CONTENTS

COMMERCIAL AIR TRANSPORT

GENERAL AVIATION

SPORT AVIATION / BALLOONS

ADDENDUMS and CORRECTIONS

(ALL TIMES IN THIS BULLETIN ARE UTC)

INCIDENT

Aircraft Type and Registration:	Airbus A319-111, G-EZEG
No & Type of Engines:	2 CFM56-5B5/P turbofan engines
Year of Manufacture:	2004
Date & Time (UTC):	30 December 2005 at 1408 hrs
Location:	Approx 15 nm north of Kidlington, Oxfordshire
Type of Flight:	Public Transport (Passenger)
Persons on Board:	Crew - 6 Passengers - 159
Injuries:	Crew - None Passengers - None
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	39 years
Commander's Flying Experience:	6,410 hours (of which 990 were on type) Last 90 days - 200 hours Last 28 days - 60 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and AAIB enquiries

Synopsis

The aircraft diverted to East Midlands Airport following reports of fumes or smoke in the cockpit. The subsequent engineering investigation could find no evidence of smoke or burning nor identify the source of the fumes.

History of the flight

The aircraft, which was en route from Aldergrove to Gatwick, was passing FL180 in the descent near Kidlington when both crew members independently identified a smell of fumes or smoke in the cockpit. The crew donned their combined oxygen masks and goggles, established communications and used the Public Address system to call the Senior Cabin Crew Member (SCCM) to the interphone. The SCCM confirmed that there was a similar smell in the forward cabin; therefore the captain made the decision to land as soon as possible. A PAN call was made to London ATC on the frequency in use, the transponder was selected to the emergency code 7700 and the captain requested a diversion to East Midlands Airport. Whilst there had been no Electronic Centralised Aircraft Monitor (ECAM) warnings, the crew decided to carry out the Quick Reference Handbook (QRH) procedure "Smoke/Fumes Removal". The QRH checklist was commenced and when the SCCM was summoned to the interphone for a further briefing he told the captain that the smell in the cabin had dissipated. The aircraft was rapidly approaching East Midlands Airport, and as there was no evidence of smoke in the aircraft, the captain suspended the QRH drill before any source diagnosis was carried. The flight deck crew were still on oxygen and would not have been able to detect any change in the smell and their priority was to land the aircraft at the nearest suitable airfield. The PAN was not cancelled. An uneventful landing was subsequently made at East Midlands Airport where the passengers were disembarked in an orderly fashion using the main aircraft exits. The flight deck crew wore their oxygen masks until the engines were shut down and the cockpit windows opened.

Response by airport authorities

The Approach Controller at East Midlands Airport was informed by London Control, Welin Sector, at 1412 hrs that the aircraft was diverting to East Midlands due to reports of smoke in the cockpit. A full emergency was initiated at East Midlands and the captain, at his request, was given vectors to an 8 mile ILS final for Runway 27. The aircraft landed safely at 1427 hrs and, as there was still no recurrence of the smell, the aircraft was directed to Stand 35. The Fire Officer spoke to the captain on 121.6 MHz prior to boarding the aircraft. A stand down message was sent at 1437 hrs.

Engineering investigation

The company's maintenance provider undertook a full investigation in accordance with their procedures following reports of smoke or smells in the cockpit and cabin. The investigation, which eliminated the galley and the application of de-icing fluids as possible causes, could not find any evidence of smoke or burning on the aircraft. There was also no record of any warnings having been displayed on the ECAM. Since the incident the aircraft has been flown regularly with no further reports of smells or smoke in either the cabin or cockpit.

Comment

During the previous year the operator had emphasised to their crews, during simulator training, the importance of landing the aircraft at the earliest opportunity following incidents of smoke or toxic fumes in the aircraft. In this incident the aircraft landed approximately 15 minutes after the captain made the PAN call to London Control.

INCIDENT

Aircraft Type and Registration:	BAe 125-800B, G-OLDD
No & Type of Engines:	2 Garrett Airesearch TFE731-5R-1H turbofan engines
Year of Manufacture:	1987
Date & Time (UTC):	30 December 2005 at 1519 hrs
Location:	Southend, Essex
Type of Flight:	Training
Persons on Board:	Crew - 5 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Minor damage to electrical wiring
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	56 years
Commander's Flying Experience:	13,500 hours (of which 3,000 were on type) Last 90 days - 100 hours Last 28 days - 25 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and enquiries made of the maintenance company

Synopsis

During the approach, an electrical short circuit produced a bang, sparks and, briefly, smoke. The circuit protection functioned rapidly and the smoke cleared. A successful landing was carried out.

History of the flight

During an ILS approach to Runway 24 at Southend Airport, a bang was heard from the left side of the cockpit, followed immediately by sparks and smoke issuing from the left pilot's footwell. A distress message was transmitted and oxygen masks donned by both pilots. Emergency drills were performed from memory. The smoke cleared within 30 seconds and the aircraft landed normally with no further untoward indications. At the end of the landing run all aircraft systems appeared to be operating normally. The aircraft was shut down with the fire crews in attendance.

Aircraft examination

Subsequent examination of the aircraft revealed an area of burnt wiring at the P1 screen heat filter; chafing and burning was found in the region of connections B1, B2 and B3. The remedial action included replacement of damaged wiring as required and general checking of the routing to prevent a recurrence. The P2 windscreen and its heating were checked and found to be in a satisfactory condition. No history of similar problems was recorded on this aircraft.

Discussion

Smoke generated from an electrical failure will present a crew with more of a significant hazard in the smaller volume in the cabin of an executive jet than in the larger cabins of scheduled passenger aircraft. In this particular event however, the smoke generated by the short circuit dissipated rapidly indicating that the circuit protection functioned rapidly and effectively. The limited area and degree of damage found on examination support this deduction.

INCIDENT

Aircraft Type and Registration:	BN2-A Mk III-2 Trislander, G-BEVT
No & Type of Engines:	3 Lycoming 0-500-E4C5 piston engines
Year of Manufacture:	1977
Date & Time (UTC):	24 April 2005 at 1335 hrs
Location:	Alderney, Channel Islands
Type of Flight:	Public Transport (Passenger)
Persons on Board:	Crew - 1 Passengers - 9
Injuries:	Crew - None Passengers - None
Nature of Damage:	Propeller de-icer boot separated from propeller
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	Not relevant
Commander's Flying Experience:	Not relevant
Information Source:	Information submitted by the operator and AAIB enquiries as part of an earlier investigation involving this aircraft

Synopsis

Following an accident where a propeller de-icer boot separated and penetrated a window, injuring a passenger, the AAIB investigated a subsequent de-icer boot separation on the same aircraft. The investigation found that the quality of the adhesive bond between the boot and the blade is dependent upon meticulous adherence to correct procedures and practices. No safety recommendations are made because, industry wide, satisfactory attachment of the boots is routinely achieved using published procedures and correct materials. However, apparently quite minor deviations in the process can cause a reduction in bond strength which can lead to boot separation.

Background

On 23 July 2004 Trislander G-BEVT was involved in an accident caused by the separation of a propeller de-icer boot from the left propeller. That accident was the subject of AAIB report number 1/2006 published on 11 January 2006. Brief details of this occurrence were as follows:

Shortly after takeoff from Guernsey Airport, a loud crack or bang was heard in the aircraft's cabin. The aircraft commander was told by a colleague in the cabin that one or more passengers had been injured and that a cabin window was broken. The aircraft returned to Guernsey Airport and landed having been airborne for approximately four minutes. After the passengers had disembarked, the pilot noticed that a de-icer boot had separated from the left propeller and was lying on a seat inside the cabin, adjacent to the broken window.

The investigation found that the accident was caused by the separation of a de-icer boot from the left propeller during takeoff. Laboratory work indicated that the de-icer boot had separated due to peel stresses generated by forces on the propeller. The peel stresses arose because of physical or contamination damage to the adhesive (often called 'cement') bond at the root of the blade.

The propeller manufacturer's blade manual required the de-icer boots to be bonded to the blade and then for a filler material to be applied at the root end of the boot. Finally the edges were to be coated with a sealer. The function of the filler material was to prevent environmental damage to the bond. The filler material had not been applied and as a result, environmental damage, or possibly physical damage, to the adhesive at the root of the boot had occurred. This left a small disbonded area which grew under stress until the de-icer boot finally separated.

As a result of this event the UK CAA identified approximately 100 propellers which had been overhauled without using the required filler. The propellers had all been overhauled by the same organisation within a six year period, which is the calendar overhaul period for these propellers. The UK CAA had also been working with the propeller manufacturer to establish an inspection and rectification regime for the affected propellers. This involved inspections and, if the condition of the adhesive bond was satisfactory, the retrospective application of filler.

The second incident, the subject of this report, occurred to the propeller on the right wing of the same aircraft. Normally, the AAIB would have regarded it as a non-reportable occurrence. However, the propeller involved had been overhauled by the same organisation, using correct procedures and materials, including the use of the correct filler material. Initial examination indicated that the cause of de-icer boot separation was not the same as before. Consequently, this second incident became the subject of this separate report.

History of the flight

The aircraft departed Alderney terminal for Guernsey with nine passengers on board. At about 60 kt during the take-off ground roll the pilot heard a muffled bang. All indications were normal so the takeoff was continued but on arrival at Guernsey, a de-icer boot was missing from the right propeller. There were no injuries sustained and no obvious damage to the aircraft. The de-icer boot was found on the runway at Alderney.

Technical investigation

The propeller, part number HCC3YR2UF serial CK3663A, was quarantined for investigation. It had accumulated 175 hours usage since it was overhauled on 2 November 2004 when new de-icer boots had been fitted. The overhaul work pack showed that the de-icer boots had been fitted in accordance with Hartzell Blade Manual 133C, including the use of Hartzell approved 3M EC 1300L adhesive and the appropriate filler. The boots fitted were not the specified BF Goodrich parts but were an acceptable alternative which carried the part number MHG2778/B. The propeller and boot were returned to the AAIB for investigation, together with a number of similar boots from the same manufacturer, which the operator had removed from seven other propellers.

An initial examination of the detached boot showed that failure had occurred between the adhesive and the boot and that there was virtually no adhesive left on the boot. There was no evidence of any gross contamination of the boot or propeller surfaces that could have hindered adhesion.

The only areas of the boot that retained significant amounts of adhesive were along the centre of the boot where it is bent around the leading edge of the propeller blade. These areas were examined and found to have smooth adhesive surfaces, indicating that no bonding to the blade had occurred. Examination of the propeller blade showed that the adhesive remained well bonded to this substrate and confirmed that bonding to the boot had not occurred in a number of locations along the leading edge. These areas corresponded to areas on the boot where the adhesive had been retained.

All the boots examined showed areas, of varying sizes along the blade leading edge, that had not been bonded. It is known that the leading edge is an area where it can be difficult to achieve adhesion because of, the complex curvatures present, and the stiffness of the boot due to the embedded heating wires. These poorly bonded areas provide a means for moisture to 'fast-track' to the centre of the joint and, as a result, possibly accelerate the rate of degradation of the adhesive bond.

The appearance of the boot that separated was in contrast to the boot from the previous failure, which retained noticeably more adhesive, with significantly more interfacial failure between the adhesive and the propeller. Furthermore, the boot did not show any evidence of moisture ingress at the root end, which had been identified as the probable cause of failure in the previous case. There was also evidence of apparently brittle adhesive cracking on this boot, which was not seen on either of the other boots removed from this propeller or on any of the other boots submitted for assessment.

Examination of the boots taken from the other propellers showed failure mechanisms similar to the previous failure, often with more interfacial failure between the adhesive and the propeller. This might be expected since it was believed that these boots were all bonded with the same adhesive, ie Bostik 2402. Furthermore, evidence of moisture ingress at both the root and the tip was found on a number of the boots, which supported the conclusion that the previous failure resulted from moisture ingress and that failure initiated at the root.

A comparison between all the boots bonded with Bostik 2402 and the failed boot, which was bonded with 3M 1300L, shows that with Bostik 2402, with one exception, there was a significantly greater degree of interfacial failure between the adhesive and the propeller. Furthermore, all the boots bonded with Bostik 2402 retained noticeably more adhesive. Therefore, it can be concluded that, for boots bonded with Bostik 2402, the weakest joint is between the adhesive and the propeller, particularly once moisture has penetrated into the joint. In contrast, for the three boots from the right propeller of G-BEVT, which had all been bonded with 3M 1300L, the weakest joint was that between the adhesive and the boot.

According to the laboratory report, both adhesives are based on polychloroprene rubber but Bostik 2402 is crosslinked using a curing agent (Bostikure D). This improves the resistance of the adhesive to heat and fluids. The origin of the rubber material used in the de-icing boots is not known, and it is possible that changes in the formulations of either the adhesives or the boots may have occurred since qualification. The composition of Bostik 2402 will change during 2006 in order to eliminate the solvent Toluene. Since the solvent will affect drying and application times, this could require a modified application technique. Furthermore, processing aids used during boot manufacture, to ease ejection from the mould, will reduce the bond strength unless they are removed using an appropriate surface cleaning technique.

There are also application differences between the two adhesives, and on occasion, differences between the relevant sets of instructions for the same adhesive. The 3M data sheet for 1300L states that the adhesive should be applied to both surfaces, allowed to dry for a maximum of 4 minutes and be bonded within 8 minutes. In contrast, the advice for Bostik 2402 is that the adhesive should be allowed to dry for between 5 and 15 minutes before bonding. The overhauler might follow the instructions contained in the propeller manufacturer's blade manual, or the boot manufacturer's instructions, or the directions in the adhesive manufacturer's product data sheet. However, Bostik 2402 adhesive is not mentioned in the Hartzell blade manual 133C but it is permitted in the BF Goodrich Installation Manual. That manual states drying and application times of one hour for the first coat and 10 to 30 minutes for the second. This varies from the Product Data sheet, which gives times of 20 to 30 minutes for the first coat and 5 to 15 minutes for the second coat.

Further AAIB enquiries

During visits to several propeller overhaul and repair organisations, the AAIB investigator was advised of a number of issues which might affect the adhesive bond strength and quality. These included temperature, humidity, cure time of the paint finish on the blade, the exact handling technique which an installer may use to apply the boot, the technique employed to brush the adhesive on to the boot, drying time between the first and second coats of the adhesive and compatibility issues between the boots and adhesives. The laboratory finding that Bostik 2402 might be stronger than 3M 1300L was supported generally by anecdotal evidence, and in particular by tests carried out by the manufacturer of the particular boot involved in this incident. There was some common experience of adhesion problems with this type of boot, although all makes of boot had been the subject of difficulties from time to time. One respected organisation, with no recent history of boot failures, described a period when the same individual on the same day would achieve results ranging from satisfactory to unserviceable. The organisation also described a complex and ultimately inconclusive investigation into the causes. One common experience was that often, particularly with the subject type of boots, little adhesive was left on the boot itself even though the first coat is applied directly to it. This led to discussion about the internal surface finish of the boot. It was observed that the boots had a textured surface which might require the adhesive to be stippled in rather than being simply brushed on with long, straight, brushstrokes. However, little of this perceived difficulty could be validated.

During this investigation the AAIB identified the following good practices which increased the likelihood of a satisfactory bond.

1 Environmental conditions
While bonding can be carried out in the field, it is ideally conducted in a dedicated, clean environment, free of condensing humidity and within the recommended temperature range. For example, Goodrich recommend 65-75ºF and a Relative Humidity (RH) below 75%; outside this range best results may not be achieved. Higher RH requires additional drying time and installation in conditions below 50ºF or above 90% RH is not recommended. Because the thermal mass of the propeller blades is significant, it is best practice to allow the blades to acclimatise to the temperature of the controlled environment for a suitable period before undertaking the bonding process.

2 Selection of materials

There is often a choice of boots and adhesive systems available. Although alternatives have been approved locally, the manufacturer's documentation is more specific and will specify certain options for adhesives, fillers and cements. Although the industry itself has views on which are the most consistent performers, consistently good results are being achieved through adherence to the manufacturer's instructions.

3 Preparation

Apart from general standards of cleanliness, degreasing and handling, there are also issues concerning the use of correct paints and primers (or in some cases the prohibition of paints) which vary from system to system. Correctly prepared substrates are essential to reliable bonding.

4 Use of materials

The adhesives must have been correctly stored and be within their shelf life. They must be free of contamination, and correctly mixed. When mixing large volumes, the process of opening cans and mixing correct amounts can introduce contamination, ageing and incorrect mixing. The use of small cans, mixing the complete contents and disposing of the unused adhesive, guarantees correct quantities for mixing; ultimately it may also avoid waste and be more economic. Mixing must be thorough and in accordance with the adhesive manufacturer's instructions. This may take more time than expected.

5 Application techniques

Long, even, brush strokes are generally used, but it may be that this causes the adhesive to 'bridge' the peaks of a textured surface rather than adhere uniformly. The boots are pressed into place with a roller but it is necessary to position them on the blade by hand. This can be a difficult task for one person and because a contact adhesive is used, it may become difficult to eliminate air bubbles and gaps.

6 Curing times

Different adhesives have different curing times and different times must be complied with between the first and second coats. Also, the blades themselves may have been overhauled and repainted, in which case incompletely cured paints or solvents could affect the adhesive bond.

Conclusion

In the light of these findings, it appears that propeller de-icing boots can routinely be satisfactorily bonded if published procedures and good practice are meticulously followed. However, apparently quite minor deviations in the process can cause a reduction in bond strength, or allow the generally poor peel strength of adhesives to be exploited by mechanical or environmental damage. This can lead to boot separation.

INCIDENT

Aircraft Type and Registration:	Boeing 747-436, G-CIVY
No & Type of Engines:	4 Rolls-Royce RB211-524G2-19 turbofan engines
Year of Manufacture:	1998
Date & Time (UTC):	28 December 2005 at 1220 hrs
Location:	Near Strumble Head, Wales
Type of Flight:	Public Transport (Passenger)
Persons on Board:	Crew - 18 Passengers - 2
Injuries:	Crew - None Passengers - None
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	40 years
Commander's Flying Experience:	13,120 hours (of which 10,730 were on type) Last 90 days - 163 hours Last 28 days - 16 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and further inquiries by AAIB

Synopsis

The aircraft was inbound to London Heathrow Airport when, prior to descent, the cabin crew reported a smell of burning and a haze in the cabin, initially in the area of the first class galley but spreading throughout the whole lower deck. A precautionary diversion to Cardiff was carried out without incident, whereupon substantial food spillage was found in the galley ovens and this is considered to have been the likely source of the smell and haze.

History of the flight

The aircraft was inbound to Heathrow after a flight from New York JFK Airport. The passenger complement comprised only two people because the No 3 engine had ingested a bird when inbound to JFK and, whilst the engine was inspected by borescope, most of the intended passengers had been dispersed to other flights. On takeoff from New York the crew could all smell a distinctive 'burnt bird' smell, with which they were familiar and which did not cause any concern. The smell dissipated shortly afterwards.

