.*
>
> *2. Rotor RPM approximately 90%.*
>
> *3. Rate of descent is about 1,350 feet per minute.'*

G-TATY descended through approximately 1,000 feet before striking the ground, which would have given the pilot up to 45 seconds in which to turn into wind, if employing this power failure procedure.

The POH Safety Notice SN-32, entitled 'HIGH WINDS OR TURBULENCE', states that flying in high winds or turbulence should be avoided but recommends that, if unexpected turbulence is encountered, airspeed be reduced to 60-70 KIAS, overcontrolling be avoided and the governor be left ON.

Accident site examination

The aircraft was resting upright in the field with its nose facing in the direction of 000º(M). Both landing gear skids had collapsed and the forward section of the right skid had fractured. The transparent portions of the cockpit canopy had shattered and there was clear evidence that a main rotor blade had cut through the canopy and struck the instrument panel. The engine rpm instrument was found 50 metres from the main wreckage and had a main rotor blade imprint in its casing. The main rotor blades were relatively undamaged apart from the tips which had been bent rearwards and up as a result of ground impact. The tail boom had partially separated and was bent to the left. The lower vertical tail fin was bent in half and the tail rotor exhibited ground impact damage. One tail rotor blade had separated but was embedded in the ground within 2 metres of the tail rotor gearbox.

All the aircraft components were accounted for and all were found within a 50 metre radius of the main wreckage. There was no evidence that any part of the aircraft had struck a tree in the wooded area a few metres south of the accident site. The damage to the aircraft and the ground witness marks indicated that the aircraft had struck the ground in a nose-low attitude, with a slight right bank, on a heading of approximately 348°(M) with a high vertical descent rate, sufficient to collapse the skids. The aircraft had then translated aft and to the left by 3 metres and yawed to the right before coming to rest.

Detailed wreckage examination

The aircraft wreckage was recovered to the AAIB facility at Farnborough for further detailed examination. The flying control tubes were checked for continuity and the few separations found were consistent with overload failures during impact. The tail rotor driveshaft had failed in torsion overload, consistent with the failure expected as a result of the tail rotor hitting the ground during impact. There were no other failures of the main rotor or tail rotor driveshafts. There was no evidence of a main rotor (MR) gearbox or tail rotor (TR) gearbox failure and both the MR and TR chip detectors were clean.

The attachment lug for the upper sheave of the electric screwjack clutch actuator had failed, which resulted in loss of tension in the 'vee' belts. Metallurgical examination of the lug failure revealed that it was caused by overload, consistent with it having occurred at impact. The clutch actuator motor and microswitches were tested by the aircraft manufacturer and operated satisfactorily. The engine rpm electronic governor control box and the trim control box were also tested by the aircraft manufacturer. Both were found to be slightly outside specification limits but, according to the manufacturer, this would not have been detectable by a pilot.

Both the governor and cyclic trim switches were found in the ON position and the transponder was found set to STANDBY.

Powerplant examination and test

A total of 29 gallons (US) of fuel was recovered from the aircraft's main and auxiliary fuel tanks which have a combined total capacity of 50 gallons (US). There was fuel remaining in the gascolator and carburettor, and the fuel filters in both the gascolator and carburettor were clean. A fuel sample was tested, was found to be free of contamination and complied with the specification requirements for AVGAS 100L.

The engine was still running after the accident so it was decided to test run it rather than carry out a strip examination. The engine was mounted on a dynamometer test rig; it was started and then ran normally after a brief warm-up period. The engine passed a series of tests and produced a maximum corrected power output of 257 bhp at 2,800 rpm. This compared favourably with the engine manufacturer's maximum specified power output of 260 bhp at 2,800 rpm.

Audio recordings of the engine test runs were made at different rpm settings and then compared to the audio recording from the '999' mobile telephone call made by the witness who first arrived at the accident scene. The engine noise was audible during the '999' call while the woman was trying to assist the pilot. When the engine noise from the call was isolated and amplified it most closely matched the recording of the engine test at 2,800 rpm.

The carburettor heat mechanism consists of a sliding valve within the air intake box controlled by a selector knob in the cockpit. The valve position adjusts the mixture of cool and heated air that flows to the carburettor. The valve was found in the full COLD position and this was consistent with the collective position which was full UP and the carburettor heat selector knob which was OFF but unlatched. With the knob unlatched, a lower collective position would have commanded some carburettor heat application.

Cooling fan examination

The engine cooling fan is mounted on a tapered shaft connected to the lower sheave. The fan is secured to the shaft with a 2-inch diameter castellated nut. Eight self-locking nuts, which surround the large fan nut, serve to secure the fan wheel to the fan hub. One of the self-locking nuts was missing and two were only finger tight. There was evidence of heat damage surrounding the nuts and some of the holes had become ovalised as a result of fretting. The fan had slipped on its shaft and was no longer in alignment with the white witness mark on the shaft. The fan wheel was difficult to remove because the hub had partially welded itself to the tapered shaft. The aircraft manufacturer reported that similar occurrences had been seen before and that, if the fan hub becomes loose and moves on the shaft, the friction generated can be sufficient to friction weld the hub and shaft together. This heat also causes the small self-locking nuts to loosen.