Over the Irish Sea, approaching Strumble, the commander received a call from a member of the cabin crew that they could smell burning in the first class galley. He asked them to check for food deposits or spills in the ovens as he knew that this was a regular occurrence. Some minutes later the Cabin Service Director (CSD) called to report the same matter again and the commander responded by asking her to personally check that his previous request had been complied with. Meanwhile, the flight crew scanned the secondary Engine Indicating and Crew Alerting System (EICAS), circuit breakers and switches to see whether a technical problem might be developing whilst simultaneously requesting an early descent should a diversion to Cardiff be necessary.

As the descent started, the CSD called again to report that the smell was getting worse and that she could discern a haze. Almost simultaneously, a 'NUMBER 3 GALLEY BUS' caption illuminated on the secondary EICAS, giving a 'RT UTILITY BUS' message on the primary EICAS. Cabin crew at the rear of the aircraft now started reporting strong smells and fumes whilst those in the centre called to report the same, as well as a loud metallic "graunching and banging" noise from under the floor. The cabin crew were instructed to turn off all galley emergency power switches as well as the in-flight entertainment and seat systems. This initially seemed to lessen the smell and fumes but they returned shortly after and grew stronger. The CSD advised that the smell was electrical in nature and definitely not burning food.

A MAYDAY was declared and a diversion to Cardiff initiated: the cabin crew were briefed to have their smoke hoods with them and to prepare for a possible slide evacuation after landing. The flight crew, meanwhile, checked the Quick Reference Handbook for the drills for electrical fire/smoke and utility bus problems (no resets were attempted). During descent the fumes, as reported by the cabin crew, came and went, appearing most strongly at FL150. The flight crew stated that at no time were they aware of any symptoms on the flight deck, although they donned oxygen masks as a precaution. Unfortunately, the co-pilots's mask microphone was unserviceable and other methods of communication were established.

An uneventful landing ensued and the commander steered the aircraft off the runway at the high-speed turnoff directly onto the parking area. No emergency evacuation was required as the fumes had largely subsided and, by the time the fire services boarded the aircraft, only a hot, oily smell remained. No 'hotspots' were detected by the fire service thermal imaging equipment.

Analysis

The sequence of events described and the nature of the problems seems to vary with the perceptions of those involved in the event and subsequent trouble-shooting. From the flight crew's perspective, they did not experience any of the symptoms described to them by the cabin staff. This could be due to the fact that the flight deck receives a smaller proportion of recirculated air than the cabin. It was noted that the flight had been despatched with an Acceptable Deferred Defect related to one of the cabin pressurisation outflow valves. This required that only two of the three air conditioning packs be used. Although the commander's statement did not mention it, the operator's maintenance organisation understood that he had isolated No 2 ACM (Air Cycle Machine) in response to the mechanical noises reported and this led to removal of the unit at Cardiff.

The maintenance organisation, however, report that a considerable build-up of food debris was found in the first-class ovens and are of the opinion that this was the cause of the smell and haze. The ACM was subsequently found to have no defects, although it was possible that some factor in the actual installation may have caused the noises (relayed to them as a vibration and 'buzzing') which simple removal cured. Detailed inspection of the galley wiring did not reveal any defects which could cause the circuit breakers to trip and, after cleaning the ovens and extended ground-testing, the aircraft was returned to service and there have been no reports of similar problems since.

ACCIDENT

Aircraft Type and Registration:	Bombardier DHC-8-402 Dash 8, G-JEDW
No & Type of Engines:	2 Pratt & Whitney Canada PW150A turboprop engines
Year of Manufacture:	2004
Date & Time (UTC):	2 December 2005 at 2000 hrs
Location:	Birmingham International Airport
Type of Flight:	Public Transport (Passenger)
Persons on Board:	Crew - 4 Passengers - 47
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to tow bar and nose wheels
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	57 years
Commander's Flying Experience:	13,200 hours (of which 165 were on type) Last 90 days - 164 hours Last 28 days - 47 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and further enquires by the AAIB

Synopsis

After an uneventful push back and engine start, when the tug and tow bar had been disconnected from the aircraft, the aircraft started moving forwards before the pilots were ready to taxi. The aircraft ran into the tow bar, damaging it and the aircraft's nose wheels. The parking brake had not been applied at the appropriate time during the push back sequence.

History of flight

The aircraft pushed back for the fourth sector of the day. The ground crew consisted of an aircraft tug driver and a coordinator who was in contact with the pilots via a headset plugged into the flight deck intercom system.

The aircraft's auxiliary power unit was unserviceable so an engine had to be started on-stand prior to push back. Starting the second engine was delayed until after the push back.

The push back and engine starts were uneventful and the 'After Start' check list was completed; this list does not include a check as to whether the parking brake is applied. On completion of the push back the co-pilot noticed the ICE DETECTED warning light and another unidentified caption on the Master Warning Panel. He attracted the commander's attention to these warnings, but the commander motioned to the co-pilot to be quiet, by placing his index finger over his lips, and acknowledged the warnings. The commander could not remember what the coordinator said to him, whether he applied the parking brake or what he said to the coordinator. He does, however, remember informing the coordinator that he was "clear to disconnect".

Having looked left and right for adjacent hazards, the commander placed the propeller condition levers to MAX. This is part of the company's 'Pre-Taxi' check. At this point the commander heard a banging noise on the nose of the aircraft and saw a member of the ground crew waving his arms. At the same time the co-pilot heard a loud, metallic noise. Both pilots immediately applied their foot brakes and the moving aircraft was brought to a halt. The parking brake was then applied.

The aircraft's nose wheels had made contact with the disconnected tow bar causing damage to one wheel, both tyres and the tow bar.

Ground crew comments

In his report to his company, the coordinator stated that initially the push back proceeded normally. At the end of the push-back, the tug driver gave the coordinator the 'brakes on' hand signal. Having instructed the commander to apply the parking brake, the coordinator received a "clear to disconnect" verbal instruction. The aircraft was then chocked and the tow bar was disconnected, first from the tug and then from the aircraft.

The tug driver added that he always left a "few inches" between the chock and the nose wheel in order to make it easier to remove the chock after start. The tow bar was then reattached to the tug before the chock was removed and placed on the tug.

Having been advised by the commander that both engines were running, the coordinator was instructed to disconnect his headset from the aircraft. As he was sealing the headset socket on the aircraft, he heard the aircraft's engines go to what he described as "full power" and the aircraft started to move. He immediately banged on the aircraft in a bid to get the commander to stop the aircraft but it continued moving forwards for a few feet until it hit the tow bar. The coordinator then reconnected his headset and informed the pilots what had happened.

Aircraft damage

As a result of the collision with the tow bar, one nose wheel tyre was damaged and one was unseated from its wheel rim. Also, a section of rim was dislodged from one wheel. Consequently both nose wheels were replaced.

Upon initial inspection the nose leg was found undamaged. However, subsequently and as a precaution, it was replaced to allow a more detailed inspection for hidden damage.

Discussion

Residual thrust

The manufacturer reported that after engine start and prior to placing the condition levers to MAX, there is likely to be a small amount of residual forward thrust from the propellers. On level ground this would not be enough to accelerate the aircraft from rest. This means that if the parking brake was not applied, the aircraft was unlikely to have moved forwards and made contact with the nose wheel chock until the engines were accelerated. When the condition levers were moved to MAX, the chock had been removed and the additional thrust was sufficient to move the aircraft forwards.

Push back procedures

It appears that whilst the commander was distracted, he cleared the ground crew to disconnect the tug without having first applied the parking brake. Also, the ground crew, on hearing the “clear to disconnect” instruction, might have misheard the commander and interpreted his message to mean that the parking brake was “set”.

CVR Procedures

As part of the operating company’s internal investigation in to this accident, the CVR was removed from the aircraft and sent to an approved avionics servicing facility for download and replay. Subsequently, when the AAIB was notified of the accident, the CVR was sent to the Branch for analysis.

Because the CVR was not electrically isolated soon after the accident, the only recordings were of conversations long after the accident. Consequently, it was not possible to determine what was said by the pilots and the coordinator during the push back.

After this accident the operating company reviewed its procedures for post-incident handling of CVRs and FDRs. They discovered that they had engineering procedures regarding the isolation of the FDR but not the CVR. As a result, the company’s procedures have been amended to ensure that both the CVR and FDR are isolated after an incident.

Conclusion

During the push back, there was a break down in CRM (Crew Resource Management) between the pilots which led to the parking brake not being applied at the appropriate time. The conversation between the pilots and the ground crew was not available to confirm what was said and by whom. Consequently, it is possible that the instruction “clear to disconnect” to the ground crew might have been misinterpreted to mean that the parking brake had been applied. Subsequently, while the ‘Pre-Taxi’ checks were being completed, the aircraft moved forward before the pilots were ready to start taxiing and it collided with the tow bar.

Comments

The parking brake should have been applied before clearance was issued to disconnect either the tug or the headset. Also, if ground crew are uncertain regarding a pilot’s message to them, they should ask for it to be repeated.

ACCIDENT

Aircraft Type and Registration:	Cessna 152, G-BPBG
No & Type of Engines:	1 Lycoming O-235-L2C piston engines
Year of Manufacture:	1981
Date & Time (UTC):	15 March 2006 at 1410 hrs
Location:	Tatenhill Airfield, Staffordshire
Type of Flight:	Training
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Nose leg collapsed, propeller damaged, engine shockloaded
Commander's Licence:	Student Pilot
Commander's Age:	40 years
Commander's Flying Experience:	33 hours (all on type) Last 90 days - 9 hours Last 28 days - 1 hour
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft bounced on landing and subsequently landed nosewheel first and the noseleg collapsed.

History of flight

The student pilot was carrying out a solo circuit consolidation exercise using Runway 08 at Tatenhill; the surface wind was from 070° at 12 kt. Although the approach to touch and go on his second circuit appeared to be normal the aircraft bounced off the asphalt surface at touchdown. Following the bounce the pilot initially applied forward pressure on the control column before applying back pressure just prior to the second touchdown. However, this was not sufficient to prevent the aircraft touching down on the nosewheel, which subsequently led to the noseleg collapsing. He was able to exit the runway to the left before shutting down and vacating the aircraft through the normal exit. The pilot's instructor, who was observing from the ATC tower, subsequently rebriefed the student on the correct technique for handling a bounced landing.

ACCIDENT

Aircraft Type and Registration:	Europa, G-FLRT
No & Type of Engines:	1 Rotax 912 ULS piston engine
Year of Manufacture:	2005
Date & Time (UTC):	12 November 2005 at 1020 hrs
Location:	Huddersfield (Crosland Moor) Airfield, West Yorkshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Aircraft damaged beyond economic repair
Commander's Licence:	JAR Private Pilot's Licence
Commander's Age:	46 years
Commander's Flying Experience:	266 hours (of which 220 were on type) Last 90 days - 5 hours Last 28 days - 5 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The engine lost power shortly after takeoff, following engine ground runs to investigate rough running on the previous flight. During the forced landing, the aircraft skidded into a dry stone wall and was seriously damaged. Examination of the aircraft some weeks after the accident revealed the presence of water in the fuel system.

History of the flight

The engine began to run roughly shortly after takeoff so the pilot returned to the airfield immediateley, landing on the reciprical runway.

After checking the aircraft and conducting four engine runs, without finding anything untoward, the pilot asked his passenger to wait while he flew a solo circuit to ensure that there were no problems. The Runway in use at the time was R/W 25, the surface of which consists of 550 m of asphalt followed by 250 m of grass. However, immediately after takeoff, at a height of approximately 30 ft, the engine ran roughly once again and lost power. The pilot elected to land straight ahead and attempted to cushion the landing by applying power; the engine did not respond. As a result, the landing was somewhat heavy. The engine then picked up, as the pilot had not retarded the throttle lever, and some deceleration time was lost as he moved his hand from the brake lever in order to close the throttle[1]. In the process, he allowed the aircraft to veer off the left side of the runway, and collide with a dry stone wall at an angle of 45º. The pilot was uninjured and left the aircraft via the normal exit.

Examination of the aircraft

As a result of delays over insurance and salvage issues, it was several weeks before the aircraft owners conducted a comprehensive investigation of the aircraft. The fuel tank was emptied by disconnecting the fuel lines upstream of the carburettors and operating the electric fuel pump, which established that the pump was serviceable[2]. Small quantities of water were found in the carburettor bowls. The engine was subsequently inspected by a Rotax agent, who reported that considerable quantities of water were present in the undamaged engine-driven fuel pump and associated fuel lines. Some internal corrosion had occurred in this pump and the carburettors, indicating that water had been present for some time; moreover, there appeared to be no possibility of water having entered the fuel system following the accident.

The fuel tank in the Europa is located in the lower fuselage aft of the seats and is saddle-shaped, with left and right lobes. The normal fuel off-take is from the front of the left lobe, via a three-way selector valve, using the electric pump, with the right lobe contents being used as a reserve. The design is such that with the aircraft in its parked attitude, any water would gravitate to the lowest point at the rear of the tank. Thus, as the tail rises when the aircraft lifts off, it is possible that water could move towards the front of the tank and into the fuel outlet. The aircraft was equipped with two fuel drains on the fuselage underside, which are designed such that they drain fuel from the lowest points of the tank, ie at the rear of the tank lobes. The pilot stated that, on the day of the accident, he had operated the drains for a few seconds but did not drain any fuel into a transparent container to check for water.

The aircraft was usually parked outside; however, it was fitted with a cockpit cover that also covered the fuel filler cap, the seal of which was reported to be in good condition. The engine was usually run on motor fuel, with refuelling conducted by means of steel jerry cans that were kept in the pilot's car. The pilot was at a loss to explain how the water came to be present in the aircraft.

Footnotes

[1] On the Europa, the brake and throttle levers are adjacent to one another, with both being operated by the pilot's right hand; it is thus effectively impossible to operate both simultaneously.

[2] Some early Europa electric fuel pumps were considered to have insufficient power and were required to be replaced with more powerful units; ref Europa Service Bulletin No 4, dated November 1999. G-FLRT had been so modified.

INCIDENT

Aircraft Type and Registration:	Piper PA-28-181 Cherokee Archer II, G-BNGT
No & Type of Engines:	1 Lycoming O-360-A4M piston engine
Year of Manufacture:	1985
Date & Time (UTC):	17 December 2005 at 1130 hrs
Location:	Edinburgh Airport
Type of Flight:	Private
Persons on Board:	Crew - 2 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to nose landing gear assembly and propeller tips
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	53 years
Commander's Flying Experience:	5,729 hours (of which 1615 were on type) Last 90 days - 39 hours Last 28 days - 12 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and metallurgical examination of components returned to the AAIB

Synopsis

Prior to takeoff the aircraft suffered a nose landing gear collapse. Stress corrosion was identified in the failed component.

History of the flight

The aircraft had taxied to the holding point Uniform 1 at Edinburgh Airport where it had completed a 180º turn into wind to carry out the pre-takeoff power checks. There were no apparent problems with the steering during the taxi and turn and the checks were completed satisfactorily. However, while turning through 180º following the power checks to line up at the holding point, the nose wheel detached from the nose landing gear assembly. The propeller tips struck the taxiway surface; the engine did not stop but was shutdown by the pilot.

Examination of the aircraft by the maintenance organisation revealed that one of the axle plugs on the nose landing gear axle rod assembly had failed causing the nose wheel to detach.

Nose landing gear axle rod assembly

The landing gear is a fixed tricycle type; the nose landing gear assembly consists of a strut and fork onto which the wheel and tyre are fixed by an axle rod assembly.

This contains a through-bolt, a spacer and an axle plug on each end, which are fastened with a washer and nut (see Figure 1). The aircraft maintenance manual contains information for the assembly and installation of the nose wheel. It states '*tighten nuts until no side play is felt (allow wheel to rotate freely)*'. It is necessary to remove the axle rod assembly whenever the wheel is removed.

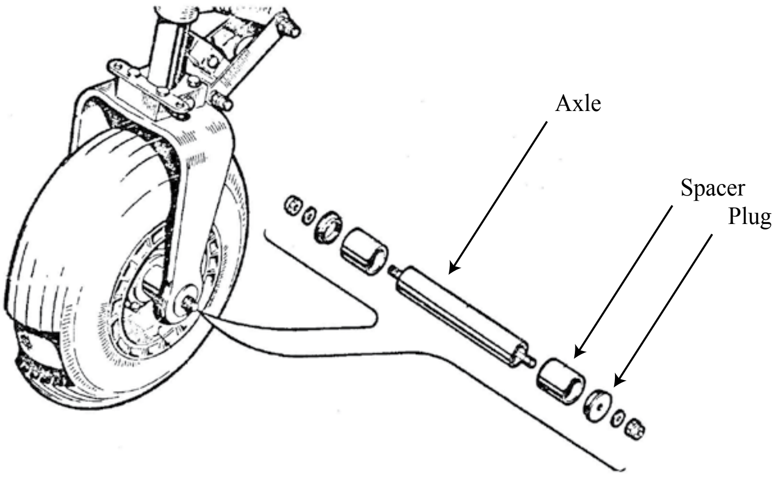

Figure 1

PA-28-181 Nose wheel axle assembly

Metallurgical examination

The failed axle plug was returned to the AAIB for metallurgical examination. The end of the plug had been plastically deformed prior to being separated from the remains of the plug, the final failure being mainly in shear (see Figure 2). Paint was present on parts of the fracture faces indicating that the separation had been progressive and that the cracks were present when the component was last painted. Examination of the failure surfaces indicated that multiple progressive, intergranular corrosion paths were present, which is typical of a slow stress corrosion mechanism in extruded aluminium alloys. Stress corrosion occurs under the simultaneous action of a tensile stress and a corrosive environment. The general direction of progression was normal to the radial tension stresses induced by the plastic deformation. It is considered that the deformation resulted from over tightening of the nut on the wheel through bolt.

Radial and circumferential cracking on similar axle plug

Failed plug with plastic deformation of the end piece and 'castellated' nature of fracture

Figure 2

Failed axle plug (right) and plug (left) showing similar cracking

Previous occurrences

Several other axle plugs were also returned to the AAIB by the maintenance organisation. All showed some distortion similar to the accident axle plug, and one showed similar radial and circumferential cracking (see Figure 2) although it had not failed. The maintenance organisation policy is now to change the axle plugs whenever distortion is observed during any disassembly of the axle.

This design of axle plug is similar on other Piper aircraft and also some Cessna aircraft. However, on the latter aircraft, the axle plug is made from steel rather than aluminium and is therefore less susceptible to this type of failure. An identical previous incident was identified on the CAA MORS database which had occurred to a PA-28 Cherokee in October 1981 and was the subject of an article in GASIL 1/82. It was additionally noted in that incident that two other aircraft also had similarly cracked axle plugs.

ACCIDENT

Aircraft Type and Registration:	Piper PA-34-200T Seneca II, N43GG
No & Type of Engines:	2 Continental TSIO-360-EB piston engines
Year of Manufacture:	1976
Date & Time (UTC):	27 September 2005 at 1438 hrs
Location:	Humberside Airport, Ulceby, South Humberside
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Both propellers bent, engines shock loaded, nose cone and nose landing gear doors damaged
Commander's Licence:	UK Private Pilot's Licence (A)
Commander's Age:	43 years
Commander's Flying Experience:	470 hours (of which 119 were on type) Last 90 days - 36 hours Last 28 days - 9 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and subsequent AAIB Engineering examination

Synopsis

On approach to Humberside Airport the pilot selected the landing gear to the down position; the landing gear position indicators showed that all three units were down and locked. After landing on the main wheels the nose of the aircraft was lowered and the nose landing gear collapsed. The aircraft continued along the runway on its main landing gear and nose fairing for approximately 120 m before coming to a halt. The collapse of the nose landing gear was caused by the geometric locking mechanism becoming ineffective.

History of the flight

The aircraft was being flown by its owner and returning to Humberside Airport. During the approach when the landing gear was selected DOWN the pilot reported seeing three green lights on the landing gear position indicator, indicating that all landing gear units were down and locked. After completing a normal approach, the aircraft landed on its main wheels, with the nose raised. As the pilot lowered the aircraft's nose it continued to fall smoothly until it hit the runway surface. The aircraft continued along the runway for approximately 120 m before coming to a halt. Both the pilot and passenger were unhurt and they opened the forward cabin door, with some difficulty, and left the aircraft prior to the arrival of the airport fire service. Both propellers had come into contact with the runway and were severely damaged; the nose cone and nose landing gear doors were also damaged in the accident.

Maintenance history

The aircraft had suffered a previous nose landing gear (NLG) collapse on 8 May 2003 when it was registered as G-ROLA (see AAIB Bulletin 4/2004). The aircraft was repaired in accordance with the recommendations of the New Piper Aircraft Inc, which included the replacement of the downlock spring link with a new item and, on completion of functional checks, the aircraft was declared serviceable. The aircraft was subsequently sold and transferred to the US register on 25 June 2004, the operator reported no problems with the landing gear or its indication system from the date of acquisition to the accident date.

Nose landing gear mechanism

The NLG of the Piper Seneca is of the forward retracting type which, when extended, has the wheel axle forward of the oleo strut pivot. When retracted, the gear is held up by hydraulic pressure in the actuator and, when extended, it is held in the down position by a geometric downlock mechanism. There are no locking hooks for either position. When the NLG is extended and under load it is prevented from collapsing by the drag link assembly (see Figure 1). When the NLG is fully extended, the offset drag link centre pivot is below the centre line of the two end pivots preventing the drag link assembly collapsing when the landing gear is under load.

The geometry of the NLG is such that the aircraft's weight on the nose-wheel applies a compressive load to the drag link assembly which tends to drive it more

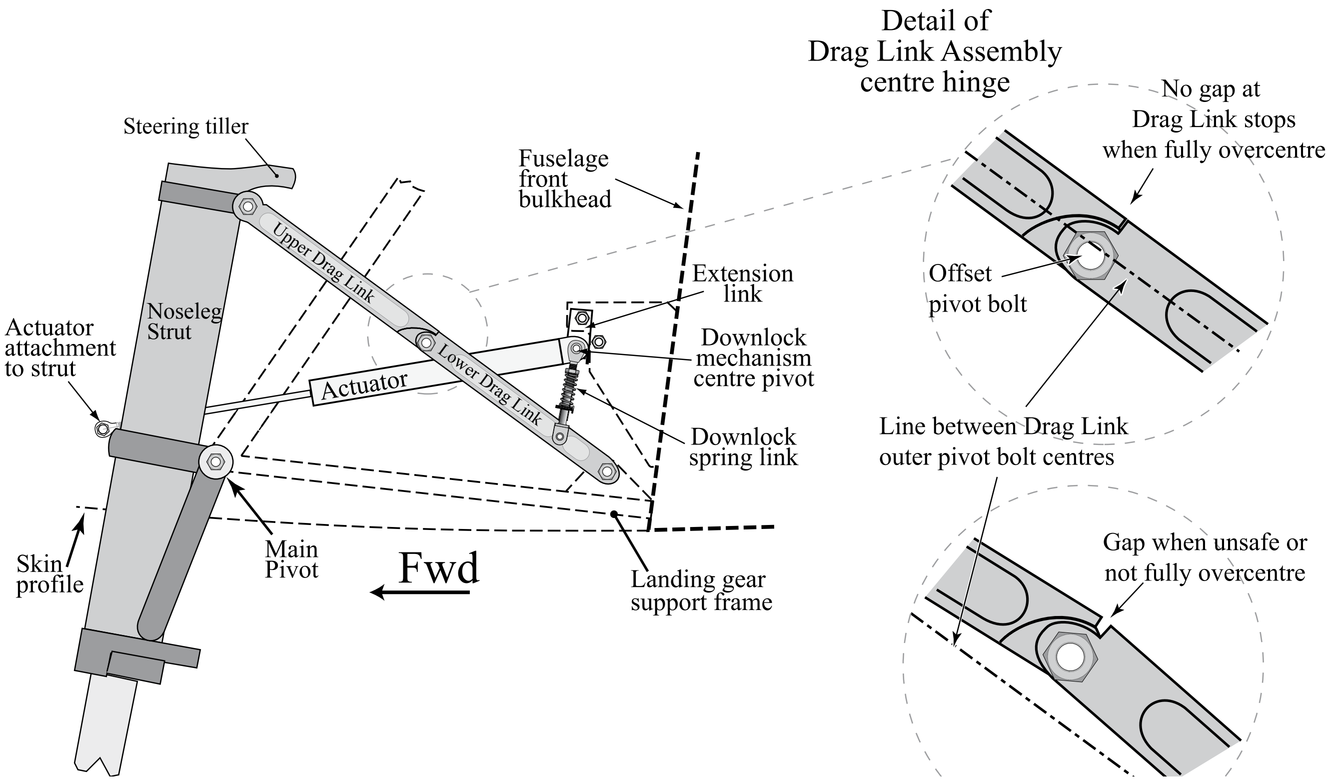

Figure 1

PA-34 nose landing gear side view showing main components in extended position
(Steering mechanism & downlock spring omitted for clarity)

firmly into the safe over centre condition when the gear is properly extended. Conversely, it will tend to cause the drag link to fold, and the gear to retract, if the load is applied when the drag link assembly is in an under centre condition.

The downlock spring link maintains the drag links in the over centre downlock position by applying a force on the lower drag link. However, small dimensional changes in this spring link can allow the drag link assembly to remain unlocked, or to have sufficient unrestrained movement to become unlocked, whilst the cockpit indicator shows the NLG to be locked down. The AAIB is aware of around nine incidents to UK registered Piper Seneca aircraft which involved uncommanded nose landing gear retraction, and the sensitivity of the NLG downlock mechanism to dimensional changes has been analysed in previous Bulletins, most recently in AAIB Bulletin 11/2005.

Nose gear examination

The aircraft was examined at Humberside Airport with the NLG secured in the down position by strops. Facilities were not available to carry out a functional test of the landing gear. The NLG extension link (see Figure 2) was found in a position corresponding to the down and locked position and the NLG micro switch had been activated, producing a 'down and locked' indication in the cockpit. The drag link assembly however was in an unlocked, under centre, condition. The downlock spring link showed some ovality in the pin slot, it was not possible to determine if this was the result of in service wear or as a result of an overload event. The central pivot pin, which secures the spring lock to the extension link and acts as the retraction jack input point, was severely distorted (see Figure 3). The retraction jack appeared to be in good condition with no evidence of external leaks or damage.

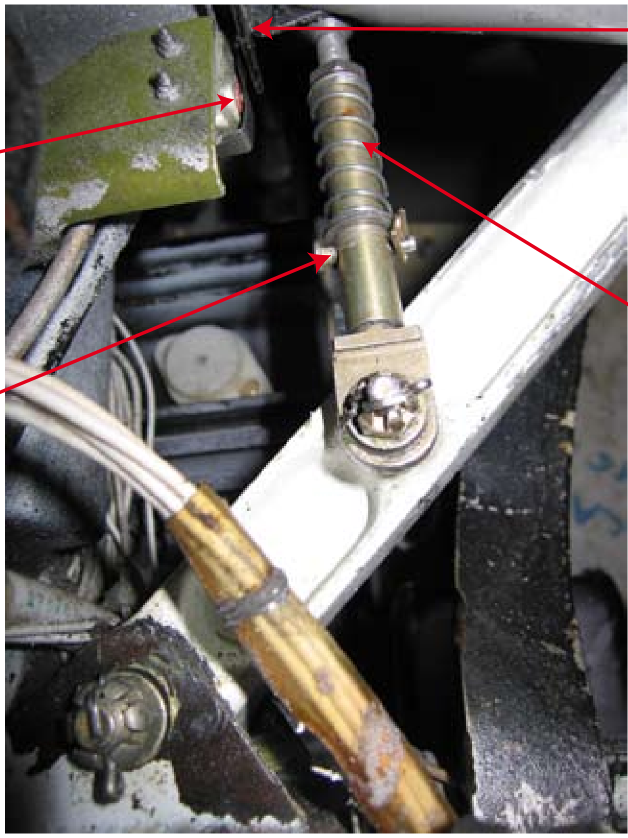

Figure 2

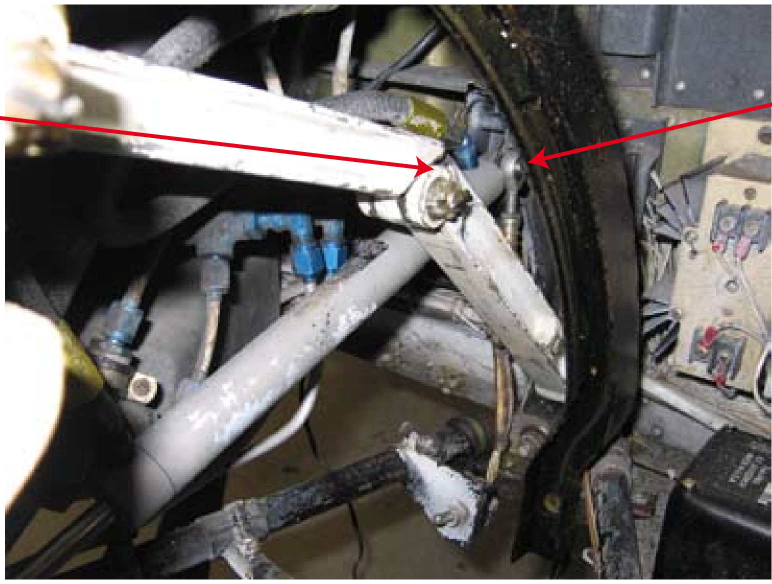

Figure 3

Analysis

Given the reportedly smooth collapse of the NLG, it appears probable that the NLG, although indicating 'down and locked' had not achieved a locked condition, leading to the 'retraction' of the NLG as weight was applied to it. In order for the NLG to remain unlocked, the ability of the downlock spring link to force the drag link into a locked position must have been compromised. The sensitivity of the Seneca NLG to small changes to the compressed length of the downlock spring link has been covered in some detail in previous Seneca landing gear collapse reports. (See AAIB Bulletin 11/2005).

Based on the results of previous investigations and the ductility of the material involved, it is probable that the distortion of the downlock mechanism centre pivot pin was produced as a result of an overload event such as a nose wheel landing, or rough surface takeoff. A review of the aircraft records and discussions with the aircraft's owner and maintenance organisation did not reveal any events which might have resulted in an overload of the link mounting pin.

During NLG extension, as the actuator extends, the extension link (see Figures 1 & 2) is rotated to make contact with the microswitch, providing an indication that the actuator has reached the limit of its extension and that the NLG is 'down and locked'. If the compressed downlock spring link remains of sufficient length, the NLG drag link assembly will be forced into the over centre position, locking the NLG in position. In a situation where the compressed downlock spring link is shorter than required, the NLG microswitch will still be activated by the extension of the NLG actuator; but the downlock spring link will not be of sufficient length to drive the drag link assembly into the 'safe' over centre position. It is probable that the combination of the distortion to the downlock mechanism centre pivot pin and the ovality of the pin slot, which introduced increased play in the downlock spring link, allowed the drag link assembly to remain in, or move to, an under centre and 'unlocked' position whilst indications showed that it was 'down and locked'.

Conclusions

The NLG failed to maintain a locked condition despite indicating to the pilot that it was 'down and locked'.

A change in geometry of the drag link spring lock, probably as a result of a combination of a high load event and in service wear prevented the drag link assembly achieving or sustaining a 'safe' condition; allowing the NLG to collapse as weight was applied to it.

The problems associated with the Piper PA-34 NLG have been thoroughly investigated in previous AAIB investigations. As a result a number of safety recommendations have been made which adequately address the causes of PA-34 NLG collapses; therefore no additional safety recommendations have been made as a result of this investigation.

Previous Safety Recommendations

As a consequence of the investigations into previous nose landing gear collapses on PA-34s, the AAIB has made five Safety Recommendations which are reproduced below. The earliest three of these have been accepted and acted on in some measure and a response on the latest two is understood to be imminent. The five Safety Recommendations were:

Safety Recommendation 2000-45 (FAA 00.327):
It is therefore recommended that the New Piper Aircraft Company should review and amplify the instructions for rigging the nose landing gear downlock mechanism contained in the Piper PA-34 Maintenance Manual.

Safety Recommendation 2000-46 (FAA 00.328):
The FAA and the CAA, in conjunction with the New Piper Aircraft Company, should investigate the causes of reported cases of Piper Seneca nose landing gear collapse. Consideration should be given to design modification which should minimise movement of the drag brace resulting from loads applied to the nose landing gear, and to ensure sufficient force is applied to the drag brace to retain it in the locked condition.

Safety Recommendation 2004-07 (FAA 04.019):
It is recommended that the Federal Aviation Administration, as the primary certificating authority for the Piper PA-34 Seneca aircraft series, should require the aircraft manufacturer to provide a clear and unambiguous description of the operation of the nose gear downlock spring link, its installation and its correct rigging by both narrative and pictorial means.

Safety Recommendation 2005-106 (FAA 05.303):
The Federal Aviation Administration of the USA should ensure that the New Piper Aircraft Company includes, in the appropriate Maintenance Manuals, clear advice on the factors affecting 'free fall' extension of this landing gear and a more precise definition of an 'acceptable' nose landing gear 'Retraction Link Retention Spring'.

Safety Recommendation 2005-107 (FAA 05.304):
The Federal Aviation Administration of the USA should ensure that the New Piper Aircraft Company reviews the content of Service Bulletin 1123A and expedites embodiment of the resulting instructions into the Maintenance Manual.

ACCIDENT

Aircraft Type and Registration:	Rockwell Commander 112TC, G-SAAB
No & Type of Engines:	1 Lycoming TO-360-C1A6D piston engine
Year of Manufacture:	1976
Date & Time (UTC):	5 March 2006 at 1305 hrs
Location:	Retford/Gamston Airport, Nottinghamshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Extensive damage to nose landing gear, engine and cowling, propeller, and engine mounts
Commander's Licence:	Private Pilot's Licence
Commander's Age:	51 years
Commander's Flying Experience:	147 hours (of which 44 were on type) Last 90 days - 2 hours Last 28 days - 2 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and subsequent AAIB enquiries

Synopsis

Whilst landing in a crosswind, the aircraft left the runway surface and sustained significant damage. The pilot reported that he had done little recent flying.

History of flight

Returning from a local flight, the pilot made an approach to Runway 03 in good weather, though the wind, from 310º at 16 kt, was across the runway. The pilot reported that the touchdown was normal but, as soon as the nose landing gear touched the runway, the aircraft veered left and he was unable to steer the aircraft back towards the runway centreline. The aircraft left the runway and came to rest in an adjacent field, having crossed a ditch which caused the nose landing gear to collapse. The pilot shut the aircraft down and vacated without injury; there was no fire. The demonstrated crosswind component quoted in the aircraft's flight manual was 20 kt.

An experienced flying instructor, who witnessed the accident, reported that the aircraft seemed to be drifting when it landed, and that it appeared that the pilot had not corrected for the crosswind on touchdown. The aircraft had recently returned to service following a wheels-up landing. Engineering investigation by the repair company revealed no defects in the landing gear or steering system which might have explained this latter (5 March) accident.

The pilot had logged 147 hours of flying time, and had flown two hours in the ninety days prior to the accident, one hour of which was the accident flight.

ACCIDENT

Aircraft Type and Registration:	Rockwell Commander AC11, N115TB
No & Type of Engines:	1 Lycoming TI0 540 AG/A piston engine
Year of Manufacture:	2000
Date & Time (UTC):	31 January 2006 at 1640 hrs
Location:	Oxford Airport, Oxfordshire
Type of Flight:	Private
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to propeller, nose landing gear doors and nose landing gear actuator
Commander's Licence:	Private Pilot's Licence (FAA)
Commander's Age:	53 years
Commander's Flying Experience:	485 hours (of which 310 were on type) Last 90 days - 8 hours Last 28 days - 1 hour
Information Source:	Aircraft Accident Report Form submitted by the pilot, AAIB examination and enquiries

Synopsis

During the first flight following maintenance work the pilot was unable to confirm the full extension of the nose landing gear. The nose gear collapsed during landing. It was not possible to conclusively determine the reason for the failure of the nose landing gear to fully extend.

History of the flight

The aircraft had been undergoing maintenance which involved the removal of the engine for crankshaft replacement and subsequent refitting. A test flight comprising a circuit was planned following the maintenance. Taxi and takeoff were normal; however, having selected the gear down on the downwind leg the pilot noticed that the green 'down and locked' indication on the nose landing gear was not illuminated. He carried out a flypast of the ATC tower, which confirmed that the nose landing gear was only partially extended. He then climbed to 3,500 ft in order to investigate the problem and, having reselected the gear several times, he carried out manoeuvres hoping to shake the landing gear down, but without effect. He then selected the landing gear down using the emergency landing gear system, but again the nose landing gear indication did not illuminate. He carried out another flypast of the ATC tower which confirmed the nose landing gear was still only partially extended.

The pilot carried out an approach and landing to the grass strip, shutting down the engine in the flare just prior to touchdown. As the nose was lowered onto the runway the aircraft continued to roll on the main landing gear, two of the three propeller blades and the nose wheel bay doors. The aircraft came to a stop and both occupants exited without injury.