No unusual vibrations were noticed by the instructor during the training flight prior to the accident flight. Therefore it is probable that the fan slippage occurred as a result of impact when the engine suddenly became unloaded following the failure of the screwjack clutch actuator.

Caution and warning panel examination

The bulb filaments from the caution and warning lights in the instrument panel were examined for indications of stretch. A stretched filament is an indication that the bulb was 'hot', and was therefore illuminated, when it was subjected to a high force. All the bulb filaments were normal apart from the LOW RPM and CLUTCH lights which both had stretched filaments. The LOW RPM light illuminates when the rotor rpm drops below 97% RPM and the CLUTCH light illuminates when the clutch actuator motor is attempting to tighten the 'vee' belts. These lights were subjected to a high force on two occasions; once when the aircraft struck the ground and then again when the main rotor struck the instrument panel. It was therefore not possible to determine if the lights were on immediately before ground impact or illuminated just after impact, once the rotor blades had slowed and the clutch actuator lug had failed.

Radar and GPS

Radar recordings were obtained for G-TATY and the police helicopter. All the radar contacts for G-TATY were primary. There were no secondary returns; this is probably explained by the aircraft's transponder being found set to STANDBY. The police helicopter gave both primary and secondary radar contacts and the lowest level that the primary contacts were recorded for this helicopter, as indicated by the secondary radar information, was 500 feet on the standard pressure setting of 1013 mb. This equated to an altitude of 620 feet amsl, which was 200 feet higher than the accident site.

Recorded information was retrieved from G-TATY's GPS equipment. The GPS memory was set to record waypoints, and their associated information, every four minutes. However, there was a gap of only one minute and three seconds between the last two points. This could have happened as a result of power being removed and then restored to the GPS at some time after the penultimate waypoint was recorded.

The recorded GPS waypoints are shown in Figure 2.