Description of the landing gear system

The aircraft is fitted with a tricycle landing gear which is retracted by an electrically driven hydraulic power pack actuated by the landing gear selector switch. When the landing gear selector switch is placed in the UP position, the landing gear retracts and, when all three gears are retracted, the pump is shut off and the gear held up by hydraulic fluid lock. A hydraulic pressure switch controls the pump by removing power when the pressure reaches a preset limit. A loss in hydraulic pressure is sensed by pressure switches which actuate the power pack to build up additional hydraulic pressure. When the landing gear selector switch is placed in the DOWN position, the hydraulic fluid lock is released and hydraulic fluid directed to the down side of the landing gear actuator cylinders. When all three landing gear are down, each drag brace moves into an over centre position so that the gear is down and locked (see Figure 1). There is no electrical indication of gear retraction other than all indicator lights being extinguished. When the landing gear extends to the down position, the three landing gear microswitches are actuated, causing the three green lights to illuminate, indicating that the gear is down and locked.

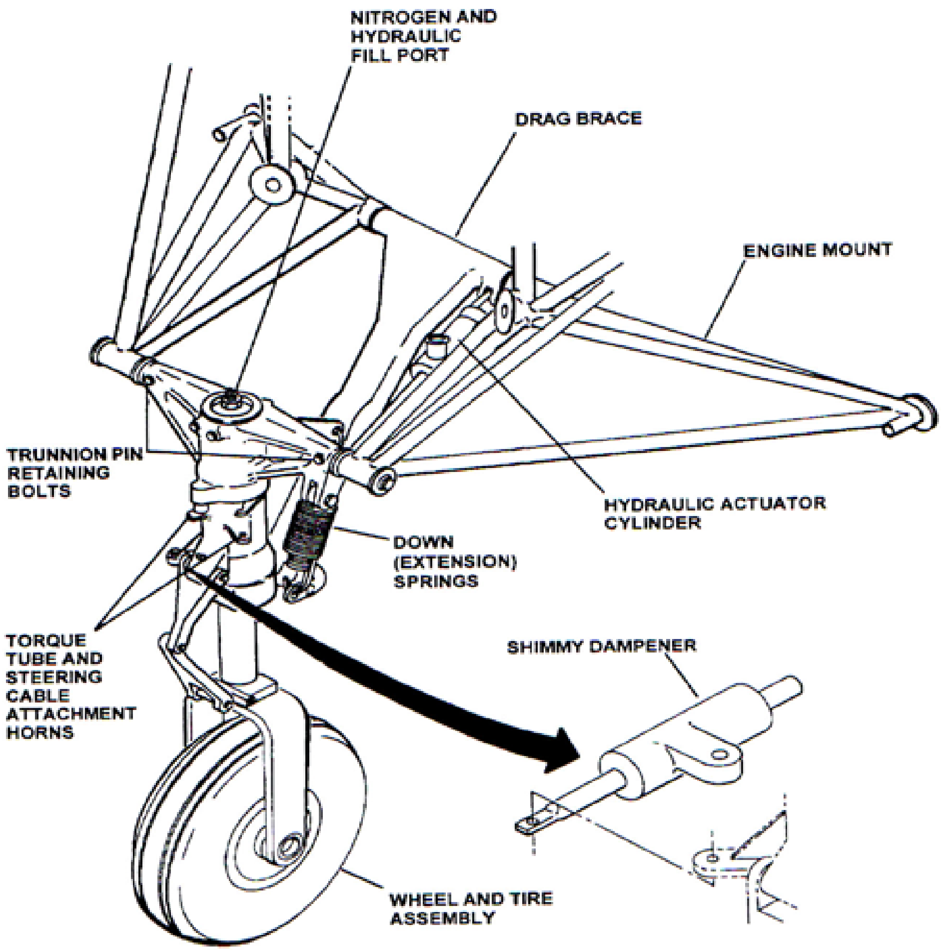

Figure 1

Nose landing gear assembly

Operation of the emergency landing gear system opens a valve which bypasses hydraulic fluid directly to the hydraulic power pack reservoir, allowing the gear to drop by gravity; gear extension is assisted by down springs.

Aircraft examination

When the aircraft's nose was lifted during recovery it was noted that during the ground roll the nose landing gear had been pushed toward the retracted position. The extension of the nose landing gear actuator shaft confirmed that the nose gear had not been fully extended when the aircraft contacted the runway. The pin attaching the nose gear actuator to the nose leg was removed following which the leg fell unhindered and unaided into the down and locked position. A thorough search was carried out from the aircraft touchdown point to the area where it came to rest; no items which could have fallen from the aircraft and which may have interfered with the nose landing gear mechanism were identified.

The aircraft was towed to the maintenance facility for a further examination by the maintenance organisation. A thorough examination of the nose landing gear revealed no witness marks to indicate that full extension may have been inhibited by a foreign object. There were some blue paint marks from the nose gear doors on the leg itself. The hydraulic pump reservoir was noted to be full. The damaged actuator was removed and a pressure test of the system carried out; this was within limits, although the hydraulic pack was only tested for a short period of time. The nose gear actuator was disassembled; fluid on the shaft side of the piston was found to contain a piece of metallic debris, which was probably a crushed drilled out rivet head. This debris was not considered to be of a sufficient size to restrict the flow of fluid from the actuator. There were no signs of scoring on the inner surface of the cylinder to indicate that the debris had been trapped between the piston and the cylinder wall. The remaining hydraulic components were purged of fluid; no further debris was found.

The maintenance manual describes a test for the emergency extension gravity system. This requires the aircraft to be on jacks and a 5½ lb weight to be applied to the nose landing gear axle to simulate the air loads. When the landing gear emergency valve control knob is operated the landing gear should free-fall and the green landing gear light should illuminate showing it is in a down and locked condition. This test was performed in the presence of the AAIB. The nose landing gear fell into the down and locked position; however, the nose landing gear actuator had not been fitted due to the non-availability of a spare so the test may not have been totally representative in that the gravitational forces were not opposed by drag from the actuator.

Subsequent examination of the nose landing gear microswitch showed that one attachment screw nut was missing and it was loose on its mounting. It was demonstrated that this could prevent the nose gear down and locked indicator light from illuminating; however, this was an intermittent fault. The condition of the screw, with dirt and grease present on the thread, suggested that it had been missing for some time.

The engine installation included a flexible fuel drain pipe from the induction manifold (Figure 2). This attached to the underside of the engine and was tie-wrapped at various points to route it around the nose landing gear bay. Some tie-wraps were present and their condition indicated that these had not been disturbed during the recent maintenance work; however the pipe was loose around the front of the nose leg. It was reported to the AAIB that on another aircraft it was possible to demonstrate that, if this pipe were loose, the nose gear could be jammed, preventing full extension by fouling the down spring lever arm around

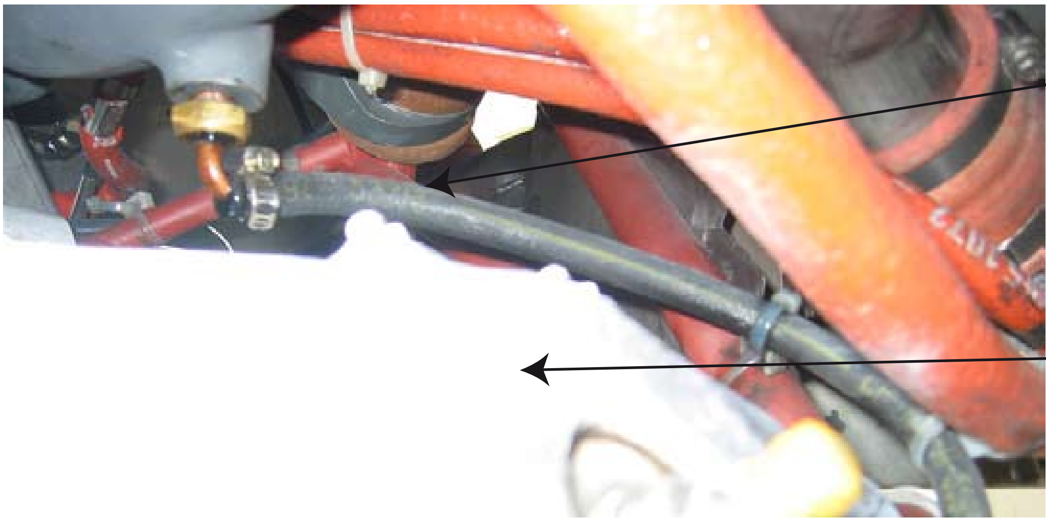

Figure 2

Flexible Fuel drain pipe

the fuel drain pipe. During the AAIB examination it was not possible to demonstrate such a jam on the accident aircraft.

Previous maintenance work

The aircraft had arrived at Oxford on 16 November 2005 for a crankshaft replacement in accordance with Lycoming Service Bulletin 566 to satisfy FAA AD 2005-19-11. The pilot reported no pre-existing defects on the aircraft. The engine was removed on 17 November and the aircraft kept in a hangar at Oxford while the work was carried out. The installation of the engine was completed and the Certificate of Release to Service issued on 31 January 2006. Engine operational and performance checks were carried out in accordance with the Aircraft Maintenance Manual and the relevant engine manufacturer's Service Information. As part of the installation engine ground runs were carried out for leak checks; however there is no requirement to carry out a landing gear function test. None of the landing gear components were disturbed during the work and there were no tools reported missing following the work.

Discussion

It was not possible to determine conclusively the reason for the failure of the nose landing gear to extend completely. The aircraft was flown past the tower with the gear extended using the normal, hydraulically operated, system and later with the gear extended using the emergency, gravity assisted, system. On both occasions ATC reported the gear to be only partially extended.

No fault was found in the hydraulic system; however it has not been possible to test the complete landing gear system as yet with a new nose landing gear actuator. If any further evidence is revealed when these tests are complete they will be reported in a later AAIB bulletin.

ACCIDENT

Aircraft Type and Registration:	Socata TB10 Tobago, G-OFLG
No & Type of Engines:	1 Lycoming O-360-A1AD piston engine
Year of Manufacture:	1979
Date & Time (UTC):	23 July 2005 at 1600 hrs
Location:	Derby Airfield, Derbyshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - 1 (Serious) Passengers - 1 (Serious)
Nature of Damage:	Extensive damage
Commander's Licence:	Private Pilot's Licence
Commander's Age:	49 years
Commander's Flying Experience:	124 hours (of which 51 were on type) Last 90 days - 6 hours Last 28 days - 3 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot, local aircraft and engine examination and further enquiries by the AAIB

Synopsis

The pilot was attempting to take off from Runway 17 at Derby Airfield. The field performance was marginal and the aircraft failed to accelerate normally; it ran off the end of the grass runway at about 50 kt. The aircraft hit a hedge and ran into a ditch, causing extensive damage to the aircraft and serious injuries to the two occupants. Examination of the engine revealed that a maintenance error had allowed an induction air leak downstream of the carburettor. The investigation concluded that the slower than normal acceleration during takeoff was not recognised in time to safely abort the takeoff.

History of flight

The pilot, with his wife as passenger, had flown the aircraft to Derby Airfield from Gloucester (Staverton) Airport on the previous evening, and was in the process of taking off from Derby on the return journey when the accident occurred. Runway 17 was in use, which was 602 m long with a grass surface. There was no significant weather, the grass was dry and the surface wind was light and variable. The pilot had calculated the take-off distance to be 445 m, based on a 'take-off' flap setting and a rotate speed of 63 kt. With a take-off run available of 513 m, the pilot acknowledged that there was little margin for error but, at the time, he was confident that the takeoff could be carried out safely.

The pilot carried out a thorough external inspection of the aircraft. There had been a continuing problem with water in one of the fuel tanks and, although it was believed that the problem had been rectified, the pilot took the precaution of taking several fuel samples, which were all free of contamination. The total fuel on board was estimated to be 140 ltr, based on known consumption and a visual check of the fuel tanks.

The engine start and the taxi were normal. The pilot carried out his engine checks and pre-takeoff checks on the runway threshold; no adverse indications were noted. Takeoff power was set prior to brake release and the pilot noted that the propeller rpm was above 2,500 rpm, although manifold pressure was not noted. After a few seconds the pilot released the brakes and commenced the takeoff.

Initially, the aircraft appeared to the pilot to accelerate normally, although the runway surface was bumpier than expected. The pilot checked his instruments and indicated airspeed during the take-off roll; the airspeed was increasing normally but was still below rotation speed at that point. The pilot then realised that the aircraft was much further down the runway than he expected, and he once again checked the airspeed, which appeared to have stopped increasing. The bumpy surface was making it difficult to read the air speed indicator, but the pilot thought the speed had stabilised at about 50 kt. Realising that it would not be possible to stop in the runway length remaining, the pilot warned his passenger. In fact, his passenger was already aware that something was wrong and that the aircraft had not accelerated as it normally did. The pilot attempted to fly the aircraft off the ground as it approached a hedge at the runway end. However, the aircraft did not become airborne and struck the hedge, passing through it and across a track before coming to an abrupt halt a few metres further on. Several persons witnessed the takeoff. Those familiar with aircraft operations at Derby Airfield were of the opinion that the aircraft's acceleration was slower than normal, and that it achieved a speed of 40 to 50 kt, which it maintained until it struck the hedge. Some witnesses also thought that the engine note sounded 'flat'. The aircraft appeared to rotate to a take-off attitude as it approached the runway end, but the main wheels did not leave the ground.

The aircraft was extensively damaged in the accident but, although there was a small fuel leak, there was no fire. The pilot and passenger remained conscious but they were seriously injured. The passenger's seat had moved forward, off the seat rails, and the aircraft structure had failed in the region of the passenger's upper seat belt attachment point. The passenger was able to release her seat belt and fall through a hole in the forward fuselage where the structure had ruptured and the engine firewall had been forced upwards during the impact. The pilot attempted to secure the aircraft as best he could, but his door was jammed and he was unable to vacate the aircraft without the assistance of the airfield fire service, which had arrived on scene. It was later established that the pilot and his wife had suffered serious leg injuries.

Aircraft performance

The pilot had telephoned Derby Airfield the day before the accident to arrange his visit. He spoke to the aerodrome owner who expressed his opinion that the aircraft type may have been unsuitable for the airfield and cautioned the pilot about the relatively short field lengths available. The pilot indicated that he was aware of the field lengths and that he was satisfied that he could safely operate his aircraft at the airfield.

The aircraft flight manual gave take-off performance figures based on an aircraft at maximum take-off mass of

1,150 kg. The actual aircraft mass at takeoff was estimated to be 1,067 kg. Interpolation within the performance chart provided gave a take-off roll of 395 m, which was valid for a takeoff at 1,150 kg and taking into account the pressure altitude and an air temperature of 20ºC. The flight manual states that this figure must be increased by 10% to allow for the increased humidity conditions in the UK, and a further 20% to allow for takeoff on short grass. The take-off ground roll would therefore have been 521 m for an aircraft at maximum mass, lifting off at 63 kt. Runway 17 had a physical length of 602 m but, because of the hedges at each end, the published take-off run available (TORA) was 513 m.

In common with most aircraft in this category, the flight manual contained unfactored data, being the performance achieved by the manufacturer using a new aircraft and engine in ideal conditions and flown by a test pilot. The Civil Aviation Authority, through its 'General Aviation Safety Sense' leaflets, '*strongly recommends'* that the appropriate Public Transport safety factors be applied to all flights. This is in order to account for incorrect speeds or techniques, poor pilot recency, less than favourable conditions and normal aircraft and engine wear and tear. For takeoff the recommended safety factor is 1.33 and, had this figure been applied, the take-off run required would be increased to 694 m. The CAA also advises pilots to calculate a 'decision point' at which the aircraft can be stopped in the event of engine or other malfunctions such as low engine rpm, loss of airspeed indicator, or lack of acceleration.

Engine examination

The aircraft was powered by a Lycoming piston engine rated at 180 HP at 2,700 rpm, driving a constant speed propeller. The engine was examined by a local aircraft and engine maintenance organisation at the AAIB's request. The mechanical fuel pump was removed and found to be serviceable and, although some fuel lines had ruptured, there were no obvious signs of leakage. Examination of the induction air heat system confirmed that the hot air flap was attached and in the 'cold' position. The air filter was disrupted as was the trunking from the air inlet, but there was no signs of a blockage in the induction system.

The carburettor was removed and it was noted that all but one of the four retention nuts were only slightly more than finger tight. The carburettor mounting arrangement consisted of four studs which protruded from the engine sump, which incorporated an integral inlet duct, onto which the updraft carburettor was mounted. A gasket was used to form an airtight seal between the carburettor mounting flange and the corresponding machined face of the sump. Compression of the gasket often provides a degree of adhesion which makes removal of the carburettor difficult, though in the case of G-OFLG the carburettor separated without difficulty.

Examination of the top flange of the carburettor showed that a twisted double tail of lockwire, used to retain the nearby closure plug of the air metering jet, had become trapped between the carburettor flange and the bottom of the engine sump. The thickness of the lockwire was 0.69 mm greater than that of the gasket. Witness marks showed minor abrasion between the lockwire tail and the sump. The interior of the mounting holes in the carburettor flange showed thread marks which matched the thread of the attachment studs, indicating relative movement between the carburettor and engine sump mounting.

Aircraft examination

The aircraft suffered extensive damage in the accident; it was examined in situ by a local engineering company who reported their findings to the AAIB. The engine had broken away and was inverted under the forward fuselage which was heavily disrupted. The engine firewall and main instrument panels had been forced upwards and to the left, and the cabin floor on the passenger's side had been forced downwards, creating the hole through which the passenger was able to evacuate. Movement of the centre consol to the left had contributed to the pilot's leg injuries. The main undercarriage had collapsed and the nose gear had collapsed and folded back beneath the fuselage. Although both wings were in approximate alignment, the right wing mainspar had sheared. The passenger's seat had collapsed downwards at its front end and a part of the aircraft structure had failed at the point where the upper seat belt fitting was attached to it. Although the equivalent structure on the pilot's side had not failed completely, there were visible signs of distress in the form of hairline cracks in the outer skin.

The aircraft had been certified in accordance with FAR 23 amendment 16, which required that the structure be designed to withstand the following inertial forces with an occupant weighing 170 lb (77 kg): upwards 3.0 g, sideways 1.5 g, forwards 9.0 g. For TB10 certification, load tests were performed on the structure with an occupant weighing 190 lb (86 kg) with no damage accruing to the structure or the seat belt assembly.

A mandatory service bulletin, number SB 10-103, had been introduced to ensure the integrity of the upper attachment of the front seat belts. The SB called for an inspection of the bolts and spacers of the upper attachment of the front belts and replacement where necessary, incorporating an upper attachment reinforcing kit and reconditioning of the seat belts. The Service Bulletin had been incorporated on G-OFLG. The failure of the structure was referred to Socata for analysis. The failure was not of the attachment point itself, but of the upper duct post to which the seat belt was attached. Socata concluded that the loads experienced in this accident exceeded those of the airworthiness requirements.