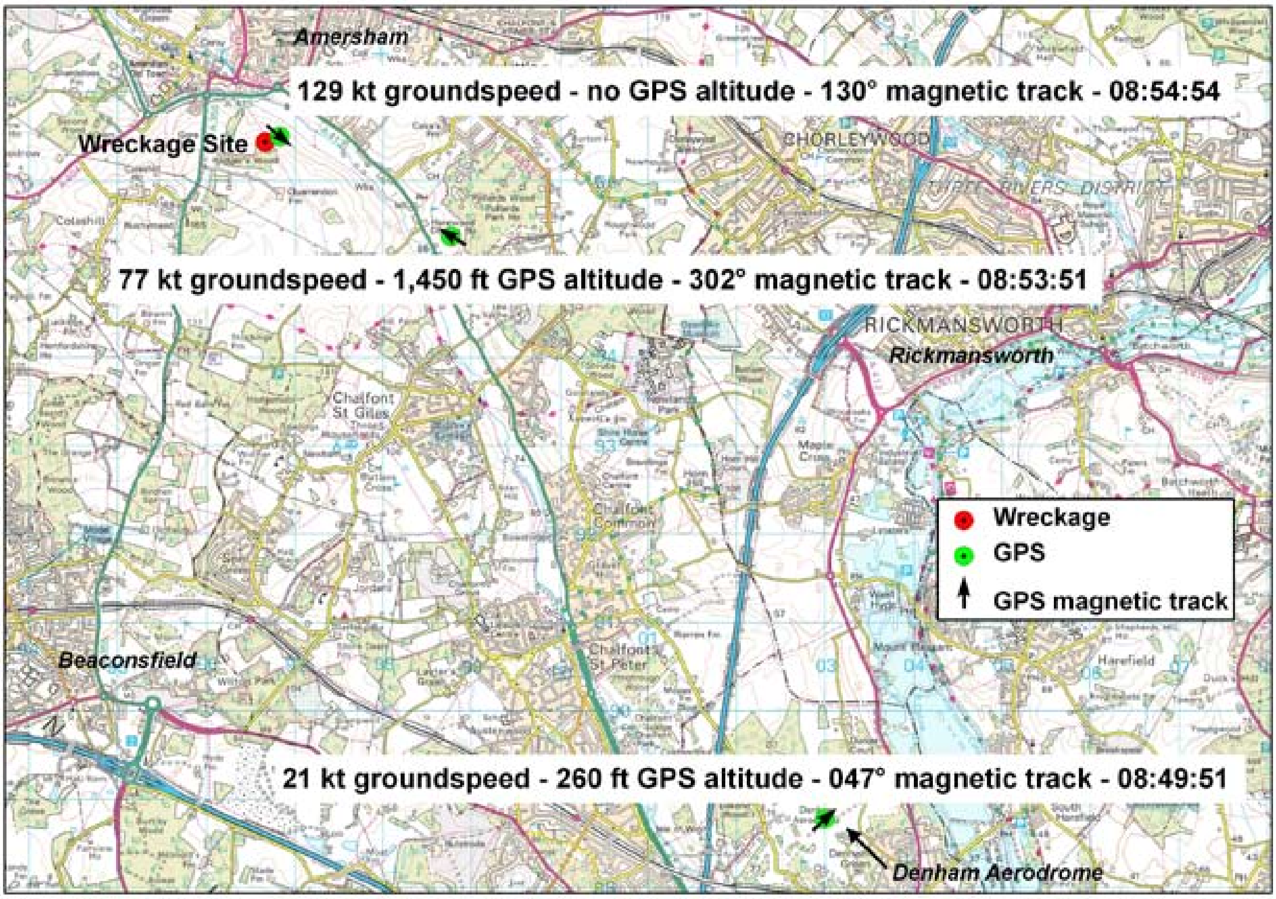


Figure 2

G-TATY recorded waypoints

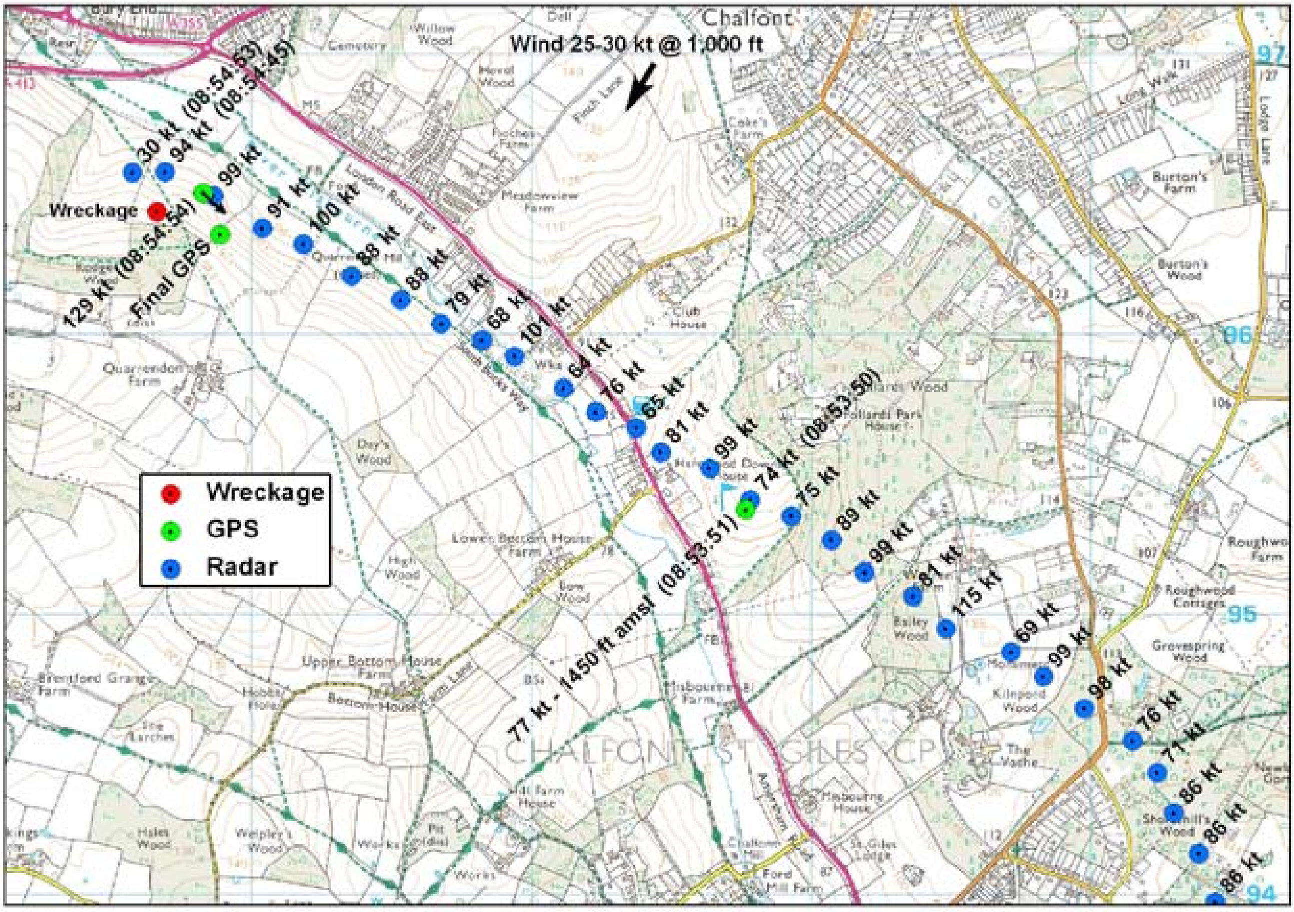


Figure 3

G-TATY radar recordings

However, the helicopter's GPS groundspeed of 129 kt at 0854:54 hrs was considered unreliable because it was not consistent with any of the witness statements, nor was it reflected in the recorded radar data, which is shown in Figure 3.

There was good correlation between the radar and GPS at 0853:51 hrs but less correlation at 0854:54 hrs.

Analysis

From the available evidence, the takeoff was conducted successfully and G-TATY reached a cruising altitude of about 1,500 feet amsl as it turned onto its outbound heading towards Westcott. However, approximately five minutes into the student pilot's first solo cross-country flight the helicopter began to descend.

The GPS and recorded radar information indicated that G-TATY descended from an altitude of 1,450 ft amsl to about 620 ft amsl in the space of 1 minute 2 seconds; an **average** rate of descent of approximately 800 fpm. This was about half the rate of descent expected during a stable autorotation. There was no specific evidence that the helicopter descended throughout that period or that it descended at a uniform rate. Conversely, there was no evidence of G-TATY having descended at a rate that indicated that it had entered autorotation. The average ground speed during that time was 86 kt and, given the wind conditions, G-TATY's airspeed averaged 88 kt. This is reflected in the speeds annotated on the plot of radar recordings in Figure 3 for the same period, which indicate fluctuations about about the mean ground speed. These fluctuations which could have been the result of variations in the positional accuracy of the radar recordings.

The engineering evidence indicated that the helicopter struck the ground in a nose-low attitude with a slight right bank and a high vertical descent rate. The helicopter then translated backwards by approximately 3 metres as a result of pilot input or possibly as a result of the main rotor striking the ground forward of the aircraft. The degree of damage to the main rotor blades indicated that the rotors were probably being driven at low power and were rotating at below normal operating rpm. The subsequent ground impact would have caused the main rotor to slow further and become unstable, consistent with the canopy then being struck. The tail boom, tail rotor driveshaft and tail rotor blade damage were a consequence of the impact. All aircraft parts were accounted for and there was no evidence of pre-impact separation and the detailed examinations did not reveal any technical fault that might have contributed to the accident. The engine was running at high rpm after the accident and engine tests revealed that it was capable of producing full power. The fan wheel fretting was probably a result of the engine suddenly becoming unloaded after impact, and did not contribute to the accident.

Thus, the evidence suggests that the main and tail rotors were turning at less than their optimal speed at the point of impact and what caused the rotor speed to decay was not ascertained during the investigation. The engine was still running when the first witness reached the aircraft and there was no evidence that the engine had stopped in flight and been restarted. The noises which witnesses recalled hearing before the aircraft struck the ground could have come from the engine or been caused by 'blade slap' (which occurs when a rotor blade interacts with the vortex trailing from a preceding blade).

Despite a concerted effort, the pilot was unable to recall any of the events on the flight and his loss of memory bore the normal traits for such a condition following a traumatic accident. However, it seems that he lost control of the helicopter during the manoeuvres which were observed shortly before G-TATY struck the ground. At some point during those manoeuvres the helicopter was flying down wind at slow speed - a situation with which the pilot was unfamiliar. Low rotor speed at this point would have presented the pilot with an extremely challenging situation.

Detailed examination of G-TATY after the accident revealed no faults prior to the helicopter striking the ground. The governor was found in the ON position suggesting that the pilot had not employed the governor failure procedure, although the switch could have been knocked into that position when the helicopter struck the ground.

The surface wind at Denham, as reported by the FISO, was outside the limiting wind speeds stipulated by the operator and by the helicopter manufacturer for a pilot of this experience. The average airspeed (88 kt) established from the radar recordings in Figure 3 did not equate with that recommended for flight in unexpected turbulence. It is not known whether the wind, and any turbulence that existed at higher altitude, affected the pilot's ability to control the aircraft or a temporary fault prompted him to descend and land in a field. However, having departed from Denham airfield only five minutes beforehand, it would have been reasonable to expect the pilot to return there for any problem that did not require an immediate landing. He did not transmit a radio call to advise others that he had a problem and the helicopter did not appear to have entered autorotation in preparation for an engine-off landing. Before the cross-country flight, the pilot had completed 10 minutes of uneventful flying in the circuit at Denham airfield, with an instructor, and had then been authorised to carry out the solo navigation exercise.

Assuming a level attitude, G-TATY probably descended initially as a result of the collective being lowered or a marked reduction in the rotor speed, or both. Had it been the consequence of a forward cyclic input, causing the helicopter to pitch down, there would have been an associated increase in speed, which was not evident. It is not possible to say whether any lowering of the collective was the result of a voluntary or inadvertent pilot input or some other involuntary cause, masked by a distraction.

Being at an early stage in the flight, the pilot may have had cause to consult his prepared chart. One possible explanation for the accident is that the clarity and scale of the information on the map may have absorbed his concentration and distracted him at a time when the problem that caused the helicopter's descent manifested itself. The end result was an uncontrolled impact with the surface. Before this the helicopter had performed some energetic manoeuvres at a low height, a situation from which the student pilot was ill-prepared to recover.

Another possible factor in the accident was carburettor icing. As noted previously, the chart of carburettor induction system icing probability in Safety Sense Leaflet 14 of LASORS indicated a 'serious risk of icing at any power setting' for the weather conditions at the time. This chart is generic and may not be directly applicable to the particular installation on the Robinson R44. However, the pilot was not in the habit of manually applying carburettor heat to keep the carburettor temperature outside the yellow arc on the gauge, as advised in the POH and relied on the 'carburettor heat assist device', which was correlated to collective position. This device does not always provide sufficient heat to keep the temperature out of the yellow arc. Therefore, G-TATY could have suffered a reduction in power during the flight as a result of carburettor ice, with the ice being dislodged as a result of the impact force and thus restoring full power after the accident.