Aircraft history

The aircraft had been extensively damaged in a previous accident on 6 May 2001. Following that accident the aircraft was repaired, and in March 2002 the engine was overhauled, 'zero-timed' and re-fitted, during which process the carburettor was also removed and re-fitted. In June 2003 the aircraft was acquired by a Gloucester based group, of which the accident pilot was one, and the aircraft was relocated to Gloucester Airport. There was no record of the carburettor having been disturbed since the engine had been overhauled.

Six weeks prior to the accident there was a reported case of loss of power in flight. After a long descent the engine failed to respond correctly and, although the pilot on that occasion reported that carburettor heat had been applied during the descent, it was felt that carburettor icing most closely fitted the symptoms, as power checks after landing were normal and no fault was found. There were no documented instances of a power loss during takeoff.

Conclusions

The trapped lockwire prevented proper seating of the carburettor, allowing an induction air leak downstream of the carburettor which may have reduced the available power during the take-off roll. As the carburettor had not been recently disturbed, the aircraft must have been operating with this latent defect for some time. Why it should have manifested itself so dramatically on this occasion is not clear, though the bumpy runway may have contributed in some way. It is possible that the three retention nuts on the carburettor, which were only slightly more than finger tight, may have been disturbed during the significant disruption of the engine at impact.

The aircraft's performance was marginal. Applying the full corrections stipulated in the aircraft flight manual, the take-off run required exceeded the take-off run available by 8 m for an aircraft at maximum weight, though G-OFLG was estimated to have been 83 kg below that weight. Had the recommended take-off safety factor been applied, the take-off run required would have exceeded that available by a considerable margin. In his report, the pilot acknowledged that he had failed to recognise the lack of acceleration until the aircraft was at a point where there was insufficient runway remaining to safely abort the takeoff.

ACCIDENT

Aircraft Type and Registration:	Yak-18T, HA-YAZ
No & Type of Engines:	1 Ivchenko Vedeneyev M-14PF piston engine
Year of Manufacture:	1977
Date & Time (UTC):	29 January 2006 at 1325 hrs
Location:	White Waltham Aerodrome, Berkshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Propeller, engine cowling and flap damaged. Minor damage to wing
Commander's Licence:	Private Pilot's Licence
Commander's Age:	51 years
Commander's Flying Experience:	289 hours (of which 27 were on type) Last 90 days - 3 hours Last 28 days - 0 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The pilot had not flown the aircraft for five weeks and planned to fly some circuits for practice. The weather was good with sunshine and light winds. Grass Runway 03 was in use with a left hand circuit pattern. The pilot had already carried out several circuits when, following what he believed had been a normal approach, he landed with the gear up. The aircraft slid to a halt and he was able to vacate the aircraft without assistance.

Afterwards it was reported to the pilot that the landing gear had been seen to retract on the downwind leg. On further consideration he commented that after takeoff on his final circuit he had turned crosswind early to maintain separation from another aircraft. He thought it possible that he had omitted to retract the gear at that stage. On the downwind leg he remembered he had experienced some difficulty in finding the gear selector, but he thought he had selected the gear down. It seems likely however that at this time he may have selected the gear up instead. He commented that the sun had been in his eyes on the downwind leg and could have prevented him from seeing the gear warning lights.

The pilot said that it was his usual practice to check for 'three greens' on final approach; he could not account for not noticing the lack of gear indications at that stage.

ACCIDENT

Aircraft Type and Registration:	Eurocopter AS350B3 'Ecureuil', G-BZVG
No & Type of Engines:	1 Turbomeca Arriel 2B turboshaft engine
Year of Manufacture:	2000
Date & Time (UTC):	18 October 2004 at 1300 hrs
Location:	Oxford Kidlington Airport
Type of Flight:	Training
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - 1 (Serious) Passengers - N/A
Nature of Damage:	Extensive damage to fuselage and main rotors
Commander's Licence:	Airline Transport Pilot's Licence with Instructor Rating
Commander's Age:	53 years
Commander's Flying Experience:	6,862 hours (of which 420 were on type) Last 90 days - 144 hours Last 28 days - 20 hours
Information Source:	Aircraft Accident Report Form submitted by the commander plus further enquiries and examination of the helicopter and its control system components

Synopsis

An instructor and student were carrying out a simulated hydraulic failure approach and landing. The student was about to carry out a run-on landing when she experienced difficulty overcoming the control feedback forces. The instructor took control and attempted to climb the helicopter but it rolled to the left and struck the ground. No evidence of pre-impact mechanical faults was found but the issue of heavy control forces in manual flight was well understood by the helicopter manufacturer. Appropriate procedures, advice and guidance had been issued, both within the helicopter's Flight Manual and through supplementary documents, but the pilots involved had neither followed the Flight Manual procedure accurately nor seen all the relevant supplementary guidance and information. One safety recommendation was made about the distribution of handling advice and information to pilots.

General information

The chief instructor of the Type Rating Training Organisation (TRTO) and the instructor on the accident flight had both flown simulated hydraulic failure exercises in G-BZVG. Both pilots had been concerned at what they considered to be abnormally high 'hydraulics OFF' control feedback forces.

The owner purchased the helicopter in December 2003 and completed his type rating on 23 January 2004. On a day that the owner believed was 14 April 2004 the chief instructor was carrying out a simulated hydraulic failure approach in G-BZVG with the owner. Just before touch down, the owner had difficulty controlling the helicopter which he attributed to his relative inexperience. The chief instructor took control and he too was unable to exert enough force on the cyclic control to correct a roll to the left which was developing. He did not want to re-instate the hydraulics at such a low height in case he over-controlled causing the main rotor blades to strike the ground. He raised the collective lever and was able to fly away from the ground but not before the helicopter had yawed to the left through 180°.

Following the incident, the chief instructor and the owner consulted the test pilot of the helicopter manufacturer's import agent. They explained that they thought the control feedback forces were abnormally high. The owner asked the test pilot to assess the control forces without hydraulic power when he next flew the helicopter. The test pilot flew G-BZVG on 14 May 2004 and carried out a full C of A test flight in June 2004; on both occasions he found the control forces with 'hydraulics OFF' to be normal for the type.

After the owner had experienced heavy control forces during a practice manual landing on 14 April, he trained regularly until he was satisfied that he had mastered the technique. Also, between 30 July and 1 October 2004, the chief instructor conducted five Licence Skill Tests using G-BZVG. A 'hydraulics OFF' approach to landing was made during each test. Although the chief instructor did not handle the controls during the exercise, none of the candidates encountered significant difficulties.

On 9 September 2004 the test pilot flew G-BZVG and again found the control feedback forces to be normal for the AS350B3. This information was passed to both the chief instructor and the owner.

The flight instructor and student involved in the accident carried out a training flight on 29 September 2004 during which a simulated hydraulic failure was attempted. Both pilots considered the control feedback forces to be abnormally high and the exercise was abandoned. After the flight, the instructor informed the chief instructor of the problem. The owner and the chief instructor went to see the test pilot who re-iterated the high forces to be expected.

On 1 October 2004 the owner and the chief instructor carried out one hour of simulated hydraulic failure training. No significant problems occurred during the training and the owner remained confident in his ability to fly the helicopter without hydraulics should the situation arise. The owner also stated that all his practice hydraulic failure approaches and landings had been carried out with the HYD TEST switch in the depressed (test) position.

History of the accident flight

The student was an experienced AS350B pilot having flown approximately 100 hours on that type in the USA on her FAA licence. The purpose of the training was to carry out a type conversion to have the AS350B3 variant endorsed on her UK PPL. She had accumulated 11.5 hours of flying on the B3 and the accident flight was the second training sortie of that day. The same instructor had carried out all her B3 training and was the instructor on the accident flight. During the earlier one-hour dual sortie, various emergencies were practiced including simulated engine governor failure. This exercise necessarily resulted in a low speed run-on landing into wind.

The instructor had fully briefed the simulated hydraulic failure exercise. She had observed the student satisfactorily demonstrate the safe handling of this exercise on a number of previous occasions. On the downwind leg of a circuit she depressed the HYD TEST switch to simulate hydraulic failure. The student correctly identified the emergency and reduced airspeed to 60 kt. When the helicopter was stable the instructor switched the hydraulic cut-off switch on the collective control lever to OFF. Next the instructor confirmed that the student was comfortable with the feel of the controls due to them being abnormally heavy on a previous flight. The student considered them normal and continued to fly the aircraft around the circuit and made an approach to the helicopter training area on a final approach track of 200º. The weather was good with a surface wind of 240º/8 kt, visibility 10 km and the lowest cloud at 3,000 ft. In the last few hundred feet of the approach, the helicopter was turned into wind for the landing.

The approach was smoothly controlled with speed reducing gradually, consistent with the correct approach profile. As the helicopter neared the ground, still with forward ground speed, the nose began to rise up and yaw to the left as the collective was raised. The instructor took control and with right tail-rotor-pedal and cyclic inputs, attempted to lower the nose, correct the yaw and correct the increasing angle of bank to the left. The lateral cyclic control forces required were very high and the student asked if she should reinstate the hydraulics by switching ON the hydraulic cut-off switch mounted on the right side collective control. Given the large force the instructor was exerting and the helicopter's close proximity to the ground, the instructor elected to remain in manual control. Because the instructor's physical efforts to correct the yaw and roll had insufficient effect, she tried to raise the collective lever in an attempt to fly away from the ground. However, the aircraft continued to roll left and it struck the grass surface of the helicopter training area. A witness in another helicopter behind G-BZVG, also operating in the training area, saw it make a steeply banked left turn and strike the ground. The helicopter came to rest upright on a heading of 020º, almost opposite in direction to its final approach track of 240°.

ATC activated the crash alarm and the airfield Rescue and Fire Fighting Service promptly attended the scene. They assisted with the removal of both pilots who had received back injuries and were subsequently taken to hospital. Although there was substantial damage to the helicopter, there was no fire.

Hydraulic system

Purpose and control forces

The helicopter is fitted with a single hydraulic system which provides the pilot with hydraulically boosted cyclic, collective and tail rotor controls. Accumulators in the main rotor servo actuator units provide a small energy reserve. The tail rotor servo unit also has an accumulator and a yaw load compensator; the latter is mounted in parallel with the servo actuator to reduce the control loads in the case of loss of hydraulic power. It does so by resisting the zero-pitch return moment of the tail rotor blades (which is only partly compensated by boss-type weights).

In the event of a loss of hydraulic pressure, the main rotor servo accumulators provide approximately 30 seconds of boost to enable the pilot either to land the helicopter if it is in the hover, or to establish the recommended safety speed range (40 to 60 kt), which minimises control forces in forward flight. The tail rotor servo unit accumulator also powers the load compensator for a period. The helicopter can be flown without hydraulic assistance but control forces are high. Within the safety speed range, the lateral cyclic forces required are as low as 9 lb for left cyclic movement and 11 lb for forward cyclic movement. The collective lever has a neutral force position at about 40% torque and any movement up or down from that position requires increasing amounts of force.

If the pilot attempts to hover the helicopter without hydraulic assistance, the control forces change in both direction and intensity as the pilot attempts to maintain a steady position. The pilot has to exert longitudinal and lateral forces of up to 12 lb which can change quickly in direction. This results in excessive pilot workload and controllability problems. During a run-on landing at about 10 kt, the pilot may have to exert a forward longitudinal force of up to 37 lb for less than 30 seconds with low lateral forces. The maximum forces which may be encountered are at the extremes of the speed envelope. These may be as high as 33 lb left or right lateral cyclic and 37 lb forward longitudinal cyclic. A force of up to 30 lb may be required to raise or lower the collective control to its maximum up or down travel. The tail rotor control pedals also exhibit high feedback forces, particularly the right pedal when the collective lever is raised. These forces are described as 'very high' if the yaw load compensator is inactive.

System control

The hydraulic system is controlled using the hydraulic cut-off switch located on the right seat collective lever and the hydraulic test pushbutton on the centre console.

Hydraulic cut-off switch

The cut-off switch is a two position guarded switch (ON/OFF), normally remaining in the ON position. It allows the main and tail rotor servos to be powered when the hydraulic system is operating normally. When selected to OFF, the system is depressurised and the accumulators on the main rotor servo safety units are depressurised simultaneously; this prevents asymmetric exhaustion of the accumulators. Asymmetric exhaustion could cause control difficulties; consequently, selecting this switch to OFF is a required action for either a real or a simulated hydraulic failure. However, the tail rotor servo accumulator is not depressurised by the cut-off switch; the tail rotor servo and compensator retain their accumulator assistance. If system hydraulic pressure is available, selecting the switch to ON immediately reinstates hydraulic pressure to the servos and re-pressurises the accumulators.

Hydraulic test pushbutton

The HYD TEST pushbutton, mounted on the centre console between the two pilots' seats, has two positions. The TEST position (button pushed in) initiates the test function and the button out position restores normal operation. The primary function of the HYD TEST pushbutton is to enable the pilot to check the functioning of the servo accumulators before flight but it is also used to simulate the onset of hydraulic failure during training. Selecting the TEST position results in the solenoid valve opening on the regulator unit, which immediately depressurises the hydraulic system. It will also open the tail rotor servo solenoid, depressurising the tail rotor accumulator, and with it the tail rotor load compensator, but it allows the main rotor servos to be powered by their accumulators until the energy stored in them is exhausted.

Hydraulic system failure training

Hydraulic system failure is simulated by carrying out a specific sequence of switch selections and corresponding actions which are documented in the aircraft Flight Manual within Supplement 7. Practice 'hydraulics OFF' approaches are conducted in two phases: firstly, a transition to recommended safety speed range from steady flight conditions and secondly, a transition to landing.

The instructor depresses the HYD TEST pushbutton to the TEST position and the student reduces airspeed to between 40 and 60 kt. The main rotor controls are pressurised through their accumulators but no hydraulic assistance is provided for the tail rotor servo and load compensator. Once the student has stabilised the helicopter at the safety speed, the first phase of the exercise is complete.

When in a steady flight condition, the instructor resets the HYD TEST pushbutton to the ON position which restores system pressure and recharges the main and tail rotor accumulators. Next the student selects the collective hydraulic cut-off switch to the OFF position which, within two seconds, introduces the main rotor manual control loads. The tail rotor accumulator continues to assist the tail rotor servo and load compensator. This switch configuration ensures that if hydraulic power is required, selecting the collective hydraulic cut-off switch to ON will immediately reinstate the powered controls.

The recommended procedure for landing is to select a clear flat area and make a shallow final approach which minimises operation of the collective lever. The pilot should perform a no hover, slow run-on landing, at about 10 kt, with the helicopter's nose into wind. Specifically, the helicopter should not be hovered or taxied without hydraulic pressure assistance.

Flight Manual supplements

At the time of the accident, Flight Manual Supplement 7 Revision 0 (zero) was current (see Appendix A). Whilst it required the same training procedure for conducting the simulation of a hydraulic failure, it contained less comprehensive additional information than Revision 1, which superseded Revision 0, particularly regarding the magnitude of expected control forces.

Revision 1 was raised by Eurocopter in the 25th week of 2003. DGAC approval for the revision was granted on 14 May 2004 with EASA approval[1] gained on 2 June 2004. By that time EASA approval was valid for all European operators and so Eurocopter issued Revision 1 to all European countries on 30 June 2004. However, when the UK CAA received Revision 1 a few days later, it was deemed not acceptable because the CAA required Eurocopter to take account of modifications which the CAA had required before granting type approval to AS350B3 helicopters registered within the UK. At the beginning of October 2004, when Eurocopter discovered that UK operators had not received Revision 1, they prepared a new master for the UK and issued it without CAA approval (because it did not need it since it had already been approved by EASA). This master (revision) was released on 21 October 2004; it reached the UK agent for the aircraft type on 29 October 2004, 11 days after the accident[2].

Between the raising of Revision 1 and its circulation, Eurocopter TELEX INFORMATION, T.F.S. No 00000153 dated 9 December 2003 was circulated regarding hydraulic power. The TELEX was issued as a CAUTION and directly applicable to the AS350B3. With regard to hydraulic system failure training, the following advice was included:

Footnotes

[1] Until September 2003, Flight Manuals intended for European operators were approved and issued in accordance with four different layouts according to the country of certification (DGAC for France, LBA for Germany, ENAC for Italy and CAA for UK). Since September 2003 the EASA approved Flight Manual version was applicable in all member States of the European Community.

[2] At the end of December 2005, Eurocopter Service Letter 1731-00-05 was issued to explain to operators that they will gradually receive normal revisions with code letter A (EASA approved) when no definition specificity applies, or with a code letter E when including definition specificity.

> *'Over a clear and flat landing area, apply the landing procedure in accordance with the Flight Manual: Make a flat approach, nose into wind, and perform a no-hover slight running landing at low speed (10 kt are sufficient)'.*

Within Revision 1 were several notes which amplified the recommended training procedure. One of these notes reiterated the advice above contained in the TELEX message. Other notes and cautions explained the importance of not attempting to hover the helicopter and of returning the HYD TEST pushbutton to the OFF position, thereby restoring system hydraulic pressure to all the actuators and accumulators before switching the hydraulic cut-off switch to OFF.

The TRTO had not received a copy of the TELEX and neither the chief instructor nor the accident flight instructor had seen a copy of the TELEX. The UK agent for the helicopter manufacturer had received the TELEX but it was unable to provide a record of when the TELEX was received or a distribution list of where and when it was re-distributed within the UK.

Previous incidents

On 16 July 2004, some three months before this accident, the helicopter manufacturer issued a cautionary TELEX message (TFS No 00000188) relevant to a number of helicopter types including the AS350B and B3 versions. The caution on page 1 stated 'THE INFORMATION AND INSTRUCTIONS CONTAINED IN THIS TELEX INFORMATION ARE INTENDED FOR FLIGHT CREWS'. The message described a previous occurrence of hydraulic problems which resulted in a hard landing and attributed some of the difficulties experienced to inadvertent operation of the HYD TEST pushbutton. The stated purposes of this message were: to remind flight crews of the function of the (yaw) load compensator; to remind flight crews of the proper use of the hydraulic test function; and to inform pilots of the consequences of unintentional actuation of the HYD TEST pushbutton.

Airworthiness Directive

Soon after this accident, on 10 November 2004, Airworthiness Directive No F-2004-174 was issued by the French DGAC on behalf of EASA. It required incorporation of Revision 1 to Supplement 7 of the Flight Manual within one month (it also applied to other variants of the AS350 helicopter). The reason stated was:

> *'This AD is issued after having noted that some crews do not understand how to comply with the emergency procedures in the event of a hydraulic power system failure or during emergency procedure training (hydraulic failure training procedures). The Flight Manuals have been revised to prevent misunderstanding'.*

Engineering examination

A detailed examination of the wreckage was undertaken after it was recovered to the helicopter's maintenance organisation's hangar at Oxford Airport. The tail rotor blade pitch control system was found to be connected but seized. Examination found that the seizure was caused by severe impact damage between the tail rotor blade balance weights and the pitch shaft outer sleeve casing; this resulted in the casing being deformed onto the shaft. There was no evidence of a pre-impact restriction or disconnection within the main rotor control systems.

All the components of the helicopter's hydraulic system were taken to the helicopter manufacturer's test facility in France where full functional tests on each component were carried out. All but two of these components functioned within the manufacturer's specifications.

Two of the three main rotor hydraulic servo actuators failed to function correctly. These two actuators were dismantled and it was found that they had failed the functional test because of damage caused during the impact sequence.

Examination of the maintenance records showed that approximately two flying hours before the accident the tail rotor pitch control hydraulic servo actuator had been replaced. It was replaced with the helicopter's original servo actuator that had previously been returned to the manufacturer for modification. This hydraulic servo was one of the items that, when tested, was found to function within the manufacturer's specifications.

Analysis

During the accident flight the instructor had correctly initiated the exercise by depressing the HYD TEST pushbutton and the student had reduced the airspeed to the recommended safety speed. The exercise then deviated from that required in the Flight Manual in that the hydraulic cut-off switch was selected to OFF before the HYD TEST pushbutton was selected out to restore hydraulic power. The pushbutton was not moved and it remained in the depressed TEST position for the remainder of the flight. This omission had two unwanted effects. Firstly it depressurised the tail rotor load compensator and thereby increased the right pedal force subsequently required to control yaw at low airspeed. Secondly, although the instructor did not accept the student's offer to select the cut-off switch to ON, even if the collective mounted switch had been selected ON, no hydraulic power would have been available due to the system being in the TEST mode.

The circuit and initial approach had been flown correctly with the aircraft reducing speed in the descent consistent with the required profile. The first indication of difficulty was the uncorrected yaw to the left. Although the angular displacement was not large, the reduction in speed caused the helicopter's nose to pitch up. The effect of the crosswind from the right due to the yaw of the helicopter probably caused the main rotor disc to flapback to the left to some degree. The effect of yaw to the left would also have caused the helicopter to roll to the left. Having taken control, the instructor was surprised by the magnitude of force she needed to exert on the cyclic control in order to try and correct the situation. She considered these forces were greater than normal when practising a 'hydraulics OFF' landing.

The physical demands of the combined feedback forces and the rate of change in attitude led the instructor to believe that raising the collective was the best option in order to climb away from the ground.

Conclusion

The accident occurred during a training exercise when the helicopter was at a low height with hydraulic power selected off. The approach was flown with the helicopter's nose into wind but the instructor had not followed the correct sequence of hydraulic switch selections. Having taken control, the instructor was unable to exert sufficient force on the controls to counteract the movement of the helicopter and so control was lost.

When he flew G-BZVG on several occasions, the import agent's test pilot found the control forces normal for the type, perhaps because he was using the correct hydraulic failure simulation technique. However, the TRTO's chief instructor and the accident instructor were not complying with the training procedure stated in the Flight Manual at Supplement 7 Revision 0. Specifically, they were not resetting the HYD TEST switch before commencing an approach to land. This may explain why they felt the control forces were too high.

Had the HYD TEST switch been reset before the second phase of the manual approach, the tail rotor accumulator would have been recharged and yaw control forces would have been reduced. Additionally, the pilots would have had the option of restoring hydraulic power very quickly using the student's collective mounted cut-off switch. However, because of her fear of over-controlling so close to the ground, in this instance the instructor elected not to re-instate the hydraulics. Consequently, the incorrect position of the HYD TEST switch at the moment control was lost made little difference to the outcome of this event.

Correct positioning of the test switch ensures that the tail rotor load compensator remains pressurised for the 'manual' approach and landing, thereby minimising yaw pedal foot loads, which in turn may reduce the magnitude of any lateral cyclic forces required to retain roll control. Moreover, its correct positioning on final approach could be relevant to future training flights so that hydraulics can be re-selected in time to avoid loss of control if the forces experienced are excessive. In the opinion of the CAA's Flight Department, the hydraulic failure training exercise, if correctly conducted, is within the capabilities of the crew.

The Flight Manual supplement in use at the time of the accident did not fully alert a pilot to the magnitude of the forces required to contain such a situation. However, the Flight Manual Section 7.8 'Hydraulic System' section did contain appropriate information. Moreover, appropriate information and advice in the form of two cautionary TELEX messages had preceded circulation of the revised Flight Manual supplement. After this accident, the importance of this revision was emphasised by the Airworthiness Directive but neither of the preceding TELEX messages had been seen by the instructors or the student.

At the time of the accident the flight manual for G-BZVG contained both Revision 0 (zero) to Supplement 7, which was current at the time the helicopter was sold to its owner, and the Section 7.8 'Hydraulic System' description. It did not contain (nor did it need to contain) copies of the cautionary TELEX messages issued by the manufacturer.

Safety action

One issue embedded in the events leading up to this accident was the use of TELEX messages and an Airworthiness Directive to convey information and instructions to pilots. These communication methods are well developed but more suited to distributing information to agents and maintenance organisations than to type-rated pilots.

The duty of producing handling advice and information to pilots rightly rests with an aircraft manufacturer and the duty of assimilating this advice and information rightly rests with type-rated pilots. However, problems arise when pilots are unaware that safety-related information intended for them has been issued in advance of a formal amendment to the Flight Manual. Their responsibility is to know and abide by the Flight Manual for the aircraft type, so the proper place for updated handling advice is in the Flight Manual.

In this case, appropriate and expanded handling advice had been prepared by the manufacturer, in the form of a revision to a Flight Manual Supplement, more than a year before this accident. However, because of regulatory issues, the revision was not issued to UK operators until more than a year later. In the meantime, the manufacturer had issued a cautionary TELEX message, basically advising pilots of the same instructions, advice and information within Revision 1 to Supplement 7 of the Flight Manual. Moreover, after an incident that was in many ways comparable to this accident, but which occurred three months earlier, the manufacturer issued a second cautionary TELEX message about correct use of the hydraulic system switches. However, the distribution method used for all these documents was not optimised for delivering handling advice to pilots. Neither of the accident pilots nor their supervisor within the TRTO had seen these documents before the accident.

Safety Recommendation

Only an authority that issues pilot licences and type ratings can have an accurate record of pilots rated on an aircraft type. Worldwide, there are a large number of such authorities. Consequently, neither a helicopter manufacturer nor its overseas agents have sufficient information with which to distribute information rapidly to pilots who have a relevant type rating or are training to acquire a relevant type rating. Furthermore, formal amendments to Flight Manuals have to be authorised by the appropriate regulatory body (in this case EASA) which, of necessity, introduces administrative delays into the issue and circulation of important safety information. However, cautionary messages and interim advice can be issued by an aircraft manufacturer without formal approval from the regulatory body. This accident might have been averted if the documents issued by the manufacturer had been read and assimilated by the TRTO's flying staff.

Most pilots now have access to the Internet and so the power of this modern communication medium is used by some aircraft manufacturers to make safety-related information available to pilots and technicians. In November 2004 Eurocopter launched a system known by the acronym T.I.P.I. (Technical Information Publication on Internet). The T.I.P.I system is described at http://www.eurocopter.com/ Applicants should select Services, Technical Publications, T.I.P.I. which will link them to the T.I.P.I. public space.

A personal subscription is available to owners and operators of Eurocopter products, maintenance centres, and representatives of official air navigation authorities. The system is free to the user and recipients can select the helicopter type or types which interest them. Thereafter, recipients can receive e-mail notification of the issue of new or revised technical documents. An example page sent by e-mail annotated with instructions and caveats is attached at Appendix B.

If all aircraft manufacturers made safety-related information available to those seeking it, pilots in particular would then be able to check a website to determine if new or revised handling advice had been issued in advance of a formal amendment to a Flight Manual. Moreover, pilots who hold a relevant type rating can register their e-mail address with the aircraft manufacturer so that they can be alerted to the issue of information appropriate to their needs. These methods could be more widely used to good effect. Consequently, it was recommended that:

Safety Recommendation 2006-005

The European Aviation Safety Agency should encourage all aircraft manufacturers to make available, for an appropriate period, via an Internet website, interim technical instructions, handling advice and similar safety-related information, until the information has been incorporated into the appropriate manuals by formal amendment.

FLIGHT MANUAL

1 GENERAL

This procedure allows training for hydraulic pressure failure on an AS 350 B3 which is equipped with a single hydraulic system.

In case of loss of hydraulic pressure (the HYDR red warning light illuminates and the gong sounds), the hydraulic pressure accumulators allow sufficient time to reach the recommended speed of 60 kt. Then the pilot must cut off the residual hydraulic pressure with the switch on the collective lever and apply the emergency procedure.

– Failure simulation (Figure 1)

In steady cruise flight, actuating the "HYD TEST" (1) pushbutton on the central console (2) produces the same effects as a real failure :

. The hydraulic pump pressure is by-passed.
. The main rotor accumulators give hydraulic assistance for a limited time.

The only difference from the real failure is that the tail rotor accumulator is discharged by this action and the pedal control loads are increased.

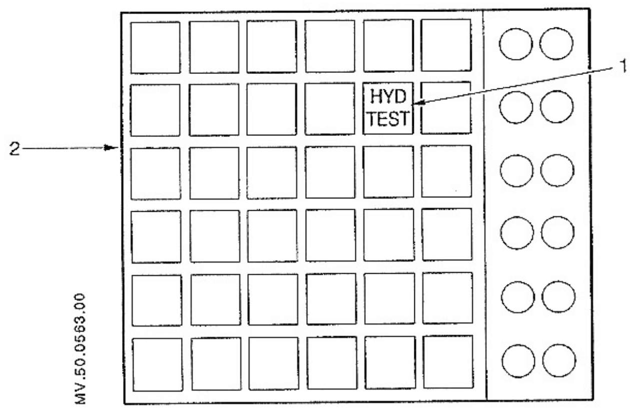

Figure 1

DGAC Approved: 350 B3 **SUP.7**

A | B | D | E | G 00-45 Page 1

Appendix A

Extract from G-BZVG's Flight Manual

AAIB WARNING NOTE: - THIS SUPPLEMENT IS OUT OF DATE

FLIGHT MANUAL

2 <u>TRAINING PROCEDURE</u> (Figures 1 and 2)

In stabilized cruise flight conditions, depress the "HYD TEST" (1) (Figure 1) pushbutton.
The red HYDR light illuminates, the "gong" sounds immediately.
Reduce collective pitch to adjust airspeed around 60 kt.
Reset the "HYD TEST" (1) pushbutton (up position) to restore hydraulic pressure in tail rotor accumulator.
Cut-off the hydraulic pressure switch (Figure 2) on the collective lever, the control loads are felt within 1 or 2 seconds. The "gong" sounds again.
Apply the appropriate emergency procedure (red HYDR warning light) SECTION 3.3 page 2 of the present Flight Manual.

<u>IMPORTANT</u> : As specified in the emergency procedure :

- Make a no-hover slightly slipping landing with head wind.
- Do not hover or make forward flight without hydraulic pressure assistance.

After landing, and before any other take-off or hovering flight, reset the hydraulic pressure switch (3) forward to restore hydraulic pressure, check that the red HYDR light goes off within 3 seconds.

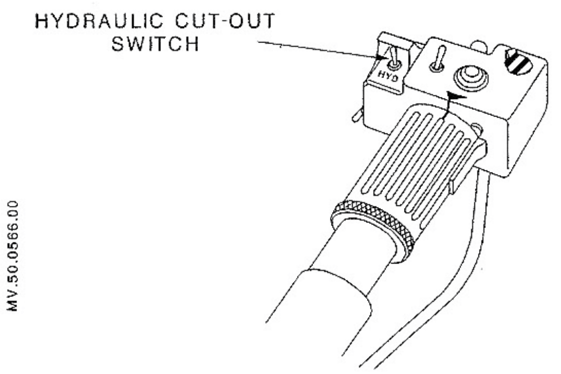

Figure 2

DGAC Approved: 350 B3 **SUP.7**

| A | B | D | E | G |

00-45 Page 2

Appendix A (Cont)

Extract from G-BZVG's Flight Manual

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WHEN THE DOCUMENTS CONTAIN INSTRUCTIONS, THESE INSTRUCTIONS SHOULD BE CONSIDERED TO BE APPLICABLE:
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With our best regards

T.I.P.I. team.

2006/03/29 WEBSITE

2006/03/28 [AS 350]

LS 1778-00-06 Operations on elevated heliports - Approvals to operate in accordance with JAROPS 3.540(a) (4)

JAR-OPS 3 – AS350 B / BA / B1 / B2 - ARRIEL 1B / 1D / 1D1 Engines

Rev 0

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2006/03/28 [AS 350]

LS 1777-00-06 Operations on elevated heliports - Approvals to operate in accordance with JAROPS 3.540(a) (4)

JAR-OPS 3 – AS350 B3 - ARRIEL 2B / 2B1 Engines

Rev 0

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Appendix B

Example E-mail alert generated by the T.I.P.I System

ACCIDENT

Aircraft Type and Registration:	Robinson R44 Astro, G-HEPY
No & Type of Engines:	1 Lycoming O-540-F1B5 piston engine
Year of Manufacture:	1999
Date & Time (UTC):	4 February 2006 at 1230 hrs
Location:	Downton on the Rock, Hereford and Worcester
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 2
Injuries:	Crew - None Passengers - None
Nature of Damage:	Minor damage to rotor blades, tail pylon and cockpit area
Commander's Licence:	Private Pilot's Licence
Commander's Age:	48 years
Commander's Flying Experience:	328 hours (all on type) Last 90 days - 15 hours Last 28 days - 9 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and AAIB inquiries

Synopsis

The engine stopped as a result of water in the fuel system. During the subsequent landing run the helicopter sustained minor damage when it collided with a fence and farm gate.

History of the flight

The pilot and his two passengers were on a private flight from Redditch to Bedstone. Approximately 15 minutes into the flight, and whilst at 1,000 ft agl, the pilot felt what he described as a couple of kicks in yaw, which he believed might have been turbulence from a ridge that he had just flown over. In order to move away from the ridge he commenced a gentle turn to the right and lowered the collective lever. About the same time as he took this action the low rpm horn sounded, the low rpm warning light illuminated and the pilot became aware that the engine noise had stopped. The pilot, therefore, entered an autorotation and selected what he believed to be the only suitable landing site on a ridge covered in woods and isolated trees. The main rotor blades clipped a number of trees on the approach to the landing site where the helicopter made a fast run-on landing before colliding with a fence and metal farm gate. The pilot and passengers were uninjured and the helicopter suffered minor damage to the rotor blades, landing skids, canopy and cockpit area.

Meteorological conditions

The synoptic situation at 1200 hrs on the day of the accident showed an area of high pressure covering the British Isles. This 'high' had been over the British Isles for at least five days prior to the accident giving a period of generally dry weather. In the area of the accident the wind at 1,000 ft was from 350º at 5 to 10 kt with a temperature of 4.5ºC, dew point of 0.6ºC and relative humidity of approximately 80%. The night time temperature during this period dropped to around -1ºC.

Description of fuel system

The aircraft fuel is stored in a main and auxiliary fuel tank, which have a combined capacity of 190 ltr. The auxiliary fuel tank is mounted on the right side of the main transmission and feeds directly into the main fuel tank, which is mounted on the left side of the transmission. The unusable capacity of the main and auxiliary fuel tanks is 4 ltr and 1 ltr respectively. Each fuel tank has its own water drain point and a refuelling orifice, the sides of which are raised above the surface of the tank. From the main fuel tank the fuel is fed, under gravity, to the gascolator then on to the carburettor fuel bowl. The gascolator is also equipped with a water drain point.

Engineering aspects

The owner stated that there had been no previous problems with the engine and apart from the carburettor air temperature gauge, which under-read, the helicopter was serviceable prior to the engine failure.

An engineering inspection was undertaken, in the presence of the owner, which revealed that there was nothing obviously wrong with the engine. On checking the fuel system it was discovered that the gascolator and carburettor fuel bowl were full of water and, subsequently, approximately 1 ltr of water was drained from the main fuel tank and ½ ltr water was drained from the auxiliary fuel tank. The seals on the fuel tank refuelling caps were assessed as being in good condition and both caps fitted securely to their respective tanks.

The owner stated that he was the sole user of the helicopter and normally refuelled it towards the end of each day's flying at Wellsbourne Mountford Airfield before flying to his house where the helicopter was either parked in his garden, or in an adjacent field. The owner normally tried to ensure that the helicopter was parked overnight with the fuel tanks full; however he would occasionally leave it with a fuel load as low as 90 ltr. On this occasion the helicopter had been parked for the two days since it was last flown with a fuel load of approximately 115 ltr.

The airport manager at Wellsbourne Mountford Airfield stated, with regard to the fuel installation, that not only were all the recent water sediment checks clear, but on the day that the pilot uplifted the fuel they had already dispensed over 1,000 ltr of Avgas to other aircraft, none of which had reported any subsequent problems.

Accumulation of water in fuel tanks

Condensation within the fuel tanks can result in the accumulation of water in the fuel system. For light aircraft condensation normally results from large variations in the day and night-time temperatures. During the day the tank heats up causing the air in the tank to expand and escape through the vents. At night the air in the tank cools down allowing moist air to be drawn into the tank with the result that condensation forms on the tank walls. The problem is most likely to occur with large fuel tanks when the aircraft is parked outside for a period of time with a partial fuel load. A specialist aviation fuels adviser has indicated that with the meteorological conditions at the time of this accident, condensation could, at most, account for the generation of a teaspoon of water in each of the fuel tanks since the previous flight.

Fuel water sediment checks

The owner stated that he normally undertook fuel/water sediment checks during the pre-flight checks just prior to flying the helicopter, but on this occasion had carried out the fuel checks the night before the accident flight. When the fuel sample was taken from the gascolator after the accident the owner had initially thought that as the fluid was clear the sample was free of water. However, it was not until the engineer pointed out that Avgas is blue that the owner realised that the sample jar was full of water. The owner confirmed that he did not normally check the colour of the fuel as he believed that the presence of water in fuel would be apparent by the presence of globules of water in the base of the sample tube or a meniscus between the water and fuel.

Comments

The use of engine governing systems in helicopters and the correlation of the carburettor butterfly valve with the collective lever mean that helicopter pilots might not be aware of the build up of carburettor icing, which could result in the sudden stopping of the engine, or severe reduction in power when the collective lever is lowered. It is, therefore, important that carburettor air temperature gauges are maintained in a serviceable condition and are regularly monitored throughout the flight.

Whilst the meteorological conditions meant that there was a serious risk of carburettor icing, the presence of a large quantity of water in the carburettor fuel bowl and gascolator indicates that it is most probable that it was water contamination of the fuel which caused the engine to stop.