This in-flight loss of power may then have resulted in a reduction in the rotor speed if the pilot had demanded more power than was available by retaining the collective control lever in a raised position, in an attempt to maintain height. Such a loss of power, and 'overpitching' of the rotor blades, would have accounted for the helicopter's descent and the lower than normal rotor speed apparent in the final stages of the flight.

ACCIDENT

Aircraft Type and Registration:	Cameron Z-315 Balloon, G-KNIX
No & type of Engines:	3 Thunder and Colt Triple Stratus burners
Year of Manufacture:	2005
Date & Time (UTC):	10 September 2006 at 0640 hrs
Location:	1 mile south of Ashton Keynes, Wiltshire
Type of Flight:	Public Transport
Persons on Board:	Crew - 1 Passengers - 16
Injuries:	Crew - None Passengers - None
Nature of Damage:	Torn fabric in the lower half of the envelope
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	42 years
Commander's Flying Experience:	1,491 hours (of which 1,250 were on type) Last 90 days - 59 hours Last 28 days - 16 hours
Information Source:	AAIB Field Investigation with assistance from the British Balloon and Airship Club

Synopsis

The balloon ascended into widespread fog and flew in the clear air above. The pilot made three deliberate descents into the fog in an attempt to land, during the second descent the balloon avoided power lines before striking and becoming lodged in a tree. Having broken clear of the tree, the balloon flew on above the fog until the pilot entered the third descent, which culminated in a safe landing. The investigation determined that the accident would have been avoided had the pilot waited for the visibility to improve before launching. The minimum visibility for the launch to occur under Visual Flight Rules was 5 km, whereas the visibility at the time of the launch was of the order of a few hundred metres.

History of the flight

The balloon operator had planned a public transport (passenger) balloon flight from a launch site on land adjacent to Lydiard Hall, Swindon. The evening before the flight, the pilot discussed the forecast weather conditions with a colleague at the operator's offices. He was assured that advice had been sought from a forecaster (through a commercial 'talk to a forecaster' service provided by the Met Office) and that conditions were forecast to be suitable for flying. In particular, it was forecast that the visibility would be clear by 0600 hrs, although there was a minimal chance of very poor visibility and haze may be prevalent. Before leaving home on the day of the accident, the pilot made a final check of the weather information on Ceefax[1].

The balloon pilot, the ground crew and 16 passengers arrived at the launch site for the planned departure at 0600 hrs and the balloon was prepared for flight. It was foggy but this was forecast to clear during the morning.

At the launch site there was some debate between the pilot and ground crew about the poor visibility and they discussed whether they should fly. The pilot telephoned a colleague who was planning to launch from a site some distance south-east of Lydiard Park where he understood that fog was making flight unlikely.

The pilot of G-KNIX stated that although the visibility posed a problem, he was also concerned that increasing thermal activity might compromise the flight if he delayed the launch. He telephoned ATC at Lyneham (seven miles south-west of Lydiard Park) to inform them of the position of the launch site and the intended flight. He then arranged for the launch and made radio contact with Lyneham ATC. The pilot reported that the visibility appeared to improve and that he had every reason to assume that the fog was clearing; he believed that the minimum required visibility was eventually achieved. He briefed the passengers that the mist and fog would clear once the balloon was airborne.

The balloon launched at 0600 hrs and ascended from Lydiard Park towards the north-west. Statements from a number of passengers, together with video and photographic evidence, showed that the surface visibility at the launch site was a few hundred metres. The passengers described losing sight of the ground shortly after launch, as the balloon rose into the fog.

The balloon emerged from the fog into clear skies. There was hardly any sight of the ground; the blanket of fog covered the ground in all directions. The pilot stated that he found there was sufficient steerage[2], with the surface wind easterly at about 5 kt and the 1,000 ft wind southerly and slightly stronger.

Although not required, the pilot carried a hand-held GPS receiver with him. Shortly before 0620 hrs, he established that the balloon was drifting over an area clear of obstructions as depicted on his customised 1:50,000 Landranger map. (This map showed significant ground detail, but did not feature small power lines, hedges, trees, or some buildings.) He then made an exploratory descent into the fog but, when he gained sight of the ground, he saw that the area was not suitable for a landing, and so climbed back into clear air.