Just prior to the engine failure the pilot felt a slight kick in yaw, which he believed was caused by turbulence, but given the light wind conditions was most probably an early indication that water was starting to enter the engine. It is normally assumed that an engine failure in a light helicopter will initially be apparent by a sudden yaw to the left or right, depending on the direction of rotation of the main rotor. However, on this occasion the pilot lowered the collective lever and, therefore, unloaded the main rotor just prior to the engine failure and it was the activation of the low rotor rpm warning horn and lack of engine noise, which prompted him to enter an autorotation.

Not only had there been no recent rain, but the condition of the fuel tanks meant that it was unlikely that water would have entered the fuel tanks by leaking through the fuel caps; moreover there was no evidence of water contamination of the fuel supply at the local airfield. It is possible that the source of the water was condensation accumulating in the unusable portion of the fuel tanks over a period of time. It is also possible that the owner did not detect the presence of water during the fuel water sediment checks as he did not consider the colour of the fluid, or appreciate that the sample might only contain water and would, therefore, contain neither globules nor a meniscus between the two fluids.

ACCIDENT

Aircraft Type and Registration:	Aerotechnik EV-97 Eurostar, G-CCKK
No & Type of Engines:	1 Rotax 912-UL piston engine
Year of Manufacture:	2003
Date & Time (UTC):	15 June 2005 at 1802 hrs
Location:	Near Wotton-under-Edge, Gloucestershire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - 1 (Fatal) Passengers - 1 (Fatal)
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Private Pilot's Licence
Commander's Age:	48 years
Commander's Flying Experience:	321 hours (of which 129 were on type) Last 90 days - 22 hours Last 28 days - 7 hours
Information Source:	AAIB Field Investigation

Synopsis

The aircraft was being flown from Shobdon Airfield in Herefordshire to its home base at Hullavington Airfield in Wiltshire. As the aircraft approached the Cotswold Hills the pilot encountered worsening weather conditions. The aircraft diverted from track in an apparent attempt to avoid the poorest weather; it was seen manoeuvring at a very low height and appeared to be preparing for a forced landing. During this manoeuvring the aircraft was seen to roll quickly to its left and descend steeply until it struck the ground. The investigation concluded that the aircraft had suffered an aerodynamic stall with insufficient height for the pilot to effect a recovery. No safety recommendations are made.

History of flight

On the evening of the accident the pilot had flown from Hullavington Airfield, where the aircraft was kept, to Shobdon Airfield in Herefordshire. The pilot was accompanied by a friend with whom he had flown on a number of occasions. The pilot's flight log, which was recovered from the aircraft, recorded his take-off time as 1550 hrs. Hullavington is an uncontrolled airfield situated beneath the western edge of the RAF Lyneham Control Area and a standing agreement was in place for the pilot to notify RAF Lyneham ATC by radio of his movements into or out of Hullavington. However, there was no record of the pilot having done so on this occasion. There was also an agreement that the pilot would telephone the Army operations centre at Hullavington with his intentions prior to flight, though again no such call was made.

The direct flight to Shobdon is a distance of 51 nm, and the pilot recorded landing there at 1630 hrs. As the aircraft was taxiing after landing, the pilot was asked if he required fuel and he said that he did not. The pilot 'booked in' at the flying club operations room at 1640 hrs, at the same time he notified an intended departure time of 1700 hrs. Both the pilot and his passenger appeared to personnel at Shobdon to be relaxed and in good spirits and they took time to have a meal and a hot drink in the restaurant before leaving for the return journey. Both made mobile telephone calls to relatives, though neither made any relevant comments about the flight to Shobdon or the proposed return journey. The latest weather information was available on a notice board in the club building but staff could not recall if the pilot checked this information. Pre-flight preparations at the aircraft were not witnessed but the airfield manager saw the aircraft take off. He recalled that there was a cloud base of between 1,200 ft and 1,500 ft with good visibility.

Other than the take-off time, which the pilot recorded on his log as 1725 hrs, there was no recorded information available to assist with a reconstruction of the accident flight between takeoff and the point at which the aircraft was observed by eye witnesses just prior to the accident. Radar recordings from Clee Hill and Burrington radars were analysed but the aircraft, which was not transponder equipped, was not displayed. During the radar analysis, it was noted that the lowest primary radar returns that had been obtained along the route from any aircraft were in the Shobdon area, for an aircraft reported to be at 2,300 ft altitude. Enquiries at airfields and ATC units along the route from Shobdon to Hullavington established that there was no record of the pilot having been in radio contact with any of them, nor was there any requirement for him to have made such contact. It was also established, from mobile telephone records, that the only calls made prior to the accident by either the pilot or his passenger were those made whilst the aircraft was on the ground at Shobdon.

The aircraft was seen in the accident area by witnesses on an adjacent golf course. The accident site was some 10 nm from the pilot's destination at Hullavington. The aircraft was seen flying low in poor weather and manoeuvring in a manner which suggested to some witnesses that the pilot was seeking a place to land. During this manoeuvring, the aircraft was seen to roll quickly to the left and descend rapidly in a nose-low attitude, disappearing behind trees before it struck the ground. The two occupants were fatally injured in the impact.

Witness information

Eye witnesses to the final moments of the flight were on the Cotswold Edge golf course, situated on the edge of the Cotswold escarpment overlooking the village of Wotton-under-Edge to the west and the Severn Vale beyond. The course lies approximately north-east / south-west with a marked down slope from an elevation of 795 ft at its north-eastern end to 700 ft at the south-western end. The accident site was at an elevation of 630 ft, about 250 m from the south-western end of the course.

The two witnesses closest to the accident site were towards the lower part of the course. It had been raining heavily but this had become a light drizzle. There had been low cloud as they descended the slope, and on looking back up the slope they could see mist settling on the higher part of the course. At the same time, conditions were brighter towards the west, and it was possible to see down the hillside towards Wotton-under-Edge and the Severn Vale. The golfers remarked at the time that the weather was changeable.

They were first alerted to the aircraft's presence by the sound of its engine behind them. Although the noise was not loud, it suggested to them that the aircraft was both close and low. They turned to look back down the slope and saw the aircraft emerge from cloud or mist at a very low height and in level flight or a shallow descent. As they watched, the aircraft flew in a north-westerly direction from their left to right, about 300 m away, close to the south-western boundary of the golf course and then appeared to enter a controlled, moderate turn to its left, away from them. The aircraft initially appeared to be maintaining altitude as it turned through about 270 degrees until it was heading back directly towards the fairway and the two witnesses. Their impression was that the aircraft was preparing to land on the fairway; one witness described the aircraft as slowing down noticeably during the latter stages of the turn and appearing to commence a descent. When the aircraft was pointing towards them it rolled wings level for a brief period but then started to roll again to the left, in a manner described by the witnesses as "*sudden*" and "*violent*". As the aircraft rolled, it turned away from the witnesses and its nose dropped until it was in a near vertical descent. Both witnesses described seeing the underside of the aircraft during its final steep descent, though the actual impact was hidden from their view by a line of trees.

One of the witnesses alerted the emergency services by mobile telephone as they ran to where the aircraft had crashed. Whilst still some distance from the accident site, the witnesses noticed a strong smell of fuel. They continued to the aircraft, but it was clear that they were unable to help the two occupants. The witnesses continued to pass information to the emergency operator but were advised to move away from the aircraft for their own safety. The fire brigade was the first of the emergency services to arrive, and was directed from the main road to the accident site by one of the witnesses.

Neither witness described any sounds of misfiring from the engine. One witness thought that there had been a change in engine note as the aircraft appeared to slow down during its turn, and the other noticed some changes in note but thought they may have been because the aircraft was turning. When the aircraft disappeared from view in its final descent, both witnesses perceived a brief period of silence before the sound of impact, but thought this was more likely due to the sound being blanked by the trees. Both witnesses agreed that the aircraft had remained very low during its manoeuvring, and that it had not re-entered cloud.

Two further witnesses on the golf course saw the aircraft. They were a little way up the slope from the two previous witnesses but described the weather as misty and noted that from their position it was not possible to see down towards the valley. Both witnesses described seeing the aircraft appearing at a very low altitude but lost sight of it before the final descent as it appeared to fly back into the mist. Both the witnesses heard the engine noise reduce as the aircraft turned away from them, though neither of them saw any of the final manoeuvring or the descent into the ground.

Wreckage examination

Initial examination of the wreckage indicated that the aircraft had struck the ground in a steep nose-down and slightly right wing down attitude, but at a relatively low forward speed. At the time of the accident the aircraft was structurally complete but initial assessment indicated that the engine appeared to have been producing no power. The fuel tank contained a significant amount of fuel.

The wreckage was removed to the AAIB's facility at Farnborough, where a more detailed examination was carried out. No evidence was found of any pre-impact failure of the aircraft or its flying controls. A separate examination of the engine revealed that there was no pre-impact mechanical defect in the unit, the two ignition systems were able to perform satisfactorily and the carburettor float chambers contained significant amounts of fuel.

It was determined from a detailed internal examination of the propeller reduction gear that the engine had been producing power at impact, although the amount of power could not be determined. (Unlike more common types of light aircraft engine, at all but high speeds, this type of geared unit will not 'windmill' if the engine ceases to develop power.)

It was noted that the airspeed indicator body was intact, the glass unbroken and the needle was registering slightly above zero. Calibration showed that the instrument had a fairly constant datum shift present throughout the speed range. It was concluded that this datum shift was consistent with the effect of impact forces on the internal mechanism.

Aircraft information

The EV-97 aircraft type was developed in the Czech Republic and supplied in kit form by the manufacturers to enable it to be completed by the customer. The design was evaluated by the Popular Flying Association (PFA), a British based member's organisation which works in accordance with powers delegated by the Civil Aviation Authority (CAA). As a result of this evaluation it was approved for amateur construction and operation in the United Kingdom. Additionally, an example of the type was test flown by a CAA test pilot and judged to have normal handling qualities which met the requirements laid down many years earlier, by the Authority, for very light aircraft.

The process of inspection, test flying and recommendation for issue of the Permit to Fly document for individual aircraft in this category, when amateur built from a kit, is administered and supervised by the PFA. This procedure was followed in the case of G-CCKK, which qualified as a microlight type by virtue of its maximum all-up weight and stalling speed falling below maxima specified in the relevant regulations. The aircraft was not equipped with any gyro flight instruments. More comprehensively equipped examples of the aircraft have been built having higher empty weights resulting in them being certificated as conventional light aircraft.

G-CCKK was completed by the owner and a number of associates in 2003 and was independently inspected during, and at the end of, the construction process by an experienced inspector approved by the PFA. Thereafter he test flew the finished aircraft. He confirmed that it performed and handled in the expected manner. The aircraft was then issued with a Permit to Fly by the CAA on the recommendation of the PFA. The Permit was revalidated on 5 November 2004 following a detailed inspection and flight test.

This aircraft was fitted with a Rotax 912 liquid cooled engine equipped with a carburettor heating system. This heating system consists of a cast water jacket type heat exchanger, supplied from the engine cooling system, surrounding the downstream end of the air passage within the carburettor. The heat exchanger is positioned adjacent to the plane of the throttle butterfly on this installation and is intended to ensure that the internal surfaces of the carburettor remain at temperatures above freezing during all phases of flight. The system is not selectable and is, therefore, always active. It does not heat the induction charge appreciably and, unlike conventional carburettor heating systems, has minimal effect on the available power. The arrangement is understood to be effective in all normal operational phases other than immediately after start-up, or those involving prolonged use of low power, when cooling of the water system occurs. Additionally, on EV-97 aircraft, the induction air is drawn from a region within the engine cowling near the radiator.

Meteorological information

An aftercast was obtained from the Meteorological Office. The synoptic situation at 1800 hrs on 15 June 2005 showed a moderate, moist, west-south-westerly airflow over west and south-west England. The weather was cloudy and overcast with outbreaks of generally slight rain or drizzle. The surface visibility was 15 to 20 km but deteriorating to between 4,000 m and 7 km in slight rain or drizzle. Visibility was as low as 100 m where cloud covered high ground. The freezing level was at 10,000 ft. There would have been a scattered cloud cover at 1,500 ft to 2,000 ft, with a more extensive cloud cover beginning at 3,000 ft to 5,000 ft.

With sea temperature in the Bristol Channel of 13ºC to 14ºC, and a moist airflow from that direction, it is likely that the cloud base would have lowered in outbreaks of slight rain or drizzle to between 900 ft and 1,200 ft, possibly even as low as 300 ft to 500 ft as a result of stratus forming over the high ground. At 1,000 ft the air temperature was 12.4ºC and dew point 9.9ºC, giving a humidity of 85%. These values placed the conditions during the flight within the area for serious risk of engine induction system icing, according to the widely used chart of probability of induction icing in typical light aircraft.

An indication of the extent of the weather deterioration that evening can be gained from the weather reports from RAF Lyneham, which is some 5 nm from Hullavington, and 15 nm from the accident site. At 1550 hrs, the time the aircraft departed from Hullavington, RAF Lyneham reported good visibility with the lowest cloud beginning at 3,000 ft. By 1750 hrs, Lyneham was being affected by drizzle, with visibility reduced to 7 km and a lowest cloud base that had reduced to 1,000 ft. The 1850 hrs report showed a visibility of 4,000 m in drizzle, temporarily reducing to 3,000 m, with the cloud base starting at 400 ft and with increased cloud cover at 700 ft.

The commander of the police helicopter, which arrived at the scene about 30 minutes after the accident, was able to provide a detailed account of the weather conditions at that time. The helicopter took off from Bristol Airport and the transit was made in generally good conditions, with a cloud base of around 3,000 ft. However, as it approached the Cotswold escarpment and the accident site, the commander encountered a *"vertical face of cloud"* with layered stratus cloud and hill fog where it met the ground. The helicopter reached the accident site with some difficulty; the cloud base was estimated to be between 100 ft and 200 ft above ground level with a visibility of 500 m or 600 m.

Meteorological flight planning

Some meteorological paperwork was recovered from the pilot's home. The information consisted of a Metform 214, which showed forecast spot winds and temperatures over the United Kingdom. The time for this forecast was 0900 hrs, with a validity period of 0600 hrs to 1200 hrs, and thus did not cover the period of the intended flight. No Metform 215, which shows the forecast in-flight weather conditions for the UK, or any other weather information was found at the pilot's home, among his personal effects or in the aircraft wreckage. Although no printed information was recovered for the period of the accident flight, it was not possible to determine whether or not the pilot had viewed this information before leaving home.

Forecast information for 1500 hrs, with a validity between 1200 hrs and 1800 hrs, would have been available from 1100 hrs. The content of the forecasts for 0600 hrs to 1200 hrs and 1200 hrs to 1800 hrs is summarised below:

Forecast for 0900, issued at 0301 and valid between 0600 hrs and 1200 hrs

An occluded front was shown, which had just moved across the area at a speed of 30 kt. The area associated with the front showed generally broken to overcast cloud beginning at 2,500 ft amsl with a visibility of 15 km. Occasionally the visibility would reduce to 7 km in rain, and the cloud base to between 1,000 ft and 1,500 ft amsl. In isolated areas over the sea and near coasts, conditions would be worse, with 2,000 m in drizzle and cloud beginning at 400 ft. The area associated with the occluded front was subject to isolated heavy showers and thunderstorms, with associated low cloud and visibility.

The area behind the frontal zone, which would be expected to be affecting the area of the flight later in the day, showed generally good visibility, with broken to overcast cloud beginning at 2,500 ft amsl. In isolated areas over land, this was forecast to reduce to 7 km visibility in rain showers and the cloud base to lower to 1,500 ft.

For both forecast areas, the following relevant warnings applied: *"Cloud on hills, moderate ice and turbulence in cloud."*

Forecast for 1500, issued at 0905 and valid between 1200 hrs and 1800 hrs

This forecast would have been available from 1100 hrs on the day of the accident. In this forecast, the occluded front was shown clear of the Cotswolds but with its northern end shown swinging back south, affecting Wales and western England. The weather conditions associated with the front were broadly similar to the previous forecast. The forecast for the rest of the south-west, including the accident area, was similar to the previous report, except that increased lower cloud was forecast, associated with isolated rain showers. In these areas, the cloud base was forecast to lower to 800 ft amsl. Again, both sectors had the warning *"Cloud on hills, moderate ice and turbulence in cloud."*

Visual Flight Rules (VFR)

Because G-CCKK was not equipped with gyroscopic flight instruments, it was restricted to flight under VFR only. The minimum weather conditions for flight under VFR depend on an aircraft's altitude and speed, as well as the category of airspace in which it is flying. In the case of G-CCKK, the pilot would have been required to keep his aircraft clear of cloud and in sight of the surface, and in a flight visibility of at least 1,500 m.

Medical and pathological information

A post-mortem examination was conducted on both the pilot and passenger. There was no evidence of any pre-existing disease, alcohol, drug or toxic substance which might have caused or contributed to the accident. Both occupants suffered fatal injuries, when the aircraft struck the ground.

Recorded information

Three GPS systems were recovered from the wreckage. One was a conventional GPS receiver which was not powered and thus not in use. The other two units were near identical Pocket PC units with GPS software. Both these units had suffered damage in the accident and attempts to recover track data from the units were unsuccessful. Information recovered from the pilot's home indicated that only one GPS route between Hullavington and Shobdon was stored in one or more of the units' memories, and this was a direct track between the two airfields.

Pilot information

The pilot had gained his Private Pilot's Licence (Aeroplanes) in 1998. In 2001 he completed construction of a Rans S6 aircraft, in which he flew 61 hours before the aircraft was destroyed in a take-off accident in 2002, from which the pilot escaped with minor injuries. The pilot then started to build G-CCKK, completing the aircraft in November 2003. Apart from a trial helicopter lesson, he had flown this aircraft exclusively since that date, accumulating a total of 122 hours in it.

On the day of the accident, the pilot had been working at his home, a few miles from Hullavington Airfield. The pilot's decision to go flying that day was a relatively late one, made either on the day of the accident or the evening before, and had been made after discussion with his passenger. During that day, the pilot had been working at home with a family member, who recalled that the weather there seemed reasonable and with some sunny periods, although it was changeable. The passenger arrived at the pilot's home at about 1500 hrs; the family member left the house at about 1510 hrs and, therefore, did not witness the pilot's final actions before he and his passenger left for Hullavington.

The pilot was known to have discussed with friends the implications of encountering bad weather whilst airborne. He had stated that, if he encountered weather conditions that were too bad to continue, he would be quite prepared to land his aircraft in a field. He was of the opinion that, as his aircraft was capable of quite slow flight, this could be accomplished at little notice and without undue difficulty.

Although many local flights were recorded in the pilot's flying logbook, he would frequently plan to land away at another airfield, and Shobdon was his most frequent destination. Information from passengers who had flown with the pilot indicated that he used the GPS map display as a primary navigation aid, but would also always have an aeronautical chart to hand. Several charts were recovered from the wreckage, including one which had direct line routes to some of the pilot's usual destinations marked on it. Apart from basic timing information, no other information was recorded on these charts. The pilot's flight log, which was of a home made type, was also recovered from the aircraft. Apart from take-off and landing times and altimeter settings, there was no other weather or navigational data recorded on the log.

Analysis

The decision to undertake the flights had been made a relatively short time beforehand. The fact that the passenger was also the pilot's long time friend may have made him feel obliged to make the flights. The flights were later in the day than the pilot had normally made. In the 18 months that he had been flying this aircraft, the pilot had only twice returned to his home airfield after 1800 hrs local time; the accident flight would have been due to return at about 1900 hrs local time. Whether the relatively late take-off time was due to other commitments, on the part of the passenger or the pilot, is uncertain, but it may have placed some time pressure on the pilot. This is supported by the lack of notification to the airfield authorities and the absence of any navigational calculations on his flight log. It is reasonably certain that the pilot had intended to fly to Shobdon from the outset, as a self-produced airfield guide was found at his house, together with the meteorological information.

Although only one part of the forecast (Metform 214) was recovered, it is probable that the pilot viewed Metform 215 on the internet at the same time, even if he did not print it. What is uncertain is whether he viewed an updated forecast, as the one found was only valid until 1200 hrs on the day of the accident. The decision to fly to Shobdon suggests that he may not have, since the forecast for 1500 hrs, which was valid between 1200 hrs and 1800 hrs showed a region of frontal weather moving across Wales towards the Shobdon area. Had the pilot seen this forecast he might be expected to have chosen to fly to another of his regular destinations, less likely to have been affected by the frontal weather. Additionally, the later forecast showed an increased risk of low cloud affecting the higher ground between Hullavington and Shobdon. The relative, who was at home with the pilot during the afternoon, did not recall him doing anything obviously connected with flight preparation. As the later forecast was only available from 1200 hrs local time, it is possible that the pilot did not obtain a weather update after that time.

The briefing chartlets associated with Metform 215 are of small scale and cannot be expected to reflect local weather effects or influences. The direct route from Hullavington to Shobdon, which the pilot had flown several times, ran close to the accident site and over the steep escarpment which forms the western edge of the Cotswolds in this area. The pilot had flown in this area since gaining his pilot's licence so it is reasonable to expect him to have been aware of the potential for localised poorer weather in the vicinity of the Cotswold Edge, particularly when a moist south-westerly airflow prevailed, and the forecast contained the warning *'cloud on hills'*.

The weather report from RAF Lyneham at 1550 hrs showed that, when the pilot departed from Hullavington, the weather was reasonable. As subsequent weather reports from Lyneham reflected, the weather steadily deteriorated after the aircraft had taken off, and continued to do so until after the accident. This deterioration also affected the accident area, as indicated by the Police helicopter pilot's report.

The weather conditions at the accident location, when viewed in conjunction with the generally accepted chart of probability of carburettor icing in typical light aircraft induction systems, were conducive to ice formation at cruise power. It should be noted, however, that the chart data relates to conventional air cooled engines operating with their induction heating systems set to 'cold'. The carburettors and induction system of the Rotax engine installed in G-CCKK were substantially different in design from those for which the accepted induction icing chart data is relevant in that the induction system in this aircraft incorporated a heat exchanger designed to prevent ice from adhering to the internal surfaces of the carburettor, provided the engine cooling water remained hot.

Thus, although the meteorological conditions quoted in the after-cast were conducive to carburettor icing on conventional light aircraft, they almost certainly had no effect on the engine operation of this machine during the cruise. It is also not thought that any descent would have been sufficiently prolonged to create low coolant temperature conditions which might permit significant icing build up. The aircraft was observed and heard to be manoeuvring under power. The engine sounded to witnesses to be running normally and the engine was running at impact. As significant induction icing will result in not only power loss at low throttle openings but also stoppage of the propeller at low flight speeds, for which there was no evidence, there is little possibility that the engine suffered to any significant degree from the effects of induction icing during the period immediately before the crash.

The actual route the pilot took for the flight to Shobdon is not known. The GPS is believed to have contained a direct route to Shobdon, and it was a direct route that was marked on the pilot's aeronautical chart.

Additionally, the times of takeoff and landing of the flight from Hullavington to Shobdon indicate that he flew a reasonably direct route. This would have taken the aircraft over terrain with an approximate elevation of 800 ft amsl, close to the area where the accident later occurred. It would be expected that he may have encountered some poorer weather in this region of high ground on the flight to Shobdon though, if he did, he was obviously able to negotiate it on that occasion.

If the weather had caused the pilot or his passenger concern, they did not show this whilst at Shobdon. Had he been concerned, the pilot would almost certainly have been keen to depart earlier on the return journey in case the weather deteriorated further. Although the pilot did intend to return to Hullavington straight away, as evidenced by the departure time that he entered in the operations log when they arrived at Shobdon; the two men in fact stayed for a meal. The relaxed, unhurried demeanour of the two men would appear to indicate that the pilot had no particular concern regarding the weather they were likely to encounter during their return flight. This suggested that either there was no poor weather in the accident area on the outbound journey, or the pilot was able to negotiate successfully the weather he had encountered. Whichever was the case, the pilot's expectation would appear to have been that a route back through the area would be possible without undue difficulty, and this may have influenced the pilot's decision to continue in the face of the worsening weather when it was encountered on the return flight. The relatively late hour and the proximity of his home base may also have served to add some pressure on the pilot to continue in an attempt to find a way through the weather, rather than to deviate around it or to divert to an alternate airfield.

When first seen by eye witnesses in the accident area, the aircraft was travelling in a direction almost opposite to that of the track towards Hullavington. Clearly, the pilot had deviated from his intended plan and, in view of the weather at the time, it is probable that this was due solely to the worsening weather conditions. The most likely courses of action that the pilot would be expected to take would be to reverse his route to seek the better weather conditions from which he had come, or to seek a route down to lower ground. The two witnesses who saw the final moments of the flight stated that they could see down the hill to the valley beyond. This would appear to have offered the pilot an escape route from the bad weather and, if he had seen it, it is probable that he would have taken it. However, although the aircraft was clearly flying at a very low height, it was probably immediately below the cloud cover; witness evidence even suggests that the aircraft may have been in cloud intermittently. The pilot's forward visibility was likely to have been severely limited in this case and his concentration would have been on the ground close to the aircraft. That this was probably the case is supported by the fact that the two other golfers, only a short distance up the slope from the first two, were unable to see down the hill to the valley and generally reported worse conditions.

Faced with the weather conditions, and given his expressed intentions to land if caught in bad weather, it is likely that the pilot was indeed seeking a place to land his aircraft. However, such a manoeuvre is not without risk and in poor weather would be demanding for any pilot. Information from the witnesses suggest that the aircraft was slowing down as if preparing to make an approach, though it is quite possible that the pilot intended a landing not on the golf course, but in the field in which the accident occurred. The manoeuvring described by witnesses suggests the pilot was setting up an orbit around his chosen field whilst looking for hazards that might affect a landing. This is the procedure that the pilot would have been taught during training. The lower cloud over the golf course would have precluded such an inspection, and the pilot would probably have been committed to a landing had he continued to fly towards the upward sloping ground of the fairway and into the lowering cloud base. However, the reducing speed and apparent descent seen by witnesses means that the possibility that the pilot was attempting to land on the golf course cannot be excluded.

Whilst turning, the aircraft would have lost airspeed had the pilot not countered this with increasing power, particularly if the turn was moderate, as described by the witnesses. Additionally, aircraft in this category have relatively low mass and therefore low inertia, and their drag causes them to slow down readily when power is reduced. Having found a landing place, the pilot would have been reluctant to take his eyes away from it in the poor visibility, and the natural tendency would be to reduce power and airspeed, both with a view to remaining close to the field and in preparation for landing. It is probable that the poor weather conditions and the need to land his aircraft served to distract the pilot from monitoring the aircraft's airspeed.

As the pilot sought to land the aircraft, his work load would have been considerable. As the aircraft speed reduced, it would have come closer to an aerodynamic stall. One of the warning signs of an approaching stall that a pilot learns during training is an excessively nose-high attitude to maintain level flight but, in the poor visibility, the lack of a natural horizon to give this attitude information would have significantly reduced the impact of this visual cue. Witness information indicates that the aircraft may have started a descent just prior to the stall. Although this was interpreted as the beginning of an approach to the golf course, it may have been as a result of the reducing airspeed. If this were the case, the aircraft's attitude would not have been so nose-high, thus also serving to mask the approaching stall from the pilot.

Additionally, the sloping ground beneath and ahead of the pilot, as the aircraft turned to fly towards the golf course, could have induced an incorrect estimate of horizon location in the pilot's perception; a known phenomenon normally associated with difficulties when approaching sloping runways. The impact evidence from the accident site and the final manoeuvre described by witnesses are consistent with a 'wing drop' occurring at the stall and a subsequent departure from controlled flight.

Conclusion

The pilot encountered an area of worsening weather conditions over the rising ground of the Cotswold escarpment. The pilot deviated from his intended track to escape the weather but was unable to find a route to a clearer area. The pilot was probably preparing for a forced landing when the aircraft stalled and departed from controlled flight at a height from which recovery was not possible.

ACCIDENT

Aircraft Type and Registration:	Flight Design CT2K, G-CBDJ
No & Type of Engines:	1 Rotax 912ULS piston engine
Year of Manufacture:	2001
Date & Time (UTC):	13 February 2006 at 1200 hrs
Location:	Bucknall Airstrip, near Lincoln
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Cockpit transparencies broken, propeller, nose landing gear, vertical stabiliser and cabin roof damaged
Commander's Licence:	Private Pilot's Licence
Commander's Age:	71 years
Commander's Flying Experience:	2,200 hours (of which 450 were on type) Last 90 days - 22 hours Last 28 days - 5 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and information provided by the aircraft manufacturer

Synopsis

The microlight aircraft's main wheels struck a hedge during landing.

History of the flight

Shortly before touchdown, on the grass Runway 16 at Bucknall, the aircraft descended unexpectedly and the main wheels brushed the top of a low hedge. Wind conditions were light and the temperature was approximately 5°C. Contact with the hedge caused the aircraft to pitch forward and touch down heavily on its nose wheel which separated from the nose landing gear leg. The nose leg then dug in, causing the aircraft to pivot slowly forwards and come to rest inverted. The composite structure of the aircraft remained substantially intact and the occupants were able to vacate the aircraft unaided.

Discussion

The aircraft had flown the short distance from Temple Bruer to Bucknall Airfield, which has two short grass strips intended primarily for the operation of microlight aircraft. Runway 16 is the longer of the two, with a total length of 300 m, but is bordered by a low hedge running perpendicular to its touchdown threshold. The pilot stated that he flew the approach at 45 kt, intending to pass close over the hedge in order to touch down as early as possible but on reflection, he considered that the runway was long enough for a successful landing without the need to do so. This view is supported by information provided by the manufacturer, which indicated that the total landing distance required from a height of 15 m was 275 m, assuming a surface of dry grass, zero wind and an approach speed of 45 kt. The pilot judged that there had been a light surface wind from the south-south-west and that the runway was dry.

BULLETIN CORRECTION

INCIDENT

Aircraft Type and Registration:	Boeing 737-73V, G-EZKA
No & Type of Engines:	2 CFM56-7B20 turbofan engines
Year of Manufacture:	2003
Date & Time (UTC):	28 December 2005 at 1840 hrs
Location:	6 miles west of Newcastle, Northumbria
Type of Flight:	Public Transport (Passenger)
Persons on Board:	Crew - 5 Passengers - 128
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:	11,121 hours (of which 4,380 were on type) Last 90 days - 206 hours Last 28 days - 78 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and subsequent enquires by the AAIB

AAIB Bulletin No 4/2006, page 49 refers

An incorrect figure (**Figure 1 -** Location of APU air inlet on Boeing 737-700) was inadvertedly printed in the above report in the April bulletin. The complete report is reproduced below:

Synopsis

Prior to the flight the aircraft was de-iced due to snow accumulation. During a 'No Engine Bleed Air Takeoff', in which APU bleed air was in use, fumes and smoke entered the cockpit and cabin causing some passengers to suffer from eye and throat irritation. After isolating the APU bleed air and selecting engine bleed air the fumes dissipated. The aircraft returned to Newcastle and the passengers were offered medical attention. The fumes were as a result of de-icing fluid entering the APU air inlet during the initial climb out.

History of flight

The aircraft was being prepared for a scheduled flight from Newcastle to Budapest. During the walkaround checks the flight crew noticed large amounts of snow had accumulated on all the upper surfaces of the airframe, wings and tailplane. Once all the passengers had boarded, the aircraft was de-iced to remove the accumulated snow and ice.

Performance limitations on the aircraft necessitated a takeoff to be made with all available engine power. This required the use of full engine thrust and the bleed air from both engines to be switched off. Bleed air from the APU was then used for air conditioning and pressurisation during the takeoff and initial climb.

The taxi and takeoff were without incident. However, on passing 300 ft, in the climb, the commander sensed a faint smell in the air, after which the first officer noticed thick black smoke appearing from behind the commander's left shoulder. The smoke quickly filled the cockpit, so the flight crew donned their oxygen masks. At the same time the cabin crew contacted the flight crew to inform them that the cabin air was also contaminated.

The suspicion was that the bleed air from the APU had become contaminated and had entered the air conditioning system. The first officer isolated the APU bleed air and changed over to engine bleed air; the fumes and smoke quickly dissipated.

A PAN was declared and a request made to ATC for an immediate return to Newcastle. During this time several passengers began to complain of eye and throat irritation. After landing, the passengers were deplaned and offered medical assistance in the terminal building.

Aircraft examination

A detailed examination of the aircraft by the maintenance organisation did not reveal any defect with the aircraft, bleed air or air conditioning system.

Previous events

A review of the CAA's Mandatory Occurrence Report database revealed at least three previous occurrences of contaminated bleed air during the takeoff on Boeing 737 aircraft. In all three cases the cause was reported as excess de-icing fluid finding its way into the APU air inlet (Figure 1) during takeoff and climb.

Manufacturer's information

The aircraft manufacturer provides information on adverse weather operations and exterior de-icing in a supplementary procedure to the flight crew operations manual. This states that during de-icing:

> *'APU and engine BLEED air switches ....OFF F/O*
>
> *The bleed air switches must be turned off to reduce the possibility of fumes entering the air conditioning system.*
>
> *CAUTION: With the APU operating, ingestion of de-icing fluid causes objectionable fumes and odors to enter the airplane. This may also cause erratic operation or damage to the APU.'*

The manufacturer also provides a supplementary procedure for 'No Engine Bleed Takeoff and Landing' but makes no mention of the possibility of de-icing fluid contamination of the APU air during climb out following a de-icing operation.

The aircraft maintenance manual, which provides the instructions on exterior de-icing, warns that fluid should not be directed at any of the engine or APU inlets and exhausts.

Discussion

The most likely cause of the fumes and smoke that entered the cockpit and cabin was excess de-icing fluid finding its way into the APU air inlet (Figure 1) during the climb out. The de-icing fluid would then enter the hot sections of the APU, causing it to produce smoke and fumes which would then pass through to the air conditioning and into the aircraft. Performance limitations for this takeoff required that all available engine power be used, necessitating that the engine bleed air be switched off and the APU bleed air used for air conditioning and pressurisation instead.

The operator has undertaken to remind those who de-ice the aircraft about the need to take care when de-icing in the vicinity of the APU inlet on Boeing 737 aircraft.

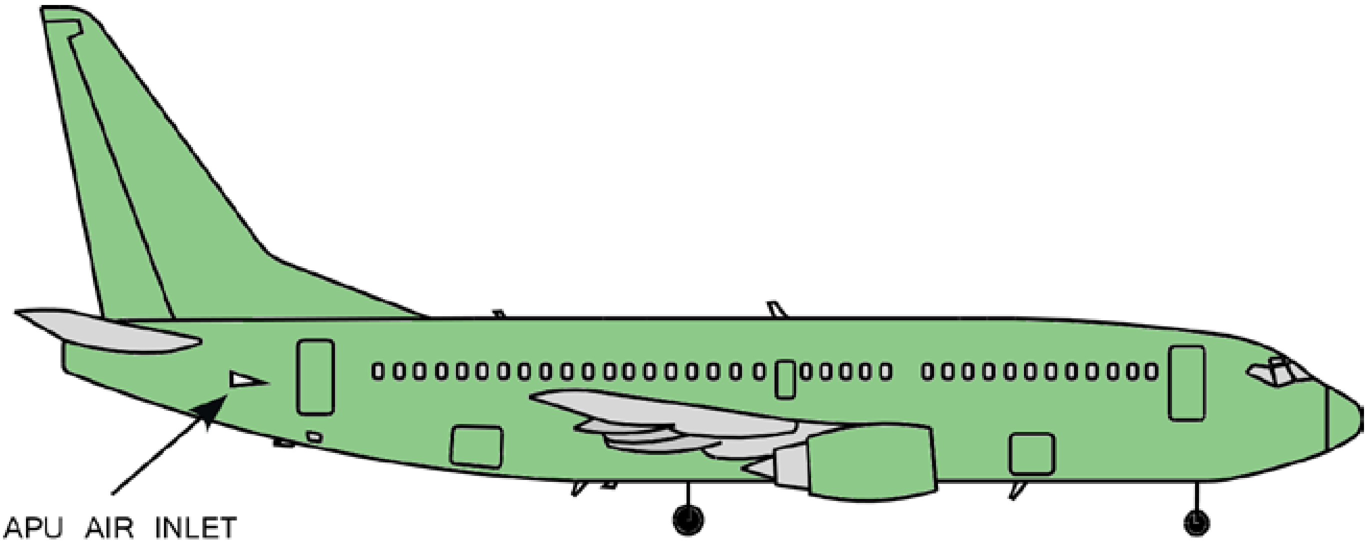

Figure 1
Location of APU air inlet on Boeing 737-700

FORMAL AIRCRAFT ACCIDENT REPORTS ISSUED BY THE AIR ACCIDENTS INVESTIGATION BRANCH

2004

1/2004 BAe 146, G-JEAK
during descent into Birmingham
Airport on 5 November 2000.

Published February 2004.

2/2004 Sikorsky S-61, G-BBHM
at Poole, Dorset
on 15 July 2002.

Published April 2004.

3/2004 AS332L Super Puma, G-BKZE
on-board the West Navion Drilling Ship,
80 nm to the west of the Shetland Isles
on 12 November 2001.

Published June 2004.

4/2004 Fokker F27 Mk 500 Friendship,
G-CEXF at Jersey Airport,
Channel Islands on 5 June 2001.

Published July 2004.

5/2004 Bombardier CL600-2B16 Series 604,
N90AG at Birmingham International
Airport on 4 January 2002.

Published August 2004.

2005

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

Published February 2005.

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

Published November 2005.

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

Published December 2005.

2006

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

Published January 2006.

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