The pilot then chose another area on the map which appeared to be free of buildings and obstructions, and prepared for landing. As the balloon descended some power lines *'loomed out of the fog'* about 200 m ahead, causing the pilot to activate the burners to climb the balloon safely above them. Subsequent investigation found that these were not high voltage power lines on large pylons, but a less substantial variety, standing less than ten metres above ground, and supported by thick wooden posts. Once past the power lines, the pilot saw a grass field, which he assessed as suitable for a landing. However, he could not see the far side of the field; he assessed the prevailing

Footnote

1 A teletext service provided by the BBC.

Footnote

2 Steerage is the degree to which a balloon pilot may steer the balloon by using variations in the wind velocity at different heights.

visibility to be about 50 m. He dumped air to initiate a descent to land but, as the balloon touched the ground it bounced. Almost simultaneously, the pilot saw a line of trees directly ahead and the balloon was carried into a substantial oak tree. One limb of the tree punctured the balloon envelope and the balloon became lodged within the tree.

The pilot judged that the basket was suspended too high above the ground to allow safe deflation and disembarkation, and so he activated the burners for one or two minutes. This eventually caused the balloon to break free and it climbed rapidly to between 1,000 and 1,500 ft. The pilot had been using a hand-held VHF radio, to communicate with ATC and his ground crew, and this fell from the basket during the encounter with the tree; the pilot subsequently used a mobile telephone for the necessary communications. Damage to the balloon was limited to four or five panels, all in the lower half of the envelope, and the pilot decided that the balloon was still capable of safe flight.

The balloon continued north-west, over the Cotswold Water Park (an area of large lakes adjacent to the River Thames west of Ashton Keynes) and, utilising information from his map, the pilot saw that the area just beyond the lakes appeared suitable for a landing. He made a descent towards this area, and with the visibility now slightly improved, made a safe landing at 0700 hrs with the branch from the oak tree still lodged in the envelope. The balloon was then deflated and the passengers disembarked without incident.

When interviewed, the pilot reported that he had not received any training relevant to flight above fog; the investigation identified no such training nor any published procedures to deal with flight above fog in a balloon.

Duty hours and flight time limitations

The pilot reported for duty at 1500 hrs on 9 September and completed his duty period 6 hours 30 minutes later at 2130 hrs. He commenced his next duty period at 0400 hrs on 10 September after 6 hours 30 minutes rest. He then rested between 1000 hrs and 1600 hrs and completed his duty at 2030 hrs. He had therefore completed 16 hours 30 minutes of duty, which included a rest period of 6 hours. The operator's flight time limitations required that after a flight duty period, the minimum rest period to be taken before another flight duty period must be at least as long as the preceding duty period and not less than 11 hours.

To provide for balloon operations for short periods in the morning and evening, provision was made in the operations manual for a reduction in the post-flight rest period to a minimum of eight hours subject to the following requirements:

(a) the duty period before and the planned duty period after the rest period do not exceed three hours each

(b) the crew member has a total of 16 hours rest in any 24 hour period (midnight to midnight)

(c) the crew member does not go for a period of more than three days with less than 12 hours continuous rest.

The operator's flight time limitations stipulated that the maximum flight duty period was to be 10 hours, extended by half of any rest period taken within that period. On the day of the accident, the maximum duty period available (taking into account a six hour rest period) was 13 hours. There was no provision for this period to be extended by use of 'discretion' or any other means; however, the pilot reported that he was not fatigued. The operator later reported that the pilot had not filled out his duty time report accurately.

Operations manual

The operator's operations manual stipulated that all flights were to be conducted under VFR. Since the launch site was within the Class D airspace of the Lyneham Control Zone the minimum flight visibility required for a flight under VFR was 5 km, (outside controlled airspace it would have been 3 km).

The operator's operations manual stated that the maximum number of occupants permitted to be on board G-KNIX was 16, including the pilot. On the accident flight, there was a total of 17 persons on board, including the pilot. The operator reported that this was a result of an oversight in the compilation of their operations manual.

Motivation to fly

The operator provided balloon flights on an ad hoc basis, selling tickets and then arranging flights from a variety of launch sites subject to weather conditions. The summer of 2006 had been a very difficult one for ballooning, with suitable weather conditions occurring less frequently than in recent years.

The pilot was a freelance professional balloon pilot (who had been working exclusively for this operator for a considerable time). He had a secondary source of income in the winter months, when less balloon flying occurs, but during the summer it was his only occupation. He depended on flying to sustain his income and was not paid for duties carried out when flights were cancelled on account of poor weather. However, an arrangement existed under which pilots were paid a minimum amount each month to ensure some income in the event of continuous poor weather. The pilot had been working exclusively for this operator for a considerable time.

Analysis

The pilot did not take the required rest period prior to reporting for the flight duty, and did not qualify for the reduction in rest applicable to morning and evening flights. Despite this, he reported that he was not fatigued. However, fatigue has an insidious quality, and a person may be fatigued and his performance impaired without realising it. The pilot continued on duty on the day of the accident after a rest period, and it appears that he was either not aware of the provisions of the operator's flight time limitations scheme or elected not to adhere to them. The operator reported that the pilot had not reported his duty times correctly, but it is notable that the pilot had been employed by the operator for a considerable period, and it would be reasonable to expect that the pilot's reporting should have been audited and appropriate training and advice given, to enable accurate completion of these records.

It was clear, from the passenger recollections, photographs, and video recording that the balloon lifted off when the visibility was very poor, and was less than the required minimum for VFR flight. The ensuing flight, above a layer of fog, placed the balloon in a potentially hazardous position: without clear sight of the ground, the pilot was unable to locate a suitable landing area and plan an approach. Instead, he found himself making two descents into the fog, in the hope of finding a suitable area. Although he used his map to ascertain that the area he approached on each occasion appeared to be clear of obstructions, his map did not show all obstructions. It was fortunate that the pilot saw the power lines, which the balloon encountered on its second descent, in time to climb the balloon over them. He was, however, unable to avoid the large oak tree.

The maximum number of occupants of the balloon, as stated in the operations manual, was exceeded. The operator reported that this was a result of an oversight in the compilation of their operations manual.

Although there were the normal pressures on the pilot to fly, both to complete the flight for the passengers and to derive income, these did not account readily for the decision to fly in the prevailing conditions. It is more probable that the pilot believed that the fog would lift during the flight, and this is reflected in his reassurances to the passengers before the launch. Alternatively, a degree of fatigue may have affected his judgement.

The loss of the VHF radio, whilst the balloon was lodged against the oak tree, was unfortunate. The pilot was also using a GPS receiver, which he had mounted on a rack together with the altimeter, although there was no requirement for such navigation devices to be securely attached. The investigation considered the possibility of the GPS being lost overboard; the situation would then have been more grave since the pilot would have been left without any means of determining the balloon's position with the ground obscured. It would therefore appear sensible that hand-held equipment, used for the navigation of a balloon, should be secured to the balloon to prevent such loss, and this was discussed with the CAA.

The lack of training or procedures relevant to a balloon pilot who finds himself flying above fog was discussed with the operator and the BBAC's Flight Safety Officer, and it was felt that by laying down such procedures or providing such training, balloon pilots might be more willing to risk finding themselves above fog, in the belief that they would be able to use the procedures and training to carry out a normal and safe landing. Therefore, it was not considered appropriate to make a Safety Recommendation on this topic.

Conclusions

This accident would have been avoided, and the passengers' safety assured, had the pilot delayed the launch until the visibility had improved to 5 km.

Safety actions

The CAA met with the operator's accountable managers some weeks after the accident and discussed the manner in which the company ensured compliance with the terms of its Air Operator's Certificate. The CAA was satisfied that the company would introduce procedures to ensure that weather and terrain considerations were fully considered in future operations.

Following discussions with AAIB, the CAA has undertaken to consider requiring commercial balloon operators to attach hand-held navigation equipment, such as VHF radios and GPS receivers, to the balloon, by suitable means. The British Balloon and Airship Club (which oversees sport ballooning in the UK) has undertaken to consider making a similar suggestion to its members.

ACCIDENT

Aircraft Type and Registration:	Easy Raider J2.2(1), G-OESY
No & Type of Engines:	1 Jabiru 2200 piston engine
Year of Manufacture:	2002
Date & Time (UTC):	17 February 2007 at 1245 hrs
Location:	Stoke Airfield, Isle of Grain
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to left main landing gear structure
Commander's Licence:	Private Pilot's Licence
Commander's Age:	44 years
Commander's Flying Experience:	467 hours (of which 75 were on type) Last 90 days - 4 hours Last 28 days - 3 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

Following a steeper than normal approach, the aircraft made a heavy landing causing damage to the left main landing gear structure.

History of the flight

The Easy Raider is a homebuilt microlight aircraft operated under a Permit to Fly. The aircraft has a high-wing, tailwheel configuration and a conventional three-axis flying control system. The pilot was undertaking a short cross-country flight from Plaistows airfield near St Albans to Stoke airfield on the Isle of Grain. The weather conditions were scattered cloud above 1,000 feet, visibility greater than 10 km and a south-south-westerly wind of 7 to 10 kt. The pilot flew a standard approach involving an overhead join and a curved final approach to Runway 24L (grass). He maintained an airspeed approximately 10 mph higher than normal to account for the light crosswind from the left. He later reported that, on short final, he was too fast and approaching at a steeper angle than normal. He then initiated the flare late which resulted in a heavy landing on all three wheels simultaneously. He taxied the aircraft off the runway, parked and then shut down. The aircraft was found to have suffered damage to the left main landing gear structure, which included a bent longeron tube and a broken crosstube.

Pilot's comments

The pilot reported that, in an effort to avoid sink over the hangar near the end of the runway, he maintained a speed that was too high and a descent angle that was too steep. Consequently, his late and insufficient flare resulted in a heavy landing. He further stated that the runway was long enough for him to have reduced his approach angle and landed further down the runway.

AIRCRAFT ACCIDENT REPORT NO 3/2007

This report was published on 31 May 2007 and is available on the AAIB Website www.aaib.gov.uk

REPORT ON THE ACCIDENT TO PIPER PA-23-250 AZTEC, N444DA 1 NM NORTH OF SOUTH CAICOS AIRPORT, TURKS AND CAICOS ISLANDS, CARIBBEAN ON 26 DECEMBER 2005

Aircraft Type:	Piper PA-23-250 Aztec
Serial number:	27-3935
Nationality:	United States of America
Registration:	N444DA
Location of Accident:	1 nm north of South Caicos Airport, Turks and Caicos Islands, Caribbean (N 21º 31' 46" W 071º 32' 37")
Date and Time:	26 December 2005 at 2339 hrs UTC (1839 hrs local) All times in this report are UTC (local times in brackets)

Synopsis

The accident was reported to the Turks and Caicos Islands (TCI) Civil Aviation Department (CAD) on the evening of the 26 December 2005. The following day a request for assistance was made to the UK Air Accidents Investigation Branch (AAIB), under the terms of a pre-existing Memorandum of Understanding. The TCI CAD appointed an Investigator In Charge (IIC) to conduct an investigation in accordance with the provisions of Annex 13 to the International Civil Aviation Organisation (ICAO) Convention. The investigation was conducted by: Mr P Forbes (Investigator-in-Charge), Ms G M Dean (AAIB Operations), Mr P Thomas (Operations), Mr A N Cable (AAIB Engineering) and Mr K Malcolm (Engineering). The USA, as the country of aircraft manufacture and registration, appointed an Accredited Representative from the National Transportation Safety Board (NTSB). Further assistance to the investigation was provided by the manufacturers of the aircraft, the engines and the propellers.

The AAIB Inspectors arrived in the TCI on 28 December 2005. Investigation activities included interviewing witnesses to the accident, obtaining details of the aircraft's and pilot's backgrounds, assessing operational factors, inspecting the accident site and organising the recovery and examination of the aircraft wreckage.

The pilot involved in the accident had purchased the aircraft in the USA and flown it to the TCI on 24 December 2005. The accident occurred two days later on an internal flight at night, within the TCI, with the pilot and three passengers on board. The aircraft was seen to turn to the left shortly after takeoff and then, after only a brief time airborne, it entered a steep descent towards the sea from which it did not recover. All four occupants were fatally injured.

Inspection of the accident site and the wreckage showed that the aircraft had struck the sea at high speed while descending in a nose down and right wing low attitude.

Detailed examination found evidence of a number of pre-impact powerplant anomalies but no signs of pre-impact failure or malfunction of the aircraft or its equipment relevant to the accident.

The pilot held a Federal Aviation Authority (FAA) Commercial Pilot's Licence (CPL). His flying experience was limited and it is quite possible that he had not previously carried out a takeoff at night with limited local environmental lighting. At the time of the accident he did not meet the relevant recency requirements for flight at night with passengers. The evidence indicated that the accident resulted from a loss of control because of the spatial disorientation of the pilot.

The investigation identified the following causal factors:

1. A lack of appreciation by the pilot of the difficulty in executing a turn, very shortly after takeoff, in conditions of almost complete darkness.
2. A loss of control of the aircraft as a result of spatial disorientation.

Two safety recommendations have been made by the TCI CAD.

Findings

1. Five passengers originally intended to travel on the flight; in the event three passengers were on board the accident flight.
2. The flight was delayed and the takeoff was carried out at night.
3. The weather was good but it was almost completely dark, with no moonlight and very little environmental ground lighting visible along the route flown.
4. The pilot was licensed to fly the aircraft at night but had not completed the required number of takeoffs and landings at night in the preceding 90 days and was therefore not allowed to carry passengers at night.
5. The pilot was not qualified to fly a multi-engine aircraft under Instrument Flight Rules, as was required at night within TCI.
6. There was a low level of ethanol present in the toxicological samples from the pilot; it was not possible to determine whether or not this was as a result of his having consumed alcohol at some time before the flight.
7. The pilot had limited night flying experience and possibly none that involved a takeoff into an area without some environmental lighting.
8. After takeoff the pilot would need to have flown the aircraft by sole reference to his flight instruments because of the darkness and absence of environmental lighting.
9. There was a left turn very soon after take off, which was probably carried out intentionally by the pilot; the subsequent flight path was erratic.
10. The aircraft descended into the sea at relatively high speed and suffered severe break-up.
11. Wreckage examination identified a substantial number of engine and propeller assembly errors; none was likely to have contributed to the accident.
12. Detailed investigation found no evidence of failure, malfunction or anomaly of the aircraft or its equipment likely to have been relevant to the cause of the accident.

13. The pilot probably suffered from spatial disorientation as a result of the accelerations during takeoff and the turn very shortly afterwards, leading to a loss of control.

Safety Recommendations

The following safety recommendations have been made by the TCI CAD:

Recommendation 2007-001

It has been recommended that the FAA require that, before flight, variable-pitch propellers receive a full functional ground check following final assembly or re-assembly.

Recommendation 2007-002

It has been recommended that the FAA take measures aimed at ensuring an adequate standard of quality control during repair and overhaul operations on light aircraft engines and propellers.

FORMAL AIRCRAFT ACCIDENT REPORTS ISSUED BY THE AIR ACCIDENTS INVESTIGATION BRANCH

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.

3/2007 Piper PA-23-250 Aztec, N444DA
1 nm north of South Caicos Airport,
Turks and Caicos Islands, Caribbean
26 December 2005

Published May 2007.

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